

# 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

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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.*

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## List of Acronyms

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	diphenylamine
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 <sub>2</sub>	nitrite
NO <sub>3</sub>	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

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## 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.

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## OVERVIEW

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

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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	<ol style="list-style-type: none"> <li>1. Remove and properly dispose of soils in selected areas that exceed the industrial SRVs.</li> <li>2. Notify tenants in affected areas of the contamination in the vicinity of their rented properties.</li> </ol>
CONCLUSION 3	MDH concluded that contaminated soils in some areas of the site pose an indeterminate public health hazard.
Basis for conclusion	<p>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.</p> <p>Current exposure is expected to be limited in frequency and duration, but future land uses may result in greater exposures.</p>
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.

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CONCLUSION 5	MDH concluded that groundwater poses an indeterminate public health hazard.
Basis for conclusion	<p>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.</p> <p>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.</p>
Recommendations	<ol style="list-style-type: none"> <li>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.</li> <li>2. Conduct vertical soil sampling in area AOC6 to determine if PAHs leached to groundwater in that area.</li> <li>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).</li> <li>4. Complete a thorough evaluation of all wells on the UM property and properly seal any wells not in use.</li> <li>5. MDH should continue to sample wells near the Coates Dump and test for antimony, thallium, and VOCs, including 1,4-dioxane.</li> </ol>

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DATA LIMITATIONS	<p>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.</p>
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## 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**

<b>GOW East</b>	
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).
<b>ABC Line</b>	
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
<b>GOW Central</b>	
GOW uses:	powder processing and packaging, East 160 <sup>th</sup> 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 160 <sup>th</sup> St. Dump, the Suspected Disposal Area, and the NPL sub-site
<b>DEF Line</b>	
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

<b>GOW East</b>	
	use included Jensen airfield
Current uses:	agriculture
Soil contaminants:	arsenic, PAHs, asbestos, construction debris
<b>Navy/Burning Grounds</b>	
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 10 <sup>th</sup> , 30 <sup>th</sup> , 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
<b>GOW West</b>	
GOW uses:	construction and demolition debris disposal area - the 154 <sup>th</sup> 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).
<b>GOW North</b>	
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 to be 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.

#### Subsequent data

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 Dalglish, 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**

<b>Area 1 – Figure 14</b>	
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
<b>Area 2 – Figure 15</b>	
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
<b>Area 3 – Figure 16</b>	
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
<b>Area 4 – Figure 17</b>	
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 ethylbenzene 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 ACMF 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 ACMF 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 ACMF 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 ACMF 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 ( $\mu\text{g}/\text{dL}$ ). 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  $\mu\text{g}/\text{dL}$  to identifying a reference level for elevated lead in children at 5  $\mu\text{g}/\text{dL}$  (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.

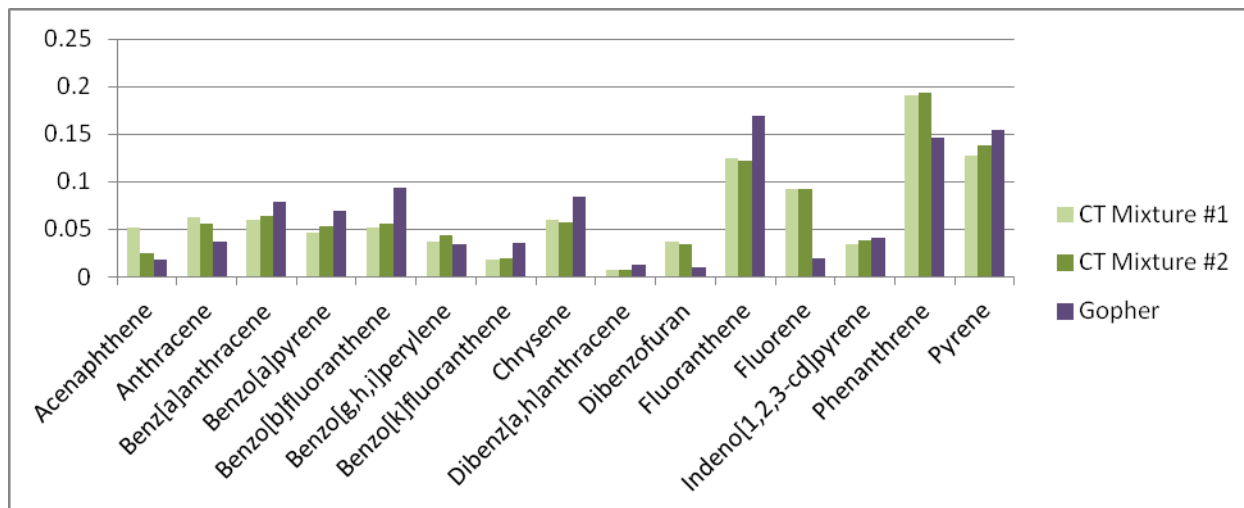
Previous MDH guidance recommends analyzing for an extended list of 25 cPAHs to more fully evaluate the cancer risks (MDH, 2001). In a recent draft toxicity assessment of PAH mixtures, EPA also uses a similar approach for calculating a cancer risk estimate from a draft list of 24 recommended cPAHs; 12 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 et 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  $11.5 \text{ (mg BaP mixture/kg-d)}^{-1}$ . 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 Dalglish, 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 2,6-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 ( $\text{NO}_3$ ) 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 ( $\text{NO}_2$ ), 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<sup>a</sup>**

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

<sup>a</sup>**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.

<sup>b</sup>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 (10<sup>th</sup> St. Dump, B Street Dump, 30<sup>th</sup> St. Dump, 160<sup>th</sup> 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 Dalglish (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 152<sup>nd</sup> Street because of lead contamination from the former lead burner shop and mercury and arsenic contamination from the former auto body shop (Janet Dalglish (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
<b>Off-Site Wells:</b>				
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)**

<b>On-Site Wells:</b>				
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 Dalglish, 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 160 <sup>th</sup> 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 160 <sup>th</sup> 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 in 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 28<sup>th</sup>, 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 / 154<sup>th</sup> 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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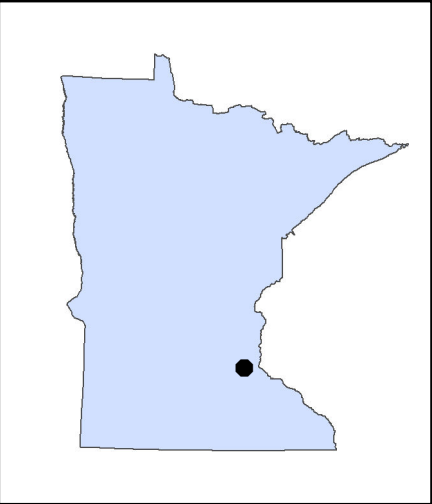
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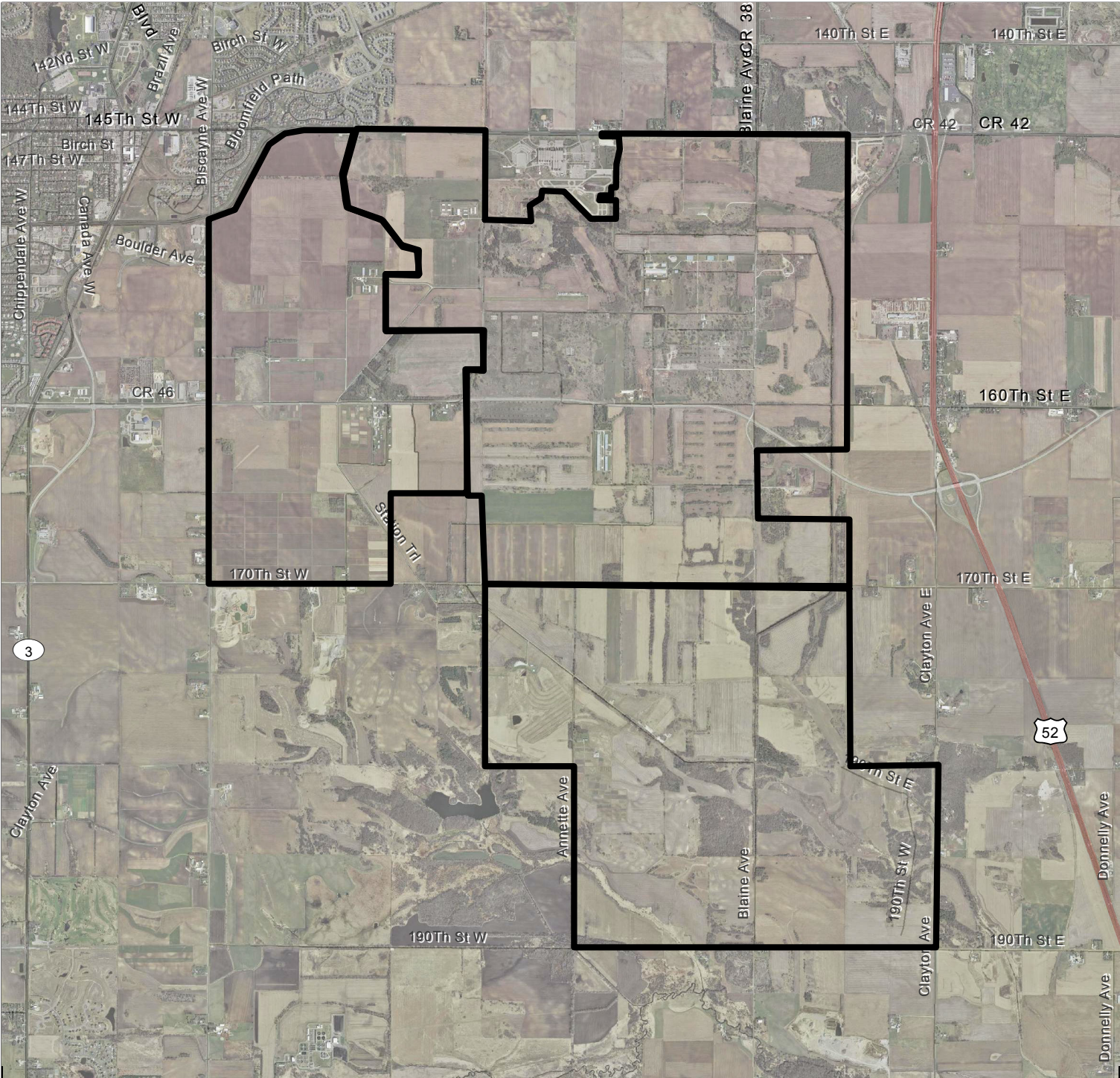
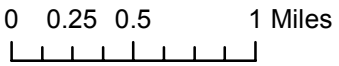


## Figures

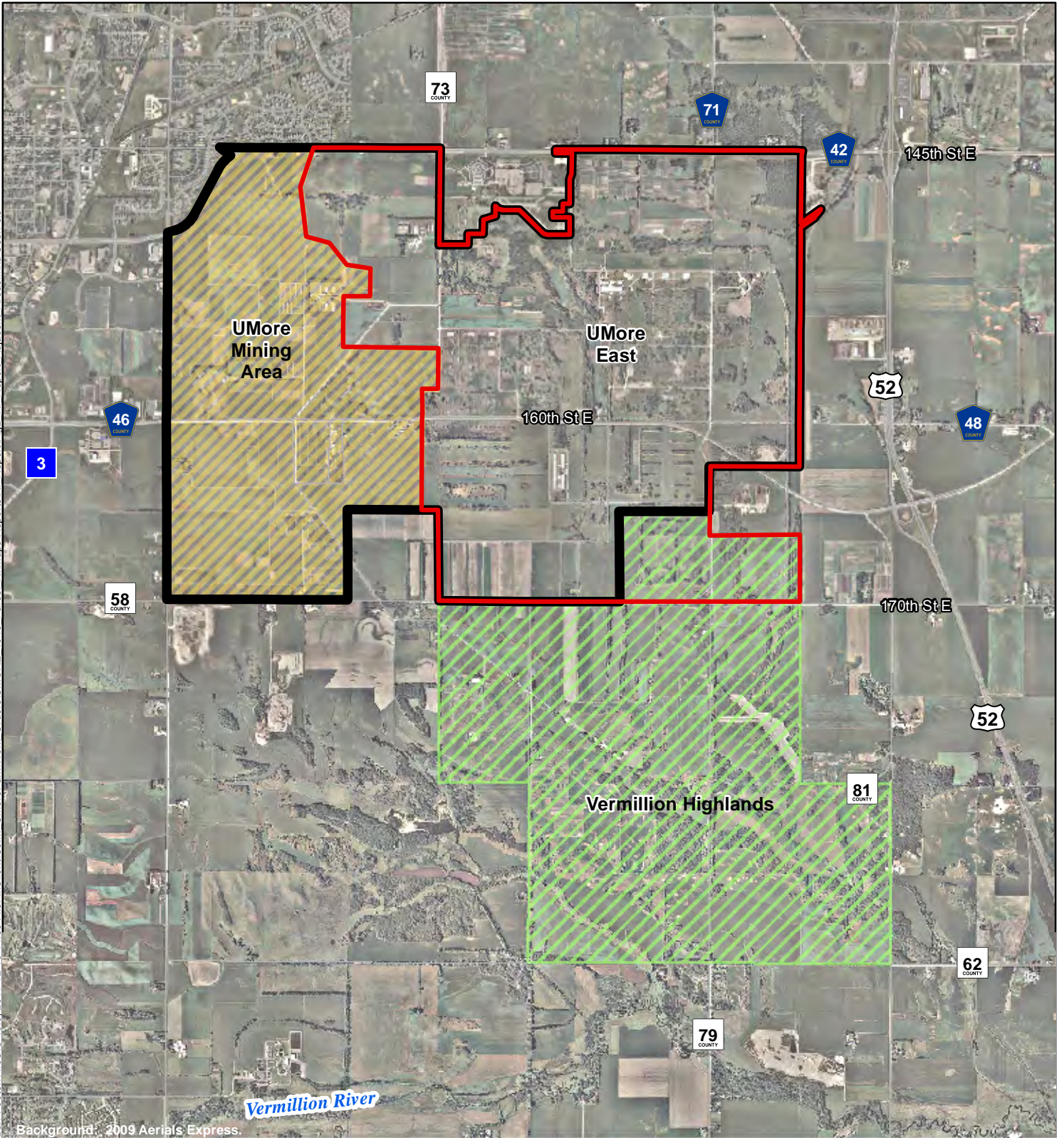
# Figure 1: Gopher Ordnance Works location






● Gopher Ordnance Works  
■ Minnesota



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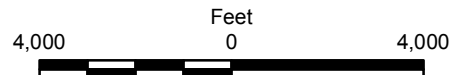


-  UMore Park Boundary
-  UMore East Project Area
-  UMore Mining Area
-  Vermillion Highlands Boundary

## Figure 2: Three sub-sections

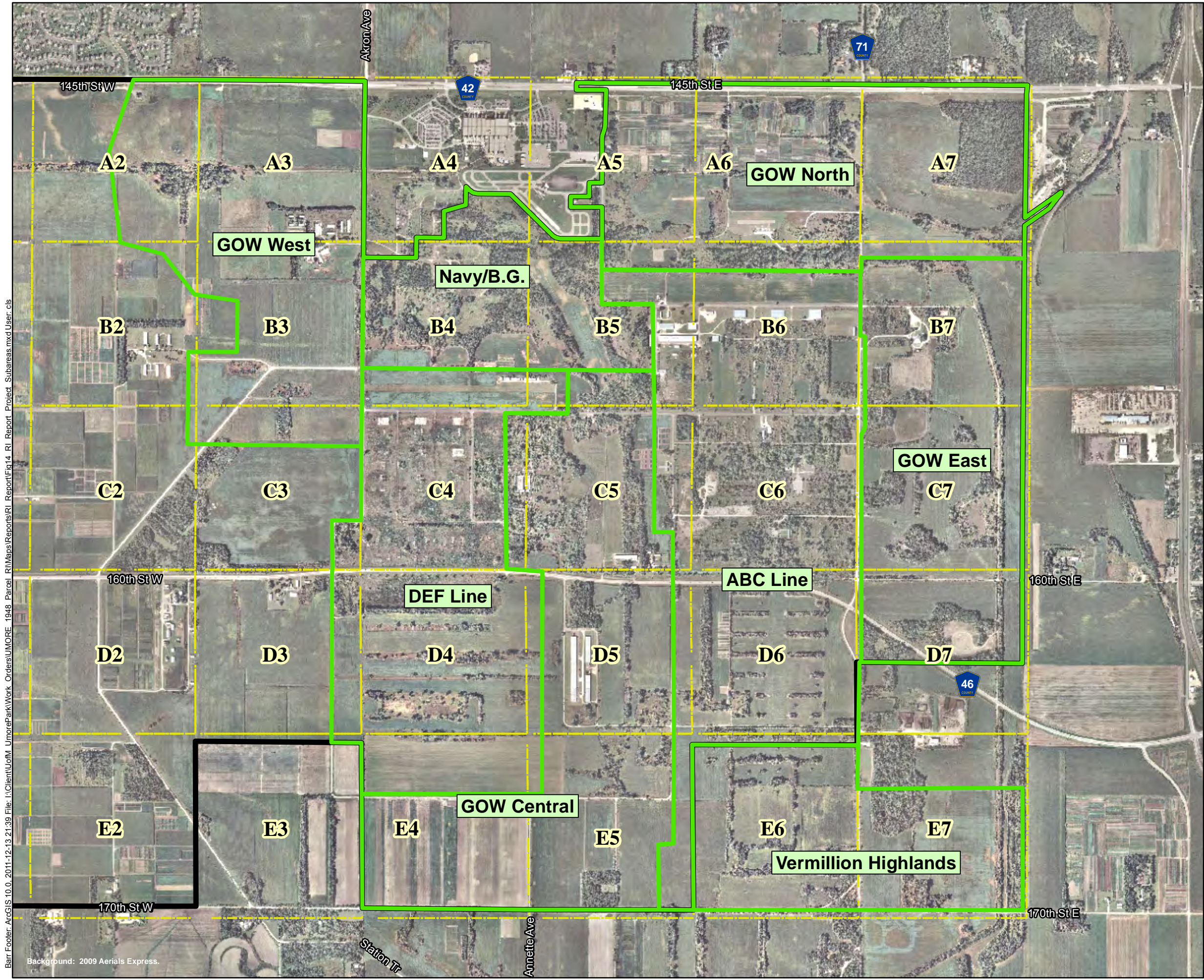
Figure 2




ADJACENT AREAS  
Remedial Investigation  
Report  
UMore East  
Dakota County, MN



Source: MnDOT, MN DNR, Dakota County, Barr, HKGi, University of Minnesota, USACE.

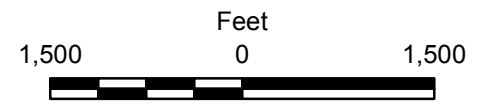




-  UMore Park Boundary
-  UMore East Subarea Boundary
-  Site Location Grid

Source: Metropolitan Council, MnDOT, Dakota County, Barr.

Figure 3: Sub-sites within UMore East



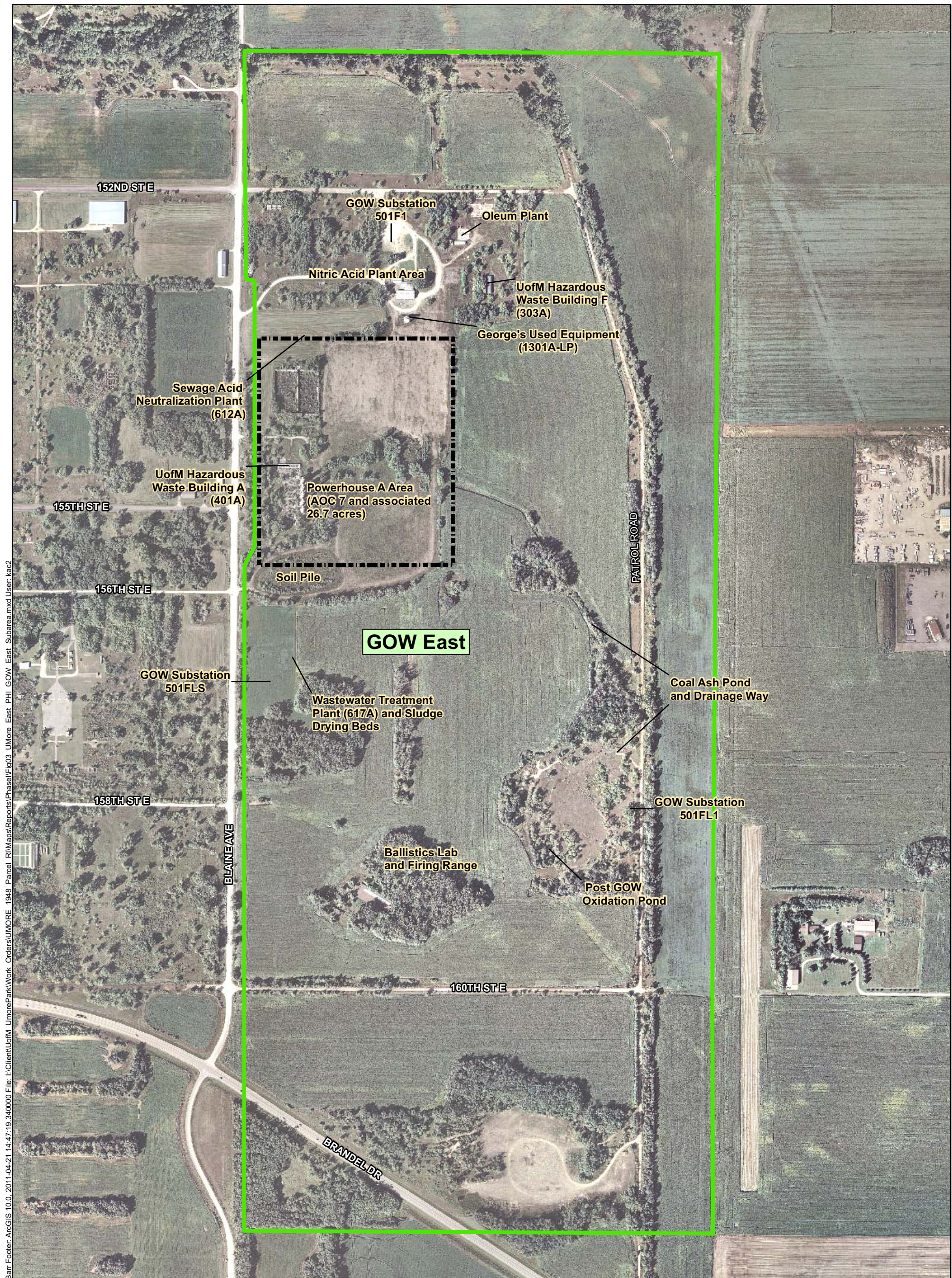
PROJECT SUBAREAS

Remedial Investigation  
Work Plan  
UMore East  
Dakota County, MN



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Background: 2009 Aerials Express.



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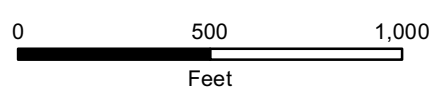
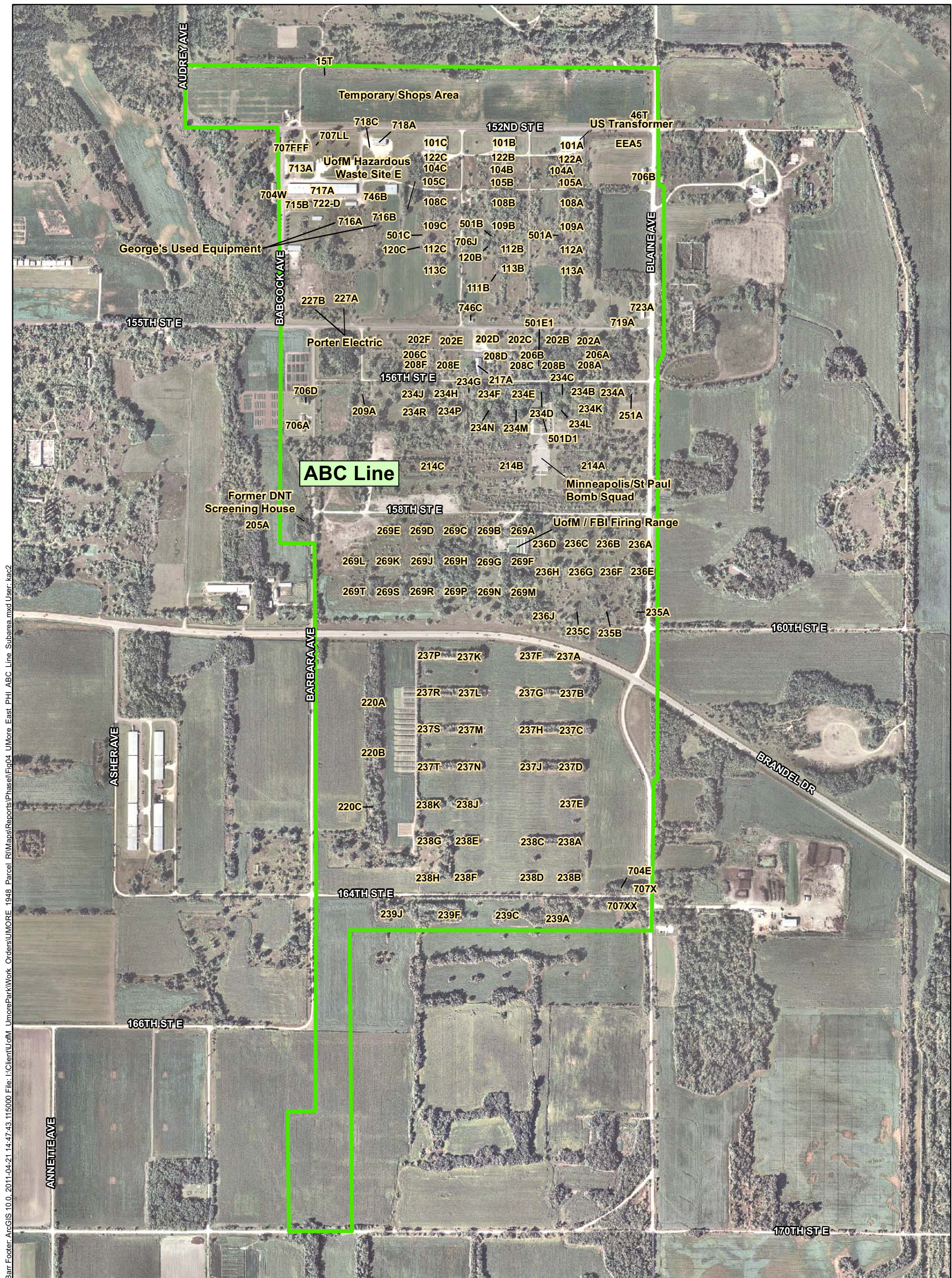
-  UMore East Subarea Boundary
-  USACE AOCs (based on Baywest 2008)

Figure 4: GOW East Subarea

**GOW EAST SUBAREA**  
  
 UMore East  
 Phase I Environmental  
 Site Assessment  
 Dakota County, MN



Data Sources: Barr Engineering Company, University of Minnesota.  
 Background: 2009 Aerials Express Photography (Twin Cities)



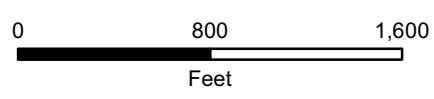
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 UMore East Subarea Boundary

Figure 5: ABC Line Subarea

ABC LINE SUBAREA

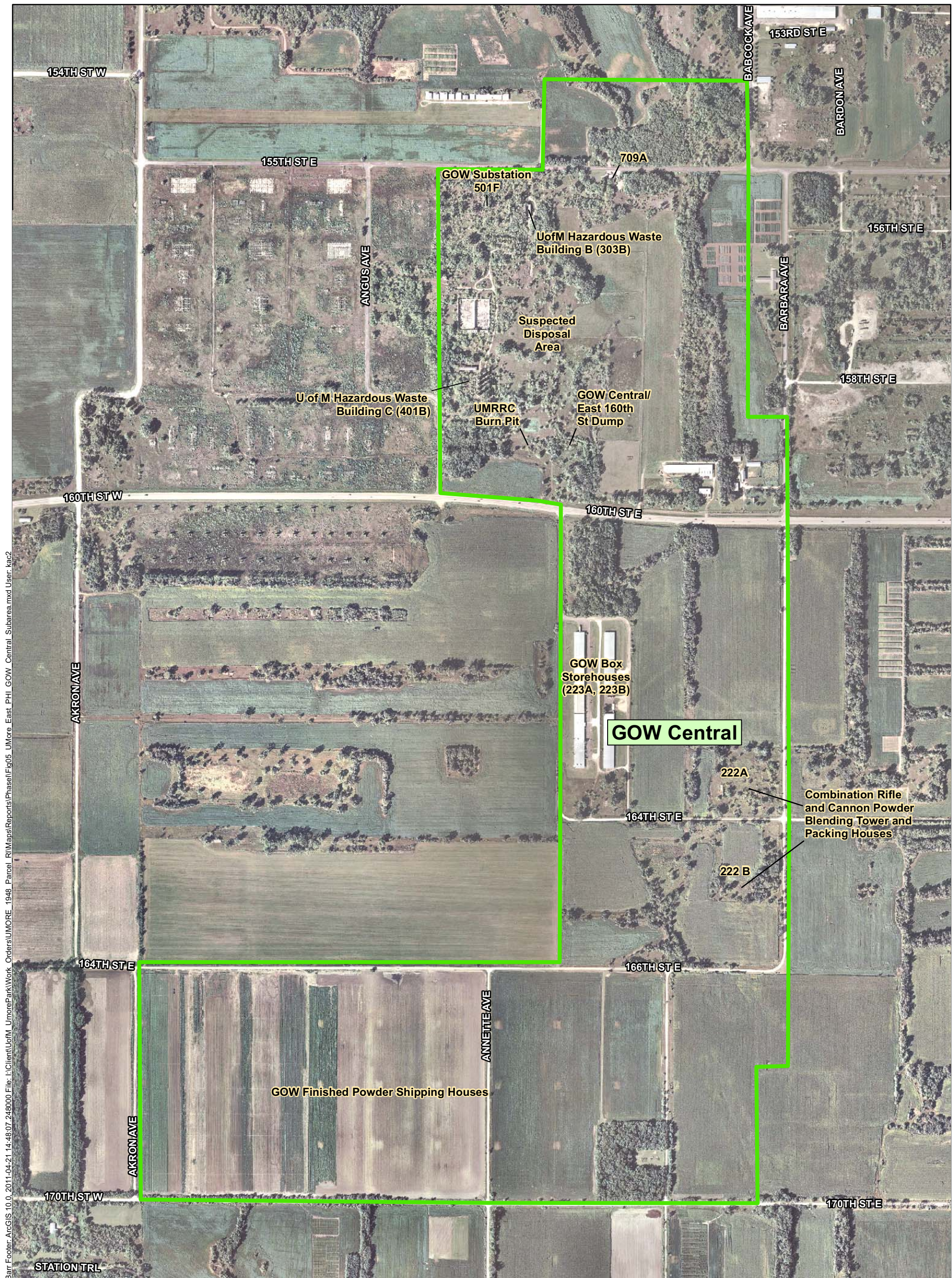
UMore East  
Phase I Environmental  
Site Assessment  
Dakota County, MN



Data Sources: Barr Engineering Company, University of Minnesota.  
Background: 2009 Aerials Express Photography (Twin Cities)



UMP011535



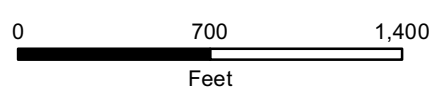
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 UMore East Subarea Boundary

Figure 6: GOW Central Subarea

GOW CENTRAL SUBAREA

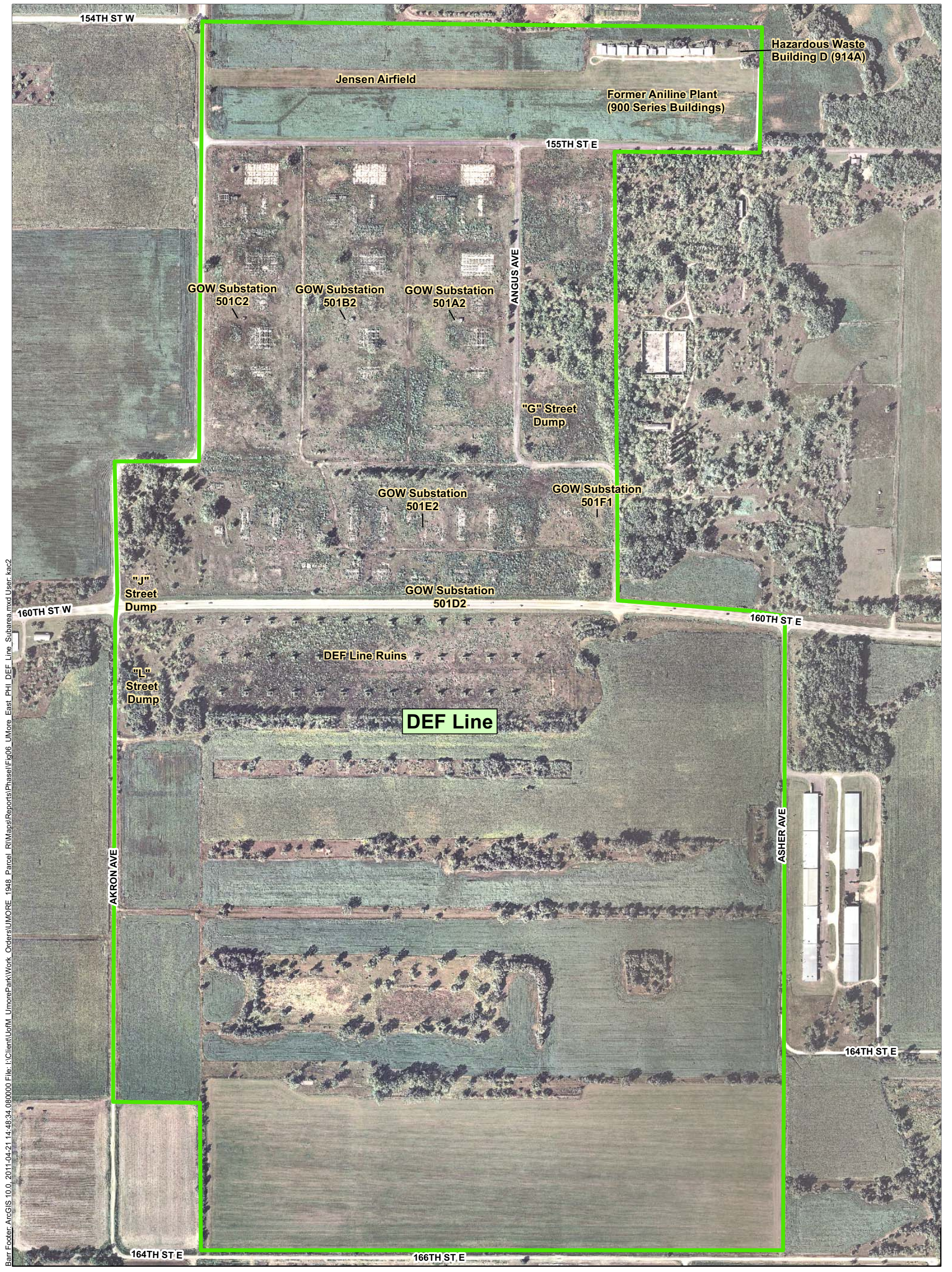
UMore East Phase I Environmental Site Assessment Dakota County, MN




Data Sources: Barr Engineering Company, University of Minnesota.  
Background: 2009 Aerials Express Photography (Twin Cities)



UMP011536

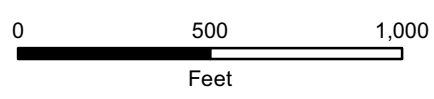


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 UMore East Subarea Boundary

### Figure 7: DEF Line Subarea

**DEF LINE SUBAREA**  
 UMore East  
 Phase I Environmental  
 Site Assessment  
 Dakota County, MN




Data Sources: Barr Engineering Company, University of Minnesota.  
 Background: 2009 Aerials Express Photography (Twin Cities)



Barr Footer: ArcGIS 10.0, 2011-04-21 14:49:00, 335000 File: I:\Client\UofM\_UmorePark\Work\_Orders\UMORE\_1948\_Parcel\_RI\Map\Reports\PhaseI\Fig07\_UMore\_East\_PhI\_NavyBG\_Subarea.mxd User: kac2

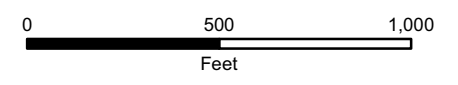


 UMore East Subarea Boundary

Data Sources: Barr Engineering Company, University of Minnesota.

Background: 2009 Aerials Express Photography (Twin Cities)

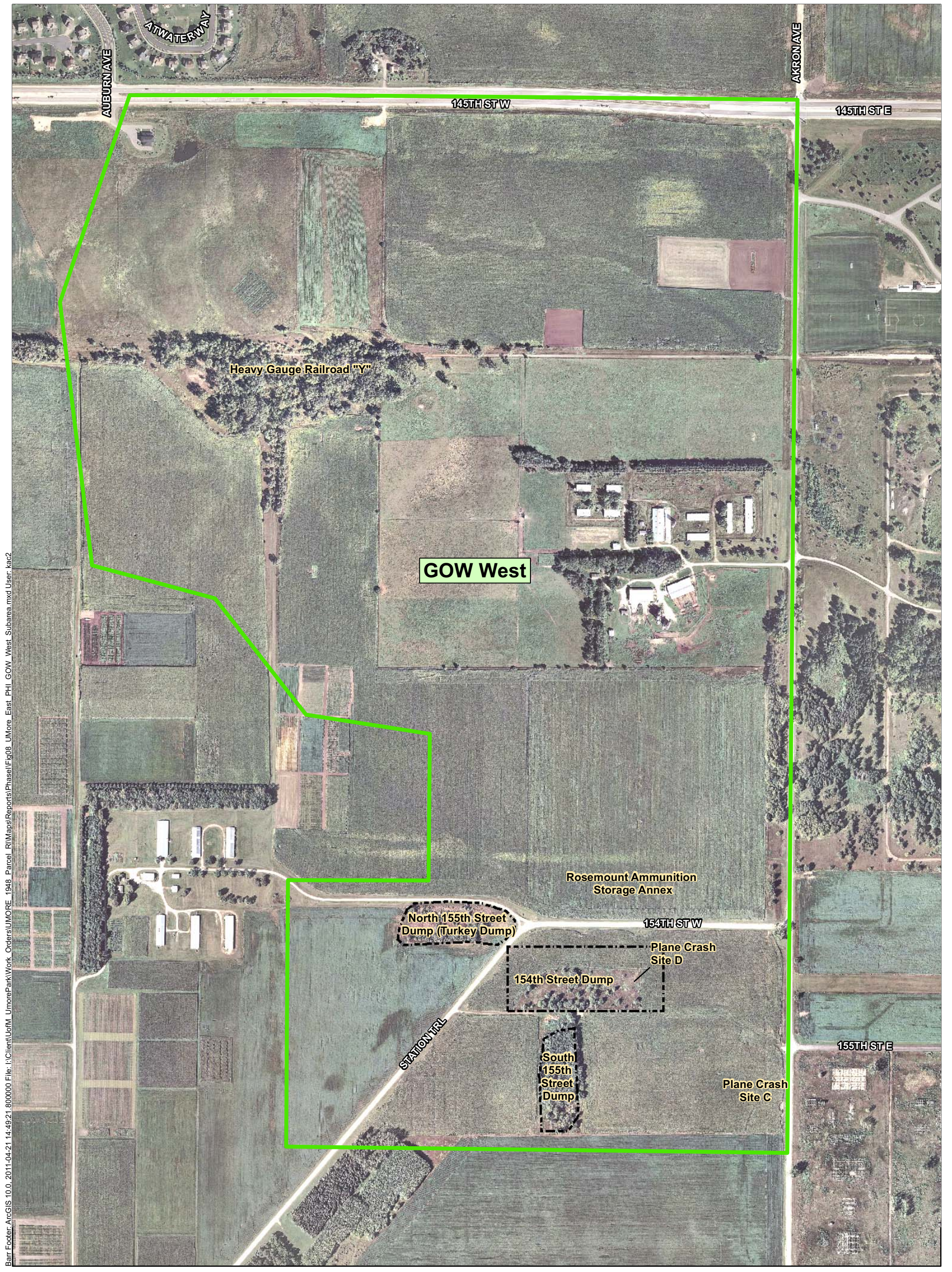
### Figure 8: Navy/Burning Grounds Subarea





**NAVY / BURNING  
GROUNDS SUBAREA**

UMore East  
Phase I Environmental  
Site Assessment  
Dakota County, MN



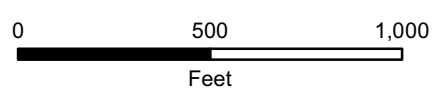


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-  UMore East Subarea Boundary
-  USACE AOCs (based on Baywest 2008)

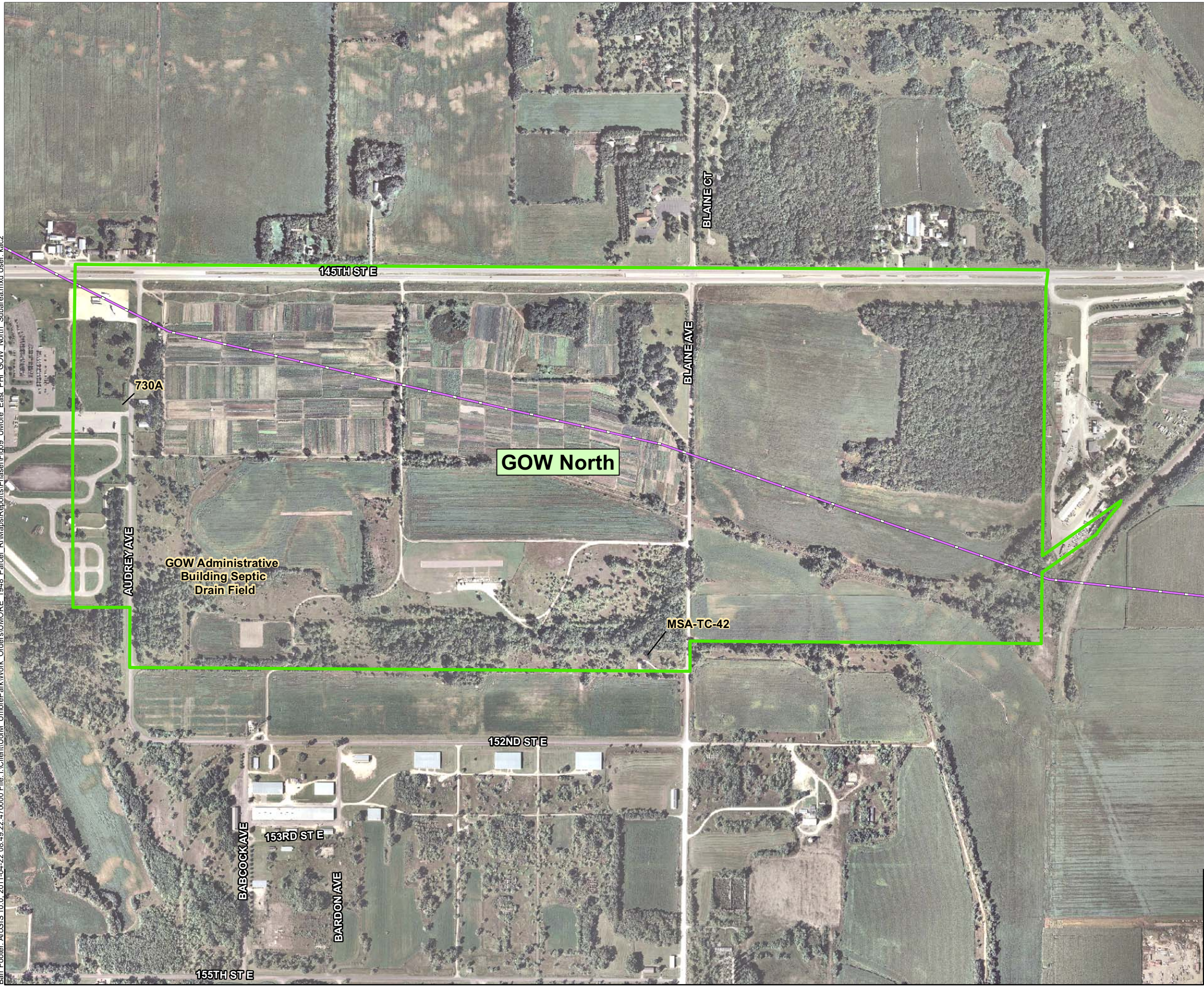
## Figure 9: GOW West Subarea



**GOW WEST SUBAREA**  
  
 UMore East  
 Phase I Environmental  
 Site Assessment  
 Dakota County, MN



Data Sources: Barr Engineering Company, University of Minnesota.  
 Background: 2009 Aerials Express Photography (Twin Cities)

Barr Footer: ArcGIS 10.0\_2011-04-22 08:49:22 470000 File: I:\Client\UofM\_UmorePark\Work\_Orders\UMORE\_1948\_Parcels\_RIMaps\Reports\Phase1\Fig09\_UMore\_East\_Ph1\_GOW\_North\_Subarea.mxd User: kac2

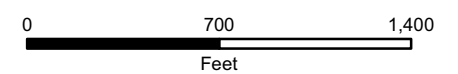


-  UMore East Subarea Boundary
-  Gas Pipelines (approximate)

Data Sources: Barr Engineering Company, University of Minnesota.

Background: 2009 Aerials Express Photography (Twin Cities)

### Figure 10: GOW North Subarea

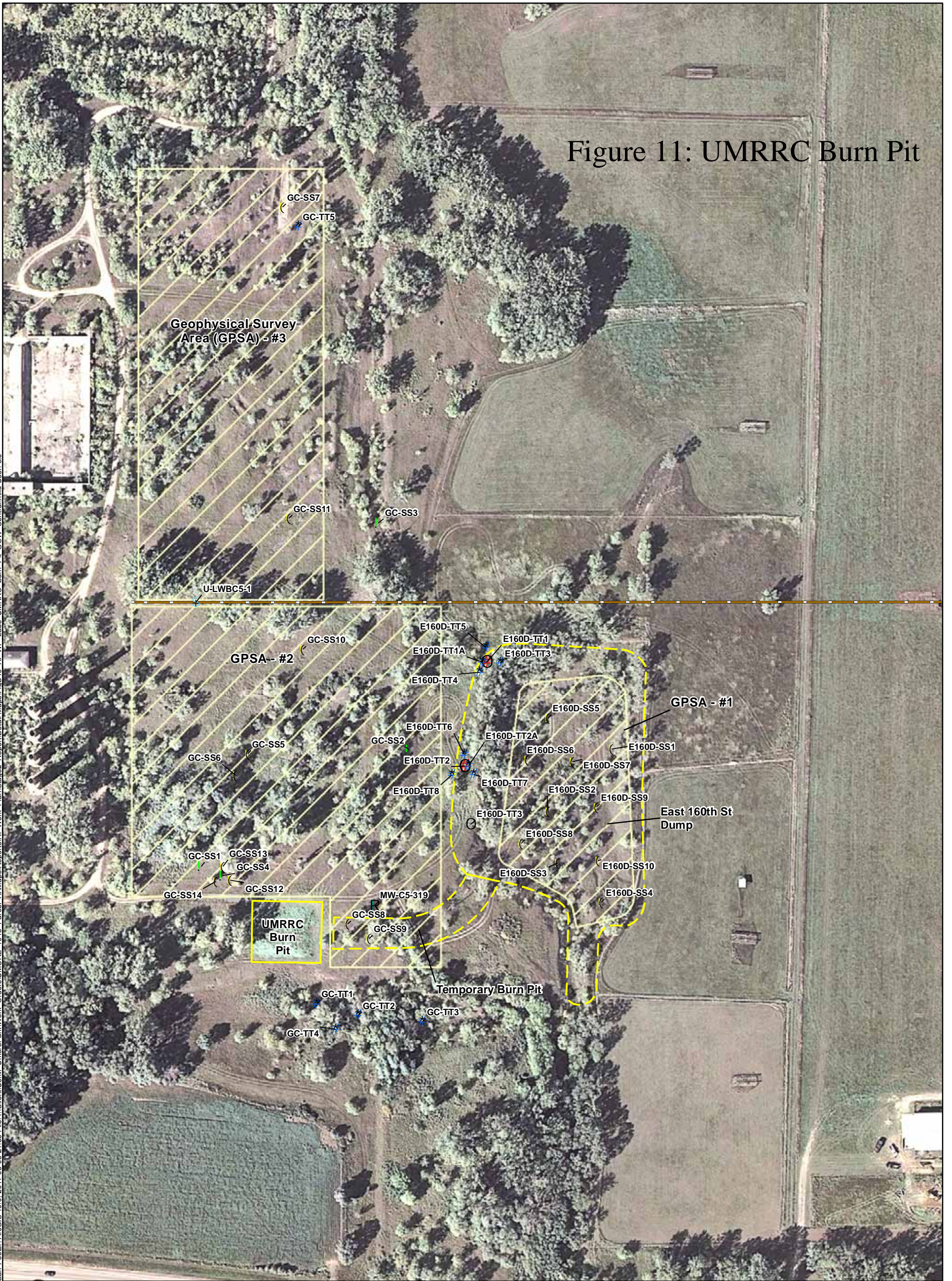


**GOW NORTH SUBAREA**

UMore East Phase I Environmental Site Assessment  
Dakota County, MN



Figure 11: UMRRC Burn Pit



**Pre-RI Sample Locations**

- T Pre-RI Sample Location
- ! Wells and Borings Surveyed by Barr

**Stage 1 Investigation Locations**

- \$ Sewer Sediment Sample
- V Soil Boring
- ! Surface Soil Sample
- T Test Trench

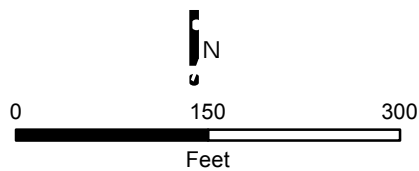
**Planned Stage 2 Investigation Locations**

- ) Soil Boring
- # Test Trench
- ( Surface Sample
- \$ Sewer Sediment Sample

— Laminex Woodbox Sewer

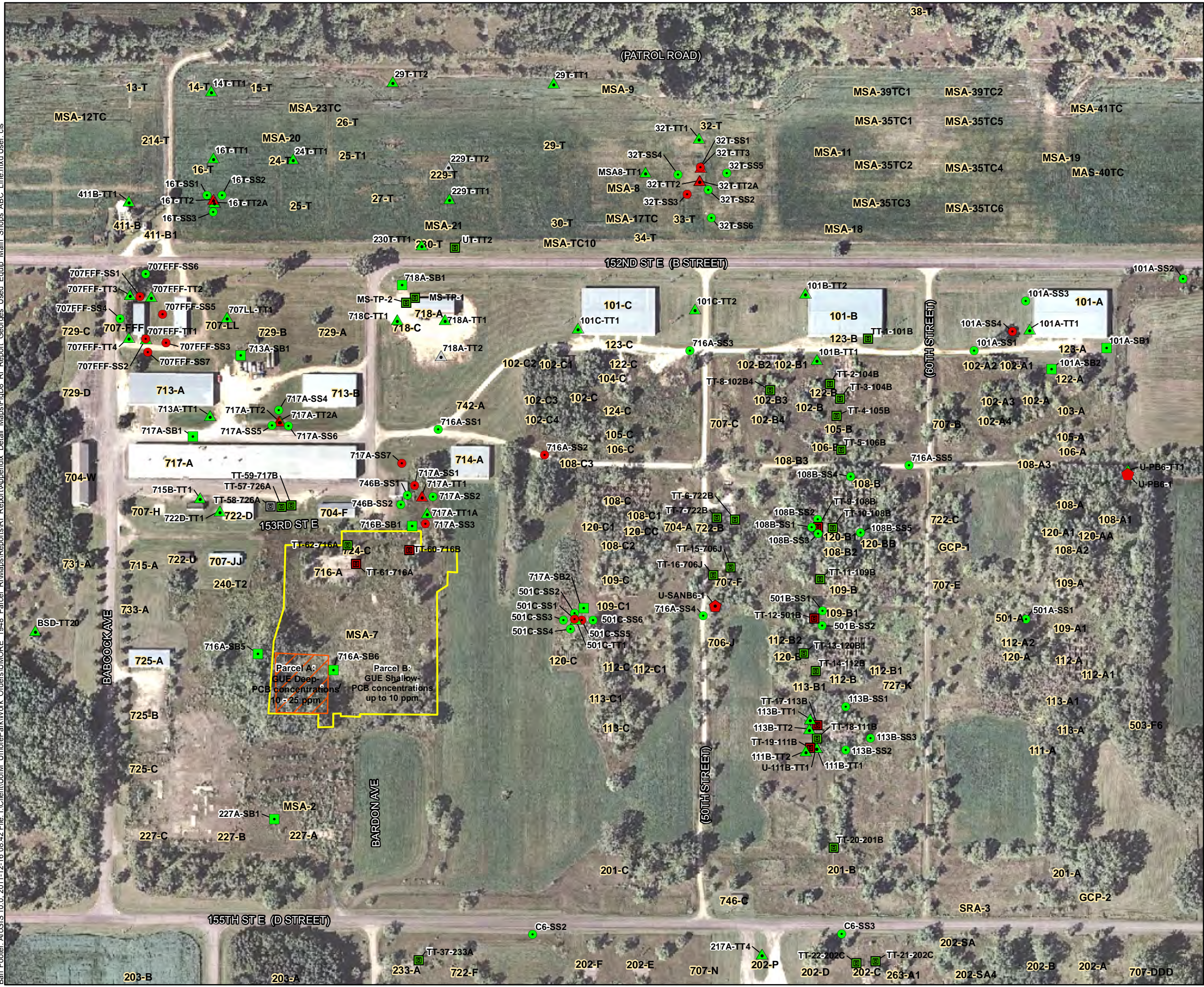
\*Red symbols indicate locations of soil samples with Tier I SRV exceedances  
 \*Pink symbols indicate locations of soil samples with Tier I SLV exceedances for 2,4- or 2,6-Dinitrotoluene  
 \*Gray symbols indicate investigation locations where no soil data was collected

UMRRC BURN PIT, GOW  
 CENTRAL / E. 160TH ST.  
 DUMPS SUSPECTED  
 DISPOSAL AREA  
 GOW Central  
 UMore East  
 RI Work Plan - Stage 2  
 Dakota County, MN



Barr Footer: ArcGIS 10.0, 2011-08-05 21:35 File: I:\Client\UofM\_LumorePark\Work\_Orders\UMORE\_1948\_Parcels\RI\Maps\Reports\RI\_Work\_Plan\Stage2\_Report\Detail\Maps\FigD19\_RI\_WP\_Labs\_UMRRC\_Burn\_Pit\_GOW\_Central.mxd User: csl

Barr Footer: ArcGIS 10.0, 2011-12-16 08:42 File: I:\Client\UoM\UmorePark\Work Orders\UMORE\_1948\_Parcel\_RI\Map\Reports\RI\_Report\Appendix\_Detail\_Maps\Fig08\_RI\_Report\_Georges\_Used\_Equip\_Main\_Shops\_ABC\_Line.mxd User: cjs



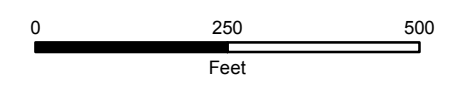
- Pre-RI Sample Locations**
- Pre-RI Sample Location
  - Wells and Borings Surveyed by Barr
- 2011 RI Investigation Locations**
- ◆ Sewer Sediment Sample
  - Soil Boring
  - Surface Soil Sample
  - ▲ Test Trench
- Laminex Woodbox Sewer

\*Red symbols indicate locations of soil samples with Tier I SRV exceedances  
 \*Gray symbols indicate investigation locations where no soil data was collected

Data Sources: Barr Engineering Company, University of Minnesota, Dakota County.

Background: 2009 Aerials Express Photography (Twin Cities)

Figure 12: George's Used Equipment (716A & B) Porter Electric (227A & B), and US Transformer (101A) locations

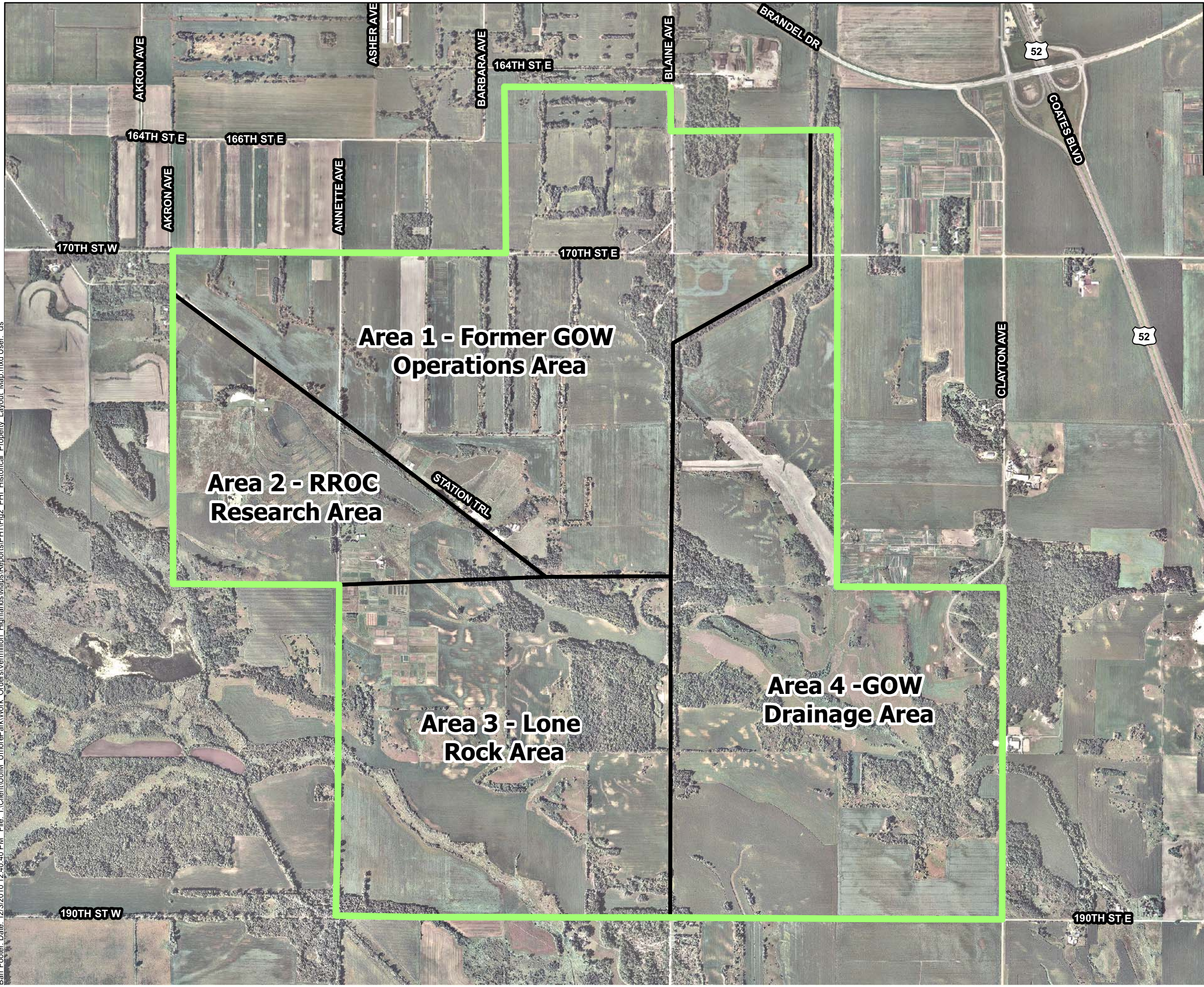




**GEORGE'S USED EQUIPMENT (BLD. 716A & B) & MAIN SHOPS AREA ABC Line**  
 UMore East RI Report  
 Dakota County, MN

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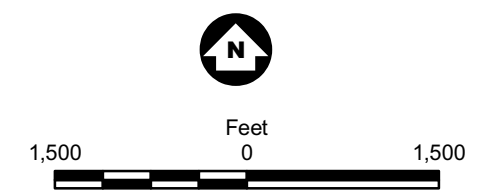
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 Vermillion Highlands Boundary  
 Area Boundaries

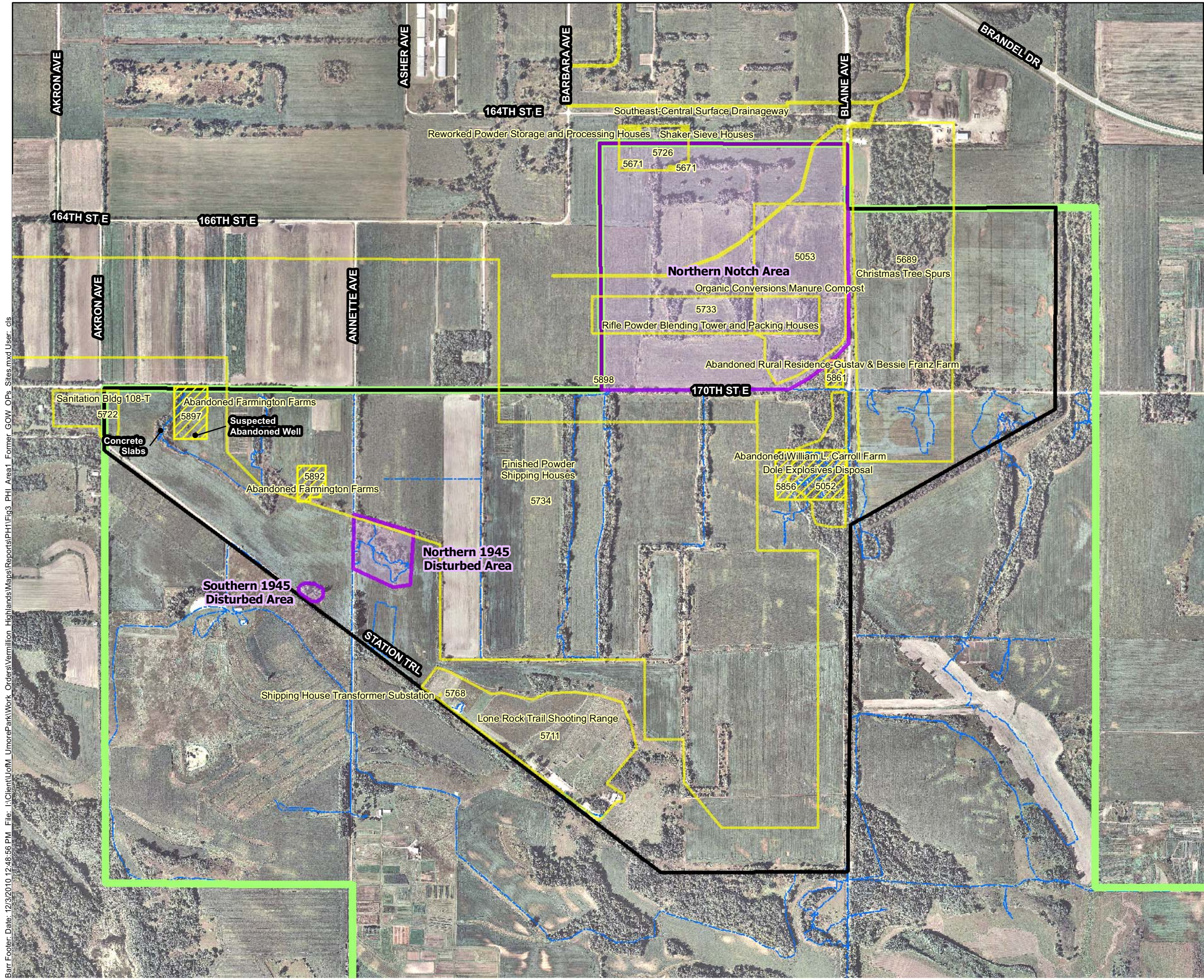
Data Sources: Barr Engineering Company, University of Minnesota.  
 Background: 2009 Aerials Express Photography.

Figure 13: Vermillion Highlands



  
 HISTORICAL PROPERTY LAYOUT MAP

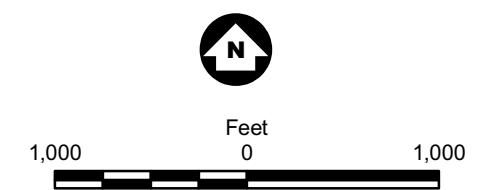
Vermillion Highlands  
 Phase I Environmental  
 Site Assessment  
 Dakota County, MN



-  Partial Site Reconnaissance Trail
-  Vermillion Highlands Boundary
-  Area 1 - Former GOW Operations
-  Dakota County Mapped Site
-  Barr Mapped Site
-  Farmstead Visited During Second Site Visit

Data Sources: Barr Engineering Company, University of Minnesota, Dakota County.  
 Background: 2009 Aerials Express Photography.

Figure 14: Vermillion Highlands Area 1

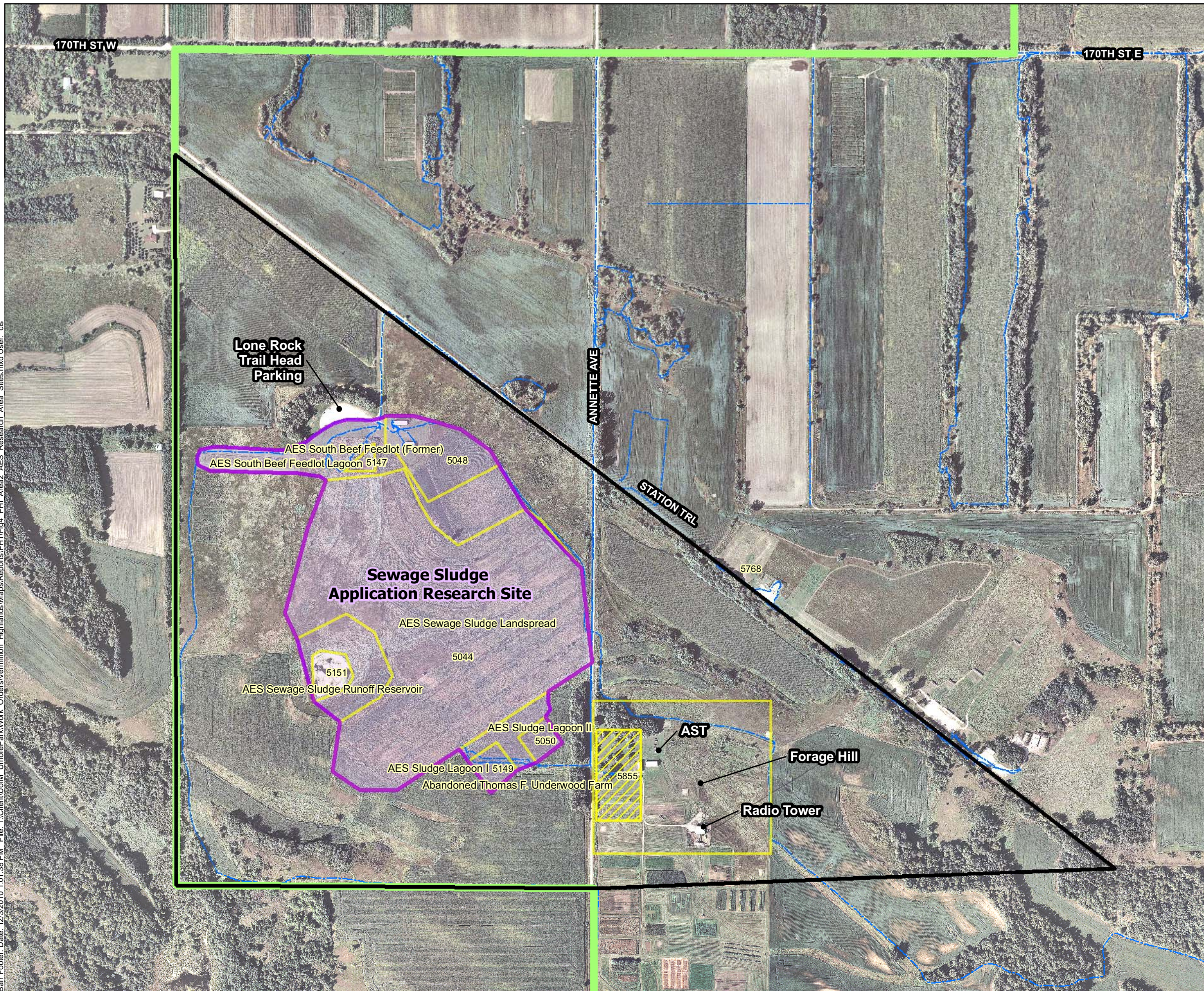


AREA 1 - FORMER GOW OPERATIONS IDENTIFIED SITES

Vermillion Highlands Phase I Environmental Site Assessment  
 Dakota County, MN

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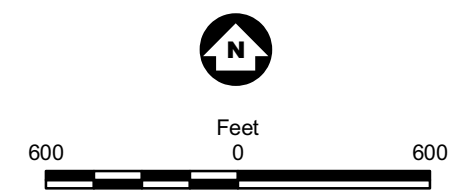


-  Partial Site Reconnaissance Trail
-  Vermillion Highlands Boundary
-  Area 2 - AES Research Area
-  Dakota County Mapped Site
-  Barr Mapped Site
-  Farmstead Visited During Second Site Visit

Data Sources: Barr Engineering Company, University of Minnesota, Dakota County.

Background: 2009 Aerials Express Photography.

### Figure 15: Vermillion Highlands Area 2

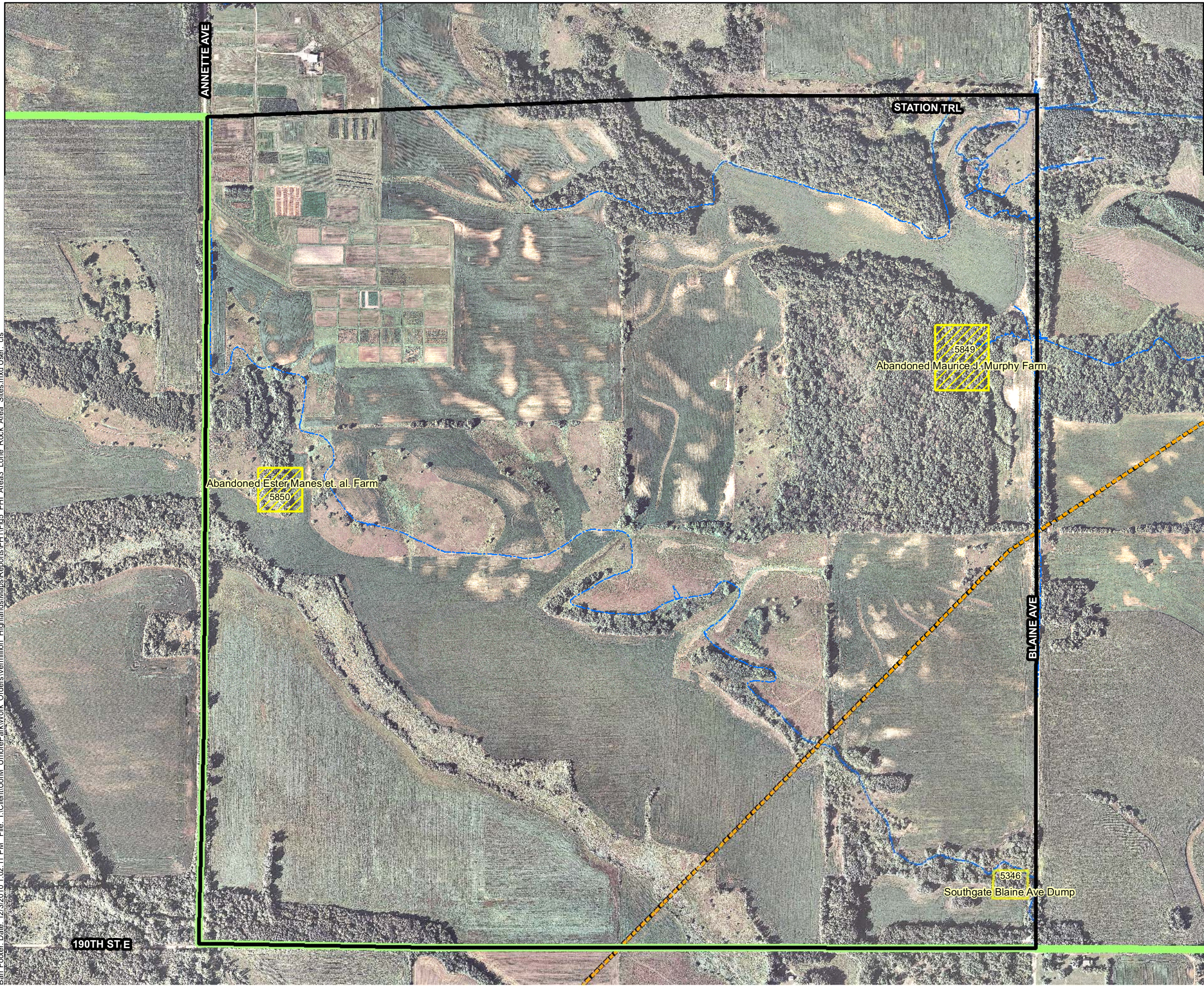


AREA 2 - RROC RESEARCH AREA IDENTIFIED SITES

Vermillion Highlands Phase I Environmental Site Assessment Dakota County, MN



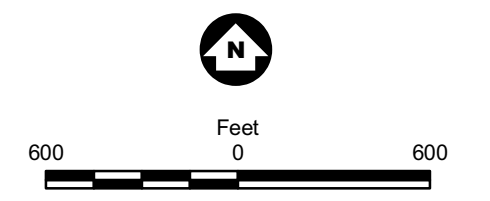
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-  Partial Site Reconnaissance Trail
-  Approximate Pipeline Location
-  Vermillion Highlands Boundary
-  Area 3 - Lone Rock Area
-  Dakota County Mapped Site
-  Farmstead Visited During Second Site Visit

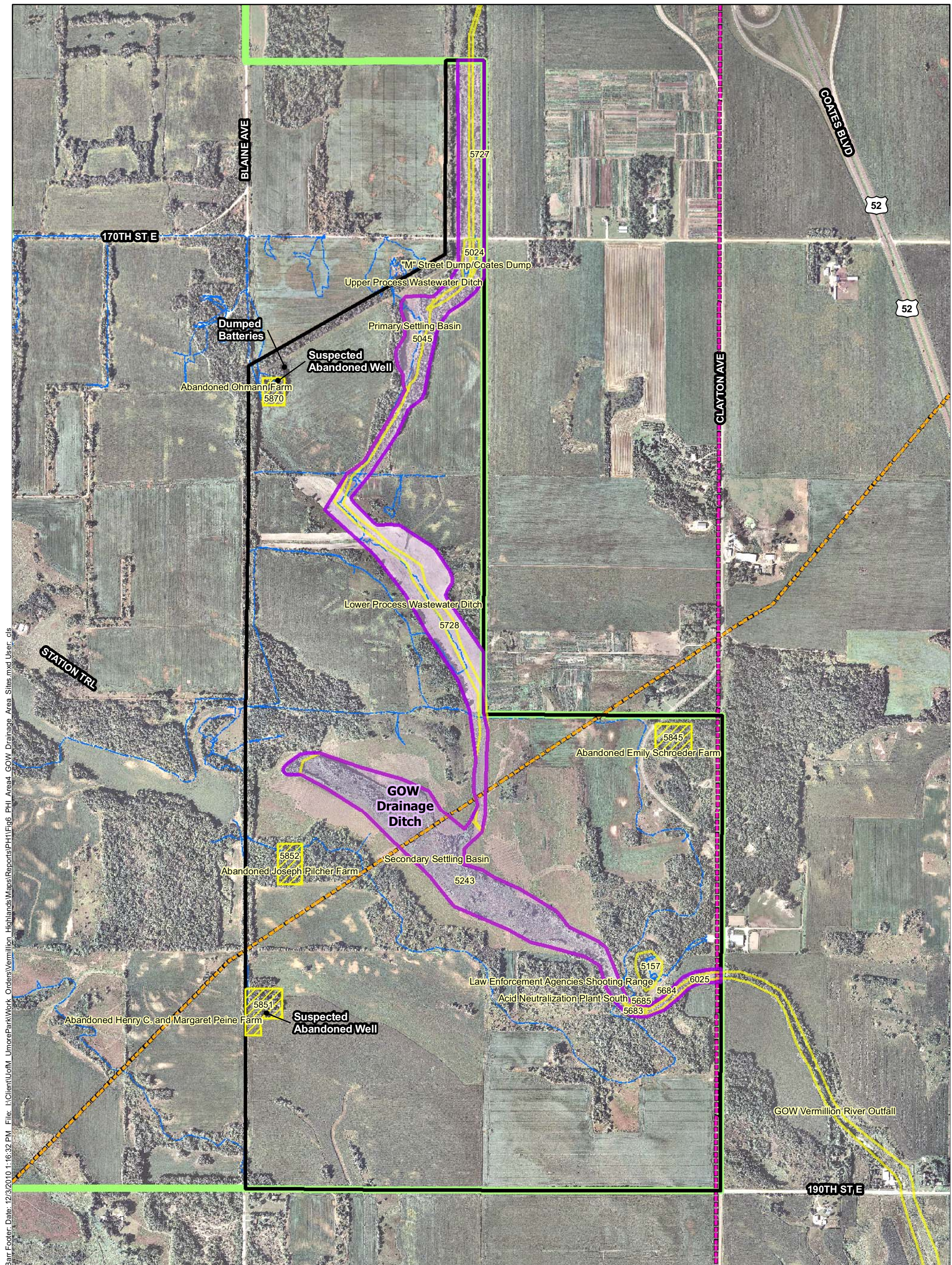
Data Sources: Barr Engineering Company, University of Minnesota, Dakota County.  
 Background: 2009 Aerials Express Photography.

Figure 16: Vermillion Highlands Area 3











AREA 3 - LONE ROCK AREA IDENTIFIED SITES

Vermillion Highlands Phase I Environmental Site Assessment  
 Dakota County, MN



Barr Footer: Date: 12/3/2010 1:16:32 PM, File: I:\Client\UoM\_UmcorePark\Work\_Orders\Vermillion\_Highlands\Maps\Reports\PH1\Fig6\_PHL\_Area4\_GOW\_Drainage\_Area\_Sites.mxd User: cjs

-  Partial Site Reconnaissance Trail
-  Suspected Pipeline Location
-  Approximate Pipeline Location
-  Vermillion Highlands Boundary
-  Area 4 -GOW Drainage Area

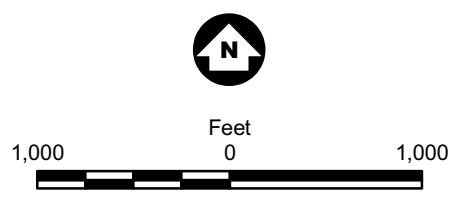
-  Dakota County Mapped Site
-  Barr Mapped Site
-  Farmstead Visited During Second Site Visit

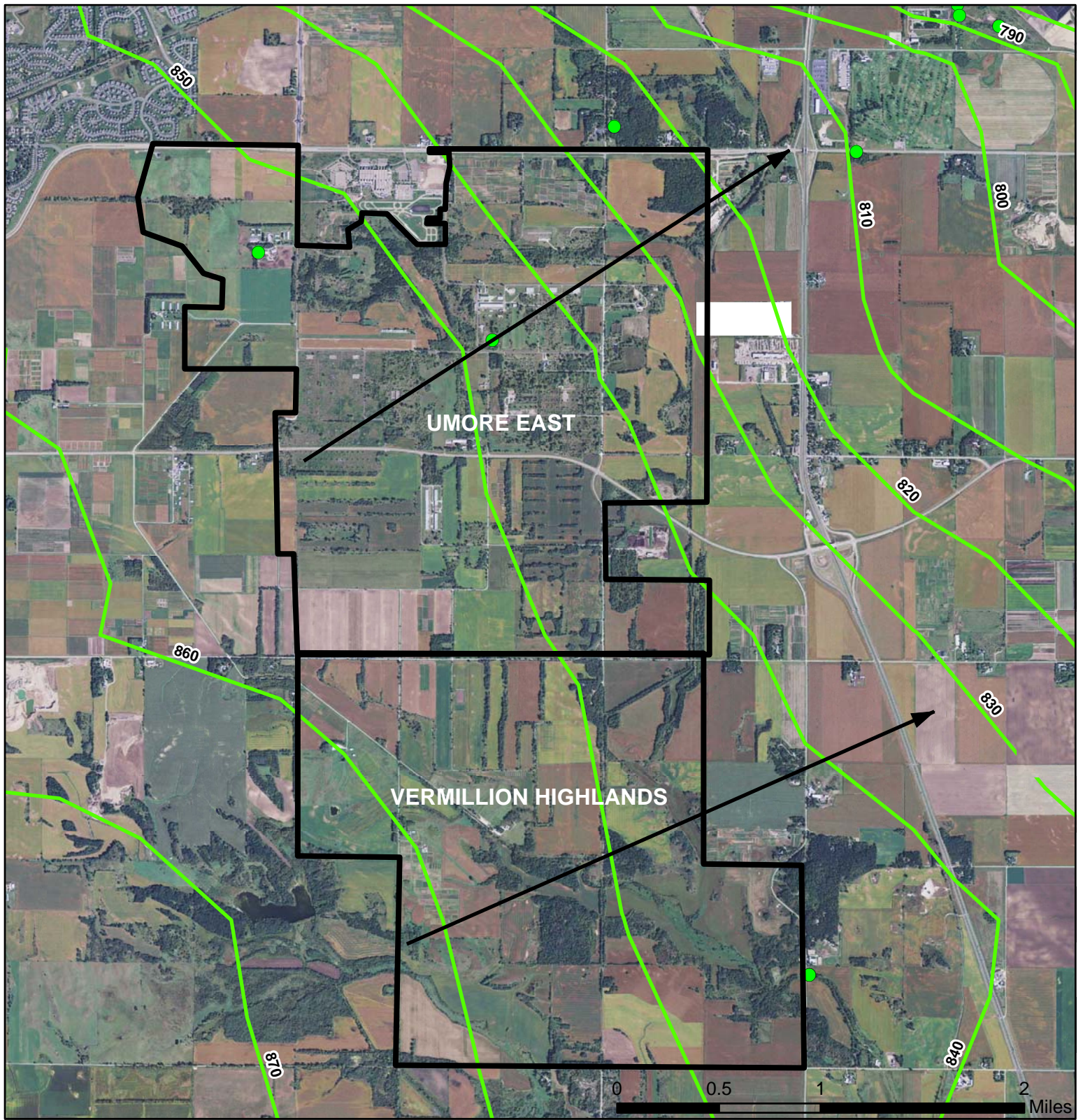
**Figure 17: Vermillion Highlands Area 4**

**AREA 4 - GOW DRAINAGE AREA IDENTIFIED SITES**

Vermillion Highlands Phase I Environmental Site Assessment  
Dakota County, MN

Data Sources: Barr Engineering Company, University of Minnesota, Dakota County.  
Background: 2009 Aerials Express Photography.

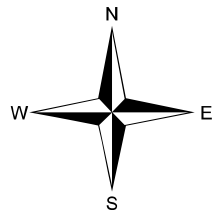




**Figure 18: Flow Directions in Quaternary Aquifer**

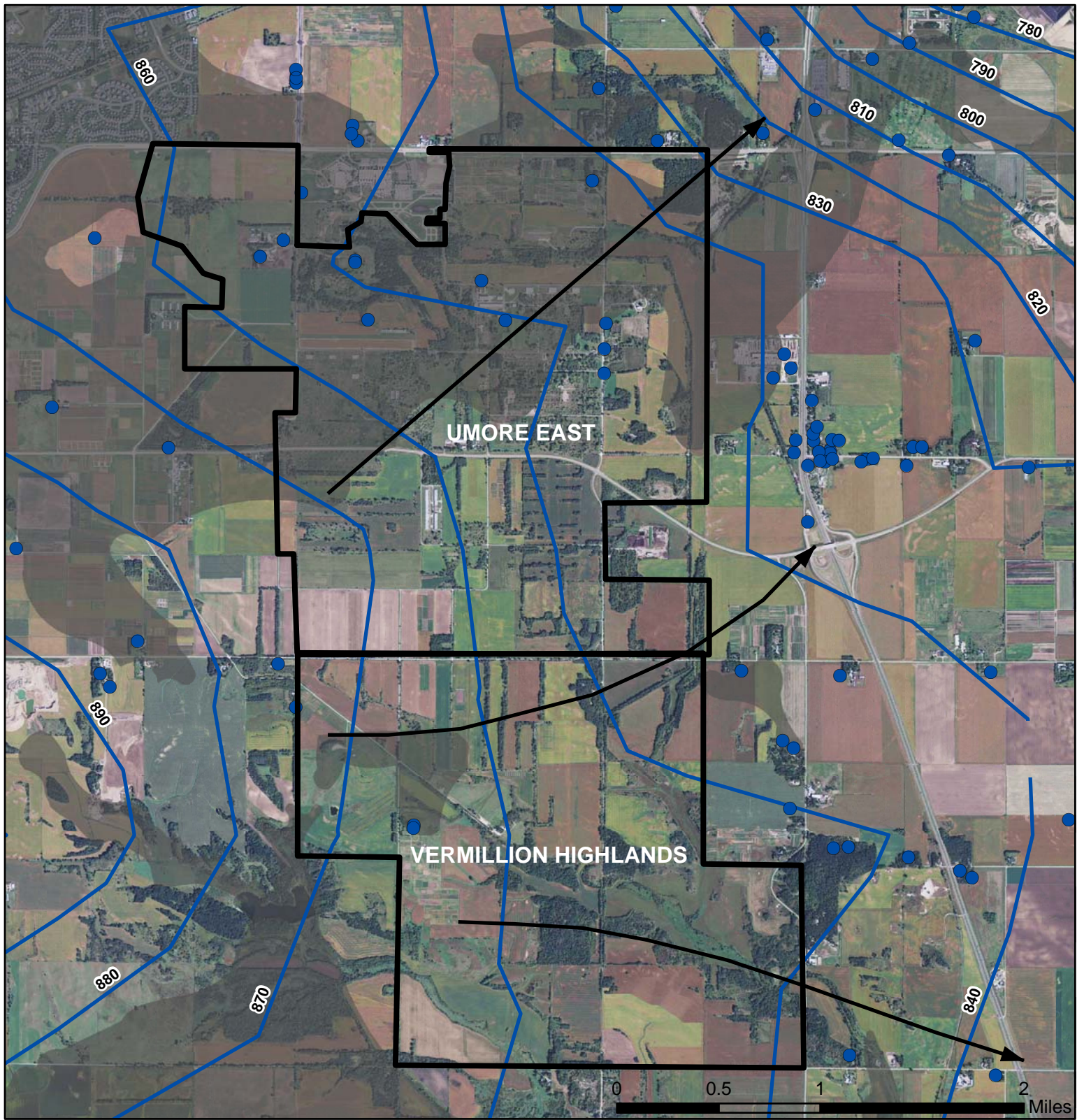
**LEGEND**

- Quaternary aquifer well
- Water level elevation contour (ft. above mean sea level)
- ➔ Groundwater flow direction



Static water level data obtained from Minnesota County Well Index

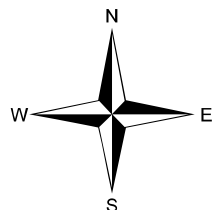
MDH, 9/18/2012

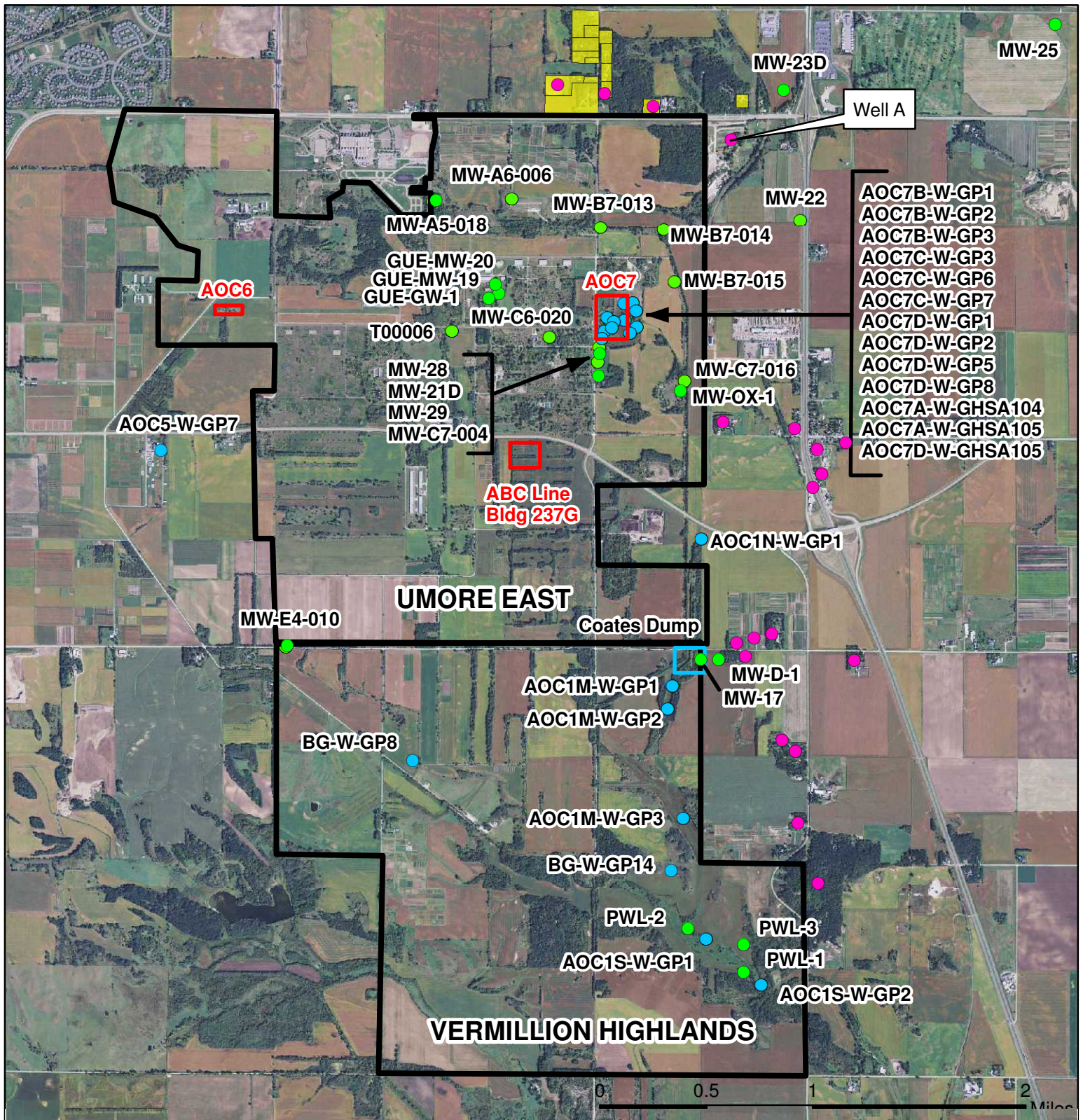


**Figure 19: Flow Directions in Bedrock Aquifers**

**LEGEND**

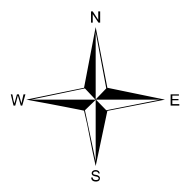
- Bedrock aquifer well (St. Peter, Prairie du Chien, and Jordan)
- Water level elevation contour (ft. above mean sea level)
- ➔ Groundwater flow direction

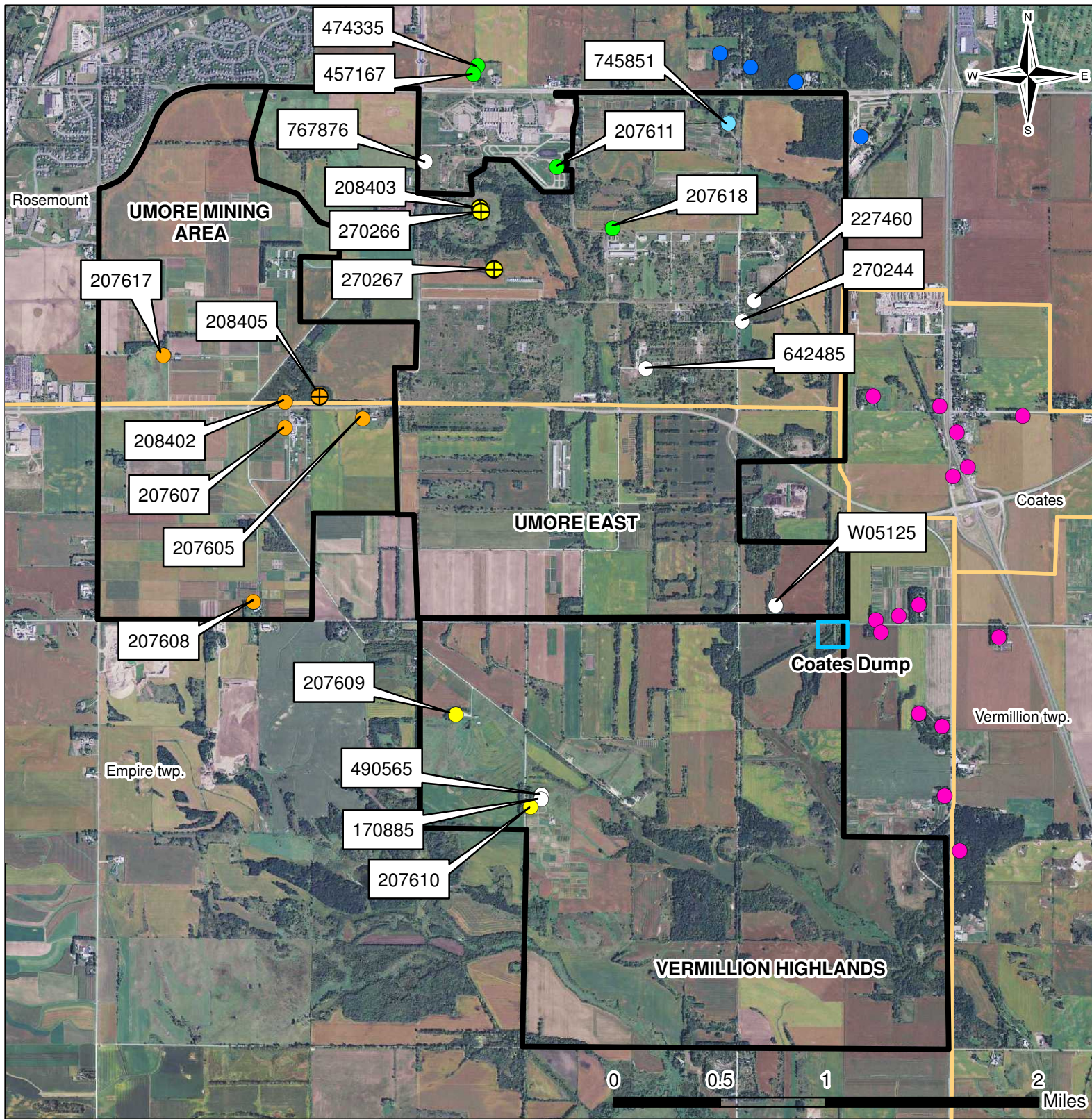




**Figure 20: Groundwater Sample Locations**

- Monitoring well sample
- Geoprobe or boring sample
- Private well sample
- Area with elevated soil detections warranting further sampling and possible monitoring well installation
- Boundary of former Coates Dump
- Parcel with no reported Rosemount city water connection

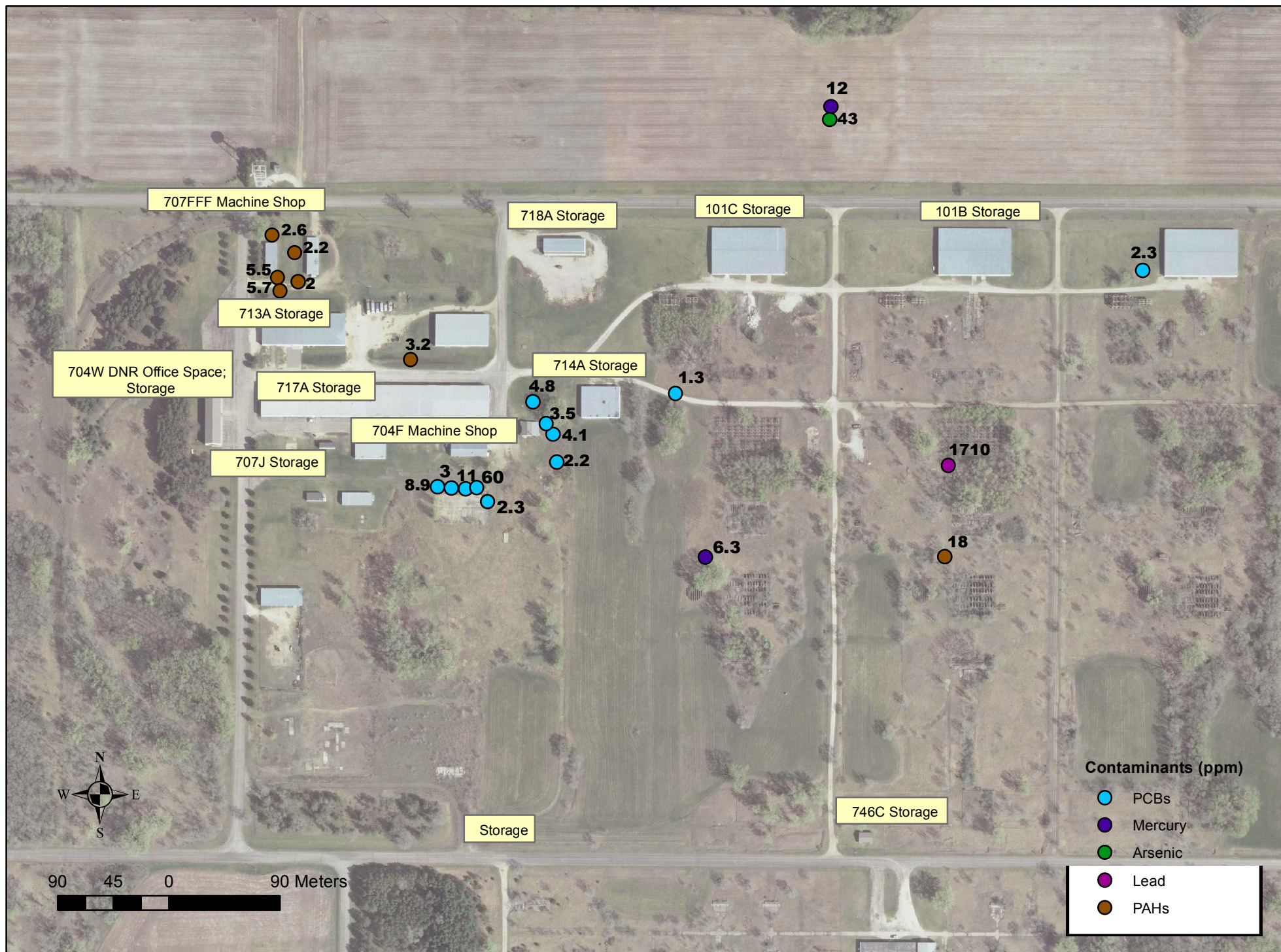




**Figure 21: Well Locations**

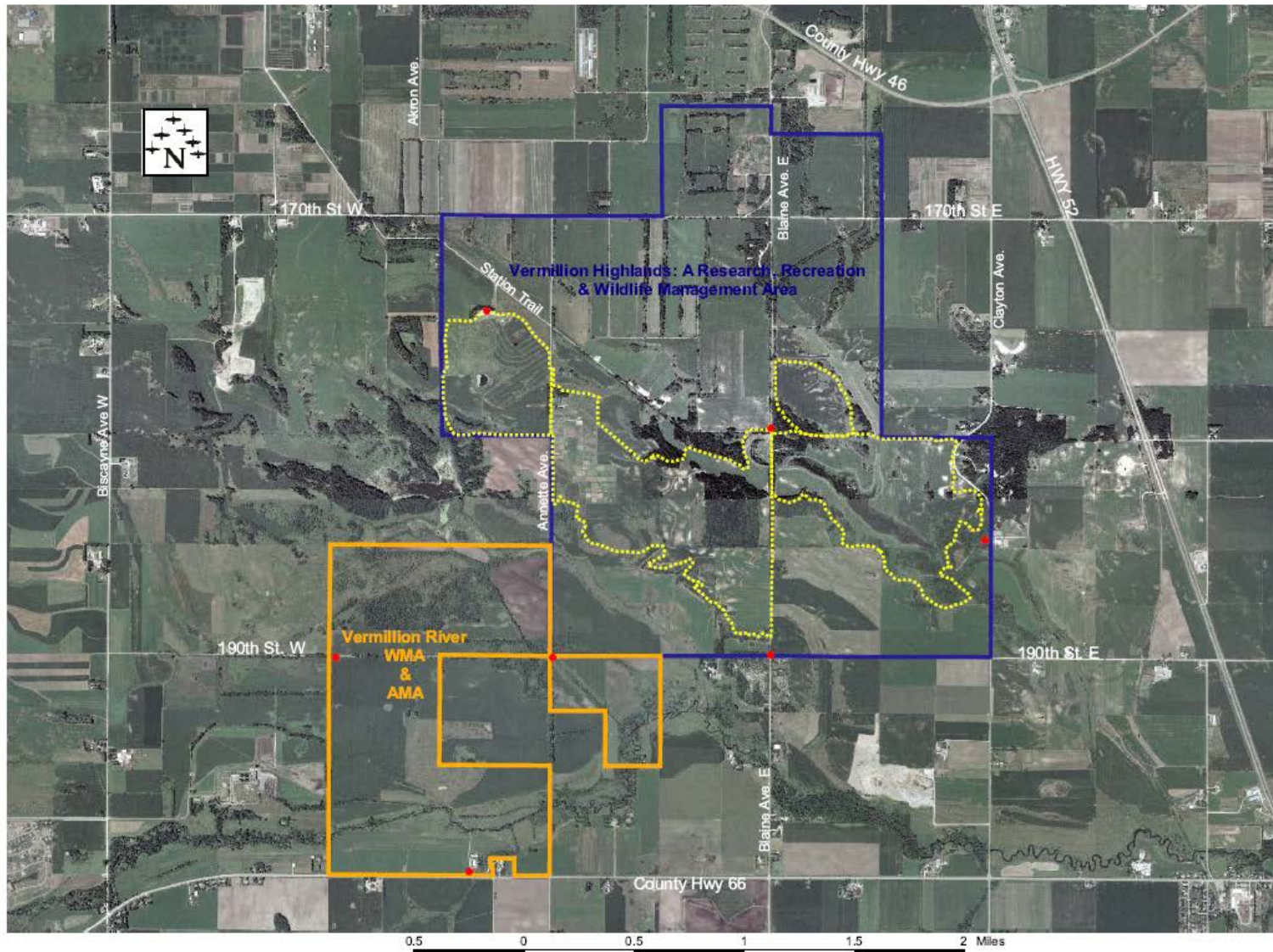
- Community public water supply well
- Non-community public water supply well
- Private wells sampled by MDH in 2013
- Private well near former Coates Dump sampled by MDH
- Former residential well
- Well - current status and/or use unknown
- ⊕ Well has been sealed
- Former Coates Dump
- City or township border
- UM Property

**Figure 22: Tenant sites in the ABC Line subarea and contaminants in surface soil above residential SRVs**

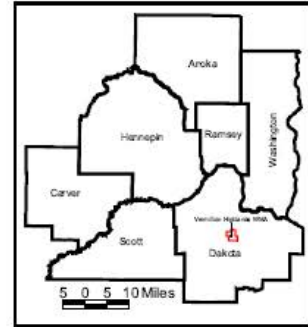


# Vermillion River Complex

Figure 23: Recreational use of Vermillion Highlands



- Vermillion Highlands WMA
- Vermillion River WMA & AMA
- Lone Rock Trail
- Parking Areas



**Vermillion Highlands  
Research Recreation  
and Wildlife  
Management Area**

Hunting & Trapping by Special  
Permit or Authorization Only

Closed to All Other Uses  
Except as Specifically Authorized

For information, contact your local DNR Wildlife Office.  
Dakota Location: 605-333-4963

13 September 2011  
tm.pharis@state.mn.us





**Figure 24: Highest PCB, lead, and cPAH concentrations in surface soil that are recommended for removal**



A concentration of cPAHs of 260 ppm is located off of the map in the southern portion of the former GOW drainage basin in the Vermillion Highlands.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
<b>UMORE East - most sites and data (unless cited) taken from 2011 Remedial Investigation Report (Barr, 2012). Not all potential subareas captured here.</b>					
<b>GOW East (Figure 4)</b>					
GOW Nitric Acid Plant Area	This area was constructed as part of GOW to produce nitric acid. After GOW was decommissioned, portions of the area were used by the University as an aeronautical research laboratory and hazardous waste storage. Other uses included explosives manufacturing and storage, labs, plastics production, and storage of antifreeze.	39 soil samples. No groundwater samples were collected in this area, but monitoring wells MW-B7-013, MW-B7-014 & MW-B7-015 are downgradient and have detected no site-related contaminants. See below for subsection results.	Figure 14; Figure D1 (Barr, 2012)	See subsections below for detailed discussion of health hazards related to soil contamination. There are no groundwater exposures in the GOW Nitric Acid Plant Area, and therefore no public health hazard associated with groundwater.	See subsections below.
Acid Area Shop (Bldg 722Y)		In 2006, two samples were analyzed for metals and SVOCs. cPAHs were detected at 0.17 ppm at a depth of 2-5 ft. Two test trenches were excavated in 2011 and no indications of soil impacts were observed, and therefore no samples were taken for analysis.	Figure D1 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.
Anhydrous Ammonia Storage (Bldg 301ALP)		In 2011, six samples were analyzed for metals. Mercury was detected at 0.54 ppm at a depth of 6 in.	The aboveground storage tank used by GOW to store anhydrous ammonia is still present. Figure D1 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although mercury is above the SRV for residential land use, current exposure is expected to be very limited and infrequent.	Areas of mercury above the SRVs may need to be removed if land use changes.
Nitric Acid Concentrator Bldg (303-A2)		In 2006, cadmium was elevated in one sample (48 ppm) at a depth of 3.5 ft. Four samples were analyzed for metals in 2011. No evidence of contamination was found.	The building was dismantled during GOW decommissioning and the University has left the area dormant. Figure D1 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although cadmium is above the SRV for residential land use, current exposure is expected to be very limited and infrequent.	Areas of cadmium above the SRVs may need to be removed if land use changes.
Nitric Acid Concentrator Bldg (303A); the University used the building to store hazardous waste.		In 2006, lead (8090 ppm) and cPAHs (19 ppm) were elevated in one sample at a depth of 0-1 ft. 18 soil samples were collected in 2011 and analyzed for metals, SVOCs, and sulfate. Lead was elevated at a depth of 6 in. in 9 samples (840-2800 ppm) and at a depth of 9 ft in one sample (8400 ppm). cPAHs were detected in five samples (0.011-0.97 ppm) at a depth of 6 in.	The building still exists, unused. Figure D1 (Barr, 2012)	This area poses a public health hazard because lead in the surface soil is significantly above the SRV for industrial land use and current exposure to the contaminants could occur.	Lead should be removed in the short-term to prevent exposure. cPAHs are above SRVs and may need to be removed if land use changes.
Nitric Acid Storage Tanks (302A); University tenants used 302A as a research lab and to store and manufacture explosives.		In 2006, mercury was elevated in one sample (1.2 ppm) at a depth of 0-1 ft. In 2011, three soil samples at 1 ft were analyzed for metals and SVOCs. Mercury (0.49 ppm) and cPAHs (0.22, 0.91, 0.93 ppm) were detected.	The building exists. The tank farm area has been dormant since GOW decommissioning. Figure D1 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although one sample of mercury exceeds the residential SRV and cPAH concentrations may be of concern, current exposure is expected to be very limited and infrequent.	Areas of mercury above the SRVs and cPAHs may need to be removed if land use changes.
Acid Change House (707A)		In 2002, mercury was elevated in one sample (42 ppm) in surface soil. In 2011, three samples at 6 in. were analyzed for metals. Mercury was detected in one sample (0.38 ppm).	The building was demolished by GOW and the area is not used by the University. Figure D1 (Barr, 2012)	This area poses an indeterminate public health hazard. Mercury in the soil is above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent.	Areas of mercury above the SRVs may need to be removed if land use changes.
Fuel Oil Tanks (303SA-AB)		In 2011, two samples at a depth of 2 and 2.5 ft were analyzed for metals and SVOCs and no evidence of contamination was found.	Aboveground storage tanks have been removed; the area is not used by the University. Figure D1 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
Oleum Storage Tanks		In 2002, arsenic (14 ppm) and lead (310 ppm) were elevated in the surface soils. DRO was detected at 5900 ppm. In 2011, buried treated wood was found at 5 ft and no analytical samples were collected.	Aboveground storage tanks have been removed; the area is not used by the University. Figure D1 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although arsenic and lead exceed the residential SRV, current exposure is expected to be very limited and infrequent.	Concentrations of arsenic and lead above the SRVs may need to be removed if land use changes.
GOW Oleum Plant Area	Used by GOW to produce sulphuric acid that was later used to concentrate nitric acid at the facility.	In 2002, 14 samples were collected and 12 samples were analyzed for metals, 2 for SVOCs, 1 for PCBs, and 1 for explosives. No contaminants were found except sulfate was measured in five samples from 140-30,000 ppm. In 2006 and 2011 one sample was analyzed for metals and SVOCs and no contaminants were found. Groundwater sampling for sulfate in this area did not detect elevated levels.	The building was dismantled by GOW and only the foundations exist. The University has not used this area. Figure D1 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Coal Ash Pond and Drainageway	This area was constructed by GOW to dispose of coal ash generated by Power Plant A. As part of decommissioning, the ash was reportedly removed. The University never operated the power plant or the coal ash pond.	In 2003, three soil samples were found to have elevated mercury (20 ppm at 0-2 ft, and 420 and 590 ppm at a depth of 2 ft). Dibutylphthalate (DBP) was detected in two samples (0.83, 1.1 ppm). In 2011, 38 samples were analyzed for metals, 18 for SVOCs, and 2 for PCBs. Arsenic was elevated in two samples (9.9 ppm at a depth of 1 ft and 11 ppm at 6 in.). Mercury was elevated in two samples (0.8 ppm at 6 in. and 2.7 ppm at a depth of 1 ft). DBP was detected in four samples (0.068-1.9 ppm). Coal ash is present. Groundwater samples within the pond (MW-OX-1 and MW-C7-016) did not detect site-related contaminants.	This area is open space. Figure D2 (Barr, 2012)	This area poses an indeterminate public health hazard. Mercury in the soil is above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. Arsenic is also above the residential SRVs. There are no groundwater exposures in this area.	Areas of mercury and arsenic above the SRVs may need to be removed if land use changes.
GOW Wastewater Treatment Plant Area	This area was used to treat wastewater from the sanitary sewer system that was linked to GOW buildings in the manufacturing area of the facility. The University operated it until about 1959.	In 2003, three soil samples were found to be elevated with mercury (23-30 ppm) at depths between 0-2 ft. One sample had a detection of BTEX, indicating petroleum contamination. In 2011, 34 samples were analyzed for metals and 8 for SVOCs. Arsenic was slightly elevated in 2 samples (9.2 ppm at a depth of 2 ft, and 10 ppm at 6 in.). cPAHs were detected at low levels in five samples (0.01-0.22 ppm). Two coal samples were analyzed for metals and SVOCs and no analytes were above residential SRVs. Surficial coal, ash, slag, and vitrified materials present. Groundwater samples in this area (MW-21D and MW-28) detected chlorinated VOCs associated with UMRRC Burn Pit plume, TCE exceeds HBV; no other site-related contaminants were detected.	This area is used for agriculture and open space. Figure D2 (Barr, 2012)	This area poses an indeterminate public health hazard. Mercury in the soil is above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. Arsenic is also above the residential SRVs. There are no groundwater exposures in this area.	Areas of mercury and arsenic above the SRVs may need to be removed if land use changes.
Post-GOW Oxidation Pond	This area is located within the outside limit of the GOW Coal Ash Pond. The Oxidation Pond was constructed in 1959 by the University to treat wastewater.	In 1984, thallium was found slight elevated at 4 ppm (TCT, 1986). In 1984-85 PCBs and chlordane were detected in the Oxidation Pond (Barr, 2011a). In 2011, 21 soil samples were collected and 21 analyzed for metals, 14 for SVOCs, 14 for PCBs, and 12 for organochlorine pesticides. One sample in a non-agricultural area at a depth of 2 ft had elevated mercury (7.3 ppm) and detections of cPAHs (0.95 ppm), PCBs (0.28 ppm) and chlordane (0.04 ppm). DBP was detected in three samples (0.07-1.1 ppm). The soils contain coal ash, white/gray granular material, pea gravel, and yellow to rusty orange discoloration. As noted above for the Coal Ash Pond, groundwater samples here did not detect site-related contaminants	This area is used for agriculture and open space. Figure D2 (Barr, 2012)	This area poses an indeterminate public health hazard. Mercury in the soil is above the SRV for industrial land use and cPAHs may be of concern; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of mercury above the SRVs and cPAHs may need to be removed if land use changes.
GOW Patrol Road Clearing Area	Arsenic-containing pesticides may have been applied along the sides of the roads to control vegetation during the GOW period.	In 2011, two samples at a depth of 6 in. were analyzed for metals and no evidence of contamination was found, so no groundwater samples collected.	This area is adjacent to agricultural use and open space. Figure D2 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Ballistics Lab and Firing Range	This area was constructed to test the ballistic value of manufactured rifle powder but reportedly used for storage since rifle powder was not produced. The University used the area for ballistic testing research.	In 2006, one sample detected low levels of cPAHs (0.14 ppm) and DBP (0.139 ppm) at a depth of 5 ft. In 2011, two samples (one at 6 in. and one at 12 ft) were analyzed for metals and SVOCs and no evidence of contamination was found, so no groundwater samples collected.	This area is wooded and adjacent to agricultural use. Recent dumping and charred debris was observed in the woods east of bldg 228A during the Phase I site visit (Barr, 2011a) Figure D2 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.
Grid Space D7	A borrow pit and surface water infiltration basin were constructed here during the operation of GOW. It continued to be used as a borrow pit and became dormant land.	In 2011, three samples were analyzed for metals and SVOCs and no evidence of contamination was found, so no groundwater samples collected.	This area is open space. Figure D3 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.

### Appendix A: Gopher Ordnance Works Site Summary

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Powerhouse A Area (AOC7 and associated 26.7 acres)	USACE subdivided this area into four subquadrants for data collection in 2007. Based on 2007 sampling, two quadrants were further investigated in 2009: AOC7A and AOC7D. The NW quadrant (AOC7A) contained the former water reservoir including the pump house, transformer pads, water inlet house and the boiler house. The SW quadrant (AOC7D) contained the steam plant and associated buildings, a drainage ditch, electrical substation, fuel oil tanks, and ash disposal pit.	In 2003, samples from 12 test pits were collected in the later-defined AOC7 area (WWTP samples 1-12 from Peer, 2003). Mercury was elevated (25 ppm) in one sample at a depth of 10 ft. Other debris was tested (tar, trash (at 4-5 ft), electrical insulation) and cPAHs (2800, 1200, and 45 ppm), PCBs (2.7 ppm), and arsenic (84 ppm), were elevated. In 2007 (USACE, 2009a) soil sampling in AOC7A found elevated lead (440, and 520 ppm at 0-6 in. and 2100 ppm at 2-4 ft), cPAHs over 2 ppm in 5 samples (13 ppm at 2-4 ft and 16-130 ppm at 0-6 in.), and PCBs over 1 ppm in 6 samples (3.4 ppm at 2-4 ft, and 1.3-26 ppm at 0-6 in.). In 2009 (USACE, 2009b) sampling in AOC7A include elevated PCBs (1.4 ppm at 2-4 ft) and BaP (7.2 ppm at 0-6 in.). In 2007 soil sampling in AOC7D found elevated arsenic (9.3, 11 ppm at 0-6 in., 12 ppm at 2-4 ft, 33 ppm at 6-8 ft), lead (730 ppm at 0-6 in. and 5400 ppm at 2-4 ft), mercury (0.55, 0.96 at 2-4 ft, and 1.1 ppm at 0-6 in.), and cPAHs over 2 ppm in 6 samples (2.2 and 7.9 ppm at 0-6 in., 4.7, 14, 52 ppm at 2-4 ft, and 46 ppm at 6-8 ft). PCBs found were less than 1 ppm. In 2009 sampling in AOC7D found elevations at 0-6 in. of mercury (1.2 ppm), cPAHs (3.1, 5.6, 9.9 ppm) and PCBs (1.6 ppm). 13 groundwater samples were collected from borings; site-related contaminants (VOCs, SVOCs, nitrocellulose and DRO) detected in 12 - benzo(a)pyrene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, DRO, 2,4,6-trichlorophenol, TCE were above drinking water criteria in at least one sample. These contaminants were not detected in MWs downgradient of AOC7, except chlorinated VOCs associated with the UMRRC Burn Pit plume.	AOC7A contains some farmland and ruins of collapsed buildings; AOC7D contains ruins of buildings. Stockpiled soil that was reportedly removed from AOC7B is also present in AOC7C and AOC7D - and has not been investigated. Figure D2 (Barr, 2012); Figure 9, 9A, 9D (USACE, 2009a); Figure 5a, 5b (USACE, 2009b)	This area poses a public health hazard because cPAHs and PCBs in the soil are significantly above SRVs for industrial land use in surface soils and current exposure to the contaminants could occur. Mercury, arsenic, and lead are also above the industrial SRVs. There are no groundwater exposures in this area.	cPAHs and PCBs should be removed in the short-term to prevent exposure. Mercury, arsenic, and lead, above the SRVs may need to be removed if land use changes.
ABC Line (Figures 5 and 12)					
GOW Temporary Shops Area	This area contained many shops that were used in the construction and operation of GOW. Most shops were removed as part of GOW decommissioning.	See subsections below for sampling results. No groundwater samples were collected in the GOW Temporary Shops area; downgradient monitoring well MW-A6-006 detected trace level PERC, possibly related to the UMRRC Burn Pit plume but not really downgradient of that area; MW-B7-013 has not detected site-related contaminants.	Entire area is used for agriculture with the exception of the water tower area. Figure 15 (Barr, 2012)	See subsections below for discussion of public health hazards associated with soil contamination. There are no groundwater exposures in the GOW Temporary Shops Area.	See subsections below.
Auto Repair Shop (32T)		In 2011, nine samples were analyzed for metals and two for SVOCs. An additional two samples were analyzed for arsenic only. Arsenic was elevated in three samples (9.4 ppm at a depth of 3 ft and 12 and 43 ppm at 6 in.) and mercury was elevated in one sample (12 ppm) at a depth of 6 in..	This area is used for agriculture. Figure D4 (Barr, 2012)	This area poses an indeterminate public health hazard. Arsenic and mercury in the soil is above the SRVs for industrial land use; however, current exposure is expected to be very limited and infrequent.	Areas of arsenic and mercury above the SRVs may need to be removed if land use changes.
Gas Pumps (MSA8)		In 2011, one soil sample was analyzed for metals, SVOCs, and VOCs at a depth of 3 ft. No evidence of contamination was found.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
Oil Storage House (29T)		In 2011, two soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
Pipe Shop Office (229T)		In 2011, one soil sample at a depth of 6 in. was analyzed for metals and SVOCs. cPAHs were found at 0.18 ppm.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.
Pipe Shop Tools (230T)		In 2011, one soil sample at a depth of 1.5 ft was analyzed for metals and SVOCs. cPAHs were found at 0.18 ppm.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.
Crane Repair Shop (24T)		In 2011, one soil sample at a depth of 3 ft was analyzed for metals and SVOCs. cPAHs were found at 0.47 ppm.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent.	More data may be needed prior to development.
Paint Shop (14T)		In 2011, one soil sample at a depth of 6 in. was analyzed for metals and SVOCs. No evidence of contamination was found.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
Machine Shop (16T)		In 2011, five soil samples were analyzed for metals (three at a depth of 6 in., one at 1 ft, and one at 4 ft) and two for SVOCs (at 6 in. and 1 ft). Arsenic was elevated in one sample (11 ppm) at a depth of 1 ft.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although arsenic is above the SRV for residential land use, current exposure is expected to be very limited and infrequent.	Areas of arsenic above the SRVs may need to be removed if land use changes.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
	Drinking Water Pump House (411B)	In 2011, one soil sample was analyzed for metals and SVOCs. DBP was detected at 0.1 ppm at a depth of 6 in..	This area is used for agriculture. The water tower is in this area. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.
	Unknown Bldg (MSA-TC4)	In 2011, one soil sample at a depth of 6 in. was analyzed for metals and SVOCs. No evidence of contamination was found.	This area is used for agriculture. Figure D4 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Warehouse (Bldg EEAS)	This GOW construction warehouse building burned down before 1945.	In 2011, three test trenches were excavated and two soil samples were analyzed for metals and SVOCs at a depth of 6 in. and 1 ft. No evidence of contamination was found, so no groundwater samples were collected. Cinders, nails, and wood debris were present in test trenches.	This area is used for agriculture. Figure D5 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Lead Burner Shop (Bldg 46T)	This shop supported construction and operation of GOW. This building was dismantled as part of the decommissioning of GOW.	In 2011, 14 test trenches were excavated and soil samples were analyzed for metals for each trench. Two samples were elevated for lead (3500 ppm at a depth of 6 in. and 780 ppm at 1 ft). No groundwater samples were collected in this subarea, but MW-B7-014 and MW-B7-015 are located downgradient and did not detect lead in the groundwater.	This area is used for agriculture. Figure D5 (Barr, 2012)	This area poses a public health hazard because concentrations of lead in the soil are significantly above SRVs for industrial land use in surface soils and current exposure to the contaminants could occur.	Lead should be removed in the short-term to prevent exposure. The University has indicated that they will no longer harvest crops in this area for human consumption.
GOW Cotton Dry House/Auto Body Shop (Bldg 101C)	This building was used for GOW powder production. The University leased it to tenants for an auto body shop.	In 2011, two test trenches were excavated and two soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples collected.	This building is currently leased to a tenant for storage of personal items. Figure D6 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Cotton Dry House/US Transformer (Bldg 101A) - part of UMRRC NPL site	This building was used for GOW powder production. In the 1970s, the University leased it to a tenant (US Transformer) who used the building for reclamation of electrical equipment which resulted in release of PCBs. Soils containing PCBs which were excavated to <10 ppm and either disposed offsite or treated and managed within the UMRRC NPL site. Contaminated sewers, concrete slabs, and debris were removed during the remedial action. The area was backfilled with <1 ppm PCB soil and 6 inches of clean topsoil.	In 1984, thallium was found slight elevated at 4 ppm (Twin City Testing Corp., 1986). In 2011, seven soil samples (two at a depth of 4 ft and five at 6 in.) were taken outside of the remediated area and analyzed for PCBs. Five samples were ND for PCBs, while Aroclor 1260 was detected at 2.3 and 0.64 ppm in two 6 inch samples. One sample was analyzed for metals and three samples for SVOCs. No other contaminants were found. No groundwater samples were collected.	By remedial design, soils may contain up to 10 ppm PCBs where no excavation occurred and up to 1 ppm PCBs below the top six inches where soil was excavated. The building still exists. The site is adjacent to an agricultural field and other current tenant sites. Figure D6 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the PCBs exceed the SRV for residential land use, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Concentrations of PCBs are expected to be above residential SRVs below the surface soils in this area. More data will need to be collected before the site is developed.
Metro Mosquito (Bldg 101B)	This building was used for GOW powder production. The University leased it to tenants including the Metropolitan Mosquito Control for an office and chemical storage.	In 2006, two samples at a depth of 0-1 ft were analyzed for metals. In 2011, two test trenches were excavated and two soil samples were analyzed for metals at a depth of 6 in. No evidence of contamination was found, so no groundwater samples collected.	This building is currently leased to a tenant for storage of personal items. Figure D6 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Boiling Tub Houses (Bldgs 108)	These buildings were used for GOW powder production. After decommissioning, the buildings were burned by the Army and trees were planted around the remaining structures.	In 2006, lead was found in surface soil at 1710 ppm. In 2011, five samples at a depth of 6 in. were analyzed for metals and SVOCs and no evidence of contamination was found, so no groundwater samples collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D6 (Barr, 2012)	This area poses an indeterminate public health hazard. Lead in the soil is above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Lead is above SRV for industrial land use and may need to be removed if land use changes.
GOW Poacher Tub Nitrocellulose Slurry Tanks (Bldgs 111)	These buildings were used for GOW powder production. After decommissioning, the buildings were dismantled by the Army and may have been burned down.	In 2006, arsenic was found at a depth of 5 ft at 9.8 ppm. In 2011, two test trenches were excavated and three soil samples taken for metals and SVOCs (one at a depth of 6 in. and two at 5 ft) with no evidence of contamination found, so no groundwater samples collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D7 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although arsenic is above the SRV for residential land use, current exposure is expected to be very limited and infrequent.	Areas of arsenic above the SRVs may need to be removed if land use changes.
GOW Blending Tub Houses (Bldg 113)	These buildings were used for GOW powder production. After decommissioning, the buildings were burned by the Army and trees were planted around the remaining structures.	In 2006, lead was found at a depth of 2 ft at 308 ppm. In 2011, four soil samples at 6 in. and two at 5 ft were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D7 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although lead is above the SRV for residential land use, current exposure is expected to be very limited and infrequent.	Areas of lead above the SRVs may need to be removed if land use changes.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Garage/George's Used Equipment (Bldgs 716A, 716B) - part of UMRRC NPL site	These buildings were used during the GOW period as a car grease shop and gasoline station. The University leased the building to tenants including George's Used Equipment (GUE) who used the area for reclamation of electrical equipment and supplies. GUE's activities resulted in releases of PCBs, lead, and copper to the soil. This area became part of the 1986 UMRRC CERCLA site and impacted soil was either excavated and disposed offsite or treated and managed onsite.	In 1984, in addition to the high PCBs, lead, and copper that were found at the site, antimony was found elevated in 3 of 4 samples (28, 37, and 676 ppm) and thallium was elevated in two of four samples (4, 11 ppm) (Twin City Testing Corp., 1986). In 2006, eight soil samples from outside the soil remediation area were analyzed for metals and PCBs (two samples for SVOCs, six samples for VOCs). PCBs were detected over 1 ppm in four of the eight samples (1.4 ppm at a depth of 1.5 ft, 2.7 ppm at 0-1 ft, and 130 and 270 ppm in sediment in floor drains). Lead was elevated in three of the samples (897 ppm at 1.5 ft, and 1390 and 2470 ppm in sediment in floor drains). Also in the sample at 1.5 ft was mercury (5.5 ppm) and cPAHs (16 ppm). 1,4-dichlorobenzene (48.7 ppm) was found in a surface sample. In 2011, five samples at a depth of 6 in. were collected on the roads in this area where PCB oil was suspected to have been applied, and three samples near GUE at 12 ft (three 6 inch samples had detections for PCBs: 0.32, 1, 1.3 ppm). Three samples taken for metals and one for VOCs at 12 ft showed no evidence of contamination (except very low detections of methylene chloride (0.15 ppm) and tetrahydrofuran (0.4 ppm) in one sample. In 2013 the impacted sediment from the floor drains of the concrete slab was removed. Additional PCB sampling in 2013 found elevated levels on the north side of GUE (up to 60 ppm at 0-6 inches) (UMN, 2013c). Groundwater samples from GUE-MW-19 and GUE-MW-20 were tested for metals: detected antimony, cadmium, chromium, lead, thallium, and zinc above their drinking water criteria and elevated levels of copper; the samples were not tested for other site-related contaminants.	GUE Deep, an area containing 10-25 ppm PCBs and elevated lead in the soil, was covered with up to 2 ppm PCBs and is fenced. Maintenance of a 10 inch soil cover over other areas of contamination up to 10 ppm PCBs is required. Building 716B was demolished but the slab is in place. The site has use restrictions. Further investigation of PCB contamination is pending. Figure D8 (Barr, 2012)	This area poses a public health hazard because concentrations of PCBs in the soil are significantly above SRVs for industrial land use in surface soils and current exposure to the contaminants could occur. Mercury and cPAHs are also above the industrial SRVs. There are no groundwater exposures in this area.	Concentrations of PCBs in surface soils are significantly above SRVs for industrial land use and should be removed in the short-term to prevent exposure. Areas of mercury and cPAHs above the SRVs may need to be removed if land use changes. Elevated metal levels detected in groundwater indicate these metals should be tested for in future samples from monitoring and private wells downgradient of this area.
GOW Dry Ingredients Storage/Porter Electric (Bldgs 227A & 227B) - part of UMRRC NPL site	These buildings were used during the GOW period as dry ingredients storage. The University leased the buildings to tenants including Porter Electric who used the area for reclamation of electrical equipment which resulted in a release of PCBs to the soil. This area became part of the 1986 UMRCC CERCLA site and PCB impacted soil was excavated and either disposed of offsite or treated and managed onsite.	In 2011, one sample was analyzed for SVOCs, RCRA metals, PCBs, and VOCs at a depth of 14 ft. No evidence of contamination was found, so no groundwater samples were collected.	This area is wooded and a portion of the building slab is still present. No soil cap was needed because after excavations the soil contained < 1 ppm PCBs. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Storehouse/Dole Explosives (Bldg 713A)	This building was used during the GOW period as a general warehouse. The University leased the building to tenants including Dole Explosives, an explosives manufacturer, for truck storage and shop. Other tenant's uses included fiberglass production, auto repair, and welding. Two underground storage tanks (USTs) were installed by Dole Explosives.	In 2011, one test trench was excavated and two soil samples were analyzed at 6 in. for metals, SVOCs, and explosives and at 12 ft for metals, SVOCs, and VOCs. No evidence of contamination was found. A previous Phase I report (Peer, 2006a) notes staining observed below the dispenser for one UST. One UST was removed in 2011. No groundwater samples were collected in this area.	This building is currently leased to a tenant for storage of merchandise. This area may still contain an UST. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no public health hazard although evidence of a leaking underground storage tank was previously found. There are no groundwater exposures in this area.	More data may be needed prior to development. MPCA regulations for USTs need to be followed.
GOW & Post-GOW Shop/Dole Explosives (Bldg 717A)	This building was used during the GOW period as a combined shop. The University continued to use the building as a combined shop and then leased portions to tenants including Dole Explosives for office and storage, a machine shop, and a mechanic shop.	In 2011, 13 soil samples were taken for one or more of the following: PCBs, metals, SVOCs, and VOCs. Four out of nine samples analyzed for PCBs had detections at a depth of 6 in. (2.2-4.8 ppm). The PCBs are likely related to the adjacent George's Used Equipment site (see above). cPAHs were elevated in two samples at 6 in. (1.7-3.2 ppm). A UST was removed in 1991 and soil was excavated in 1992. No groundwater samples were collected in this area.	This building is currently leased to a tenant for the storage of a vehicle. A previous Phase I report (Peer, 2006a) notes the building contains two indoor fuel oil aboveground storage tanks (ASTs) that were installed in 1944. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although concentrations of PCBs and cPAHs exceed the residential SRVs, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of PCBs and cPAHs above the SRVs may need to be removed if land use changes; MPCA regulations for ASTs need to be followed.
GOW Locomotive House (Bldg 718A)	This building was used during the GOW period to store and service locomotive engines and as a gas station. The University continued to use it as a locomotive house and leased it for construction equipment storage.	In 2011, two soil samples, one at a depth of 12 ft and the other at 6 in., were analyzed for metals, SVOCs, and VOCs. No evidence of contamination was found, so no groundwater samples were collected.	This building is currently leased to a tenant for the storage of construction equipment. A 12,000 gallon UST from 1943 may be present on the north side of the building. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development. MPCA regulations for USTs need to be followed.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Fuel Oil Pump House (Bldg 718C)	The University continued to use this building as a fuel oil pump house after the GOW period.	In 2011, one soil sample at a depth of 6 in. was analyzed for metals, SVOCs, and VOCs. No evidence of contamination was found, so no groundwater samples were collected. This area contained a fuel oil UST.	The building still exists. The area may still contain an UST. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Paint Area Shop (Bldg 722D)	The University continued to use this building as a paint shop after the GOW period.	In 2011, one soil sample at a depth of 6 in. was analyzed for metals and SVOCs. cPAHs were found at 0.55 ppm. No groundwater samples were collected in this area.	The building still exists. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Paint Storage/Pipe Fabrication (Bldg 715B)	The University continued to use this building for paint storage after the GOW period and leased the building to tenants including a pipe fabrication company.	In 2011, one soil sample at a depth of 6 in. was analyzed for metals, SVOCs, VOCs, and PCBs. cPAHs were found at 0.67 ppm. No groundwater samples were collected in this area.	The building still exists. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.
Post-GOW Lab/Circuit Fabrication/ Machine Shop (Bldg 707FFF)	This building was used as the GOW transportation change house. The University used it as a radiological research lab. Tenants uses include animal research, circuit fabrication, and a machine shop.	In 2011, eleven soil samples were analyzed for SVOCs (five for metals, two for VOCs). cPAHs were detected in all of the samples from (0.012-5.7 ppm). All samples were at a depth of 6 in. except one at 1.5 ft. DBP was detected at a trace level (0.059 ppm). No groundwater samples were collected in this area; wells MW-B7-013 and MW-B7-014, distantly downgradient, did not detect site-related contaminants.	This building is currently leased to a tenant for a machine shop. Figure D8 (Barr, 2012)	This area poses a public health hazard because cPAHs in the soil are above SRVs for industrial land use and the property is currently being leased for industrial use. There are no groundwater exposures in this area.	Areas of cPAHs above the SRVs for industrial land use should be removed.
GOW Field Canteen/Auto Repair (Bldg 746B)	This building was used as a GOW field canteen. University tenants included auto repair and a welding shop.	In 2011, two soil samples at a depth of 6 in. were analyzed for metals and SVOCs. cPAHs were found at 0.35 and 1.0 ppm. No groundwater samples were collected in this area.	The building still exists. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Shops Change House/Machine Shop (Bldg 707LL)	This building was used as a GOW change house for the shops area. The University used it for storage, and an animal surgery lab and animal shelter. Tenants uses included a paint shop and a machine shop.	In 2011, one soil sample at a depth of 1 ft was analyzed for metals, SVOCs, and VOCs. No evidence of contamination was found, so no groundwater samples were collected in this area.	The building still exists. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Ether Mix Houses (Bldgs 206)	These buildings were used to dissolve DPA, DNT, and DBP in ether for GOW powder production. The Army partially dismantled the buildings during decommissioning.	In 2006, two samples were analyzed for metals and SVOCs. cPAHs were elevated in one sample at a depth of 5 ft (1.6 ppm) and DBP was detected in two samples (0.13 ppm at 5 ft and 2.19 ppm at 1.5 ft). In 2011, three soil samples (two at 5 ft and one at 6 in.) were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D9 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Mixer Macerator Houses (Bldgs 208)	These buildings were used to mix in DPA, DNT, and/or DBP for GOW powder production. The Army partially dismantled the buildings during decommissioning.	In 2006, two samples were analyzed for metals and SVOCs. No evidence of contamination was found. In 2011, eight soil samples were analyzed for SVOCs and four for metals. cPAHs were detected at very low levels in five samples, and at 3.1 ppm in one sample in surface soil. 2,4-DNT was detected in five samples (0.46 to 10 ppm) and 2,6-DNT was detected in two samples (0.13-0.72 ppm) at the surface or at a depth of 6 in. DBP was detected in five samples (0.42-9.2 ppm) and n-nitrosodiphenylamine was detected in three samples (0.057-0.96 ppm) also at the surface or at 6 in. MW-C6-020 is located in this area and was sampled for metals, VOCs, and SVOCs - 1.6 ppb chloroform was detected, likely associated with the UMRRC Burn Pit plume.	The building foundations are still present and the surrounding area is open space with trees. Figure D9 (Barr, 2012)	This area poses an indeterminate public health hazard. cPAHs in the soil are above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of cPAHs above the SRVs may need to be removed if land use changes.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Tray Dryer/Circulation Houses (Bldgs 237)	These buildings were used for GOW powder production. The Army dismantled and burned the buildings during decommissioning.	In 2006, three samples were analyzed for metals and two for SVOCs and two had elevated arsenic (10.2 ppm at a depth of 1.5 ft and 13.4 ppm in surface soil). One surface sample had 2,4-DNT at 0.24 ppm and DBP at 0.97 ppm. In 2011, six soil samples were taken for metals and SVOCs (and one sample for explosives) along with one sample from the sump at former bldg 237B. DBP was detected in one sample at a depth of 6 in. at 0.085 ppm. 2,4-DNT (1.4 ppm), 2,6-DNT (0.076 ppm), DBP (3.7 ppm), and n-nitroso-DPA (0.16 ppm) were detected in another sample at a depth of 6 in. A 2008 boring at Bldg. 237G detected a liquid "...that smelled of mothballs...from 25-45 feet below ground surface" which may indicate naphthalene or other PAHs, but no groundwater samples have been collected in this area.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D10 (Barr, 2012)	Based on current soil sampling, this area poses no apparent public health hazard because although concentrations of arsenic are above the SRVs for residential land use, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area, but there are private wells are present within one mile downgradient, in the town of Coates.	A groundwater sample should be collected near Building 237G. Areas of arsenic above the SRVs may need to be removed if land use changes.
GOW Glaze Barrel Houses (Bldgs 238)	These buildings were used for GOW powder production. The Army dismantled and burned the buildings during decommissioning.	In 2006, three samples were analyzed for metals and one for SVOCs. Arsenic (10, 15 ppm) and lead (392, 429 ppm) were elevated in two surface soil samples. In 2011, six soil samples were analyzed for metals and SVOCs. cPAHs were detected in two samples (0.26, 1.1 ppm) at a depth of 6 in. DBP was detected in one sample at 0.09 ppm at 6 in. No groundwater samples were collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D32 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although concentrations of arsenic and lead are above the SRVs for residential land use and the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of arsenic and lead above the SRVs and cPAHs may need to be removed if land use changes.
GOW Rifle Powder Water Dry Houses (Bldgs 235)	These buildings were reportedly not used during GOW powder production. The Army dismantled the buildings during decommissioning.	In 2006, two soil samples were analyzed for metals, and one for SVOCs. One sample at a depth of 3.5 ft had elevated arsenic (15.7 ppm) and cPAHs (8.9 ppm). In 2011, 7 samples were analyzed for metals and 23 for SVOCs. cPAHs were elevated in four samples at a depth of 6 in. (2.5-31 ppm), and 3.1 ppm at 1 ft and 2.9 ppm at 3.5 ft. Five additional samples had cPAHs under 1 ppm. Tar debris was observed. No groundwater samples were collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D12 (Barr, 2012)	This area poses an indeterminate public health hazard. cPAHs in the soil are above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	cPAHs above the SRVs may need to be removed if land use changes.
University-FBI Firing Range	This area has been an active firing range since 2001. The University is implementing best management practices (BMPs).	No soil or groundwater data was collected. Wells MW21D, MW-28, MW-29, MW-C7-004 downgradient of this area detect only chlorinated VOCs associated with UMRRC Burn Pit plume.	This area is an active firing range. The future development plans keep the land use the same. Figure 4 (Barr, 2011a)	Active shooting ranges using BMPs are not expected to cause adverse health impacts. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Knife Grinding and Die Shop/Fluidyne (Bldg 217A)	This building was used as a GOW knife-grinding/die shop. The University used it as an aeronautical lab. Tenant's uses include a research lab, welding/fabrication, fertilizer storage, and cabinet manufacturing.	In 2011, 13 soil samples were analyzed for SVOCs, 10 for arsenic, 7 for metals, and 1 for VOCs. Arsenic was elevated in two samples (10 ppm at a depth of 6 in., 140 ppm at 1 ft). cPAHs were detected in 8 of the 13 samples (0.058-16 ppm at 6 in., 130 ppm at 1 ft). MW-C6-020 is located in this area and was sampled for metals, VOCs, and SVOCs - only chloroform (1.6 ppb) was detected, likely associated with the UMRRC Burn Pit plume.	The building exists. A 1,000 gallon fuel oil AST is inside of the building. Figure D13 (Barr, 2012)	This area poses an indeterminate public health hazard. Arsenic and cPAHs in the soil are above the SRVs for industrial land use; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of cPAHs and arsenic above the SRVs may need to be removed if land use changes.
GOW Lab/Auto Shop (Bldg 706A)	This building was used as a GOW powder testing lab. Tenant's uses included paint and tool storage, paint sprayer manufacturing, and auto equipment storage.	In 2011, 13 soil samples were analyzed for metals and four for SVOCs. Mercury was elevated in four samples at a depth of 6 in. (0.67-4.4 ppm). No groundwater samples were collected.	The building still exists. Figure D14 (Barr, 2012)	This area poses an indeterminate public health hazard. Mercury in the soil is above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of mercury above the SRVs may need to be removed if land use changes.
GOW Lab/Tech Ordnance (Bldg 706D)	This building was used as a GOW powder testing lab. Tenants included an explosives manufacturer.	In 2011, one soil sample at a depth of 6 in. was analyzed for metals, SVOCs, and explosives. No evidence of contamination was found, so no groundwater samples were collected.	The building still exists. Figure D14 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Scrap Rework House (Bldg 209A)	This building was used during the GOW period to dissolve and reclaim off-spec powder. The Army dismantled and burned the building during decommissioning.	In 2006, one soil sample at a depth of 0-1 ft was analyzed for metals, SVOCs, and VOCs. One sample at 4 ft was analyzed for just SVOCs. Both samples had detectable levels of DBP (4.1, 0.25 ppm) and DPA (0.16, 0.58 ppm). 2,4-DNT (1.8 ppm) and 2,6-DNT (0.06 ppm) were detected at the 0-1 ft sample. cPAHs were detected at 0.49 ppm in the 4 ft sample. Three soil samples at a depth of 6 in. were analyzed in 2011 for SVOCs (one sample also analyzed for metals). No evidence of contamination was found in the 2011 sampling. No groundwater samples were collected in this area; wells MW21D, MW-28, MW-29 downgradient of this area detect only chlorinated VOCs associated with UMRRC Burn Pit plume.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D14 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.



### Appendix A: Gopher Ordnance Works Site Summary

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW DNT Screening House (Bldg 205A)	This building was used to ensure GOW powder particle size. The Army dismantled and burned the building during decommissioning.	In 2006, two samples were analyzed for metals, SVOCs, and PCBs. No contamination was found. In 2011, two samples were analyzed for metals and SVOCs at a depth of 6 in. 2,4-DNT was measured in both samples (0.05, 1.3 ppm) and 2,6-DNT was detected in one sample at 0.096 ppm. No groundwater samples were collected in this area; wells MW21D, MW-28, MW-29 downgradient of this area detect only chlorinated VOCs associated with UMRRC Burn Pit plume.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D15 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern. There are no groundwater exposures in this area.	More data may be needed prior to development.
Activated Carbon Recovery System/ Technical Ordnance (Bldg 251A)	This building was used during the GOW period to house an activated carbon solvent recovery system. The University continued to operate the system then later leased the building to Technical Ordnance, an explosives manufacturer.	In 2011, nine samples were analyzed for SVOCs (three sampled for explosives and metals also). cPAHs were detected in six of the nine samples at a depth of 6 in. (0.07-5.8 ppm). Groundwater samples from nearby, downgradient monitoring wells (MW-21D, 28, and 29) detected only chlorinated VOCs associated with the UMRRC Burn Pit plume - SVOCs were not detected.	The building still exists. Figure D16 (Barr, 2012)	This area poses an indeterminate public health hazard. cPAHs in the soil are above the SRV for industrial land use; however, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of cPAHs above the SRVs may need to be removed if land use changes.
Activated Carbon Recovery System/ Minneapolis Bomb Squad (Bldg 251B)	This building was used during the GOW period to house an activated carbon solvent recovery system. The University continued to operate the system then later leased the building and surrounding land to the Minneapolis bomb squad.	In 2006, two samples were analyzed for SVOCs and VOCs around bldg 251B and cPAHs were detected (0.26 ppm at a depth of 5 ft and 15 ppm in the surface soil). Because this is an active tenant site it was not investigated in 2011. According to the 2011 Phase I (Barr, 2011a) soil that was brought on site to construct a berm in 1987 contained debris. Annual soil sampling from 1992-1997 did not detect a release. Groundwater samples from nearby, downgradient monitoring wells (MW-21D, 28, and 29) detected only chlorinated VOCs associated with the UMRRC Burn Pit plume - SVOCs were not detected.	The current tenant is the Minneapolis Bomb Squad. The site is surrounded by a chain-link fence. Figure 4 (Barr, 2011a)	This area poses an indeterminate public health hazard. cPAHs in the soil are above the SRV for industrial land use; however, public access is restricted and current tenant exposure is unknown. There are no groundwater exposures in this area.	Areas of cPAHs above the SRVs may need to be removed if land use changes.
GOW Controlled Circulation Dryer Houses (Bldgs 220)	These buildings were used during the GOW period to remove volatiles and moisture from the powder. The Army dismantled and burned the buildings during decommissioning.	In 2006, two samples (one at a depth of 6 in. and the other at 0-1 ft) contained elevated arsenic (22.3 ppm), lead (547 ppm), cPAHs (2 ppm), 2,4-DNT (3.8, 0.2 ppm), DBP (6.5, 1.6 ppm), and DPA (0.2, 0.24 ppm). In 2011, eight soil samples were analyzed for SVOCs (two surface samples, one at a depth of 6 in., and five at a depth of 1 ft). The 1 ft samples were also analyzed for metals. Four samples contained cPAHs (0.09-1.2 ppm) and 2,4-DNT (0.046-0.8 ppm), and 2,6-DNT was detected in one sample (0.065 ppm). DBP was detected in all samples (0.13-6.1 ppm). No groundwater samples were collected in this area, but no site-related contaminants were detected in MW-C7-016 or MW-OX-1 which are located distantly downgradient.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D17 (Barr, 2012)	This area poses an indeterminate public health hazard. Arsenic in the soil is above the SRV for industrial land use, and the cPAH mixture potency is underestimated. However, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of arsenic, lead, and cPAHs above the SRVs may need to be removed if land use changes.
GOW Change Houses (Bldgs 707X, 707XX)	These buildings were used as GOW changing rooms. The Army dismantled and burned the buildings during decommissioning.	In 2011, two soil samples at a depth of 6 in. were analyzed for metals and SVOCs. cPAHs were found at 0.05 and 0.74 ppm. No groundwater samples were collected in this area.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D18 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Supervisor's Office (Bldg 704E)	This building was used as GOW office space. The Army dismantled and burned the building during decommissioning.	In 2011, one soil sample at a depth of 6 in. was analyzed for metals and SVOCs. No evidence of contamination was found besides cPAHs at 0.06 ppm, so no groundwater samples were collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D18 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Cotton Dry Lab (Bldg 706J)	This building was used during the GOW period to analyze characteristics of nitrocellulose. The Army dismantled and burned the building during decommissioning.	In 2006, three samples were analyzed for metals (two at a depth of 0-1 ft and one at 5 ft) and one for SVOCs (at 5 ft) near this building and no evidence of contamination was found, so no groundwater samples were collected. It was not investigated in 2011.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D8 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
GOW Acid Area and Supply Lab (Bldg 706B)	This building was used during the GOW period as a lab to determine the degree of nitration and ensure quality of acids and nitrocellulose. After decommissioning the University continued to use it as a laboratory.	No soil or groundwater data was collected. MW-B7-014 is located downgradient of this area and did not detect site-related contaminants.	The building still exists. Figure 4 (Barr, 2011a)	Because no data has been collected, this area is an indeterminate public health hazard. There are no groundwater exposures in this area.	More data may be needed prior to development.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Central (Figures 6 and 11)					
UMRRC Burn Pit plus temporary burn pit - part of NPL site	This area was used as a GOW surface water drainage ditch. The University used this area from the 1960s to 1974 to burn/bury chemical wastes. A chloroform plume was detected in the groundwater from the leaching of wastes. The burn pit was closed with a layer of lime and a clay cap.	No soil or groundwater data was collected in the UMRRC Burn Pit. In 2011, a geophysical survey was conducted to identify buried metallic debris and one small metallic object was identified. Two soil samples at a depth of 6 in. were analyzed for metals and SVOCs near the temporary burn pit to the east and no evidence of contamination found. Chlorinated VOCs have been detected in monitoring wells (MW-21D, MW-22, MW-23D, MW-25, MW-28, MW-29, MW-C6-020, and T00006) and private wells located as far as 3.5 miles downgradient of the burn pit.	The burn pit was lined with lime, backfilled with sand, and capped with clay in 1980 (EPA, 2007). Four fence posts mark the location, but no fence exists. There is a limited activity use restriction on the property. The temporary burn pit has not been capped or marked. Figure D19 (Barr, 2012)	This area is an indeterminate public health hazard because there is subsurface contamination and the area is a source of groundwater contamination. Based on the remedial design, there is no current public health hazard due to exposure to soil contamination because the burn pit was capped. There are no groundwater exposures in this area, but VOC plume extends off UMore property to the NE. Recent (2013) sampling detected VOCs in a private well which is no longer used for drinking water; it is unclear if additional wells may be at risk.	More data will be needed prior to development. A thorough well search should be completed and any private wells w/ 1,000 ft. downgradient of UMore property should be tested for site-related contaminants.
GOW Central/East 160th St. Dump	This area was used during the GOW period as a borrow pit and then as a demolition dump during decommissioning. Dumping occurred in the 1950/60s through the 1980s. Pathological specimens preserved in formaldehyde were disposed here. The southern portion was used to detonate shock sensitive or unstable materials. The dump was never formally closed. Surface debris is visible.	In 2011, a geophysical survey was conducted and several small metallic objects were identified. Sixteen soil samples (14 at a depth of 6 in., two at 3 ft) were analyzed for metals and SVOCs (four sampled for VOCs). Arsenic (9.1 ppm at 3 ft and 11 ppm at 6 in.) was slightly elevated in two samples. cPAHs were elevated in three samples at 6 in. (1.0, 9.8, 27 ppm). Trace levels of three VOCs were found in two 3-ft samples. Trace levels of three SVOCs were found in one surface sample. No groundwater samples were collected.	The dump was never formally closed. Currently it is vegetated and surficial debris is visible. Figure D19 (Barr, 2012)	This area poses an indeterminate public health hazard. cPAHs in the soil are above the SRV for industrial land use and arsenic is above the SRV for residential land use; however, current exposure is expected to be very limited and infrequent. No subsurface data has been collected and dump debris can be a physical as well as chemical public health hazard. There are no known groundwater exposures in this area, but a well is in use at a nearby cattle barn. Alternate water is available, but incidental use for drinking water may occur.	Access to dump materials should be restricted. Areas of cPAHs and arsenic above SRVs may need to be removed if land use changes. The well at the nearby cattle barn should be sampled for VOCs, bacteria, and nitrate OR signs should be posted to warn staff that water is not tested and may not be potable.
Suspected Disposal Area	This area is suspected to be a dump site or burn pit for University lab wastes and/or miscellaneous wastes. Disturbances were observed in 1957 and 1964 aerial photos.	In 2011, a geophysical survey was conducted and significant amount of metal was found in this area. Fourteen soil samples were analyzed (13 for metals, 14 for SVOCs, 5 for VOCs, 3 for pesticides - all at a depth of 6 in. except one sample at two ft - and one coal sample. The coal sample had a total cPAH of 0.11 ppm. Arsenic was elevated in one sample (13 ppm) at 2 ft. cPAHs were detected in 11 of the 14 samples (0.006-2.4 ppm). Very low levels of several VOCs were found in four of the five samples analyzed for VOCs. DBP was detected in two samples (0.048, 0.056 ppm). Small metal debris in surface soil throughout area. No groundwater samples were collected in this area.	This area is wooded and near agricultural areas. Figure D19 (Barr, 2012)	This area is an indeterminate public health hazard because no subsurface data has been collected and dump debris can be a physical as well as chemical public health hazard. Based on current sampling, this area poses no public health hazard to soil contamination because although cPAHs and arsenic are above the SRVs for residential land use, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Access to dump materials should be restricted. Areas of cPAHs and arsenic above SRVs may need to be removed if land use changes.
GOW Combination Rifle and Cannon Powder Blending Tower and Packing Houses (Bldgs 222)	These buildings were used as part of the GOW powder production line. The buildings were dismantled by the Army during decommissioning. The University left the area dormant.	In 2006, three samples (at surface, 3 and 3.5 ft) were analyzed. The surface sample had elevated arsenic (16.1 ppm) and detected 2,4-DNT (0.21 ppm). All three detected DBP (0.1-0.4 ppm). In 2011, eleven soil samples (10 at a depth of 6 in. and one at 3 ft) were analyzed for metals and six also for SVOCs. Arsenic was elevated in one sample (14 ppm). cPAHs were elevated in one sample (1.2 ppm), 2,4-DNT detected in two samples (0.1, 0.17 ppm) and DBP detected in three samples (0.16-0.64 ppm). No groundwater samples were collected in this area.	This area contains trees around the remaining structures and the surrounding area is agriculture. Figure D20 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although concentrations of arsenic are above the SRVs for residential land use and the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of arsenic and cPAHs above SRVs may need to be removed if land use changes.
GOW Finished Powder Houses (Bldgs 229)	These buildings were used as part of the GOW powder production line. The sixty buildings were constructed with treated wood. The buildings were dismantled by the Army during decommissioning.	In 2011, eleven soil samples were analyzed for metals (ten at a depth of 6 in., one at 4 ft) and seven samples also analyzed for SVOCs. Two samples were elevated for arsenic (10 ppm at 4 ft and 13 ppm at 6 in.). Samples were collected near bldg 229-19 and 229-26 only. No groundwater samples were collected in this area.	This area is agricultural, with the exception of the wooded area around former bldg 229-26. Figure D21 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although concentrations of arsenic are above the SRVs for residential land use, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	Areas of arsenic above the SRVs for may need to be removed if land use changes.
Grid Space D5, E5	Within this space is a former GOW staging area and drainage ditch, and area of soil disturbance visible on a 1945 photograph. The University left these areas dormant between agricultural fields.	In 2011, four soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected.	This is area is agricultural with dormant land between fields. Figure D22 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found. There are no groundwater exposures in this area.	More data may be needed prior to development.
GOW Box Storehouses (223A, 223B)	After GOW decommissioning, the University used these buildings for storage. The University also leased the buildings for uses including industrial equipment storage, light manufacturing, storage of electrical supplies, and plastic extruding.	No soil or groundwater data was collected.	The buildings are currently leased for electrical supply storage, office space, and light manufacturing. Figure D22 (Barr, 2012)	Because no data has been collected, this area is an indeterminate public health hazard. There are no groundwater exposures in this area.	More data may be needed prior to development.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
Bldg 709A	This building was used during the GOW period as the fire headquarters. The University also used it as a fire headquarters and for storage. The University also leased the building for uses including equipment and auto repair and storage.	No soil or groundwater data was collected because the building was leased at the time of 2011 RI.	This building is currently not leased. Figure 16 (Barr, 2012)	Because no data has been collected, this area is an indeterminate public health hazard. There are no groundwater exposures in this area.	More data may be needed prior to development.
<b>DEF Line (Figure 7)</b>					
GOW Aniline Plant Area	The GOW aniline plant was constructed to manufacture DPA but was cancelled due to an increase of DPA production elsewhere. It is unclear whether plant was ever used. The University used one building for hazardous waste storage (where soil has been previously excavated for PCBs) and leased to tenants including the Jensen Airfield.	In 2011, twelve samples were analyzed for metals and SVOCs (ten at a depth of 6 in., two at 7-8 ft). No evidence of contamination was found except for cPAHs at 6 in. (0.006 and 0.3 ppm), so no groundwater samples were collected.	Some buildings are still present. Figure D23 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	More data may be needed prior to development.
"L" and "J" Street Dumps	It is uncertain if this area was used during the GOW period. The "L" Street Dump may have been a soil borrow pit or an intended future building site. The sites have been identified as potential former disposal sites and the University has left the area dormant.	In 2011, thirteen soil samples (eleven at a depth of 6 in. and two at 1 ft) were analyzed for metals and SVOCs and three for VOCs. One 6 in. sample that included a tar-like substance was elevated for arsenic (28 ppm), cPAHs (230 ppm), naphthalene (54 ppm) and other PAHs. Two samples showed DBP just above the detection limit at 0.048 and 0.051 ppm. Buried building materials including concrete, asphalt, and shingles were observed in test trenches. No groundwater samples were collected in this area.	This area is dormant, wooded land between agricultural fields. Figure D24 (Barr, 2012)	This area poses a public health hazard because concentrations of cPAHs in the soil are significantly above SRVs for industrial land use in surface soils and current exposure to the contaminants could occur. Arsenic is also above the SRV for industrial land use. Dump debris can be a physical as well as chemical public health hazard. There are no groundwater exposures in this area.	Concentrations of cPAHs in surface soils are significantly above SRVs for industrial land use and should be removed in the short-term to prevent exposure. Areas of arsenic above SRVs may need to be removed if land use changes. Access to dump materials should be restricted.
"G" Street Dump	This area is likely to have been in mid-construction when GOW was decommissioned. The foundation appeared to have been excavated in 1945. The University has left the area dormant and it has been identified as a potential former disposal site.	Two samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected. No debris was found in four test trenches.	This area is wooded. Figure D25 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
Grid Spaces C4, D4 (DEF line ruins)	This area includes the majority of the GOW DEF powder production lines that were reportedly never used. The University has left the area dormant but limited military training has been conducted in the area.	In 2011, seven soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found with the exception of cPAH detections of 0.13 and 0.26 ppm, so no groundwater samples were collected. Asbestos-containing mastic still remains on some of the foundations at the DEF line ruins.	This area is dormant and contains GOW ruins. Figure D26 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although the cPAH mixture potency is underestimated, current exposure is expected to be very limited and infrequent. Asbestos found on site poses an indeterminate public health hazard because although pieces of ACBM are found at the site, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area.	May need to collect more data before the site is developed. Asbestos needs to be removed if land use changes.
<b>Navy/Burning Grounds (Figure 8)</b>					
GOW Burning Grounds	The GOW burning grounds were constructed in 1944 and operated until 1948. The area was used to detonate gunpowder and to burn nitro-body-contaminated building materials and hazardous waste. After burning, the top two inches were removed and thin spread. The University leased the area to the Navy in 1954.	In 2002, 37 soil samples found elevated concentrations at a depth of 0-1 ft of arsenic (14 ppm), lead (390, 1000, 3100 ppm), mercury (13, 16 ppm), and two elevated cPAH samples in surface soil (1.8, 420 ppm). In 2011, 20 soil samples were analyzed for metals, 17 for SVOCs and 9 for VOCs. Lead was elevated at a depth of 6 in. (480 ppm) and 2,4-DNT was detected (0.06 ppm). Methylene chloride was measured in six samples at 2 and 6 ft (0.49-0.63 ppm). No groundwater samples were collected during the investigations, but no site related contaminants (except transient, trace levels of 1,2-dichloropropane) were detected in the three nearby former drinking water wells (see "Navy Operations" subarea) or the UM community water supply well (UN207611) or MW-A5-018 downgradient of this area.	This area is dormant, wooded land. Figure D27 (Barr, 2012)	This area poses a public health hazard because concentrations of lead and cPAHs in the surface soil are significantly above SRVs for industrial land use and current exposure to the contaminants could occur. Mercury is also above the SRV for industrial land use and arsenic is above the SRV for residential land use. There are no current groundwater exposures in this area; the three wells at the former Navy Burning Ground property were sealed in 2009. The UM community water supply well is routinely tested.	Concentrations of lead and cPAHs are significantly above levels of concern for industrial land use and should be removed in the short-term to prevent exposure. Areas of mercury arsenic above the SRVs may need to be removed if land use changes.
Air Force Building 12 (AF12)	The University leased this area to the Air Force after GOW decommissioning. The building was used to store small quantities of hazardous waste.	In 2011, two soil samples at 2 and 6 ft were sampled for metals, SVOCs, VOCs, and PCBs. No evidence of contamination was found, so no groundwater samples were collected in this area.	The buildings were demolished in 2009. This area is open space, surrounded by trees and near agriculture. Figure D27 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
Rosemont Ammunition Storage Bunker (RASB)	The University leased this area to the Air Force and Navy after decommissioning of GOW. The building was used to store ammunition magazines.	In 2011, eight soil samples at a depth of 1.5 ft were sampled for metals and SVOCs. One sample contained 2,4-DNT (1.3 ppm), 2,6-DNT (0.043 ppm) and DBP (0.38 ppm). No groundwater samples were collected in this area, but well MW-A5-018, which is located downgradient, did not detect any site related contaminants.	The buildings were demolished in 2009. This area is open space, surrounded by trees and near agriculture. Figure D27 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern	More data may be needed prior to development.
Navy Operations - Navel Intelligence Reserve Center (NIRC)	The University leased the area to the Navy for the NIRC after GOW decommissioning. In 2009, the Navy demolished bldgs, sealed the drinking water wells, and disposed of PCB-impacted soil, concrete, and asphalt in the vicinity of bldg 4U.	The Navy conducted an investigation in 2009 and removed 49 tons of PCB contaminated soil, concrete and asphalt. 28 soil confirmation samples were analyzed and PCBs were detected in 5 samples at low levels (0.07-0.52 ppm in surface, 1, and 2 ft samples) (Versar, 2010). No groundwater samples were collected during the investigations, but no site related contaminants (except transient, trace levels of 1,2-DCP) were detected in the three former drinking water wells in this subarea.	The buildings were demolished in 2009. This area is open space, surrounded by trees and near agriculture. Figure D27 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern. There are no current groundwater exposures in this area.	More data may be needed prior to development.
Navy Firing and Shooting Ranges	The area is near the GOW Burning Grounds but not occupied during GOW. The University leased the area to Navy and they constructed recreational firing and shooting ranges on the east side of NIRC.	In 2009, 88 surface soil samples were analyzed for metals by XRF. Only arsenic was elevated (9.12-13 ppm) in the surface soil in five locations. Lead appeared to be at about natural background. In 2011, four samples at a depth of 6 in. were analyzed for arsenic and none were elevated. Five samples were analyzed in the middle of the shooting range (four at 6 in. and one at 5 ft) and lead was elevated (1300 ppm) in one 6 inch sample. No groundwater samples were collected in this area, but well MW-A5-018, located downgradient, did not detect any site-related contaminants.	This area is open space, surrounded by trees and near agriculture. Figure D27 (Barr, 2012)	This area poses an indeterminate public health hazard. Lead in the soil is above the SRV for industrial land use, and arsenic is above the residential SRV; however, current exposure is expected to be very limited and infrequent.	Areas of lead and arsenic above SRVs and may need to be removed if land use changes.
10th Street Dump	This area was a GOW borrow source and possibly a demolition dump. The University leased this area to the Navy/Air Force after GOW decommissioning. The Navy may have used it for a disposal area.	In 2011, 18 soil samples were analyzed for metals, 14 for SVOCs, and 4 for VOCs. Two samples were elevated for lead (730 ppm at a depth of 1.5 ft, and 4500 ppm at 6 in.). The sample at 1.5 ft also contained mercury (0.79 ppm), silver (4.8 ppm) and DBP (0.17 ppm). Five samples at 6 in. contained methylene chloride at low levels (0.36-0.54 ppm). Dump materials including slag, metal, concrete, and discolored soil were observed in test trenches. No groundwater samples were collected, but no site related contaminants (except transient, trace levels of 1,2-DCP) were detected in three former drinking water wells downgradient of this area (see "Navy Operations" subarea).	This area is open space, surrounded by trees and near agriculture. Figure D28 (Barr, 2012)	This area poses a public health hazard because concentrations of lead in the soil are significantly above SRVs for industrial land use in surface soils and current exposure to the contaminants could occur. Dump debris can be a physical as well as chemical public health hazard. There are no groundwater exposures in this area.	Concentrations of lead in surface soils are significantly above SRVs for industrial land use and should be removed in the short-term to prevent exposure. Access to dump materials should be restricted.
GOW Aniline Spread Area	During the GOW period this area was constructed to spread aniline sludge waste, but it reportedly was not used due to the cancellation of the Aniline Plant.	In 2011, three soil samples at a depth of 6 in. were analyzed for metals and SVOCs in the northern portion of the area and no evidence of contamination was found, so no groundwater samples were collected.	The area is in a dormant, wooded area, adjacent to agricultural fields. Figure D28 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
"B" Street Dump	During the GOW period this area was a borrow source and possibly a dump. The University has left this area dormant.	In 2011, a geophysical survey of this area was conducted and small subsurface anomalies were found but no large metallic objects. Surficial and buried concrete and asphalt and water distribution pipes were encountered in test trenches. Ten samples (six at a depth of 6 in., and 3, 4, 7, and 10 ft) were analyzed for metals and 7 for SVOCs. One sample at 4 ft was elevated for lead (360 ppm). No groundwater samples were collected.	This area is dormant open space and is surrounded by trees and near agricultural areas. Figure D29 (Barr, 2012)	This area poses an indeterminate public health hazard. Dump debris can be a physical as well as chemical public health hazard. There are no groundwater exposures in this area.	Access to dump materials should be restricted.
30th Street Dump	During the GOW period it appeared to be the location of an intended future building and subsequently used as a dump. The University has not used the area.	In 2011, a geophysical survey of this area was conducted and a number of anomalies were identified but no large metallic objects. Seven soil samples (five at a depth of 6 in. and 3 and 10 ft) were analyzed for metals and SVOCs and one for VOCs (at 6 in.). No evidence of contamination was found, so no groundwater samples were collected. Dump materials including tar, metal, concrete, and asphalt were found in seven test trenches.	This area is wooded and adjacent to agricultural use. Figure D29 (Barr, 2012)	This area poses an indeterminate public health hazard. Dump debris can be a physical as well as chemical public health hazard.	Access to dump materials should be restricted.
<b>GOW West (Figure 9)</b>					
Grid Spaces A2, A3, B3	The site history of this area is unknown. A drainage ditch and an area of disturbance are in this area.	In 2011, three samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected.	This area is used for agriculture. Figure D30 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
154th Street Dump (AOC6)	During the GOW period this area was used as a borrow source for sand and gravel and for disposal of debris at decommissioning. The University continued to use it as a borrow source and a dump. It is a football-field-sized depression containing surface and buried construction debris.	In 2007, (USACE, 2009a) 12 soil samples were analyzed for metals and PAHs. Six soil samples were elevated for cPAHs (2-10 ppm at 0-6 in., 70 ppm at 5 ft, and 710 ppm at 3 ft). Mercury was elevated in three samples (0.56 and 0.74 ppm at 0-6 in., 0.59 ppm at 2 ft). One sample was elevated for arsenic at 14 ppm (5 ft). In 2009, (USACE, 2009b) 18 soil samples were analyzed for metals and PAHs. One sample contained cPAHs at 23 ppm at a depth of 2-4 ft. ACBM is likely present. This area was not included in 2011 RI. Although BaP and other PAHs exceeded the SLVs, no groundwater samples were collected in this area and the nearest downgradient monitoring well is >1 mi.	This area is overgrown with weeds, brush, and trees and is surrounded by agriculture. Debris is present at the ground surface. Figure D30 (Barr, 2012); Figure 4 (USACE, 2009b)	This area poses an indeterminate public health hazard. cPAHs in the soil are above the SRV for industrial land use, mercury and arsenic are above residential SRVs, cPAHs are above the SLVs, and asbestos is present. However, current exposure is expected to be very limited and infrequent. There are no groundwater exposures in this area, but it is located upgradient of the community well(s). Dump debris can be a physical as well as chemical public health hazard.	Vertical soil sampling should be completed to determine whether PAH contamination extends to groundwater in this area. Areas of cPAHs, mercury, and arsenic above SRVs may need to be removed if land use changes. Access to dump materials should be restricted. Asbestos needs to be removed if land use changes.
Future Ballfields	The site history of this area is unknown. This area is across the street from planned future ballfields.	In 2009, two soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected.	This area is used for agriculture. Figure D30 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
<b>GOW North (Figure 10)</b>					
Former Betz Residence (Bldg MSA-TC-42)	During the GOW period this was used as a guard tower. The University leased it to tenants, including a resident who reportedly used PCB oil to heat the building.	In 2011, two samples (one at a depth of 6 in. and one at 5 ft near a former heating oil tank and furnace) were analyzed for metals, SVOCs, and PCBs. No evidence of contamination was found, so no groundwater samples were collected. A shallow well was sealed on this property in 2006 and replaced by a deeper well (UN 745851) which in 2013 was converted to a monitoring well for future use. A second shallow well was also sealed in 2013. MDH found no record of water samples from any of these wells.	This area is wooded and adjacent to agricultural use. Figure D31 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
Grid Spaces A5, A6, A7	During the GOW period this area was used as the septic drain fields for the administrative offices. The University has used this area for agriculture and leased it for use as a model airplane landing strip.	In 2011, five soil samples at a depth of 6 in. and one at 12 ft were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected.	This area is used for agriculture. Figure D31 (Barr, 2012)	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	More data may be needed prior to development.
<b>Site Wide</b>					
GOW Heavy Gauge Railroad	During the GOW period, heavy gauge railroad tracks were constructed and operated. The rails and ties were removed during decommissioning of GOW and the land was returned to agriculture or left dormant.	In 2009, 17 total soil samples were analyzed (5 for metals, 12 for SVOCs, 3 for VOCs and pesticides). No evidence of contamination was found besides one surface sample with elevated cPAHs (2.8 ppm). In 2011, nine samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected associated with the railroad.	The railroad samples taken were mainly in wooded areas adjacent to agriculture. Figure D35 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because although cPAHs are above the SRV for residential land use, current exposure is expected to be very limited and infrequent.	Areas of cPAHs above SRVs may need to be removed if land use changes.
GOW Laminex Wood Box Sewer and Clay Pipe Trunks	During the GOW period, approximately 11,160 linear ft of Laminex wood box sewer was installed to transport process water across the site and it served as the main trunk of the sewer. The University continued to use limited sections of the sewer until the 1980s. The sewers remain in place.	Nineteen sewer sediment samples were analyzed for metals, SVOCs, VOCs, and 18 for pesticides and PCBs. Arsenic was elevated in three samples (21, 24, 18 ppm). Mercury was elevated in eight samples (1.8-100 ppm). cPAHs were elevated in five samples (3.9-60 ppm) and detected in five more (0.37-1.3 ppm). 2,4-DNT was detected in six samples (0.05-10 ppm) and 2,6-DNT detected in three samples (0.36-0.88 ppm). DBP was detected in nine samples (0.069-23 ppm). NDPA was detected in three samples (0.80-0.17 ppm). 4,4-DDT (0.63 ppm) and chlordane (0.18 ppm) were detected in one sample. PCBs (1.2-2.1 ppm) were also detected in three samples. Very low levels of a few VOCs were also detected. Asbestos containing material was present at the joints of the clay pipe sewer in the ABC line. Groundwater samples collected in borings and MWs near the woodbox sewer and clay pipe trunks did not detect any of the contaminants found in soil samples associated with those structures.	The sewer system remains largely in place. A video of approximately 650 ft of the GOW sewers was taken during the RI and the sewer was found to be in good condition. Figure D36 (Barr, 2012)	This area poses an indeterminate public health hazard. cPAHs, mercury, and arsenic in the sediment are above SRVs for industrial land use; however, current exposure is expected to be very limited and infrequent. Groundwater in this area does not appear to have been impacted by the wood box sewers or clay pipe trunks.	Areas of cPAHs, mercury, and arsenic in the sewer sediment above SRVs may need to be removed if land use changes.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
GOW Transformers (501 Bldgs in GOW East, GOW Central, ABC Line, and DEF Line subareas)	During the GOW period, twelve substations were constructed and operated. These were left energized after decommissioning. It is not clear when the University stopped using them. PCB-containing oils have been historically used in electrical transformers.	In 2006, three soil samples near one transformer showed high lead at a depth of 6 ft (550 ppm) and cPAHs in the surface soil (18 ppm). In 2011, 39 soil samples were collected and analyzed (27 for metals, 21 for SVOCs, 1 for VOCs, and 23 for PCBs). Mercury was elevated in two samples at a depth of 6 in. (0.95, 6.3 ppm). Lead was elevated in one 6 inch sample (340 ppm) and PCBs found in two samples (1.9 at 6 in. and 3.5 ppm at 2 ft). cPAHs were detected in 16 samples - above the industrial SRVs in two samples at 6 in. (3.2, 39 ppm) and detected in 12 more (0.01 -1.7 ppm) all at 6 in. except one at 2 ft and one at 3 ft. Groundwater samples collected from wells near the 501 buildings in GOW East (MW-21D, MW-28, MW-29, MW-C7-004, MW-C7-016), GOW Central (T00006), and ABC Line (MW-21D, MW-28, MW-29) did not detect cPAHs, lead or mercury, but were not tested for PCBs. No groundwater samples were collected near the 501 buildings in the DEF Line subarea.	The buildings still exist. Pole-mounted transformers are also present throughout the property. Figure D37 (Barr, 2012)	This area poses an indeterminate public health hazard. cPAHs and mercury in the soil are above SRVs for industrial land use, and lead and PCBs are above residential SRVs; however, current exposure is expected to be very limited and infrequent. There do not appear to be any groundwater exposures associated with these sites.	Areas of cPAHs, mercury, lead, and PCBs above SRVs may need to be removed if land use changes.
Ditches	Ditches were constructed during the GOW period to transport surface water to surface water collection ponds and the ditches remained in use after GOW was decommissioned.	Six soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found except for three low detections of cPAHs (0.075-0.15 ppm). No groundwater samples were collected in the ditches, but no SVOCs were detected in nearby well samples (T00006, MW-C6-020, MW21D, MW-28, MW-29, MW-C7-004).	The ditches are still present. Figure D38 (Barr, 2012)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	More data may be needed prior to development.
<b>Vermillion Highlands - sites (unless cited) taken from 2010 Vermillion Highland Phase I report (Barr, 2010)</b>					
<b>Area 1 - Former GOW operations (Figure 14)</b>					
Abandoned Farmington Farm	This is an abandoned farm that reportedly has physical hazards associated with farm remnants (Barr, 2010). May have an abandoned well.	No soil or groundwater data was collected.	This abandoned farmstead is North of the Lone Rock Trail and may be visited by the occasional hunter/recreator. Figure 3 (Barr, 2010)	Physical hazards are public health hazards.	Physical hazards should be removed or access restricted. All wells not in use should be located and sealed.
Christmas Tree Railroad Spurs/Grid Space E7 (Barr, 2012)	This area was reportedly used during the GOW period to temporarily store smokeless gunpowder in cars on the railroad spurs.	In 2003, 15 soil samples at a depth of 0-1 ft were taken along the railroad spurs and north of this area for construction of a dog park. The soil samples were analyzed for metals, PAHs, and explosives and the only evidence of contamination was low cPAHs (0.13 and 0.19 ppm). In 2011, three samples at a depth of 6 in. were analyzed for metals and SVOCs and no evidence of contamination was found, so no groundwater samples collected.	This wooded area is just South of the current dog park. It may be visited by the occasional hunter/recreator. Figure 3 (Barr, 2010); Figure D3 (Barr, 2011b)	Based on current sampling, this area poses no apparent public health hazard because detected levels are too low to be of health concern.	May need to collect more data if land use changes.
GOW Finished Powder Houses (also under GOW Central - adjacent land)	These buildings were used during the GOW period as part of the powder production line. The sixty buildings were constructed with treated wood. The buildings were dismantled by the Army during decommissioning.	In 2009, six soil samples at two locations at various depths analyzed for DNT, diphenylamine, and nitrocellulose as part of AOC2, and all were nondetectable (USACE, 2009a), so no groundwater samples were collected. Also see results under GOW Central.	This area is agricultural, with the exception of the wooded area around former bldg 229-26. This area is north of the Lone Rock Trail. Figure 3 (Barr, 2010); ACE March 2009 Figure 4	Based on current sampling, this area poses no public health hazard because no evidence of contamination was found.	May need to collect more data if land use changes.
Northern 1945 Disturbed Areas	This area was identified as a potential area of concern because soil was disturbed in a 1945 aerial photograph. The area was later planted with trees.	No soil or groundwater data was collected. During the 2010 VH Phase I (Barr, 2010) site visit, this area was noted to be elevated and concrete debris and a crushed 55-gallon drum were observed.	This area is North of the Lone Rock Trail. It may be visited by the occasional hunter/recreator. Figure 3; Photo 1 (Barr, 2010)	Because historical dumping is suspected and no data has been collected, this area is an indeterminate public health hazard.	Further investigation should occur to provide more confidence in the safety of the area.
Northern Notch Area - GOW Shaker Sieve and Reworked Powder Houses (Bldg 239) (Barr, 2012)	These buildings were used for the GOW powder production line. The buildings were burned as part of GOW decommissioning and the foundations are still present.	In 2006, two soil samples were analyzed for metals and 2,4-DNT and one sample for VOCs. No evidence of contamination was found. Suspected ACBM was observed on the ground during 2010 VH Phase I (Barr, 2010) site visit. In 2011, four soil samples at a depth of 6 in. were analyzed for metals and SVOCs. No evidence of contamination was found, so no groundwater samples were collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. This area is restricted by a fence due to physical hazards and asbestos. Figure 3 (Barr, 2010); Figure D32 (Barr, 2012)	Because this area is restricted by a fence, it poses no public health hazards.	Further investigation should occur and physical hazards and asbestos removed prior to allowing public access.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
Northern Notch Area - GOW Blending Tower and Packing Houses (Bldg 240) (Barr, 2012)	These buildings were used for the GOW powder production line. The buildings were burned as part of GOW decommissioning.	In 2006, arsenic (12.6, 16.3 ppm) and lead (332 ppm) were elevated in surface soils and cPAHs (0.18 ppm) were detected at a depth of 2 ft. In 2011, five samples at 6 in. were analyzed for SVOCs and three for metals. 2,4-DNT was detected at 0.13 ppm and DBP at 0.4 ppm. ACBM was observed on the ground during the 2010 VH Phase I (Barr, 2010) site visit. No groundwater samples were collected in this area.	This area contains trees around the remaining structures and the surrounding area is agriculture. This area is restricted by a fence due to physical hazards and asbestos. Figure 3 (Barr, 2010); Figure D33 (Barr, 2012)	Because this area is restricted by a fence, it poses no public health hazards.	Further investigation should occur and physical hazards and asbestos removed prior to allowing public access.
Northern Notch Area - GOW Air Test Houses (Bldg 224) (Barr, 2012)	These buildings were used for the GOW powder production line. The buildings were burned as part of GOW decommissioning.	In 2006 and 2011, two samples were analyzed for metals and SVOCs at depths between 0-1 ft. No evidence of contamination was found, so no groundwater samples were collected.	This area contains trees around the remaining structures and the surrounding area is agriculture. This area is restricted by a fence due to physical hazards and asbestos. Figure 3 (Barr, 2010); Figure D33 (Barr, 2012)	Because this area is restricted by a fence, it poses no public health hazards.	Further investigation should occur and physical hazards and asbestos removed prior to allowing public access.
Dole Explosives	Dole Explosives leased this site from 1969-2010; site usage include storage of explosives for quarrying and demolition applications.	No environmental data was collected. Ash was observed on the ground during the 2010 VH Phase I (Barr, 2010) site visit.	This area is mainly wooded and adjacent to agriculture. Figure 3; Photos 7 and 8 (Barr, 2010)	Because historical waste burning and explosive storage is suspected and no data has been collected, this area is an indeterminate public health hazard.	Further investigation should occur to provide more confidence in the safety of the area.
Lone Rock Trail Shooting Range (Dakota County Gun Club)	This area was undeveloped during the GOW period and was agricultural until 1997. Currently it is a shooting range that implements best management practices (BMPs) and annually reclaims spent shot.	No soil or groundwater data was collected.	This is an active shooting range north of the Lone Rock Trail. Figure 3 (Barr, 2010)	Active shooting ranges using BMPs are not expected to cause adverse health impacts.	May need to collect more data if land use changes.
<b>Area 2 - RROC Research Area (Figure 15)</b>					
Sewage Sludge Application Research Area	This area was a sewage sludge application research area that received biosolids nearly every year from 1974-1993.	Sloan et al. 2001 reported mercury concentrations up to 0.5 ppm measured in 1995 at the sludge application areas. No other soil data was collected. A water sample (BG-W-GP8) from a "background" soil boring immediately downgradient of this area contained 310 ppb barium; this is below the HRL, but the highest Ba detection in groundwater on the UMore property.	This area is adjacent to the Lone Rock Trail Head Parking lot. Figure 4; Photo 14 (Barr, 2010)	Because historical sewage sludge application occurred and very little data has been collected, this area is an indeterminate public health hazard. A well (UN 207609) is present at the South Beef Farm - current use is unknown but may be a potential route for groundwater exposures. The nearby Lone Rock Trail has only non-potable water available.	Further investigation should occur to provide more confidence in the safety of the area. Due to its proximity to the UM sewage sludge application site, the well at the South Beef Farm should be sampled for nitrate, barium, bacteria and PFCs OR should be posted to warn workers that it is not tested and may not be potable.
Forage Hill	This is a current site of University agricultural research activities. During the Phase I site visit (Barr, 2010), stained soil was observed below an above ground storage tank (AST).	No soil or groundwater data was collected.	This area is adjacent to the Lone Rock Trail and SW of RROC. Figure 4; Photos 11-13 (Barr, 2010)	Because stained soil was observed, and no data has been collected, this area is an indeterminate public health hazard. A transient, non-community public supply well (UN 490565) is still used at the NPR radio transmitter bldg. and may be a pathway for groundwater exposure.	MPCA regulations for ASTs need to be followed. Due to the proximity to the UM sewage sludge application site, the NPR well should be sampled for nitrate, bacteria, barium, and PFCs OR posted to warn workers that it is not tested and may not be potable.
<b>Area 3 - Lone Rock Area (Figure 16)</b>					
Abandoned Manes Farm	This is an abandoned farm that reportedly has physical hazards associated with farm remnants including foundations and fencing (Barr, 2010).	In 2009, (USACE, 2009a) four samples were taken as background samples and analyzed for metals. No evidence of contamination was found, so no groundwater samples were collected.	This abandoned farm is in a wooded area near the Lone Rock Trail. It may be visited by the occasional hunter/recreator. Figure 5 (Barr, 2010)	Physical hazards are public health hazards.	Physical hazards should be removed or access restricted.
Southgate Blaine Ave Dump	This is a potential dump site; however, no evidence of large-scale dumping was found during the Phase I site visit (Barr, 2010).	No soil or groundwater data was collected.	This area is near the southernmost parking area for hunting and near the Lone Rock Trail. It may be visited by the occasional hunter/recreator. Figure 5 (Barr, 2010)	Because historical dumping is suspected and no data has been collected, this area is an indeterminate public health hazard.	Further investigation should occur to provide more confidence in the safety of the area.

**Appendix A: Gopher Ordnance Works Site Summary**

Site Name	Site Description/Waste Disposal History	Soil & Groundwater Investigation Results	Current Status/Maps	Evaluation of Public Health Hazard	Recommendations
<b>Area 4 - GOW Drainage Area (Figures 17 and 20)</b>					
GOW Drainage Ditch	The GOW drainage ditch was reportedly designed to handle 100 million gallons of wastewater/day. It includes a primary settling basin, a lower process wastewater ditch, a secondary settling basin, and a secondary acid neutralization plant. The GOW wastewater flowed out to the Vermillion River. USACE divided this area into northern, middle and southern sections (AOC1N, AOC1M, and AOC1S).	In 1984, six soil samples were analyzed for metals - antimony was elevated in five samples up to 36 ppm; thallium in three samples (4, 23, 36 ppm) (Twin City Testing Corp., 1986). Later soil samples were not analyzed for antimony and thallium. 2,4-DNT (0.37, 0.75 ppm) and 2,6-DNT (0.52, 0.88 ppm) were detected in soil in the primary settling basin at depths of 6 ft and 3-4 ft, respectively (Peer, 2003). In 2007, (USACE, 2009a) mercury was elevated (11 ppm) and 2,4-DNT was detected (0.55 ppm) in one surface soil sample in AOC1N. In AOC1M, mercury was elevated in three surface samples (0.86-4.9 ppm), 2,4-DNT was detected at 2-4 ft (0.32, 1.4 ppm) and estimated in other samples at very low levels. AOC1S had elevated arsenic (9.3 ppm in surface soil and 9.5 ppm at 8-10 ft) and lead (320 ppm) and cPAHs (22 ppm) in a surface sample. Nitrocellulose was reported throughout AOC1, at up to 18,000 ppm. Several SVOCs and VOCs were estimated at very low levels throughout AOC1. In 2009, (USACE, 2009b) one surface sample in AOC1N had elevated mercury (7.3 ppm) and detected 2,4-DNT (0.67 ppm). In AOC1M, mercury was elevated in a surface sample at 1.5 ppm, and 2,4-DNT was detected at 0.37 ppm at 2-4 ft (and estimated in very low levels in several samples). No contaminants were detected in 2009 AOC1S soil samples, but two surface sediment samples in AOC1S were elevated for arsenic (10, 11 ppm). 1984 groundwater samples (PWL-1, PWL-2, PWL-3) contained antimony and thallium above current HRLs, but 1985 samples (PWL-2 and PWL-3) did not detect these metals. 2007 water samples from borings detected low levels of VOCs, SVOCs, and possibly nitrocellulose; TCE and bis(2-ethylhexyl)phthalate exceeded current drinking water criteria (in AOC1M-W-GP3, AOC1N-W-GP1). This area was not included in the 2011 RI.	The drainage ditch is partly wooded and adjacent to agricultural fields. The Lone Rock Trail crosses the drainage basin twice in the Middle and Southern sections. Figure 6 (Barr, 2010)	This area poses an indeterminate public health hazard. Mercury and cPAHs in the soil are above SRVs for industrial land use, and arsenic and lead are above SRVs for residential land use. However, current exposure is expected to be very limited and infrequent. Groundwater from this area does not appear to pose a public health hazard. Residential wells are present <1 mile downgradient of this subarea, four of which were sampled for VOCs and metals in 1988 and 2003 as part of the Coates Dump monitoring project - in 1988 0.4 ppb carbon tetrachloride (CT) was detected in one well (UN 174676, downgradient of AOC1M-W-GP3); in 2003 that well had an unquantified trace level detection of CT <0.2 ppb; VOCs were not detected in the other wells, metals were at naturally occurring levels, and elevated nitrate was consistent with regional groundwater concentrations.	Further investigation should occur to provide more confidence in the safety of the area. Areas of elevated cPAHs, arsenic, mercury, lead, antimony, and thallium may need to be removed. MDH should attempt to resample UN 174676 to confirm water quality trend.
Abandoned Peine Farm	This is an abandoned farm that reportedly has physical hazards associated with farm remnants, including foundations, walls, and concrete structures (Barr, 2010). An abandoned well was identified during the Phase I site visit.	No soil or groundwater data was collected.	This abandoned farmstead is adjacent to the Lone Rock Trail and may be visited by the occasional hunter/recreator. Figure 6 (Barr, 2010)	Physical hazards are public health hazards.	Physical hazards should be removed or access restricted. All wells not in use should be sealed.
Coates Dump (location shown on Fig. 20)	This dump was reportedly constructed over the former wastewater ditch during the demolition of GOW in 1946 or 1947 (Barr, 2010) and operated as an open, unregulated dump until the 1970s or 1980s, accepting mixed municipal waste and possibly industrial and hazardous waste.	No soil data was apparently collected at the site. Two monitoring wells (MW-D-1 and MW-17) were installed in 1984-1985. A 1984 sample from MW-D-1 detected antimony & thallium above the HRLs and low levels of toluene and xylenes. Since 1994, MDH has periodically sampled residential wells downgradient of the dump for VOCs, metals, and nitrate. Chlorinated VOCs (TCA, TCE, PCE, carbon tetrachloride) were detected in some wells, but concentrations did not exceed levels of health concern and concentrations have decreased over time.	Evidence of fugitive dumping of construction debris was noted during the Phase I site visit (Barr, 2010). Figure 6 (Barr, 2010)	This area poses an indeterminate public health hazard. Dump debris can be a physical as well as chemical public health hazard. Residential well sampling has not detected any contaminants above levels of health concern, but samples have not been tested for antimony, thallium, or 1,4-dioxane.	Access to dump materials should be restricted. Residential wells should continue to be tested periodically to confirm decreasing VOC trend; they should also be tested for metals (including antimony & thallium) and 1,4-dioxane.
Former Law Enforcement Shooting Range	Lead bullets were observed on the ground of this former shooting range during the Phase I site visit (Barr, 2010). Three monitoring wells are at the site (PWL-1, PWL-2, PWL-3).	According to the 2010 VH Phase I, a 1996 draft Phase II report includes data that indicates lead contamination in the soil and 1985 water samples from PWL-2 and PWL-3 contained elevated lead levels (15 and 13 ppb, respectively), but 2007 geoprobe samples did not detect lead. As noted above, 1984 samples contained elevated levels of antimony & thallium, but these metals were not detected in 1985.	This area is adjacent to the Lone Rock Trail and may be visited by the occasional hunter/recreator. Figure 6 (Barr, 2010)	This area is an indeterminate public health hazard, based on unknown levels of elevated lead reported in 1996 (Peer, 1996), although exposure is currently infrequent.	Lead data from 1996 should be evaluated and areas of elevated lead may need to be removed. Monitoring wells not in use should be sealed.
Abandoned Ohmann Farm battery dumping	This is an abandoned farm that reportedly has physical hazards associated with farm remnants (Barr, 2010). Approximately 10 car batteries (some broken) were observed during the Phase I site visit. An abandoned well (UN 235759) was identified during the site visit.	No soil or groundwater data was collected, but 2007 downgradient groundwater samples (AOC1M-W-GP1 and AOC1M-W-GP2) detected only 2.1 ppb of bis(2-ethylhexyl)phthalate.	This abandoned farmstead is near parking for hunting and may be visited by the occasional hunter/recreator. Figure 6; photo 15 of an abandoned well (Barr, 2010)	Physical hazards are public health hazards. Because historical dumping is suspected and no data has been collected, this area is an indeterminate public health hazard.	Physical hazards should be removed or access restricted. All wells not in use should be sealed.



## Appendix B: Groundwater Investigations – Detailed Description and Data Tables

### Investigation Activities On and Downgradient of UMore East

In 1984, chlorinated organic compounds were detected in the groundwater beneath the University's Burn Pit Area (OU1 of the former UMRRRC Superfund Site) and in 16 private wells located northeast (downgradient) of the OU1 site (Twin City Testing, 1985 as summarized in MDH, 1989). The maximum concentrations of the groundwater contaminants detected at that time are shown below:

#### Maximum concentrations of groundwater contaminants detected at and downgradient of UMore East in 1984

Contaminant	On-site (ppb, max.)	Private Wells (ppb, max.)	Current HRL or HBV*
Chloroform	72	16	30
Carbon tetrachloride	14	1.5	1
1,2-dichloroethane (DCA)	16	1.1	100
1,1,1-trichloroethane (TCA)	1.1	0.6	9,000
Trichloroethene (TCE)	4.4	0.4	0.4

\*Health Risk Limits (HRLs) and Health Based Values (HBVs) are health based drinking water guidance values derived by the Minnesota Department of Health.

In 1991, the University of Minnesota installed two water supply wells (UN 457167 and 474335, completed in the Jordan Sandstone) and water lines as a drinking water supply for the affected residential area; this system is now operated by the City of Rosemount (MDH, 1993). No site related contaminants have been detected in the wells and nitrate+nitrite concentrations range from 1,200 – 5,000 ppb, below the Maximum Contaminant Level (MCL, the federal drinking water standard) of 10,000 ppb.

In 1985-1986, monitoring wells were installed at two locations in UMore East: GUE (in the ABC Line area) and the Oxidation Pond (in the GOW East area) (Twin City Testing, 1986). Samples from two monitoring wells at GUE (GUE-MW-19 and GUE-MW-20) were analyzed for metals, PCBs, and TCDDs/TCDFs. PCBs and TCDD/TCDF were not detected. Antimony, cadmium, thallium, and zinc were detected at concentrations above their HRLs. A sample from one monitoring well at the Oxidation Pond (MW-OX-1) was analyzed for PCBs, VOCs, nitrate, and oil & grease. Only nitrate was detected, below the HRL.

Between 1990 and 2002, the MPCA's consultant sampled monitoring wells MW-21D, MW-22, MW-23, MW-25 and MW-28 five times for VOCs (Delta, 2002). The five chlorinated VOCs detected in 1984 (see table above) all decreased in concentration during this time period (see Table B-1). By 2002, only one well (MW-28) had any chlorinated VOCs (carbon tetrachloride) present above its HRL.

In 2007, USACE collected ten groundwater samples from temporary borings in the former steam plant area (AOC7) within GOW East (USACE, 2009a). Temporary borings, while commonly used in site investigations, are more prone to false detections than monitoring wells due to soil contamination of the probe. Low concentrations, below levels of health concern, were measured for a number of VOCs

**Table B-1 – Chlorinated VOCs in Monitoring Wells, 1990 - 2002**

Analyte			Carbon Tetrachloride	Chloroform	1,2-DCA	1,1,1-TCA	1,1,2-TCE
Drinking Water Criteria			1	30	1	9,000	0.4
Well	Year	Units					
<b>MW-21D</b>	1990	ppb	2.1	26	1.4	0.7	2.4
	1992	ppb	1.1	26	1	ND	0.6
	1993	ppb	1.3	23	0.8	0.7	1.4
	1995	ppb	1	14	0.8	1.1	1.7
	2002	ppb	ND	11	ND	ND	ND
<b>MW-22</b>	1990	ppb	ND	6	ND	ND	ND
	1992	ppb	ND	2.8	ND	ND	ND
	1993	ppb	ND	2.7	ND	ND	ND
	1995	ppb	ND	3.4	ND	0.7	ND
	2002	ppb	ND	2.3	ND	ND	ND
<b>MW-23D</b>	1990	ppb	0.5	9.9	0.6	ND	0.7
	1992	ppb	0.5	14	0.3	0.2	3.4
	1993	ppb	ND	4.7	ND	ND	2.4
	1995	ppb	0.5	8.6	0.4	ND	6.4
	2002	ppb	ND	8.9	ND	ND	2.6
<b>MW-25</b>	1990	ppb	ND	2	ND	ND	ND
	1992	ppb	ND	1	ND	ND	ND
	1993	ppb	ND	1.8	ND	ND	ND
	1995	ppb	ND	2.3	ND	ND	ND
	2002	ppb	ND	2.7	ND	ND	ND
<b>MW-28</b>	1990	ppb	1.4	29	ND	0.6	2
	1992	ppb	1.2	31	1.8	ND	0.7
	1993	ppb	1.7	36	1.6	0.9	2.1
	1995	ppb	1.4	23	1.2	0.9	2.4
	2002	ppb	1.1	23	ND	ND	1.8

**NOTES:**


Data from Delta (2002) summary tables; lab reports not available so results (if any) for other analytes are unknown.

ppb = parts per billion

DCA = dichloroethane

TCA = trichloroethane

TCE = trichloroethene

 Indicates concentration exceeds drinking water criterion

and SVOCs (Table B-2). Only five compounds were detected above any state or federal drinking water standards: benzo(a)pyrene, bis(2-ethylhexyl)phthalate, 2,4,6-trichlorophenol, diesel range organics (DRO), and total cPAHs. Bis(2-ethylhexyl)phthalate was also detected in quality control samples, suggesting its presence in these particular samples may have been due to laboratory contamination. Except for carbon tetrachloride, chloroform, and trichloroethene, none of these VOCs or SVOCs were detected in later monitoring well samples; DRO was not analyzed for in the monitoring well samples.

In September 2009, USACE obtained one additional groundwater sample in AOC7D which contained low concentrations of acetone, chloroform, and methyl ethyl ketone (USACE, 2009b). These did not exceed any state or federal drinking water standards.

The 2011 RI (Barr, 2012) included groundwater sampling from fifteen monitoring wells - six new and nine existing. Locations of the six new wells were chosen to increase confidence that contamination of the former GOW operational area was not affecting groundwater, including 2,4- and 2,6-DNT, which had been detected at concentrations exceeding the soil leaching values (SLVs); contaminant concentrations in soil above the SLVs are considered to represent unacceptable potential risk to groundwater via the leaching pathway.

Total nitrate + nitrite greater than or equal to the drinking water standard of 10,000 ppb was detected in 7 of 15 monitoring wells, with the highest at 30,000 ppb. However, upgradient monitoring well MW-E4-010 (Figure 20) had the second highest nitrate level (22,000 ppb), suggesting the nitrate in the groundwater at the site reflects concentrations related to agricultural activities in this area rather than any GOW-related activities.

None of the groundwater samples in the 2011 RI were analyzed for antimony, thallium, or zinc, which had been detected in earlier samples at several locations at concentrations above health concern.

Four chlorinated VOCs were detected in the monitoring well samples. Chloroform was detected in seven of the samples, TCE in three samples, tetrachloroethylene in one sample, and carbon tetrachloride in one sample (Table B-2). TCE was the only compound to exceed the drinking water standards. Four of the monitoring wells sampled by Barr in 2011 (MW-21D, MW-22, MW-23D, and MW-28) were also sampled in 2002 (Delta, 2002), as described above; in each of these wells the concentrations of chloroform and/or TCE decreased during the nine years between the sampling events. The nearest monitoring wells downgradient of AOC7 (MW-B7-014 and MW-B7-015) did not show VOCs, PAHs, or other SVOCs.

Although no groundwater samples collected outside of AOC7 detected contaminants at levels of concern, there is at least one area with high soil contaminant concentrations that has had no groundwater sampling (Figure 20). The deepest samples (ranging from 2 to 5 feet) collected by the USACE from two sample locations (FGOW-AOC6-S-TP3 and FGOW-AOC6-S-TP5), spanning a distance of more than 325 feet in the north half of AOC6, contained levels of BaP and other PAHs that significantly exceeded the SRVs and SLVs. PAHs generally have low mobility in soil, so it is possible that groundwater has not been impacted in this area. However, the lack of sampling at depths below 5 feet makes it impossible to rule out possible groundwater contamination. PAHs have not been detected in monitoring wells MW-A5-018 and MW-A6-006, but these wells are located more than a mile to the northeast of area AOC6 and may not provide an adequate monitoring network for this portion of the site, particularly as the water table in this portion of the site is present within a thick sequence of unstratified glacial till (Barr, 2012). In such deposits, localized groundwater flow patterns may be

different from the overall regional flow direction and monitoring wells nearer to AOC6 may be necessary. Additional delineation of the vertical extent of soil contamination will be needed before any planned development can occur. If additional soil sampling indicates contaminants have migrated downward in these locations, groundwater monitoring wells may be needed to ensure soil contaminants are not migrating to and degrading the groundwater.

Another area of possible concern is located in the former ABC Line area. A soil boring advanced during a 2008 geological assessment encountered soils that contained “a frothy liquid that smelled of mothballs...from 25-45 feet below ground surface outside of Building 237G” (as cited in Barr, 2011a). This odor may indicate naphthalene or other related PAHs. The depth to groundwater in this area is approximately 50 – 55 feet, based on nearby monitoring well water level data (based on Figure 10, Barr, 2012). Subsequent 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 olfactory observations of contamination in the initial soil boring and the absence of detectable contaminants in the second boring leaves this as something of an unresolved question. There are no monitoring wells downgradient of the former Building 237G area, but there are drinking water wells located less than a mile in the downgradient direction, in the town of Coates.

In 2013, the City of Rosemount provided city water connection information to MDH that indicated approximately a dozen properties located north and northeast of UMore East may still use private wells as their primary drinking water source. MDH contacted the owners of the six closest properties and obtained permission to sample at four. Samples were analyzed for VOCs (including 1,4-dioxane), antimony, and thallium. 1,4-dioxane and several chlorinated VOCs were detected in one well (“Well A”, Fig. 20 of Public Health Assessment) at concentrations below their individual HRLs, but the combined concentrations exceeded an acceptable health risk level and MDH issued a drinking water advisory for the well. The property where the well is located already has a connection to city water and use of the affected well was only incidental; the owner indicated it would be posted as “non-potable”. No VOCs were detected in the other wells tested; antimony and thallium were not detected in any of the wells. MDH plans to expand private well sampling to determine if additional wells have been contaminated in this area.

### **Investigation Activities On and Downgradient of Vermillion Highlands:**

In 1984-1985, Twin City Testing installed monitoring wells and collected groundwater samples at two locations in the Vermillion Highlands: Coates Dump Site and the Process Water Lagoon in the Area 4-GOW Drainage Area (Twin City Testing, 1986). A surface water sample was also collected in the process water lagoon. Samples collected from two monitoring wells at the Coates Dump Site (MW-D-1 and MW-17) were analyzed for VOCs. Only toluene and xylenes were detected, below their HRLs, in well MW-D-1, but were not detected in a subsequent sample from that well. The initial sample from MW-D-1 was also tested for metals, chloride, sulfate, and nitrate; antimony and thallium exceeded their HRLs. Samples collected from three monitoring wells at the Process Water Lagoon (PWL-1, PWL-2, and PWL-3) and a surface water sample collected from the former lagoon area were analyzed for metals, chloride, sulfate, and nitrate; antimony, thallium and nitrate exceeded their HRLs in all of the samples (except nitrate in PWL-1).

Five groundwater samples were collected by the USACE in 2007 from temporary boreholes within the middle and southern sections of the former GOW drainage ditch in Area 4 (Figure 20). No contaminants

were found at or above levels of health concern; however many of the reporting limits were higher than the relevant drinking water criteria, especially for SVOCs. Bis(2-ethylhexyl) phthalate was detected in three samples, one of which (AOC1N-W-GP1) exceeded the MCL of 6 ppb, but not the HRL of 20 ppb. [Note: bis(2-ethylhexyl)phthalate is a common laboratory contaminant, but was not detected in quality control samples associated with these samples]. The following contaminants were detected at concentrations below levels of health concern: phenanthrene, acetone, chloromethane, hexachlorobutadiene, 1,2,3-trichlorobenzene, trichloroethylene, and nitrocellulose.

A groundwater sample collected in 2007 from a temporary boring in AOC1N contained bis(2-ethylhexyl) phthalate (74 ppb) above the HRL (20 ppb) and low amounts of chromium, 1,2,3-trichlorobenzene, chloromethane, and hexachlorobutadiene (USACE, 2009a). 2,4-dinitrotoluene was found at 0.26 ppb, just over half of the MPCA screening value of 0.5 ppb. In the 2012 Remedial Investigation (Barr, 2012) one well sample was collected from MW-E4-010, near the northwest corner of Area 1 in the Vermillion Highlands. Only nitrate+nitrite was detected, at 22,000 ppb. However, the detection limits for 2,4- and 2,6-DNT may not have been low enough to detect the presence of the explosives in the groundwater samples. See the "Dinitrotoluene" section in the text of the Public Health Assessment for more discussion.

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	GUE MW-19			GUE MW-20		Screening Criteria	
		Oct. 1985 TCT, 1986	Jan. 1986 TCT, 1986	Jan. 1986 (dupl) TCT, 1986	Oct. 1985 TCT, 1986	Jan. 1986 TCT, 1986	Drinking Wtr. Criterion	Source
Units								
<b>General Parameters</b>								
Chloride	ppb	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	NA	NA	NA	NA	10,000	HRL
Sulfate	ppb	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
<b>Metals</b>								
Antimony	ppb	12	NA	NA	7	NA	6	HRL
Arsenic	ppb						10	MCL
Barium	ppb	NA	NA	NA	NA	NA	2,000	HRL
Cadmium	ppb	10	3.8	<1	10	<1	4	HRL
Copper	ppb	<10	830	<10	<10	<10	1,300	AL
Chromium	ppb	<10	160	<10	<10	<10	100	HRL**
Lead	ppb	15	900	<2	9	5	15	AL
Selenium	ppb	<3	NA	NA	<3	NA	30	HRL
Thallium	ppb	2	NA	NA	<2	NA	0.6	HRL
Zinc	ppb	6,090	20,200	3,550	1,440	2,090	2,000	HRL
<b>VOCs</b>								
Acetone	ppb	NA	NA	NA	NA	NA	4,000	HRL
Benzene	ppb	NA	NA	NA	NA	NA	2	HRL
Carbon tetrachloride	ppb	NA	NA	NA	NA	NA	1	HRL
Chloroform	ppb	NA	NA	NA	NA	NA	30	HRL
Chloromethane	ppb	NA	NA	NA	NA	NA	NE	
Ethylbenzene	ppb	NA	NA	NA	NA	NA	50	HRL
Hexachlorobutadiene	ppb	NA	NA	NA	NA	NA	1	HRL
Methylene chloride	ppb	NA	NA	NA	NA	NA	5	MCL
Methyl ethyl ketone (MEK)	ppb	NA	NA	NA	NA	NA	4,000	HRL
n-Butylbenzene	ppb	NA	NA	NA	NA	NA	NE	
Tetrachloroethylene	ppb	NA	NA	NA	NA	NA	5	HRL
Toluene	ppb	NA	NA	NA	NA	NA	200	HRL
1,2,3-Trichlorobenzene	ppb	NA	NA	NA	NA	NA	NE	
Trichloroethene (TCE)	ppb	NA	NA	NA	NA	NA	0.4	HBV
Xylenes	ppb	NA	NA	NA	NA	NA	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 [shaded] indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Sample ID	Sample date	GUE MW-19			GUE MW-20		Screening Criteria	
		Oct. 1985 TCT, 1986	Jan. 1986 TCT, 1986	Jan. 1986 (dupl) TCT, 1986	Oct. 1985 TCT, 1986	Jan. 1986 TCT, 1986	Drinking Wtr. Criterion	Source
Analyte	Units							
<b>SVOCs</b>								
2,4-Dinitrotoluene	ppb	NA	NA	NA	NA	NA	0.5	SV
2,4,6-Trichlorophenol	ppb	NA	NA	NA	NA	NA	30	HRL
2-Methylnaphthalene	ppb	NA	NA	NA	NA	NA	NE	
4-Nitroanaline	ppb	NA	NA	NA	NA	NA	NE	
4-Nitrophenol	ppb	NA	NA	NA	NA	NA	NE	
Benzidine	ppb	NA	NA	NA	NA	NA	NE	
Benzo(a)anthracene	ppb	NA	NA	NA	NA	NA	0.6	HBV*
Benzo(a)pyrene	ppb	NA	NA	NA	NA	NA	0.06	HBV
Benzo(ghi)perylene	ppb	NA	NA	NA	NA	NA	NE	
Benzo(k)fluoranthene	ppb	NA	NA	NA	NA	NA	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	NA	NA	NA	NA	NA	NE	
bis(2-ethylhexyl)phthalate	ppb	NA	NA	NA	NA	NA	6	MCL
Butyl benzyl phthalate	ppb	NA	NA	NA	NA	NA	100	HRL
Carbazole	ppb	NA	NA	NA	NA	NA	NE	
Chrysene	ppb	NA	NA	NA	NA	NA	6	HBV*
Fluoranthene	ppb	NA	NA	NA	NA	NA	300	HRL
Phenanthrene	ppb	NA	NA	NA	NA	NA	NE	
Pyrene	ppb	NA	NA	NA	NA	NA	200	HRL
<b>TPH</b>								
Diesel range organics	ppb	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>								
Nitrocellulose	ppb	NA	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Units	Sample ID Sample date Data source	MW-OX-1	Coates MW-D-1		Coates MW-17	Lagoon PWL-1	Screening Criteria	
			Oct. 1985 TCT, 1986	11/20/1984 TCT, 1986	10/16/1985 TCT, 1986	10/16/1985 TCT, 1986	11/20/1984 TCT, 1986	Drinking Wtr. Criterion	Source
<b>General Parameters</b>									
Chloride	ppb		NA	<b>11,000</b>	NA	NA	<b>6,000</b>	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb		<b>3,000</b>	<b>9,200</b>	NA	NA	<b>2,000</b>	10,000	HRL
Sulfate	ppb		NA	<b>52,000</b>	NA	NA	<b>20,000</b>	250,000	MCL <sub>2</sub>
<b>Metals</b>									
Antimony	ppb		NA	<b>16</b>	NA	NA	<b>9</b>	6	HRL
Arsenic	ppb		NA	<b>4</b>	NA	NA	<1	10	MCL
Barium	ppb		NA	NA	NA	NA	NA	2,000	HRL
Cadmium	ppb		NA	<10	NA	NA	<10	4	HRL
Copper	ppb		NA	<10	NA	NA	<10	1,300	
Chromium	ppb		NA	<10	NA	NA	<10	100	HRL**
Lead	ppb		NA	<10	NA	NA	<10	15	
Selenium	ppb		NA	<b>8</b>	NA	NA	<1	30	HRL
Thallium	ppb		NA	<b>8</b>	NA	NA	<b>8</b>	0.6	HRL
Zinc	ppb		NA	<b>20</b>	NA	NA	<10	2,000	HRL
<b>VOCs</b>									
Acetone	ppb		NA	NA	NA	NA	NA	4,000	HRL
Benzene	ppb		NA	<1	NA	NA	NA	2	HRL
Carbon tetrachloride	ppb		<0.1	NA	<0.1	<0.1	NA	1	HRL
Chloroform	ppb		<0.1	NA	<0.1	<0.1	NA	30	HRL
Chloromethane	ppb		<0.1	NA	<0.1	<0.1	NA	NE	
Ethylbenzene	ppb		NA	NA	NA	NA	NA	50	HRL
Hexachlorobutadiene	ppb		NA	NA	NA	NA	NA	1	HRL
Methylene chloride	ppb		<0.3	NA	<0.3	<0.3	NA	5	MCL
Methyl ethyl ketone (MEK)	ppb		NA	NA	NA	NA	NA	4,000	HRL
n-Butylbenzene	ppb		NA	NA	NA	NA	NA	NE	
Tetrachloroethylene	ppb		<0.1	NA	<0.1	<0.1	NA	5	HRL
Toluene	ppb		NA	<b>63</b>	<0.1	<0.1	NA	200	HRL
1,2,3-Trichlorobenzene	ppb		NA	NA	NA	NA	NA	NE	
Trichloroethene (TCE)	ppb		<0.1	NA	<0.1	<0.1	NA	0.4	HBV
Xylenes	ppb		NA	<b>25</b>	<0.1	<0.1	NA	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 [shaded box] indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established



**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	MW-OX-1 Oct. 1985 TCT, 1986	Coates MW-D-1		Coates MW-17 10/16/1985 TCT, 1986	Lagoon PWL-1 11/20/1984 TCT, 1986	Screening Criteria	
			11/20/1984 TCT, 1986	10/16/1985 TCT, 1986			Drinking Wtr. Criterion	Source
<b>SVOCs</b>	<b>Units</b>							
2,4-Dinitrotoluene	ppb	NA	NA	NA	NA	NA	0.5	SV
2,4,6-Trichlorophenol	ppb	NA	NA	NA	NA	NA	30	HRL
2-Methylnaphthalene	ppb	NA	NA	NA	NA	NA	NE	
4-Nitroanaline	ppb	NA	NA	NA	NA	NA	NE	
4-Nitrophenol	ppb	NA	NA	NA	NA	NA	NE	
Benzidine	ppb	NA	NA	NA	NA	NA	NE	
Benzo(a)anthracene	ppb	NA	NA	NA	NA	NA	0.6	HBV*
Benzo(a)pyrene	ppb	NA	NA	NA	NA	NA	0.06	HBV
Benzo(ghi)perylene	ppb	NA	NA	NA	NA	NA	NE	
Benzo(k)fluoranthene	ppb	NA	NA	NA	NA	NA	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	NA	NA	NA	NA	NA	NE	
bis(2-ethylhexyl)phthalate	ppb	NA	NA	NA	NA	NA	6	MCL
Butyl benzyl phthalate	ppb	NA	NA	NA	NA	NA	100	HRL
Carbazole	ppb	NA	NA	NA	NA	NA	NE	
Chrysene	ppb	NA	NA	NA	NA	NA	6	HBV*
Fluoranthene	ppb	NA	NA	NA	NA	NA	300	HRL
Phenanthrene	ppb	NA	NA	NA	NA	NA	NE	
Pyrene	ppb	NA	NA	NA	NA	NA	200	HRL
<b>TPH</b>								
Diesel range organics	ppb	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>								
Nitrocellulose	ppb	NA	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	Lagoon PWL-1	Lagoon PWL-2		Lagoon PWL-3		Screening Criteria	
		Oct. 1985 TCT, 1986	11/20/1984 TCT, 1986	Oct. 1985 TCT, 1986	11/20/1984 TCT, 1986	Oct. 1985 TCT, 1986	Drinking Wtr. Criterion	Source
<b>General Parameters</b>	<b>Units</b>							
Chloride	ppb	NA	<b>23,000</b>	NA	<b>20,000</b>	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	<b>18,000</b>	NA	<b>18,000</b>	NA	10,000	HRL
Sulfate	ppb	<b>19,000</b>	<b>21,000</b>	<b>21,000</b>	<b>19,000</b>	<b>67,000</b>	250,000	MCL <sub>2</sub>
<b>Metals</b>								
Antimony	ppb	<4	<b>16</b>	<4	<b>19</b>	<4	6	HRL
Arsenic	ppb	<3	<1	<3	<1	<3	10	MCL
Barium	ppb	NA	NA	NA	NA	NA	2,000	HRL
Cadmium	ppb	<0.1	<10	<b>0.2</b>	<10	<0.1	4	HRL
Copper	ppb	<10	<10	<10	<10	<b>70</b>	1,300	
Chromium	ppb	<10	<10	<10	<10	<10	100	HRL**
Lead	ppb	<2	<10	<b>15</b>	<10	<b>13</b>	15	
Selenium	ppb	<2	<b>7</b>	<2	<1	<2	30	HRL
Thallium	ppb	<2	<b>13</b>	<2	<b>12</b>	<2	0.6	HRL
Zinc	ppb	<b>30</b>	<10	<b>20</b>	<10	<b>40</b>	2,000	HRL
<b>VOCs</b>								
Acetone	ppb	NA	NA	NA	NA	NA	4,000	HRL
Benzene	ppb	NA	NA	NA	NA	NA	2	HRL
Carbon tetrachloride	ppb	NA	NA	NA	NA	NA	1	HRL
Chloroform	ppb	NA	NA	NA	NA	NA	30	HRL
Chloromethane	ppb	NA	NA	NA	NA	NA	NE	
Ethylbenzene	ppb	NA	NA	NA	NA	NA	50	HRL
Hexachlorobutadiene	ppb	NA	NA	NA	NA	NA	1	HRL
Methylene chloride	ppb	NA	NA	NA	NA	NA	5	MCL
Methyl ethyl ketone (MEK)	ppb	NA	NA	NA	NA	NA	4,000	HRL
n-Butylbenzene	ppb	NA	NA	NA	NA	NA	NE	
Tetrachloroethylene	ppb	NA	NA	NA	NA	NA	5	HRL
Toluene	ppb	NA	NA	NA	NA	NA	200	HRL
1,2,3-Trichlorobenzene	ppb	NA	NA	NA	NA	NA	NE	
Trichloroethene (TCE)	ppb	NA	NA	NA	NA	NA	0.4	HBV
Xylenes	ppb	NA	NA	NA	NA	NA	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 [shaded box] indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

	Sample ID Sample date Data source	Lagoon PWL-1	Lagoon PWL-2		Lagoon PWL-3		Screening Criteria	
		Oct. 1985 TCT, 1986	11/20/1984 TCT, 1986	Oct. 1985 TCT, 1986	11/20/1984 TCT, 1986	Oct. 1985 TCT, 1986	Drinking Wtr. Criterion	Source
Analyte	Units							
<b>SVOCs</b>								
2,4-Dinitrotoluene	ppb	NA	NA	NA	NA	NA	0.5	SV
2,4,6-Trichlorophenol	ppb	NA	NA	NA	NA	NA	30	HRL
2-Methylnaphthalene	ppb	NA	NA	NA	NA	NA	NE	
4-Nitroanaline	ppb	NA	NA	NA	NA	NA	NE	
4-Nitrophenol	ppb	NA	NA	NA	NA	NA	NE	
Benzidine	ppb	NA	NA	NA	NA	NA	NE	
Benzo(a)anthracene	ppb	NA	NA	NA	NA	NA	0.6	HBV*
Benzo(a)pyrene	ppb	NA	NA	NA	NA	NA	0.06	HBV
Benzo(ghi)perylene	ppb	NA	NA	NA	NA	NA	NE	
Benzo(k)fluoranthene	ppb	NA	NA	NA	NA	NA	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	NA	NA	NA	NA	NA	NE	
bis(2-ethylhexyl)phthalate	ppb	NA	NA	NA	NA	NA	6	MCL
Butyl benzyl phthalate	ppb	NA	NA	NA	NA	NA	100	HRL
Carbazole	ppb	NA	NA	NA	NA	NA	NE	
Chrysene	ppb	NA	NA	NA	NA	NA	6	HBV*
Fluoranthene	ppb	NA	NA	NA	NA	NA	300	HRL
Phenanthrene	ppb	NA	NA	NA	NA	NA	NE	
Pyrene	ppb	NA	NA	NA	NA	NA	200	HRL
<b>TPH</b>								
Diesel range organics	ppb	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>								
Nitrocellulose	ppb	NA	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC1N-W-GP1	AOC1M-W-GP1	AOC1M-W-GP2	AOC1M-W-GP3	AOC1S-W-GP1	Screening Criteria	
		9/18/2007 USACE, 2009a	9/19/2007 USACE, 2009a	9/20/2007 USACE, 2009a	9/21/2007 USACE, 2009a	9/24/2007 USACE, 2009a	Drinking Wtr. Criterion	Source
<b>General Parameters</b>	<b>Units</b>							
Chloride	ppb	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	NA	NA	NA	NA	10,000	HRL
Sulfate	ppb	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
<b>Metals</b>								
Antimony	ppb	NA	NA	NA	NA	NA	6	HRL
Arsenic	ppb	<25	<25	<25	<25	<25	10	MCL
Barium	ppb	<b>33</b>	<b>30</b>	<b>63</b>	<b>71</b>	<b>63</b>	2,000	HRL
Cadmium	ppb	<5	<5	<5	<5	<5	4	HRL
Copper	ppb	NA	NA	NA	NA	NA	1,300	
Chromium	ppb	<b>2.6 J</b>	<15	<15	<15	<15	100	HRL**
Lead	ppb	<15	<15	<15	<15	<15	15	
Selenium	ppb	<22	<22	<22	<22	<22	30	HRL
Thallium	ppb	NA	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>								
Acetone	ppb	<10	<10	<10	<b>3.6 J</b>	<10	4,000	HRL
Benzene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	2	HRL
Carbon tetrachloride	ppb	<2.0	<2.0	<2.0	<2.0	<2.0	1	HRL
Chloroform	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	30	HRL
Chloromethane	ppb	<b>0.31 J</b>	<2.0	<2.0	<2.0	<2.0	NE	
Ethylbenzene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	50	HRL
Hexachlorobutadiene	ppb	<b>0.15 J</b>	<1.0	<1.0	<1.0	<1.0	1	HRL
Methylene chloride	ppb	<5.0	<5.0	<5.0	<5.0	<5.0	5	MCL
Methyl ethyl ketone (MEK)	ppb	<6.0	<6.0	<6.0	<6.0	<6.0	4,000	HRL
n-Butylbenzene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	NE	
Tetrachloroethylene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	5	HRL
Toluene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	200	HRL
1,2,3-Trichlorobenzene	ppb	<b>0.42 J</b>	<1.0	<1.0	<1.0	<1.0	NE	
Trichloroethene (TCE)	ppb	<1.0	<1.0	<1.0	<b>0.47 J</b>	<1.0	0.4	HBV
Xylenes	ppb	<3	<3	<3	<3	<3	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC1N-W-GP1	AOC1M-W-GP1	AOC1M-W-GP2	AOC1M-W-GP3	AOC1S-W-GP1	Screening Criteria	
		9/18/2007 USACE, 2009a	9/19/2007 USACE, 2009a	9/20/2007 USACE, 2009a	9/21/2007 USACE, 2009a	9/24/2007 USACE, 2009a	Drinking Wtr. Criterion	Source
<b>SVOCs</b>	<b>Units</b>							
2,4-Dinitrotoluene	ppb	<b>0.26 J</b>	<0.4	<0.4	<0.4	<0.4	0.5	SV
2,4,6-Trichlorophenol	ppb	<20	<20	<20	<20	<20	30	HRL
2-Methylnaphthalene	ppb	<10	<10	<10	<10	<10	NE	
4-Nitroanaline	ppb	<50	<50	<50	<50	<50	NE	
4-Nitrophenol	ppb	<50	<50	<50	<50	<50	NE	
Benzdine	ppb	<200	<200	<200	<200	<200	NE	
Benzo(a)anthracene	ppb	<10	<10	<10	<10	<10	0.6	HBV*
Benzo(a)pyrene	ppb	<10	<10	<10	<10	<10	0.06	HBV
Benzo(ghi)perylene	ppb	<10	<10	<10	<10	<10	NE	
Benzo(k)fluoranthene	ppb	<10	<10	<10	<10	<10	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	<10	<10	<10	<10	<10	NE	
bis(2-ethylhexyl)phthalate	ppb	<b>74 J</b>	<b>2.1 J</b>	<10	<10	<b>1.8 J</b>	6	MCL
Butyl benzyl phthalate	ppb	<20	<20	<20	<20	<20	100	HRL
Carbazole	ppb	<10	<10	<10	<10	<10	NE	
Chrysene	ppb	<10	<10	<10	<10	<10	6	HBV*
Fluoranthene	ppb	<20	<20	<20	<20	<20	300	HRL
Phenanthrene	ppb	<10	<10	<10	<b>2.2 J</b>	<10	NE	
Pyrene	ppb	<10	<10	<10	<10	<10	200	HRL
<b>TPH</b>								
Diesel range organics	ppb	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>								
Nitrocellulose	ppb	<500	<500	<500	<b>130 B</b>	<500	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC1S-W-GP2	AOC5-W-GP7	AOC7B-W-GP1	AOC7B-W-GP2	AOC7B-W-GP3	AOC7C-W-GP3	Screening Criteria	
		9/24/2007 USACE, 2009a	9/6-18/2007 USACE, 2009a	8/16/2007 USACE, 2009a	8/17/2007 USACE, 2009a	8/20/2007 USACE, 2009a	8/21/2007 USACE, 2009a	Drinking Wtr. Criterion	Source
<b>General Parameters</b>	<b>Units</b>								
Chloride	ppb	NA	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	NA	NA	NA	NA	NA	10,000	HRL
Sulfate	ppb	NA	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
<b>Metals</b>									
Antimony	ppb	NA	NA	NA	NA	NA	NA	6	HRL
Arsenic	ppb	<25	<25	<25	<25	<25	<25	10	MCL
Barium	ppb	<b>73</b>	<b>130</b>	<b>100 B</b>	<b>100 B</b>	<b>79</b>	<b>70</b>	2,000	HRL
Cadmium	ppb	<5	<5	<5	<5	<5	<5	4	HRL
Copper	ppb	NA	NA	NA	NA	NA	NA	1,300	
Chromium	ppb	<15	<15	<15	<b>11 J</b>	<15	<b>31</b>	100	HRL**
Lead	ppb	<15	<15	<15	<15	<15	<15	15	
Selenium	ppb	<22	<22	<22	<22	<22	<22	30	HRL
Thallium	ppb	NA	NA	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>									
Acetone	ppb	<10	NA	<10	<b>3.8 J</b>	<10	<b>5.8 J</b>	4,000	HRL
Benzene	ppb	<1.0	NA	<1.0	<1.0	<1.0	<b>0.21 J</b>	2	HRL
Carbon tetrachloride	ppb	<2.0	NA	<2.0	<2.0	<2.0	<2.0	1	HRL
Chloroform	ppb	<1.0	NA	<b>3.1</b>	<b>3</b>	<1.0	<b>1</b>	30	HRL
Chloromethane	ppb	<2.0	NA	<2.0	<2.0	<2.0	<2.0	NE	
Ethylbenzene	ppb	<1.0	NA	<1.0	<1.0	<1.0	<1.0	50	HRL
Hexachlorobutadiene	ppb	<1.0	NA	<1.0	<1.0	<1.0	<1.0	1	HRL
Methylene chloride	ppb	<5.0	NA	<5.0	<5.0	<5.0	<5.0	5	MCL
Methyl ethyl ketone (MEK)	ppb	<6.0	NA	<6.0	<6.0	<6.0	<b>2.3 J</b>	4,000	HRL
n-Butylbenzene	ppb	<1.0	NA	<1.0	<b>0.15 J</b>	<1.0	<1.0	NE	
Tetrachloroethylene	ppb	<1.0	NA	<1.0	<1.0	<1.0	<1.0	5	HRL
Toluene	ppb	<1.0	NA	<1.0	<b>0.37 J</b>	<b>0.24 J</b>	<b>0.35 J</b>	200	HRL
1,2,3-Trichlorobenzene	ppb	<1.0	NA	<1.0	<b>0.24 J</b>	<1.0	<1.0	NE	
Trichloroethene (TCE)	ppb	<1.0	NA	<b>0.4 J</b>	<b>0.32 J</b>	<b>0.39 J</b>	<b>0.23 J</b>	0.4	HBV
Xylenes	ppb	<3	<3	<3	<3	<3	<3	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC1S-W-GP2 9/24/2007 USACE, 2009a	AOC5-W-GP7 9/6-18/2007 USACE, 2009a	AOC7B-W-GP1 8/16/2007 USACE, 2009a	AOC7B-W-GP2 8/17/2007 USACE, 2009a	AOC7B-W-GP3 8/20/2007 USACE, 2009a	AOC7C-W-GP3 8/21/2007 USACE, 2009a	Screening Criteria	
								Drinking Wtr. Criterion	Source
<b>SVOCs</b>	<b>Units</b>								
2,4-Dinitrotoluene	ppb	<0.4	<0.4	<20	<20	<20	<20	0.5	SV
2,4,6-Trichlorophenol	ppb	<20	NA	<20	<20	<20	<20	30	HRL
2-Methylnaphthalene	ppb	<10	NA	<10	<10	<10	<10	NE	
4-Nitroanaline	ppb	<50	NA	<50	<50	<b>1.1 J</b>	<50	NE	
4-Nitrophenol	ppb	<50	NA	<50	<50	<b>1.8 J</b>	<50	NE	
Benzdine	ppb	<200	NA	<200	<200	<b>1.5 J</b>	<200	NE	
Benzo(a)anthracene	ppb	<10	<10	<10	<10	<10	<10	0.6	HBV*
Benzo(a)pyrene	ppb	<10	<10	<10	<10	<b>0.91 J</b>	<10	0.06	HBV
Benzo(ghi)perylene	ppb	<10	<10	<10	<10	<b>1.1 J</b>	<10	NE	
Benzo(k)fluoranthene	ppb	<10	<10	<10	<b>4.4 J</b>	<80	<10	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	<10	NA	<10	<10	<b>4.5 J</b>	<10	NE	
bis(2-ethylhexyl)phthalate	ppb	<10	NA	<b>2.5 J B</b>	<b>6.4 J B</b>	<20	<b>6.6 J</b>	6	MCL
Butyl benzyl phthalate	ppb	<20	NA	<20	<20	<b>1.3 J</b>	<20	100	HRL
Carbazole	ppb	<10	NA	<10	<10	<b>1.4 J</b>	<10	NE	
Chrysene	ppb	<10	<10	<10	<10	<10	<10	6	HBV*
Fluoranthene	ppb	<20	<b>1.3 J</b>	<20	<20	<20	<20	300	HRL
Phenanthrene	ppb	<10	<10	<10	<10	<10	<10	NE	
Pyrene	ppb	<10	<b>1.6 J</b>	<10	<10	<10	<10	200	HRL
<b>TPH</b>									
Diesel range organics	ppb	NA	<b>410</b>	<100	<100	<100	NA	200	HBV
Gasoline range organics	ppb	NA	<b>54 J B</b>	NA	NA	NA	NA	200	HBV
<b>Other</b>									
Nitrocellulose	ppb	<500	<500	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

**0.91 J** indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC7C-W-GP6	AOC7C-W-GP7	AOC7D-W-GP1	AOC7D-W-GP2	AOC7D-W-GP5	Screening Criteria	
		8/22/2007 USACE, 2009a	8/23/2007 USACE, 2009a	8/27/2007 USACE, 2009a	8/28/2007 USACE, 2009a	8/31/2007 USACE, 2009a	Drinking Wtr. Criterion	Source
<b>General Parameters</b>	<b>Units</b>							
Chloride	ppb	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	NA	NA	NA	NA	10,000	HRL
Sulfate	ppb	NA	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
<b>Metals</b>								
Antimony	ppb	NA	NA	NA	NA	NA	6	HRL
Arsenic	ppb	<25	<25	<25	<25	<25	10	MCL
Barium	ppb	<b>57</b>	<b>100</b>	<b>81</b>	<b>91</b>	<b>87</b>	2,000	HRL
Cadmium	ppb	<5	<5	<5	<5	<5	4	HRL
Copper	ppb	NA	NA	NA	NA	NA	1,300	
Chromium	ppb	<15	<15	<15	<15	<15	100	HRL**
Lead	ppb	<15	<15	<15	<15	<15	15	
Selenium	ppb	<22	<22	<22	<22	<22	30	HRL
Thallium	ppb	NA	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>								
Acetone	ppb	<10	<10	<b>2.6 J</b>	<b>4.8 J</b>	<10	4,000	HRL
Benzene	ppb	<1.0	<1.0	<1.0	<1.0	<b>0.26 J</b>	2	HRL
Carbon tetrachloride	ppb	<2.0	<2.0	<2.0	<2.0	<2.0	1	HRL
Chloroform	ppb	<b>1</b>	<b>1</b>	<b>0.99 J</b>	<b>0.45 J</b>	<b>1</b>	30	HRL
Chloromethane	ppb	<2.0	<2.0	<2.0	<2.0	<2.0	NE	
Ethylbenzene	ppb	<1.0	<1.0	<1.0	<1.0	<b>0.45 J</b>	50	HRL
Hexachlorobutadiene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	1	HRL
Methylene chloride	ppb	<5.0	<5.0	<5.0	<5.0	<b>0.77 J</b>	5	MCL
Methyl ethyl ketone (MEK)	ppb	<6.0	<6.0	<6.0	<6.0	<6.0	4,000	HRL
n-Butylbenzene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	NE	
Tetrachloroethylene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	5	HRL
Toluene	ppb	<1.0	<1.0	<b>0.29 J</b>	<b>0.18 J</b>	<b>1</b>	200	HRL
1,2,3-Trichlorobenzene	ppb	<1.0	<1.0	<1.0	<1.0	<1.0	NE	
Trichloroethene (TCE)	ppb	<b>0.17 J</b>	<1.0	<b>0.27 J</b>	<b>0.17 J</b>	<b>0.18 J</b>	0.4	HBV
Xylenes	ppb	<3	<3	<3	<3	<3	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established



**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC7C-W-GP6	AOC7C-W-GP7	AOC7D-W-GP1	AOC7D-W-GP2	AOC7D-W-GP5	Screening Criteria	
		8/22/2007 USACE, 2009a	8/23/2007 USACE, 2009a	8/27/2007 USACE, 2009a	8/28/2007 USACE, 2009a	8/31/2007 USACE, 2009a	Drinking Wtr. Criterion	Source
<b>SVOCs</b>	<b>Units</b>							
2,4-Dinitrotoluene	ppb	<0.4	<0.4	<20	<20	<20	0.5	SV
2,4,6-Trichlorophenol	ppb	<20	<20	<20	<20	<b>94</b>	30	HRL
2-Methylnaphthalene	ppb	<10	<10	<10	<10	<b>75</b>	NE	
4-Nitroanaline	ppb	<50	<b>2 J</b>	<50	<50	<50	NE	
4-Nitrophenol	ppb	<50	<b>2.6 J</b>	<50	<50	<50	NE	
Benzdine	ppb	<200	<200	<200	<200	<200	NE	
Benzo(a)anthracene	ppb	<10	<b>1.4 J</b>	<10	<10	<10	0.6	HBV*
Benzo(a)pyrene	ppb	<10	<10	<10	<10	<10	0.06	HBV
Benzo(ghi)perylene	ppb	<10	<10	<10	<10	<10	NE	
Benzo(k)fluoranthene	ppb	<10	<10	<10	<10	<10	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	<10	<10	<10	<10	<10	NE	
bis(2-ethylhexyl)phthalate	ppb	<b>2.2 J</b>	<b>2.3 J B</b>	<b>2 J</b>	<10	<10	6	MCL
Butyl benzyl phthalate	ppb	<20	<20	<20	<20	<20	100	HRL
Carbazole	ppb	<10	<b>1.9 J</b>	<10	<10	<10	NE	
Chrysene	ppb	<10	<b>1.5 J</b>	<10	<10	<10	6	HBV*
Fluoranthene	ppb	<20	<b>1.2 J</b>	<20	<20	<20	300	HRL
Phenanthrene	ppb	<10	<10	<10	<10	<10	NE	
Pyrene	ppb	<10	<b>1.1 J</b>	<10	<10	<10	200	HRL
<b>TPH</b>								
Diesel range organics	ppb	NA	NA	<b>35 J B</b>	<b>68 J B</b>	<100	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>								
Nitrocellulose	ppb	<b>870*</b>	<b>220 B</b>	NA	<500	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

**94** indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

\* nitrocellulose was not detected in two duplicates of this sample (<0.5)

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC7D-W-GP8	AOC7A-W-HSA104	AOC7A-W-HSA105	AOC7D-W-HSA105	Screening Criteria	
		8/30/2007 USACE, 2009a	9/25/2009 USACE, 2009b	9/25/2009 USACE, 2009b	9/25/2009 USACE, 2009b	Drinking Wtr. Criterion	Source
Units							
<b>General Parameters</b>							
Chloride	ppb	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	NA	NA	NA	10,000	HRL
Sulfate	ppb	NA	NA	NA	NA	250,000	MCL <sub>2</sub>
<b>Metals</b>							
Antimony	ppb	NA	NA	NA	NA	6	HRL
Arsenic	ppb	<25	<25	<25	<25	10	MCL
Barium	ppb	<b>75</b>	<b>80 J</b>	<b>78 J</b>	<b>88</b>	2,000	HRL
Cadmium	ppb	<5	<0.56	<5	<5	4	HRL
Copper	ppb	NA	NA	NA	NA	1,300	
Chromium	ppb	<15	<0.71	<15	<15	100	HRL**
Lead	ppb	<15	<15	<15	<15	15	
Selenium	ppb	<22	<b>6 J</b>	<22	<22	30	HRL
Thallium	ppb	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>							
Acetone	ppb	<10	<10	<10	<b>9.1 J</b>	4,000	HRL
Benzene	ppb	<1.0	<1.0	<1.0	<1.0	2	HRL
Carbon tetrachloride	ppb	<2.0	<2.0	<2.0	<2.0	1	HRL
Chloroform	ppb	<b>1.1</b>	<1.0	<b>3.4 J</b>	<b>0.79 J</b>	30	HRL
Chloromethane	ppb	<2.0	<2.0	<2.0	<2.0	NE	
Ethylbenzene	ppb	<1.0	<1.0	<1.0	<1.0	50	HRL
Hexachlorobutadiene	ppb	<1.0	<1.0	<1.0	<1.0	1	HRL
Methylene chloride	ppb	<b>0.45 J</b>	<5.0	<5.0	<5.0	5	MCL
Methyl ethyl ketone (MEK)	ppb	<6.0	<6.0	<6.0	<b>2.2 J</b>	4,000	HRL
n-Butylbenzene	ppb	<1.0	<1.0	<1.0	<1.0	NE	
Tetrachloroethylene	ppb	<1.0	<1.0	<1.0	<1.0	5	HRL
Toluene	ppb	<b>0.19 J</b>	<1.0	<1.0	<1.0	200	HRL
1,2,3-Trichlorobenzene	ppb	<1.0	<1.0	<1.0	<1.0	NE	
Trichloroethene (TCE)	ppb	<b>0.25 J</b>	<1.0	<b>0.48 J</b>	<1.0	0.4	HBV
Xylenes	ppb	<3	<3	<3	<3	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting lii  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	AOC7D-W-GP8 8/30/2007 USACE, 2009a	AOC7A-W-HSA104 9/25/2009 USACE, 2009b	AOC7A-W-HSA105 9/25/2009 USACE, 2009b	AOC7D-W-HSA105 9/25/2009 USACE, 2009b	Screening Criteria	
						Drinking Wtr. Criterion	Source
<b>SVOCs</b>	<b>Units</b>						
2,4-Dinitrotoluene	ppb	<20	NA	NA	NA	0.5	SV
2,4,6-Trichlorophenol	ppb	<20	NA	NA	NA	30	HRL
2-Methylnaphthalene	ppb	<10	NA	NA	NA	NE	
4-Nitroanaline	ppb	<50	NA	NA	NA	NE	
4-Nitrophenol	ppb	<50	NA	NA	NA	NE	
Benzidine	ppb	<200	NA	NA	NA	NE	
Benzo(a)anthracene	ppb	<10	NA	NA	NA	0.6	HBV*
Benzo(a)pyrene	ppb	<10	NA	NA	NA	0.06	HBV
Benzo(ghi)perylene	ppb	<10	NA	NA	NA	NE	
Benzo(k)fluoranthene	ppb	<10	NA	NA	NA	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	<10	NA	NA	NA	NE	
bis(2-ethylhexyl)phthalate	ppb	<10	NA	NA	NA	6	MCL
Butyl benzyl phthalate	ppb	<20	NA	NA	NA	100	HRL
Carbazole	ppb	<10	NA	NA	NA	NE	
Chrysene	ppb	<10	NA	NA	NA	6	HBV*
Fluoranthene	ppb	<20	NA	NA	NA	300	HRL
Phenanthrene	ppb	<10	NA	NA	NA	NE	
Pyrene	ppb	<10	NA	NA	NA	200	HRL
<b>TPH</b>							
Diesel range organics	ppb	<100	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	200	HBV
<b>Other</b>							
Nitrocellulose	ppb	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

	Sample ID	MW-21D (aka T00019)		MW-22 (aka T00020)		MW-23D (aka T00022)		Screening Criteria	
		Sample date	1/17/2002 Delta, 2002	7/13/2011 Barr, 2012	1/17/2002 Delta, 2002	12/8/2011 Barr, 2012	1/17/2002 Delta, 2002	7/14/2011 Barr, 2012	Drinking Wtr. Criterion
Analyte	Units								
<b>General Parameters</b>									
Chloride	ppb	NA	<b>16,000</b>	NA	<b>96,000</b>	NA	<b>11,000</b>	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	<b>11,000</b>	NA	<b>2,000</b>	NA	<b>9,000</b>	10,000	HRL
Sulfate	ppb	NA	<b>24,000</b>	NA	<b>27,000</b>	NA	<b>33,000</b>	250,000	MCL <sub>2</sub>
<b>Metals</b>									
Antimony	ppb	NA	NA	NA	NA	NA	NA	6	HRL
Arsenic	ppb	NA	<10	NA	<10	NA	<10	10	MCL
Barium	ppb	NA	<b>53</b>	NA	<b>66</b>	NA	<b>51</b>	2,000	HRL
Cadmium	ppb	NA	<1	NA	<1	NA	<1	4	HRL
Copper	ppb	NA	NA	NA	NA	NA	NA	1,300	
Chromium	ppb	NA	<10	NA	<10	NA	<10	100	HRL**
Lead	ppb	NA	<3	NA	<3	NA	<3	15	
Selenium	ppb	NA	<20	NA	<20	NA	<20	30	HRL
Thallium	ppb	NA	NA	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>									
Acetone	ppb	<5.0	<3.8	<5.0	<3.8	<5.0	<3.8	4,000	HRL
Benzene	ppb	<1.0	<0.071	<1.0	<0.071	<1.0	<0.071	2	HRL
Carbon tetrachloride	ppb	<1.0	<b>0.25 J</b>	<1.0	<0.15	<1.0	<0.15	1	HRL
Chloroform	ppb	<b>11</b>	<b>4.2</b>	<b>2.3</b>	<0.15	<b>8.9</b>	<b>5</b>	30	HRL
Chloromethane	ppb	<1.0	<0.24	<1.0	<0.24	<1.0	<0.24	NE	
Ethylbenzene	ppb	<1.0	<0.28	<1.0	<0.28	<1.0	<0.28	50	HRL
Hexachlorobutadiene	ppb	<1.0	<0.42	<1.0	<0.42	<1.0	<0.42	1	HRL
Methylene chloride	ppb	<1.0	<0.85	<1.0	<0.85	<1.0	<0.85	5	MCL
Methyl ethyl ketone (MEK)	ppb	<5.0	<0.65	<5.0	<0.65	<5.0	<0.65	4,000	HRL
n-Butylbenzene	ppb	<1.0	<0.15	<1.0	<0.15	<1.0	<0.15	NE	
Tetrachloroethylene	ppb	<1.0	<0.28	<1.0	<0.28	<1.0	<0.28	5	HRL
Toluene	ppb	<1.0	<0.1	<1.0	<0.1	<1.0	<0.1	200	HRL
1,2,3-Trichlorobenzene	ppb	<1.0	<0.35	<1.0	<0.35	<1.0	<0.35	NE	
Trichloroethene (TCE)	ppb	<1.0	<b>0.43 J</b>	<1.0	<0.18	<b>2.6</b>	<b>0.92 J</b>	0.4	HBV
Xylenes	ppb	<3	<0.8	<3	<0.8	<3	<0.8	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

	Sample ID	MW-21D (aka T00019)		MW-22 (aka T00020)		MW-23D (aka T00022)		Screening Criteria	
		Sample date	1/17/2002	7/13/2011	1/17/2002	12/8/2011	1/17/2002	7/14/2011	Drinking Wtr. Criterion
Analyte	Units	Delta, 2002	Barr, 2012	Delta, 2002	Barr, 2012	Delta, 2002	Barr, 2012		
<b>SVOCs</b>									
2,4-Dinitrotoluene	ppb	NA	<0.42	NA	<0.42	NA	<0.42	0.5	SV
2,4,6-Trichlorophenol	ppb	NA	<0.55	NA	<0.55	NA	<0.55	30	HRL
2-Methylnaphthalene	ppb	NA	<0.81	NA	<0.81	NA	<0.81	NE	
4-Nitroanaline	ppb	NA	<0.83	NA	<0.83	NA	<0.83	NE	
4-Nitrophenol	ppb	NA	<0.72	NA	<0.72	NA	<0.72	NE	
Benzdine	ppb	NA	<7.0	NA	<7.0	NA	<7.0	NE	
Benzo(a)anthracene	ppb	NA	<0.46	NA	<0.46	NA	<0.46	0.6	HBV*
Benzo(a)pyrene	ppb	NA	<0.38	NA	<0.38	NA	<0.38	0.06	HBV
Benzo(ghi)perylene	ppb	NA	<0.41	NA	<0.41	NA	<0.41	NE	
Benzo(k)fluoranthene	ppb	NA	<0.43	NA	<0.43	NA	<0.43	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	NA	<0.21	NA	<0.21	NA	<0.21	NE	
bis(2-ethylhexyl)phthalate	ppb	NA	<0.75	NA	<0.75	NA	<0.75	6	MCL
Butyl benzyl phthalate	ppb	NA	<0.42	NA	<0.42	NA	<0.42	100	HRL
Carbazole	ppb	NA	<0.31	NA	<0.31	NA	<0.31	NE	
Chrysene	ppb	NA	<0.56	NA	<0.56	NA	<0.56	6	HBV*
Fluoranthene	ppb	NA	<0.56	NA	<0.56	NA	<0.56	300	HRL
Phenanthrene	ppb	NA	<0.32	NA	<0.32	NA	<0.32	NE	
Pyrene	ppb	NA	<0.61	NA	<0.61	NA	<0.61	200	HRL
<b>TPH</b>									
Diesel range organics	ppb	NA	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>									
Nitrocellulose	ppb	NA	NA	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	MW-25	MW-28		MW-29	MW-A5-018	MW-A6-006	Screening Criteria	
		1/17/2002 Delta, 2002	1/17/2002 Delta, 2002	7/14/2011 Barr, 2012	7/14/2011 Barr, 2012	12/7/2011 Barr, 2012	12/7/2011 Barr, 2012	Drinking Wtr. Criterion	Source
<b>General Parameters</b>	<b>Units</b>								
Chloride	ppb	NA	NA	<b>14,000</b>	<b>20,000</b>	<b>4,400</b>	<b>14,000</b>	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	NA	NA	<b>10,000</b>	<b>11,000</b>	<b>600</b>	<b>9,800</b>	10,000	HRL
Sulfate	ppb	NA	NA	<b>26,000</b>	<b>25,000</b>	<b>8,500</b>	<b>30,000</b>	250,000	MCL <sub>2</sub>
<b>Metals</b>									
Antimony	ppb	NA	NA	NA	NA	NA	NA	6	HRL
Arsenic	ppb	NA	NA	<10	<10	<10	<10	10	MCL
Barium	ppb	NA	NA	<b>66</b>	<b>70</b>	<b>48</b>	<b>71</b>	2,000	HRL
Cadmium	ppb	NA	NA	<1	<1	<1	<1	4	HRL
Copper	ppb	NA	NA	NA	NA	NA	NA	1,300	
Chromium	ppb	NA	NA	<10	<10	<10	<10	100	HRL**
Lead	ppb	NA	NA	<3	<3	<3	<3	15	
Selenium	ppb	NA	NA	<20	<20	<20	<20	30	HRL
Thallium	ppb	NA	NA	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>									
Acetone	ppb	<5.0	<5.0	<3.8	<3.8	<3.8	<3.8	4,000	HRL
Benzene	ppb	<1.0	<1.0	<0.071	<0.071	<0.071	<0.071	2	HRL
Carbon tetrachloride	ppb	<1.0	<1.0	<0.15	<0.15	<0.15	<0.15	1	HRL
Chloroform	ppb	<b>2.7</b>	<b>18</b>	<b>7.9</b>	<b>1.2</b>	<0.15	<0.15	30	HRL
Chloromethane	ppb	<1.0	<1.0	<0.24	<0.24	<0.24	<0.24	NE	
Ethylbenzene	ppb	<1.0	<1.0	<0.28	<0.28	<0.28	<0.28	50	HRL
Hexachlorobutadiene	ppb	<1.0	<1.0	<0.42	<0.42	<0.42	<0.42	1	HRL
Methylene chloride	ppb	<1.0	<1.0	<0.85	<0.85	<0.85	<0.85	5	MCL
Methyl ethyl ketone (MEK)	ppb	<5.0	<5.0	<0.65	<0.65	<0.65	<0.65	4,000	HRL
n-Butylbenzene	ppb	<1.0	<1.0	<0.15	<0.15	<0.15	<0.15	NE	
Tetrachloroethylene	ppb	<1.0	<1.0	<0.28	<0.28	<0.28	<b>0.37 J</b>	5	HRL
Toluene	ppb	<1.0	<1.0	<0.1	<0.1	<0.1	<0.1	200	HRL
1,2,3-Trichlorobenzene	ppb	<1.0	<1.0	<0.35	<0.35	<0.35	<0.35	NE	
Trichloroethene (TCE)	ppb	<1.0	<1.0	<b>0.75 J</b>	<0.18	<0.18	<0.18	0.4	HBV
Xylenes	ppb	<3	<3	<0.8	<0.8	<0.8	<0.8	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

	Sample ID Sample date Data source	MW-25	MW-28		MW-29	MW-A5-018	MW-A6-006	Screening Criteria	
		1/17/2002 Delta, 2002	1/17/2002 Delta, 2002	7/14/2011 Barr, 2012	7/14/2011 Barr, 2012	12/7/2011 Barr, 2012	12/7/2011 Barr, 2012	Drinking Wtr. Criterion	Source
Analyte	Units								
<b>SVOCs</b>									
2,4-Dinitrotoluene	ppb	NA	NA	<0.42	<0.42	<0.42	<0.42	0.5	SV
2,4,6-Trichlorophenol	ppb	NA	NA	<0.55	<0.55	<0.55	<0.55	30	HRL
2-Methylnaphthalene	ppb	NA	NA	<0.81	<0.81	<0.81	<0.81	NE	
4-Nitroanaline	ppb	NA	NA	<0.83	<0.83	<0.83	<0.83	NE	
4-Nitrophenol	ppb	NA	NA	<0.72	<0.72	<0.72	<0.72	NE	
Benzdine	ppb	NA	NA	<7.0	<7.0	<7.0	<7.0	NE	
Benzo(a)anthracene	ppb	NA	NA	<0.46	<0.46	<0.46	<0.46	0.6	HBV*
Benzo(a)pyrene	ppb	NA	NA	<0.38	<0.38	<0.38	<0.38	0.06	HBV
Benzo(ghi)perylene	ppb	NA	NA	<0.41	<0.41	<0.41	<0.41	NE	
Benzo(k)fluoranthene	ppb	NA	NA	<0.43	<0.43	<0.43	<0.43	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	NA	NA	<0.21	<0.21	<0.21	<0.21	NE	
bis(2-ethylhexyl)phthalate	ppb	NA	NA	<0.75	<0.75	<0.75	<0.75	6	MCL
Butyl benzyl phthalate	ppb	NA	NA	<0.42	<0.42	<0.42	<0.42	100	HRL
Carbazole	ppb	NA	NA	<0.31	<0.31	<0.31	<0.31	NE	
Chrysene	ppb	NA	NA	<0.56	<0.56	<0.56	<0.56	6	HBV*
Fluoranthene	ppb	NA	NA	<0.56	<0.56	<0.56	<0.56	300	HRL
Phenanthrene	ppb	NA	NA	<0.32	<0.32	<0.32	<0.32	NE	
Pyrene	ppb	NA	NA	<0.61	<0.61	<0.61	<0.61	200	HRL
<b>TPH</b>									
Diesel range organics	ppb	NA	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>									
Nitrocellulose	ppb	NA	NA	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	MW-B7-013	MW-B7-014	MW-B7-015	MW-C6-020	MW-C7-004	MW-C7-016	Screening Criteria	
		12/7/2011 Barr, 2012	12/7/2011 Barr, 2012	12/7/2011 Barr, 2012	12/7/2011 Barr, 2012	7/12/2011 Barr, 2012	12/7/2011 Barr, 2012	Drinking Wtr. Criterion	Source
<b>General Parameters</b>	<b>Units</b>								
Chloride	ppb	17,000	21,000	17,000	15,000	9,400	3,300	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb	8,700	30,000	8,000	8,500	4,100	370	10,000	HRL
Sulfate	ppb	30,000	14,000	15,000	17,000	16,000	8,100	250,000	MCL <sub>2</sub>
<b>Metals</b>									
Antimony	ppb	NA	NA	NA	NA	NA	NA	6	HRL
Arsenic	ppb	<10	<10	<10	<10	<10	<10	10	MCL
Barium	ppb	93	85	92	90	99	67	2,000	HRL
Cadmium	ppb	<1	<1	<1	<1	<1	<1	4	HRL
Copper	ppb	NA	NA	NA	NA	NA	NA	1,300	
Chromium	ppb	<10	<10	<10	<10	<10	<10	100	HRL**
Lead	ppb	<3	<3	<3	<3	<3	<3	15	
Selenium	ppb	<20	<20	<20	<20	<20	<20	30	HRL
Thallium	ppb	NA	NA	NA	NA	NA	NA	0.6	HRL
Zinc	ppb	NA	NA	NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>									
Acetone	ppb	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	4,000	HRL
Benzene	ppb	<0.071	<0.071	<0.071	<0.071	<0.071	<0.071	2	HRL
Carbon tetrachloride	ppb	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	1	HRL
Chloroform	ppb	<0.15	<0.15	<0.15	1.6	<0.15	<0.15	30	HRL
Chloromethane	ppb	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	NE	
Ethylbenzene	ppb	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28	50	HRL
Hexachlorobutadiene	ppb	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	1	HRL
Methylene chloride	ppb	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	5	MCL
Methyl ethyl ketone (MEK)	ppb	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	4,000	HRL
n-Butylbenzene	ppb	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	NE	
Tetrachloroethylene	ppb	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28	5	HRL
Toluene	ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	200	HRL
1,2,3-Trichlorobenzene	ppb	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	NE	
Trichloroethene (TCE)	ppb	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	0.4	HBV
Xylenes	ppb	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established



**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Sample ID Sample date Data source	MW-B7-013 12/7/2011 Barr, 2012	MW-B7-014 12/7/2011 Barr, 2012	MW-B7-015 12/7/2011 Barr, 2012	MW-C6-020 12/7/2011 Barr, 2012	MW-C7-004 7/12/2011 Barr, 2012	MW-C7-016 12/7/2011 Barr, 2012	Screening Criteria	
								Drinking Wtr. Criterion	Source
<b>SVOCs</b>	<b>Units</b>								
2,4-Dinitrotoluene	ppb	<0.42	<0.42	<0.37	<0.42	<0.42	<0.42	0.5	SV
2,4,6-Trichlorophenol	ppb	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	30	HRL
2-Methylnaphthalene	ppb	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	NE	
4-Nitroanaline	ppb	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	NE	
4-Nitrophenol	ppb	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	NE	
Benzdine	ppb	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0	NE	
Benzo(a)anthracene	ppb	<0.46	<0.46	<0.46	<0.46	<0.46	<0.46	0.6	HBV*
Benzo(a)pyrene	ppb	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	0.06	HBV
Benzo(ghi)perylene	ppb	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	NE	
Benzo(k)fluoranthene	ppb	<0.43	<0.43	<0.43	<0.43	<0.43	<0.43	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	NE	
bis(2-ethylhexyl)phthalate	ppb	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	6	MCL
Butyl benzyl phthalate	ppb	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	100	HRL
Carbazole	ppb	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	NE	
Chrysene	ppb	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	6	HBV*
Fluoranthene	ppb	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	300	HRL
Phenanthrene	ppb	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	NE	
Pyrene	ppb	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	200	HRL
<b>TPH</b>									
Diesel range organics	ppb	NA	NA	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	NA	NA	200	HBV
<b>Other</b>									
Nitrocellulose	ppb	NA	NA	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level

SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

█ indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Units	Sample ID	T00006	BG-W-GP8	BG-W-GP14	Screening Criteria		
		Sample date	7/13/2011	7/13/2011	9/14/2007	9/21/2007	Drinking Wtr. Criterion	Source
		Data source	Barr, 2012	Barr, 2012	USACE, 2009a	USACE, 2009a		
<b>General Parameters</b>								
Chloride	ppb		24,000	6,800	NA	NA	250,000	MCL <sub>2</sub>
Nitrate + Nitrite	ppb		22,000	4,700	NA	NA	10,000	HRL
Sulfate	ppb		26,000	24,000	NA	NA	250,000	MCL <sub>2</sub>
<b>Metals</b>								
Antimony	ppb		NA	NA	NA	NA	6	HRL
Arsenic	ppb		<10	<10	<25	<25	10	MCL
Barium	ppb		86	83	310	77	2,000	HRL
Cadmium	ppb		<1	<1	<5	<5	4	HRL
Copper	ppb		NA	NA	NA	NA	1,300	
Chromium	ppb		<10	<10	<15	<15	100	HRL**
Lead	ppb		<3	<3	<15	<15	15	
Selenium	ppb		<20	<20	<22	<22	30	HRL
Thallium	ppb		NA	NA	NA	NA	0.6	HRL
Zinc	ppb		NA	NA	NA	NA	2,000	HRL
<b>VOCs</b>								
Acetone	ppb		<3.8	<3.8	NA	NA	4,000	HRL
Benzene	ppb		<0.071	<0.071	NA	NA	2	HRL
Carbon tetrachloride	ppb		<0.15	<0.15	NA	NA	1	HRL
Chloroform	ppb		<0.15	0.24 J	NA	NA	30	HRL
Chloromethane	ppb		<0.24	<0.24	NA	NA	NE	
Ethylbenzene	ppb		<0.28	<0.28	NA	NA	50	HRL
Hexachlorobutadiene	ppb		<0.42	<0.42	NA	NA	1	HRL
Methylene chloride	ppb		<0.85	<0.85	NA	NA	5	MCL
Methyl ethyl ketone (MEK)	ppb		<0.65	<0.65	NA	NA	4,000	HRL
n-Butylbenzene	ppb		<0.15	<0.15	NA	NA	NE	
Tetrachloroethylene	ppb		<0.28	<0.28	NA	NA	5	HRL
Toluene	ppb		<0.1	<0.1	NA	NA	200	HRL
1,2,3-Trichlorobenzene	ppb		<0.35	<0.35	NA	NA	NE	
Trichloroethene (TCE)	ppb		<0.18	<0.18	NA	NA	0.4	HBV
Xylenes	ppb		<0.8	<0.8	NA	NA	300	HRL

**NOTES:**  
 ppb = parts per billion  
 NA = not analyzed  
 HRL = MDH Health Risk Limit  
 HBV = MDH Health Based Value

AL = Action Level (USEPA)  
 J indicates concentrations is estimated  
 B indicates compound also detected in sample blank  
 < indicates compound not detected at or above method reporting limit  
 indicates compound present above drinking water criterion

HRL\*\* - this HRL is for chromium VI  
 MCL = Maximum Contaminant Level  
 MCL<sub>2</sub> = secondary MCL  
 NE = none established

**Table B-2: Summary of Chemicals Detected in Groundwater Investigation Samples**

Analyte	Units	MW-E4-010 7/13/2011 Barr, 2012	T00006 7/13/2011 Barr, 2012	BG-W-GP8 9/14/2007 USACE, 2009a	BG-W-GP14 9/21/2007 USACE, 2009a	Screening Criteria	
						Drinking Wtr. Criterion	Source
<b>SVOCs</b>							
2,4-Dinitrotoluene	ppb	<0.42	<0.42	NA	NA	0.5	SV
2,4,6-Trichlorophenol	ppb	<0.55	<0.55	NA	NA	30	HRL
2-Methylnaphthalene	ppb	<0.81	<0.81	NA	NA	NE	
4-Nitroanaline	ppb	<0.83	<0.83	NA	NA	NE	
4-Nitrophenol	ppb	<0.72	<0.72	NA	NA	NE	
Benzidine	ppb	<7.0	<7.0	NA	NA	NE	
Benzo(a)anthracene	ppb	<0.46	<0.46	NA	NA	0.6	HBV*
Benzo(a)pyrene	ppb	<0.38	<0.38	NA	NA	0.06	HBV
Benzo(ghi)perylene	ppb	<0.41	<0.41	NA	NA	NE	
Benzo(k)fluoranthene	ppb	<0.43	<0.43	NA	NA	0.6	HBV*
bis(2-chlorisopropyl)ether	ppb	<0.21	<0.21	NA	NA	NE	
bis(2-ethylhexyl)phthalate	ppb	<0.75	<0.75	NA	NA	6	MCL
Butyl benzyl phthalate	ppb	<0.42	<0.42	NA	NA	100	HRL
Carbazole	ppb	<0.31	<0.31	NA	NA	NE	
Chrysene	ppb	<0.56	<0.56	NA	NA	6	HBV*
Fluoranthene	ppb	<0.56	<0.56	NA	NA	300	HRL
Phenanthrene	ppb	<0.32	<0.32	NA	NA	NE	
Pyrene	ppb	<0.61	<0.61	NA	NA	200	HRL
<b>TPH</b>							
Diesel range organics	ppb	NA	NA	NA	NA	200	HBV
Gasoline range organics	ppb	NA	NA	NA	NA	200	HBV
<b>Other</b>							
Nitrocellulose	ppb	NA	NA	NA	NA	NE	

**NOTES:**

ppb = parts per billion

NA = not analyzed

HRL = MDH Health Risk Limit

HBV = MDH Health Based Value

MCL = Maximum Contaminant Level


SV = Minnesota screening value

HBV\* - these values based on compound toxicity relative to benzo(a)pyrene

J indicates concentrations is estimated

B indicates compound also detected in sample blank

< indicates compound not detected at or above method reporting limit

 indicates compound present above drinking water criterion

TPH = total petroleum hydrocarbons

**Appendix C, Table 1: Soil screening levels from MPCA and ATSDR**

Contaminant	MPCA Soil Reference Value <sup>1</sup> (ppm)		ATSDR Residential Comparison Value <sup>2</sup> (ppm)		
	Residential	Industrial	Child	Adult	cancer
Lead	300	700	--	--	--
PCBs	1.2	8	--	--	0.35
Arsenic	9	20	15	210	0.47
Mercury	0.5	1.5	--	--	--
Mercury (elemental)	--	--	--	--	--
Mercuric Chloride (mercury salts)	--	--	15	210	--
cPAHs (BaPE)	2	3	--	--	0.096
2,4-DNT	50	355	100	1400	
2,4- and 2-6 DNT mixture	12	23	--	--	1
DBP	2,440	16,300	5,000	70,000	--
2,3,7,8-TCDD (dioxin)	20 ppt	35 ppt	50 ppt	700 ppt	--
Antimony	12	100	20	280	--
Thallium	3	21	--	--	--

Soil screening values that are calculated by state and federal agencies may use slightly different exposure assumptions, toxicity values, and cancer risk levels to arrive at different values. Sites in Minnesota generally use the MPCA SRVs as screening and/or cleanup levels.

<sup>1</sup> Minnesota Pollution Control Agency Site Remediation Section Draft Guidelines: Risk-Based Guidance for the Soil-Human Health Pathway, Volume 2 Technical Support Document. January 1999.

<sup>2</sup> Agency for Toxic Substances and Disease Registry Soil Comparison Values from ATSDR's Sequoia Database, March 2013.

## Appendix C, Table 2: Equations and Assumptions for the SRVs

### Residential Noncancer SRV - based on child up to age 6

$$\text{Res}_{\text{NC}} \text{SRV} = \frac{\text{HQ}}{\left\{ \left( \frac{\text{IR} \times \text{RBA} \times \text{CF} \times \text{ED} \times \text{EF}_{\text{ing}}}{\text{BW} \times \text{AT}} \right) / \text{RfD} \right\} + \left\{ \left( \frac{\text{SA} \times \text{AF} \times \text{CF} \times \text{EF}_{\text{der}} \times \text{ED} \times \text{ABS}_{\text{d}}}{\text{BW} \times \text{AT}} \right) / (\text{RfD} \times \text{ABS}_{\text{GI}}) \right\} + \left\{ \frac{\text{EF}_{\text{inh}} \times \text{ED} \times \left( \frac{1}{6 \text{ yr VF}} + \frac{1}{\text{PEF}} \right)}{\text{AT}} \right\} / \text{RfC} \right\}}$$

HQ	hazard quotient	0.2
RfD	reference dose	chemical specific
BW	body weight (kg)	15
AT	averaging time (days)	2190
RBA	relative bioavailability	chemical specific
IR	soil ingestion rate (mg/day)	100
CF	conversion factor	0.000001
ED	exposure duration (years)	6
EF <sub>ing</sub>	exposure frequency ingestion (days)	350
EF <sub>der</sub>	exposure frequency dermal (days)	150
EF <sub>inh</sub>	exposure frequency inhalation (days)	350
SA	surface area (cm <sup>2</sup> )	2000
AF	adhesion factor (mg/cm <sup>2</sup> )	0.2
ABS <sub>d</sub>	dermal absorption fraction	chemical specific
ABS <sub>GI</sub>	gastrointestinal absorption fraction	chemical specific
6 yr VF	volatilization factor	chemical specific
PEF	particulate emission factor	7.7E+08

## Appendix C, Table 2: Equations and Assumptions for the SRVs

### Residential Cancer SRV- based on age-adjusted exposure parameters

$$Res_C SRV = \frac{CR \times AT}{\left( \left\{ CSF \times RBA \times EF_{ing} \times CF \times \left( \frac{ED \times IR}{BW} \right) \right\} + \left\{ \frac{CSF}{ABS_{GI}} \times EF_{der} \times ABS_d \times CF \times \left( \frac{ED \times AF \times SA}{BW} \right) \right\} + \left\{ EF_{inh} \times 1000 \times (ED \times IUR) \times \left( \frac{1}{VF} + \frac{1}{PEF} \right) \right\} \right)}$$

CR	cancer risk level	0.00001
AT	averaging time (days)	25550
CSF	cancer slope factor	chemical specific
RBA	relative bioavailability	chemical specific
CF	conversion factor (kg/mg)	0.000001
ED	exposure duration (years)	33
IR	ingestion rate, adult (mg/day)	68
EF <sub>ing</sub>	exposure frequency - ingestion (days)	350
EF <sub>der</sub>	exposure frequency - dermal (days)	97
EF <sub>inh</sub>	exposure frequency - inhalation (days)	350
BW	body weight, 2-16 years (kg)	51
ABS <sub>d</sub>	dermal absorption fraction	chemical specific
ABS <sub>GI</sub>	gastrointestinal absorption fraction	chemical specific
AF	dermal adhesion factor, 16-30 years (mg/cm <sup>2</sup> )	0.17
SA	skin surface area, 16-30 years (cm <sup>2</sup> )	3609
IUR	inhalation unit risk	chemical specific
VF	volatilization factor (m <sup>3</sup> /kg)	chemical specific
1/PEF	particulate emission factor (m <sup>3</sup> /kg)	7.7E+08

## Appendix C, Table 2: Equations and Assumptions for the SRVs

### Industrial Noncancer

$$\text{Ind}_{\text{NC}} \text{SRV} = \frac{\text{HQ}}{\left( \left( \frac{\text{IR} \times \text{RBA} \times \text{CF} \times \text{ED} \times \text{EF}_{\text{ing}}}{\text{BW} \times \text{AT}} \right) / \text{RfD} \right) + \left( \frac{\text{SA} \times \text{AF} \times \text{CF} \times \text{EF}_{\text{der}} \times \text{ED} \times \text{ABS}_{\text{d}}}{\text{BW} \times \text{AT}} \right) / (\text{RfD} \times \text{ABS}_{\text{GI}}) + \left( \frac{\text{EF}_{\text{inh}} \times \text{ED} \times \left( \frac{1}{6 \text{ yr VF}} + \frac{1}{\text{PEF}} \right)}{\text{AT}} \right) / \text{RfC} \right)}$$

HQ	hazard quotient	0.2
RfD	reference dose	chemical specific
BW	body weight (kg)	70
AT	averaging time (days)	9125
RBA	relative bioavailability	chemical specific
IR	soil ingestion rate (mg/day)	80
CF	conversion factor	0.000001
ED	exposure duration (years)	25
EF <sub>ing</sub>	exposure frequency ingestion (days)	250
EF <sub>der</sub>	exposure frequency dermal (days)	150
EF <sub>inh</sub>	exposure frequency inhalation (days)	250
SA	skin surface area (cm <sup>2</sup> )	3400
AF	dermal adhesion factor (mg/cm <sup>2</sup> )	0.13
ABS <sub>d</sub>	dermal absorption fraction	chemical specific
ABS <sub>GI</sub>	gastrointestinal absorption fraction	chemical specific
VF <sub>IND</sub>	volatilization factor	chemical specific
PEF	particulate emission factor	3.8E+08

## Appendix C, Table 2: Equations and Assumptions for the SRVs

### Industrial Cancer

$$\text{Ind}_c \text{SRV} = \frac{CR \times AT}{\left( \left\{ CSF \times RBA \times EF_{ing} \times CF \times \left( \frac{ED \times IR}{BW} \right) \right\} + \left\{ \frac{CSF}{ABS_{GI}} \times EF_{der} \times ABS_d \times CF \times \left( \frac{ED \times AF \times SA}{BW} \right) \right\} + \left\{ EF_{inh} \times 1000 \times (ED \times IUR) \times \left( \frac{1}{VF} + \frac{1}{PEF} \right) \right\} \right)}$$

CR	cancer risk level	0.00001
AT	averaging time (days)	25550
CSF	cancer slope factor	chemical specific
RBA	relative bioavailability	chemical specific
CF	conversion factor (kg/mg)	0.000001
ED	exposure duration (years)	25
IR	soil ingestion rate (mg/day)	80
EF <sub>ing</sub>	exposure frequency - ingestion (days)	250
EF <sub>der</sub>	exposure frequency - dermal (days)	150
EF <sub>inh</sub>	exposure frequency - inhalation (days)	250
BW	body weight (kg)	70
ABS <sub>GI</sub>	gastrointestinal absorption fraction	chemical specific
ABS <sub>d</sub>	dermal absorption fraction	chemical specific
AF	dermal adhesion factor (mg/cm <sup>2</sup> )	0.13
SA	skin surface area (cm <sup>2</sup> )	3400
IUR	inhalation unit risk	chemical specific
VF	volatilization factor (m <sup>3</sup> /kg)	chemical specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	3.8E+08



**Appendix C, Table 3: Toxicity Values Used in the SRV Equations**

SRV contaminant	Toxicity value used		Source <sup>2</sup>
	Reference dose	Cancer Slope Factor	
PCBs	5.0E-05		MDH, 2001 <sup>3</sup>
Arsenic Residential SRV	3.0E-04		USEPA, 1993
Arsenic Industrial SRV		1.5	USEPA, 1998
Mercury <sup>1</sup>	3.0E-04		USEPA, 1995
cPAHs		7.3	USEPA, 1994
2,4 DNT	2.0E-03		USEPA, 1995
2,4-and 2,6-DNT mixture		6.8E-01	USEPA, 1995
DBP	1.0E-01		USEPA, 1995
Dioxin		1.4E+06	MDH, 2009 <sup>4</sup>
Antimony	4.0E-04		USEPA, 1991
Thallium	8.0E-05		USEPA, 1990

<sup>1</sup> The mercury SRV uses both the mercuric chloride RfD (USEPA, 1995) as well as the RfC for elemental mercury (USEPA, 1995)

<sup>2</sup> The USEPA sources are all from the US EPA Integrated Risk Information System (IRIS) and can be found here: <http://www.epa.gov/ncea/iris/index.html>

<sup>3</sup> The PCB reference dose is used in deriving an MDH multi-media Health Risk Value: <http://www.health.state.mn.us/divs/eh/risk/rules/air/hrvsonar.pdf>

<sup>4</sup> Current MDH guidance for estimating cancer risks from dioxin: <http://www.health.state.mn.us/divs/eh/risk/guidance/dioxinmemo1.pdf>

## Appendix D: Gopher Ordnance Works data used in the cPAH analysis

Sample ID	TT-60-716B	717A-TT2	707FFF-SS7	746B-SS2	TT-25-206B	208E-SS1	235A-TT4	251A-TT3	E160D-TT2	207-DD-TT1											
Date	9/11/2006	7/1/2011	10/13/2011	6/27/2011	9/7/2006	10/28/2011	6/23/2011	6/28/2011	7/14/2011	6/24/2011											
Depth (ft)	1.5-1.5	0.5-0.5	0.5-0.5	0.5-0.5	5-5	0-0.5	0.5-0.5	0.5-0.5	0.5-0.5	0.5-0.5											
Location	GUE (716B)	717A	707FFF	746B	206	208	235	251A	160th St. Dump	L and J Dump											
BaPE, NDs at zero (ppm)	16	3.2	5.7	1	1.6	3.1	31	5.8	9.8	230											
	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Conc. (ppm)	%	Average %
Acenaphthene	2.9	2%	0.42	1%	0.75	1%	0.2	2%	0.32	2%	0.23	1%	8.2	2%	0.42	1%	2	2%	82	3%	<b>2%</b>
Anthracene	5.9	4%	0.64	2%	0.88	1%	0.42	4%	0.6	4%	0.56	2%	18	5%	1.4	3%	4.9	5%	170	6%	<b>4%</b>
Benz(a)anthracene	13.11	8%	2.5	8%	4.1	7%	0.79	7%	1.2	8%	2	8%	26	8%	4.5	9%	7.8	8%	210	8%	<b>8%</b>
Benzo(a)pyrene	10.54	7%	2.2	7%	4	7%	0.67	6%	1.1	7%	2.1	8%	21	6%	4	8%	6.9	7%	160	6%	<b>7%</b>
Benzo(b)fluoranthene	15.26	10%	3.1	10%	6.4	11%	1	9%	1.3	8%	3	11%	26	8%	5.2	11%	8.4	8%	190	7%	<b>9%</b>
Benzo(g,h,i)perylene	6.1	4%	1.2	4%	1.7	3%	0.47	4%	0.5	3%	1.3	5%	9.9	3%	1.8	4%	2.3	2%	57	2%	<b>3%</b>
Benzo(k)fluoranthene	5.8	4%	1.1	3%	1.9	3%	0.37	4%	0.5	3%	1.1	4%	11	3%	2.1	4%	3.7	4%	78	3%	<b>4%</b>
Chrysene	14.51	9%	2.8	9%	5	9%	0.81	8%	1.2	8%	2.5	10%	27	8%	4.5	9%	8.2	8%	200	7%	<b>8%</b>
Dibenz(a,h)anthracene	2.9	2%	0.32	1%	0.43	1%	0.12	1%	0.25	2%	0.35	1%	3.5	1%	0.56	1%	0.9	1%	21	1%	<b>1%</b>
Dibenzofuran	1.8	1%	0.19	1%	0.2	0%	0.14	1%	0.22	1%	0.08	0%	4.8	1%	0.23	0%	1	1%	52	2%	<b>1%</b>
Fluoranthene	23.5	15%	6.2	19%	11	19%	1.7	16%	2.5	16%	4.5	17%	53	16%	8.1	17%	19	18%	420	16%	<b>17%</b>
Fluorene	3.6	2%	0.37	1%	0.36	1%	0.2	2%	0.4	3%	0.19	1%	8.8	3%	0.47	1%	2.1	2%	100	4%	<b>2%</b>
Indeno(1,2,3-cd)pyrene	6.63	4%	1.3	4%	2.1	4%	0.66	6%	0.52	3%	1.5	6%	12	4%	2.2	5%	3.1	3%	66	2%	<b>4%</b>
Phenanthrene	21.6	14%	4.5	14%	9	15%	1.5	14%	2.3	15%	2.8	11%	57	17%	5.1	11%	17	16%	500	19%	<b>15%</b>
Pyrene	23.2	15%	5.5	17%	11	19%	1.5	14%	2.5	16%	3.9	15%	45	14%	6.9	15%	16	15%	390	14%	<b>15%</b>
<b>total PAHs</b>	<b>157.35</b>		<b>32.34</b>		<b>58.82</b>		<b>10.55</b>		<b>15.41</b>		<b>26.11</b>		<b>331.2</b>		<b>47.48</b>		<b>103.3</b>		<b>2696</b>		

Data sources:

2011 data from the Remedial Investigation Report, UMore East, Dakota County, Minnesota. Prepared by Barr Engineering for the University of Minnesota, February 2012.

2006 data from the Concrete and Soil Assessment, UMore Park, Rosemount, Minnesota. Prepared by Peer Engineering, October 2006.

## Appendix E: Surface Soil Contaminants Above Industrial Soil Reference Values (SRVs)

Contaminant	Concentration (ppm)	Date	Depth (ft)	location	Sample ID
Arsenic	43	6/21/2011	0.5 ft	ABC Line	32T-TT2
Arsenic	22	9/11/2006	0-1 ft	ABC Line	TT-63-220C
Mercury	42	12/30/2002	0 ft	GOW East	NA-TP-4
Mercury	30	1/2/2003	0-2 ft	GOW East	WWTP-TP-14
Mercury	29	1/2/2003	0-1 ft	GOW East	WWTP-TP-13
Mercury	20	1/2/2003	0-2 ft	GOW East	WWTP-TP-22
Mercury	16	12/31/2002	0-1 ft	Navy/B.G.	BG-TP-8
Mercury	13	12/31/2002	0-1 ft	Navy/B.G.	BG-TP-2
Mercury	12	10/11/2011	0.5 ft	ABC Line	32T-SS1
Mercury	11	9/27/2007	0-0.5 ft	GOW East	AOC1N-SS1
Mercury	7.3	9/28/2009	0-0.5 ft	GOW East	AOC1N-GP102
Mercury	6.3	7/7/2011	0.5 ft	Sitewide	501C-SS1
Mercury	4.9	9/27/2007	0-0.5 ft	Vermillion Highlands	AOC1M-SS2
Mercury	4.4	10/28/2011	0.5 ft	ABC Line	706A-SS7
Mercury	4.4	6/19/2009	0.5 ft	Outside of 1948 Parcel	BF-SS3
Mercury	1.9	9/27/2007	0-0.5 ft	Vermillion Highlands	AOC1M-GP1
Mercury	1.7	10/28/2011	0.5 ft	ABC Line	706A-SS8
Mercury	1.5	9/24/2009	0-0.5 ft	Vermillion Highalnds	AOC1M-GP101
PCBs	60	10/4/2013	0-0.5 ft	ABC Line - GUE	716A SS13-1
PCBs	26	8/15/2007	0-0.5 ft	GOW East – AOC7A	AOC7A-SS1
PCBs	11	10/4/2013	0-0.5 ft	ABC Line - GUE	716A SS12-1
PCBs	8.9	10/4/2013	0-0.5 ft	ABC Line - GUE	716A SS10-1
Lead	8090	9/11/2006	0-1 ft	GOW East – Bldg 303A	TT-56-303A
Lead	4500	6/27/2011	0.5 ft	Navy/B.G.	10SD-TT3
Lead	3500	6/21/2011	0.5 ft	ABC Line	46T-TT6
Lead	3100	12/31/2002	0-1 ft	Navy/B.G.	BG-TP-15
Lead	2800	10/10/2011	0.5 ft	GOW East – Bldg 303A	303A-SS9
Lead	2400	6/22/2011	0.5 ft	GOW East – Bldg 303A	303A-SS1
Lead	2000	6/22/2011	0.5 ft	GOW East – Bldg 303A	303A-SS2
Lead	1710	9/6/2006	0-0.4 ft	ABC Line	TT-9-108B
Lead	1400	6/22/2011	0.5 ft	GOW East – Bldg 303A	303A-SS5
Lead	1400	6/22/2011	0.5 ft	GOW East – Bldg 303A	303A-SS3
Lead	1300	6/27/2011	0.5 ft	Navy/B.G.	10SD-TT9
Lead	1100	10/28/2011	0.5 ft	GOW East – Bldg 303A	303A-TT3
Lead	1100	10/10/2011	0.5 ft	GOW East – Bldg 303A	303A-SS6
Lead	1000	12/31/2002	0-1 ft	Navy/B.G.	BG-TP-1
Lead	970	6/22/2011	0.5 ft	GOW East – Bldg 303A	303A-SS4
Lead	840	10/10/2011	0.5 ft	GOW East – Bldg 303A	303A-SS10
Lead	730	8/30/2007	0-0.5 ft	GOW East	AOC7D-GP5
cPAHs	260	10/1/2009		Vermillion Highlands	AOC1S-S110
cPAHs	130	8/15/2007	0-0.5 ft	GOW East – AOC7A	AOC7A-SS3

## Appendix E: Surface Soil Contaminants Above Industrial Soil Reference Values (SRVs)

Contaminant	Concentration (ppm)	Date	Depth (ft)	location	Sample ID
cPAHs	54	8/7/2007	0-0.5 ft	GOW West	AOC6-TP3
cPAHs	54	8/15/2007	0-0.5 ft	GOW East – AOC7A	AOC7A-SS1
cPAHs	39	10/10/2011	0.5 ft	Sitewide	501A2-SS4
cPAHs	31	6/23/2011	0.5 ft	ABC Line	235A-TT4
cPAHs	29	8/15/2007	0-0.5 ft	GOW East – AOC7A	AOC7A-SS2
cPAHs	27	7/14/2011	0.5 ft	GOW Central	E160D-TT1
cPAHs	19	9/11/2006	0-1 ft	GOW East – Bldg 303A	TT-56-303A
cPAHs	18	9/6/2006	0-0.3 ft	ABC Line	TT-12-501B
cPAHs	16	10/14/2011	0.5 ft	ABC Line	217A-SS6
cPAHs	16	10/13/2011	0.5 ft	ABC Line	235A-SS2
cPAHs	16	8/15/2007	0-0.5 ft	GOW East – AOC7A	AOC7A-SS4
cPAHs	15	9/7/2006	0-0.5 ft	ABC Line	TT-33-251B
cPAHs	13	10/14/2011	0.5 ft	ABC Line	217A-SS4
cPAHs	10	10/13/2011	0.5 ft	ABC Line	235A-SS3
cPAHs	10	8/7/2007	0-0.5 ft	GOW West	AOC6-TP4
cPAHs	10	9/29/2009	0-0.5 ft	GOW East – AOC7A	AOC7A-SS107
cPAHs	9.9	9/29/2009	0-0.5 ft	GOW East	AOC7D-SS109
cPAHs	9.8	7/14/2011	0.5 ft	GOW Central	E160D-TT2
cPAHs	7.9	8/28/2007	0-0.5 ft	GOW East	AOC7D-GP3
cPAHs	5.8	6/28/2011	0.5 ft	ABC Line	251A-TT3
cPAHs	5.7	10/13/2011	0.5 ft	ABC Line	707FFF-SS7
cPAHs	5.6	9/30/2009	0-0.5 ft	GOW East	AOC7D-SS113
cPAHs	5.5	6/24/2011	0.5 ft	ABC Line	707FFF-SS2
cPAHs	4.6	8/7/2007	0-0.5 ft	GOW West	AOC6-TP6
cPAHs	4.3	7/13/2011	0.5 ft	ABC Line	217A-TT1
cPAHs	3.4	10/13/2011	0.5 ft	ABC Line	251A-SS5
cPAHs	3.2	6/29/2011	0.5 ft	Sitewide	501A2-SS1
cPAHs	3.2	7/1/2011	0.5 ft	ABC Line	717A-TT2
cPAHs	3.1	10/28/2011	0-0.5 ft	ABC Line	208E-SS1
cPAHs	3.1	9/22/2009	0-0.5 ft	GOW East	AOC7D-GP102

It is recommended to remove or prevent access to soil for contaminant concentrations shaded in gray.

Two surface samples of building materials, both containing elevated cPAHs and one containing elevated arsenic, were excluded from Appendix E because they are not soil samples. However, pieces of building materials should also be removed from the surface soils.