Appendix F

Field Methods

Field Methods

UMore Mining Area Groundwater Assessment

Prepared for
University of Minnesota

October22, 2008

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University of Minnesota

October 22, 2008

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Field and Modeling Methods

October 22, 2008

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1.0 Introduction

This document describes the techniques to be used to collect data during the UMore Mining Area (UMA) Groundwater Assessment (Assessment). Routine sampling and data-gathering methods are presented herein. Field investigation tasks will be performed in accordance with the standard operating procedures (SOPs) included in Appendix A. General tasks to be implemented during the Assessment include:

- Drilling and well installation
- Well development
- Soil description
- Water level monitoring
- Aquifer testing
- Groundwater sampling for analytical parameters
- Surveying

No surface water, air, or soil samples will be collected for chemical analysis as part of the Assessment. However, if the scope is modified and additional data collection procedures are required, this document will be revised with addenda.

2.0 Drilling and Well Installation

Environmental drilling will be conducted to advance the pilot boreholes for soil characterization purposes and to install wells for continued hydrogeologic monitoring and testing. The following sections describe the technical approach and general drilling methods that will be employed during the Assessment.

2.1 Pilot Borehole Drilling

Pilot boreholes will be advanced at each planned well location for the purpose of characterizing and correlating the unconsolidated glacial sediments across the UMA and greater UMore Park site. The primary objective for each pilot borings is to characterize the geologic units at that location such that effective monitoring or pumping test wells may be installed.

At each pilot borehole location, soil samples will be collected continuously from the ground surface to the top of the bedrock to ensure complete characterization of the unconsolidated sediments. Due to the significant depths to bedrock at some parts of the site, the granular nature of the glacial sediments and the likelihood of encountering significant hydrostatic pressure at depth possibly resulting in heaving sands, rotasonic drilling techniques will be used to drill the pilot boreholes.

Typical rotasonic drilling will include advancing a 4-inch inner diameter core barrel through the sampling interval and then advancing a 6-inch inner diameter override casing over core barrel while injecting water or a thin drilling fluid to prevent binding. Soil samples will be retrieved in 10 to 20 foot intervals and the soil will be extruded from the core barrel into plastic sleeves at the drilling location. The soil samples will be described in the field by a field geologist and the borehole will be sealed in accordance with State Well Code (MR Rules Chapter 4725) prior to moving to the next pilot borehole location. Specific details regarding soil description are included in Section 4.0.

Based on the geologic descriptions, the field geologist and project manager will determine if a well(s) will be installed at the pilot borehole location. If, based on the geologic descriptions, it is decided that the location is not suitable for a well(s), an alternate location may be selected for the advancement of an additional pilot borehole. If a well is to be installed, the geologic descriptions from that and surrounding pilot borings will be used to select suitable well screens intervals. Well installation methods are described in the following section.

2.2 Well Installation

Two types of wells, pumping wells and monitoring wells, will be installed at the site as part of the Assessment. Pumping wells will be a minimum of 4-inches in diameter and constructed for the purpose of aquifer testing and to provide hydraulic head and water quality monitoring at the base of the surficial aquifer under non-pumping conditions. Monitoring wells will be two-inches in diameter and constructed to monitor hydraulic head and water quality near the water table surface in the surficial aquifer.

Each of the wells will be installed by a licensed well contractor in accordance with State and County well construction standards.

2.2.1 Pumping Wells

The pumping wells will be designed for usage of groundwater extraction during aquifer testing and long term monitoring after the aquifer testing has been completed. The pumping wells will target permeable zones of outwash at the base of the surficial aquifer. The at-depth placement of the well screens will allow for vertical hydraulic gradient estimations with the adjacent monitoring wells.

Preliminary calculations using literature hydraulic conductivity estimates for outwash and other approximated aquifer properties suggest pumping wells constructed with four-inch diameter, 20-foot long well screens will be sufficient to conduct pumping tests as described in Section 6.0. An eight inch diameter (minimum) borehole will be required to accommodate the installation of a four-inch diameter pumping well and annular materials. Due to drilling depths and possibility of encountering heaving sand, mud rotary drilling will likely be used to install the pumping wells.

At each pumping well location, a minimum of one monitoring well will be installed for use as an observation well during pumping tests and to gauge hydraulic head near the water table. Additional monitoring wells at pumping well locations will be considered by the project manager and University staff.

2.2.2 Monitoring Wells

Monitoring wells will be constructed with 2-inch diameter, ten-foot long screens set near the water table. Total depths will be based on geologic descriptions made at the nearby pilot hole. Boreholes used for monitoring well installations will likely be drilled using rotasonic techniques as described in Section 2.1.

3.0 Well Development

Well development will be conducted to remove remnant drilling fluid from the well screen intervals and improve hydraulic connection between the well and the surrounding formation. Well development will occur after a minimum of 48 hours has passed since well installation (to allow for the annular materials to seal).

3.1.1 Pumping Wells

Pumping wells will be developed by a combination of over-pumping and surging until the well produces clean water throughout the screened interval. Development water from the pumping wells will be directed into a settling tank before discharging to the ground surface. Development of pumping wells may take up to 24 hours per well.

3.1.2 Monitoring Wells

Monitoring wells will be developed by bailing, and over-pumping, and/or other methods as described in Appendix A. Development water from monitoring wells will be discharged on the ground surface near the well. Monitoring well development will be considered complete when development water is generally free of sediment. Development of monitoring wells is anticipated to take up to four hours per well.

4.0 Soil Description

The following subsections describe the procedures to be used to describe soils encountered during pilot borehole drilling. In general, soil descriptions during well installation work will focus on confirming the soil descriptions from the pilot borehole.

4.1 Classification

Soil type and textural classification will be determined using visual manual techniques described in ASTM D2488 and recorded on boring logs. In addition, observations regarding the appearance and odor of return drilling fluid, loss or gain of fluid from the formation, ease of drilling and other relevant observations will be recorded on the boring logs or in the field notes.

4.2 Field Screening

Field screening for odor, discoloration, and headspace will be conducted over two-foot-long intervals through the uppermost ten feet of each borehole. Below the upper ten feet, field screening will be conducted in intervals where evidence of contamination (e.g., elevated organic vapor readings, odor, or visual evidence such as staining, sheen, or coatings on soil grains) is present.

4.2.1 Odor

Care will be taken at all times to avoid inhaling dust or vapors from samples. However, incidental odors can be a valuable means of detecting contamination since the odor threshold for many constituents (particularly VOCs) is often much lower than the detection limits of many field instruments.

Incidental odor will be described so that it can be determined the type and magnitude of odor. If obvious and familiar (e.g. fuel type such as diesel or gasoline), then state the likely type of odor. If the odor is less obvious, the general properties perceived or analogous substance with the qualifier “similar to” will be recorded as an approximation. The magnitude of odor will be described as slight (barely detectable), moderate (clearly noticeable), or strong (more than merely noticeable).

4.2.2 Discoloration

Typically, visual evidence of contamination can be either direct (staining, sheen, metal) or indirect (stressed vegetation). The type and magnitude of the visual evidence will be noted on the boring log or field notes. The type of discoloration will define the obvious visual characteristics. If it is sheen, it should be given a color (e.g. rainbow, red, or yellow) as applicable. If an oily residue (coal tar or petroleum) the color should also be given. The magnitude should be classified as trace, light, moderate, heavy, thin film, to free product (thickness if in sample jar with water).

4.2.3 Headspace

All samples will be evaluated using a photo-ionizing detector (PID) equipped with a 10.6 eV lamp. Headspace evaluation will be in accordance with MCPA guidance (Fact sheet 3.22). The method consists of sealing each sample in a half full quart-size Ziploc bag, agitating briefly, allowing headspace to develop for approximately 10 minutes; agitating again and then quickly inserting the probe into a discrete opening about half-way into the bag. The first peak on the instrument shall be recorded.

5.0 Water Level Monitoring

Water level monitoring will be conducted in soil borings during drilling and in wells constructed as part of the Assessment.

5.1 Borehole Measurements

The water level in rotasonic boreholes will be measured by the field geologist upon encountering a suspected confining unit (i.e. measure the unconfined or perched water level) and upon completion of the borehole. If drilling fluid has been used to advance the casing and/or the core barrel, the water level will be allowed to stabilize before continuing to drill.

5.2 Well Measurement

Water levels will be measured manually using an electronic water level indicator in network monitoring and pumping wells on a bimonthly basis in accordance with the SOP included in Appendix A. Depth to water will be measured relative to the surveyed measurement point on the well casing.

6.0 Aquifer Testing

Constant rate aquifer tests will be conducted in the pumping well has returned to static elevation. The constant-rate test will be run for approximately 8 hours. Discharge water will be plumbed approximately 200 feet (minimum) from the pumping well and observation well(s) to avoid recirculation during the pumping test.

6.1 Water Level Monitoring during Aquifer Testing

Water levels in pumping and monitoring wells will be measured before, during, and after the constant-rate aquifer tests. To assure data quality, both manual and automatic measurements will be made. Manual water level measurements will be conducted using an electronic water level indicator. Automatic measurements will be made by a pressure transducer and recorded on a datalogger. The

6.1.1 Manual Measurements

Manual water level measurements will be taken at least bimonthly at all wells from the time of well installation until the conclusion of the study. At pumping wells and associated monitoring wells, manual water levels will be taken at the intervals listed below (times are approximate):

- 12 to 24 hours prior to the constant-rate pumping test
- 1 hour prior to the constant-rate pumping test
- As frequently as is logistically feasible during the constant-rate pumping test
- Near the end of the constant-rate pumping test
- As frequently as is logistically feasible in the 1 hour immediately following the constant-rate pumping test or until water levels have recovered, whichever occurs first
- Within 12 to 24 hours after the constant-rate pumping test until water levels have recovered

Depending on location, other wells near a pumping well may be identified for more frequent monitoring during aquifer tests.

6.1.2 Pressure Transducer/Datalogger Measurements

Pressure transducer/dataloggers (dataloggers) will be installed in the pumping wells and associated monitoring wells during constant-rate pumping testing. Dataloggers will be started at least 12 hours prior to the start of testing and will continue monitoring until water levels have recovered. The following recording intervals will be used (times are approximate):

- Logarithmic (maximum timestep = 2 minutes) during the constant-rate test
- Logarithmic (maximum timestep = 5 minutes) during recovery from the constant-rate test

7.0 Analytical and Geotechnical Samples

Groundwater analytical samples will be collected from all wells during two sampling events. Geotechnical soil samples will be collected to provide additional hydrogeologic characterization data for each primary hydrostratigraphic unit. The collection of soil samples for chemical analysis is not anticipated, however, samples may be collected if evidence of contamination is encountered. The methodology to be used for all sampling is described in the following subsections.

7.1 General Sampling Guidelines

7.1.1 Sample Labeling Convention

Samples will be labeled so as to indicate both the sample location and date. The exception to this rule is duplicate and QC samples, which will be labeled anonymously. Example sample names are given below; this naming convention is to be used for all samples:

- Soil Sample: SB-A2-008(52-54), 12092008
    - SB = soil boring
    - A2 = site grid location
    - 008 = boring/well number
    - (52-54) = sampled depth interval
    - 12092008 = month day year
- Groundwater Sample: MW-B3-004, 11072008
    - MW = monitoring well
    - B3 = site grid location
    - 004 = boring/well number
    - 11072008 = month day year
- Duplicate and QC samples will be identified with the following prefixes followed by a sequential number:
    - M = duplicate (M-1, M-2…)
    - FB = field blank (FB-1, FB-2…)
    - TB = trip blank (TB-1, TB-2…)

7.1.2 Quality Control

7.1.2.1 Duplicates

Field duplicate samples are independent samples collected in such a manner that they are equally representative of the parameter(s) of interest at a given point in space and time. . Duplicate samples, when collected, processed, and analyzed by the same organization, provide intra-laboratory precision information for the entire measurement system, including sample acquisition, homogeneity, handling, storage, preparation, and analysis. Duplicate samples are submitted to the laboratory as blind or masked samples (e.g. M-3). In general, approximately 10% of samples collected will be duplicate samples.

7.1.2.2 Field and Trip Blanks

Trip blanks generally pertain to volatile organic samples only. Trip blanks are prepared prior to the sampling event in the actual containers used to transport the samples, and are kept with the investigative samples throughout the sampling event. They are packaged for shipment and sent for analysis along with the other samples. There should be one trip blank included in each cooler containing VOC samples. At no time after their preparation will the sample containers be opened before they reach the laboratory.

Field blanks (also known as equipment blanks or rinsate blanks) are defined as samples which are obtained by running analyte-free, deionized water through sample collection equipment (bailer, pump, auger, etc.) after decontamination and placing it in the appropriate sample containers for analysis. These samples will be used to determine if decontamination procedures have been sufficient. Soil field blanks are referred to as rinsate blanks. Because most of the samples will be collected with disposable equipment, cross-contamination is less likely. For this reason, field blanks will be collected at a frequency of one per twenty samples.

7.1.3 Sample Logistics

All samples will be containerized in laboratory supplied sample containers and preserved in accordance with analytical methodology requirements. Non-metals samples will be cooled to 4 degrees Celsius. Sample containers collected for VOC will be sealed as separate sample sets within a Ziploc plastic bag for each set of sample containers. All sample containers will be segregated to the extent possible in sample storage coolers according to expected concentrations of contaminants; soil and water samples will be stored separately and according to expected concentrations of parameters of interest.

Samples will be delivered or shipped to the laboratory via a next-day delivery service within 36 hours of sample collection. Shipping receipts will be retained for all samples.

7.2 Groundwater Analytical Samples

Prior to sampling, depth to water and total depth will be measured and recorded along with date and time information. Wells will then be purged and field analytical parameters collected until stability has been reached. Field analytical parameters consist of pH, Eh, conductivity, dissolved oxygen, and turbidity, which will be measured at 3-minute intervals. Stabilization in this case is reached when parameters are stable for three successive readings using the following criteria:

- ±0.1 for pH
- ±3% for specific conductance
- ±10 mV for ORP
- ±10% for dissolved oxygen
- ±10% or below 20 NTUs for turbidity

If five well volumes have been purged and stabilization has not been reached, then the sample will be collected.

7.3 Soil Geotechnical Samples

Geotechnical samples will be collected to estimate soil properties of primary geologic units for hydrogeological characterization purposes. Laboratory testing will include particle size analysis and/or hydraulic conductivity estimates via falling head permeameter testing.

8.0 Surveying

One or more of the following surveying methods will be used to locate boreholes and wells.

- **Global Positioning System (GPS) Receiver** – The default method for locating the horizontal position of sampling locations at the Property will be by GPS receiver. Because the Property consists of open ground with relatively little overhead vegetation, submeter accuracy of GPS readings is attainable. Each point measured with GPS will be stored in UTM coordinates. In general vertical position (elevation) will be collected with GPS but cross-referenced with an optical survey where accuracy of 0.01 feet is required (e.g. for monitoring wells).
- **Total Station** – Total station methods may be used to spot check the GPS readings and/or grid locations and elevations.
- **Optical (Level) Survey** – This method will use an optical autolevel to acquire elevations where accuracy of 0.01 foot is needed. The level will be relative to a temporary or known benchmark. Measurements collected relative to a temporary benchmark will be converted once a permanent benchmark reference is obtained.

9.0 References

MN Rules Chapter 4725, *Rules for Construction and Sealing of Wells and Environmental Boreholes*

ASTM D-422 *Standard Method for Particle Size Analysis of Soils*

ASTM D-1586 *Standard Methods for Penetration Test and Split-Barrel Sampling of Soils*

ASTM D-1587 *Standard Practice for Thin-Walled Tube Sampling of Soils*

ASTM D-2487 *Test Method for Classification of Soils for Engineering Purposes*

ASTM D-2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure*

Appendix A

Standard Operating Procedures

STANDARD OPERATING PROCEDURE

Measuring Static Water Level, Immiscible Layers and Total Well Depth

Revision 0

June 12, 2006

Approved By:

Andrea Nord	Andrea Nord [signature]	11/17/06
Print	QA Manager(s) Signature	Date
Kim Johannessen	Kim Johannessen [signature]	11/17/06
Print	Field Technician(s) Signature	Date

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Annual Review of the SOP has been performed and the SOP still reflects current practice.

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Standard Operating Procedures for Measuring Static Water Level, Immiscible Layers and Total Well Depth

Purpose

The purpose of this procedure is to describe the use of proper instruments and techniques for measuring static water level and total well depth.

Applicability

This SOP applies to all field personnel who measure the water level and total well depth of groundwater wells. These procedures apply to water level contours, well volume measurements, groundwater flow, and purging equipment.

Equipment

Popper
Electric water level indicator
Electronic Oil/Water Interface Probe
Tape
Chalk
Field Sampling Report
Field Log Cover Sheet
Field Log Data Sheet
Water Level Data Sheet
Steel Wool
Distilled Water
Hexane
Tap water
Container
Liquinox®

References

Procedures for Ground Water Monitoring: MPCA Guidelines; Quality Assurance Manual: Groundwater and Surface water Sampling Procedures, Barr Engineering Co.

Responsibilities

The environmental technician(s) is responsible for the proper measurement and documentation of water level and /or immiscible layers and well depth. The role of the Health and Safety Officer is to oversee all aspects of job safety.

Discussion

For new wells, water level measurements should not be taken until the water table has stabilized—preferably 24 hours after well installation and/or development. Water levels will be measured before sample collection.

Types of water level measurement devices:

Popper

A popper consists of a hollow weight, usually a deep socket with an eye bolt attached. This is secured to the end of a measuring tape. When the socket strikes the water surface, a "popping" sound is made. The accurate reading can be made by lifting and lowering the socket in short strokes, reading the tape when the weight barely strikes the water. Most poppers have a correction factor because of the way they are made. Always check the unit's correction factor and record both the direct reading and the corrected water level. Poppers are ineffective in wells where the water level is within the well screen.

Note: The "popping" sound cannot be heard in wells where the water level is in the well screen. An alternate water level measuring device should be used in this type of well.

- **Electric Water Level Indicator**

  This instrument consists of a spool of marked cable, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed, and a meter light and/or buzzer attached to the spool signals the contact. The depth to water is indicated by the markings on the cable. AA or 9V batteries are normally used for a power source. Always have spare batteries on hand.

- **Tape and Chalk**

  The tape and chalk method is used when neither the popper nor the electric water level indicator method are successful. To determine the water level with tape and chalk, cover the first 2 to 3 feet of metal tape with chalk or paste. Lower the tape to the expected depth of the water, and note the depth of the tape against the high side of the well casing. After removing the tape from the well, note the highest point on the tape that has been wetted. Subtract that number from the total depth of the tape to determine the depth to water.

  Note: Tape and chalk method does not work until the bottom is felt.

- **Electronic Oil/Water Interface Probe**

  This instrument consists of a flat measuring tape with a probe attached to the end and a grounding mechanism. Turn the product level indicator on by the switch/crank handle. Attach the grounding mechanism to a metal source (well casing) and lower the probe down the well. A solid buzz signals the contact of the static level of product. Continue lowering the probe through the product until the original signal changes to an intermittent buzz. This signals the contact of the static water level. The instruments power source is six AA batteries, or two nine volt batteries.

Procedure

A. Measuring Water level

Water levels are usually taken at all wells on the same day, before purging any wells. Lower chosen type of water level-indicating device into the well. Read the water level directly off of the tape. Record the data on the appropriate data sheets (make any corrections if a popper was used). Rinse the portion of the device that made contact with the water. Collect all rinsate water in a bucket.

All groundwater level measurements are made from the north side of the well riser and double check each reading. The water and product levels are recorded to the nearest 0.01 foot and total depths to the nearest 0.5 foot.

To ensure consistent results, all groundwater level measurements are made in reference to an established point on the well casing. Water level measurements are made from the high side of the riser pipe or well casing unless otherwise specified. If the top of the riser is apparently level, take the readings at the north side of the riser. Measuring the distance from the top of the well to the groundwater surface can be accomplished using a popper, an electric water level indicator, or the tape and chalk method, described below. All water level measuring devices will be cleaned between wells with tap water and TSP and rinsed with tap water.

B. Determine Well Depth

Determine the total well depth by lowering the device into the well. After feeling the bottom of the well, raise and lower the device several times to ensure the bottom is being felt. Record total well depth and rinse the device. Collect all rinsate water in a bucket.

C. Determine Product Thickness

To determine the product thickness, slowly lower the probe into the well. If product is present, a steady tone will activate. If there is no floating product, an intermittent tone will activate. Raise and lower the probe gently to determine the exact upper level of nonconductive floating product. Read the level of the air/product interface from the measuring tape.

To ready the product/water interface, lower the probe into the water until the intermittent tone remains on. Shake probe slightly to clear product from the conductivity sensor. Raise the probe slowly until a steady tone activates. Read the level directly from the tape.

Note: Tape-and-chalk method does not work until the bottom is felt.

Cleaning and Maintenance

After each use, the tape should be wiped clean and carefully rewound onto the reel.

Decontamination

The probe should be cleaned as follows:

- Wash probe thoroughly with a detergent, such as TSP, Liquinox® or equivalent.

- Use cleaning brush through side and base holes to remove all product from inner part of the probe.

- Use steel wool to scrub bottom pin.

- Rinse probe thoroughly with distilled water; wipe dry.

- Return the probe to the holder, ensuring that both switches are turned off.

Other suitable cleaning methods include:

- Hexane and distilled water rinsing.

- Steam cleaning for tape only.

Disposal

Rinsate water from the above cleaning procedures shall be collected in a bucket for proper disposal, (e.g., at an onsite industrial wastewater treatment facility or sewer system as determined by the client). All disposal procedures shall meet all applicable Federal, State and Local regulations.

Documentation

The field technician will record the water level, total depth, and product level measurements on the water level data sheet and the field log data sheet for each well.

Attachments

Attachment 1: Field Sampling Report
Attachment 2: Field Log Cover Sheet
Attachment 3: Field Log Data Sheet
Attachment 4: Water Level Data Sheet

Attachment 1
Field Sampling Report

BARR

FIELD SAMPLING REPORT

Date:

Project:

Contact:

Barr Engineering Company
4700 W. 77th Street
Minneapolis, MN 55435-4803

Field Sampling

Field Report

Attachments:

-
-
-
-
-
-
-

Laboratory Analysis Status

____
<Name inserts here>
Environmental Technician

Document1

Barr Engineering Company ˙ 4700 W. 77th Street ˙ Minneapolis, MN 55435-4803 ˙ 952/832-2600

Attachment 2
Field Log Cover Sheet

BARR

FIELD LOG COVER SHEET
WATER SAMPLING

Client: **Project No.:**

Technician: **Sampling Period:**

Date	Temperature	Wind Speed	Wind Direction	Cloud Cover

Summary of Field Activities

Document1

Barr Engineering Company ' 4700 W. 77th Street ' Minneapolis, MN 55435-4803 ' 952/832-2600

Attachment 3
Field Log Data Sheet

BARR

Barr Engineering Company
Field Log Data Sheet

Client:	**Monitoring Point:**
Location:	**Date:**
Project #:	**Sample Time:**

GENERAL DATA		STABILIZATION TEST						
Barr lock:		Time/ Volume	Temp. °C	Cond. @ 25	pH	Eh	D.O.	Turbidity Appearance
Casing diameter:								
Total well depth:*								
Static water level:*								
Water depth:*								
Well volume: (gal)								
Purge method:								
Sample method:								

Start time:		Odor:
Stop time:		Purge Appearance:
Duration: (minutes)		Sample Appearance:
Rate, gpm:		Comments:
Volume, purged:		
Duplicate collected?		
Sample collection by:		CO2- Mn2- Fe(T)- Fe2-

Others present:

WELL INSPECTION (answer for each category, state if lock replaced, detail any repairs needed on back of form)

CASING & CAP: COLLAR: LOCK: OTHER:

MW: groundwater monitoring well WS: water supply well SW: surface water SE: sediment other:

VOC- semi-volatile- general- nutrient- cyanide- DRO- Sulfide-

oil,grease- bacteria- total metal- filtered metal- methane- filter-

Others:

*Measurements are referenced from top of riser pipe, unless otherwise indicated.

S:\DM\Templates\FieldLogDataSheet.doc

Attachment 4
Water Level Data Sheet

WATER LEVEL REPORT

Project: ______________________________

Project Number: ______________________________

Environmental Staff: ______________________________ Date: ______________

Monitoring Location	Measuring Point Elevation	Water Level Depth	Total Well Depth	Static Water Elevation	Comments

STANDARD OPERATING PROCEDURE

For Monitoring Well Development

Revision 1

April 21, 2008

Approved By:	Andrea Nord	Andrea Nord	06/25/08
	Print	QA Manager(s) Signature	Date
	Kim Johannessen	Kim Johannessen	06/25/08
	Print	Field Technician(s) Signature	Date

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Annual Review of the SOP has been performed and the SOP still reflects current practice.

Initials: ______________	Date: ______________
Initials: ______________	Date: ______________
Initials: ______________	Date: ______________
Initials: ______________	Date: ______________
Initials: ______________	Date: ______________

Standard Operating Procedures for Monitoring Well Development

Purpose

To describe how to develop a) new monitoring wells that have just been installed or b) existing monitoring wells that may have become partially filled with sediment during use as a monitoring well. These procedures are performed with the objective of obtaining representative groundwater information and water quality samples from aquifers. These procedures may also be employed for development of fractured bedrock formation monitoring wells.

Applicability

These procedures are used to remove the fine-grained materials from a well or well bore as a result of boring or well construction. Monitoring wells must be developed to provide water free of suspended solids and to yield representative samples. Well development should result in a well that yields visibly clear groundwater.

Definitions

Bridging: The tendency for particles moving towards a well under unidirectional flow (pumping) to develop a blockage that restricts subsequent particles to move into a well.

Surge Block: A tool used to destroy bridging by inducing agitation and inducing flow into and out of the well and aquifer formation.

References

American Society for Testing and Materials (ASTM), 1994. *Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers.* Designation D5521-94. Pp. 347-361.

Driscoll, F.G., 1986. *Groundwater and Wells. Johnson Filtration Systems, St. Paul, Minnesota.* Pp. 497-533.

Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells by the National Water Well Association.

US Environmental Protection Agency, 1986. *RCRA Ground-Water Monitoring Technical Enforcement Document.* Prepared by the Offices of Waste Programs Enforcement and Solid Waste and Emergency Response. Pp. 87-88.

Discussion

Successful development methods include bailing, surging, and flushing with air or water. The basic principle behind each method is to create reversals of flow in and out of the well (and/or bore hole) to break-down the mud cake or disturbed zones where fine-grained particles may be concentrated at the borehole-formation interface, and to draw the finer materials into the hole for removal. This process also helps remove fine fraction formation materials in proximity to the borehole, leaving behind a “natural” pack of coarser-grained materials.

Responsibilities

The well drillers should be responsible for the development of monitoring wells at the time of installation, unless otherwise specified in the contract. Successful development of a new well may be a requirement of the drilling specifications. A well driller would typically be engaged to assist in re-developing an existing well since drilling contractors have the best access to the necessary tools and equipment to perform the development work.

Procedure

Bailing. In relatively clean, permeable formations where water flows freely into the borehole, bailing is an effective development technique. Let the bailer fall down the well until it strikes the surface of the groundwater which produces an outward surge. Rapidly withdraw the bailer to create a drawdown and/or after the bailer hits the groundwater lower it to the bottom of the well and agitate it with rapid short strokes. Continue bailing with repeated up and down "surging motions" until water bailed from the well is free from suspended particles.

Note: During this process, if the well goes dry, stop bailing and let the well recharge before continuing.

Surge Block (Preferred Method). A surge block is used alternately with either a pump or bailer. Let the surge block fall down the well until it strikes the groundwater surface. This creates a vigorous outward surge; rapidly retrieve the surge block. Lower the surge block to the top of the well intake and begin a pumping action with a typical stroke of approximately 3 feet and gradually work downward through the screened interval. Remove the surge block at regular intervals to discard the loosened suspended particles by either bailing or pumping. Continue the cycle of surging/bailing/pumping until satisfactory development has been attained.

Pumping/Over-pumping. In both pumping techniques, the groundwater flow is induced to flow into the well and the fine particulate material moves into the well and is discharged by the pump. In the case of over-pumping, the pump is operated at a capacity that substantially exceeds the ability of the formation to deliver water. Once pumping has begun, start the surging action by lowering and raising the hose/pumping apparatus through the screened interval. Bailing or bailing and surging may be combined with pumping for efficient well development. Continue pumping until such time as satisfactory development has been attained based on field observation of visibly clear water produced. If an analytical measure is needed, use turbidity meter readings to document initial turbidity and final turbidity readings. Well stabilization parameters may also be measured and documented pre- and post-development.

Note: The types of pumps used are described in the SOP on purging groundwater wells.

Documentation

The field technician(s) will document the method of development and any deviations thereof and the volume of water purged.

Attachments

Attachment 1: Field Sampling Report
Attachment 2: Field Log Cover Sheet
Attachment 3: Field Log Data Sheet

Attachment 1
Field Sampling Report

BARR

FIELD SAMPLING REPORT

Date:

Project:

Contact:
Barr Engineering Company
4700 W. 77th Street
Minneapolis, MN 55435-4803

Field Sampling

Field Report

Attachments:

-
-
-
-
-
-
-

Laboratory Analysis Status

____
<Name inserts here>
Environmental Technician

Document1

Barr Engineering Company · 4700 W. 77th Street · Minneapolis, MN 55435-4803 · 952/832-2600

Attachment 2
Field Log Cover Sheet

BARR

FIELD LOG COVER SHEET
WATER SAMPLING

Client: **Project No.:**

Technician: **Sampling Period:**

Date	Temperature	Wind Speed	Wind Direction	Cloud Cover

Summary of Field Activities

Document1

Barr Engineering Company ' 4700 W. 77th Street ' Minneapolis, MN 55435-4803 ' 952/832-2600

BARR

Attachment 3
Field Log Data Sheet

Client:								Monitoring Point:
Location:								**Date:**
Project #:								**Sample time:**
GENERAL DATA		**STABILIZATION TEST**						
Barr lock:		Time/ Volume	Temp. ºC	Cond. @ 25	PH	ORP/ unit	D.O.	Turbidity Appearance
Casing diameter:								
Total well depth:*		NA						
Static well level:*								
Water depth:*								
Well volume: (gal)								
Purge method:								
Sample method:								
Start time:		Odor:						
Stop time:		Purge Appearance:						
Duration: (minutes)		Sample Appearance:						
Rate, gpm:		Comments:						
Volume purged:								
Duplicate collected:								
Sample collection by:								
Others present:			Well condition:					
MW: groundwater monitoring well	WS: water supply well	SW: surface water	SE: sediment	Other: sump				
VOC	Semi-volatile	General	Nutrient	Cyanide	DRO	Sulfide		
Oil, grease	Bacteria	Total Metal	Filtered Metal	Methane	Filter			
Others:								

Tables

TABLE 1
PROPOSED WELL NETWORK
UMA Groundwater Assessment Work Plan
Dakota County, Minnesota

Well ID Number	Pilot Boring	Planned Screen Placement		Planned Location (approximate)		Approximate Ground Elevation (ft MSL)	Estimated Water Table Elevation (ft MSL)	Estimated Bedrock Elevation (ft MSL)	Estimated Depth to Bedrock (ft)	Planned Well Depth (ft)	Planned Screen Interval			Well Diameter (inches)	Monitored Unit	Planned Uses
		Water Table	Below Water Table	UTM E (m)	UTM N (m)						Top (ft bgs)		Bottom (ft bgs)			
MW-B1-001		X		490908	4953113	950	885	825	125	80	70	-	80	2	Outwash	HH, WQ
MW-D1-002		X		491015	4951603	945	890	775	170	70	60	-	70	2	Outwash	HH, WQ
MW-A3-003	X	X		493193	4953524	940	880	800	140	75	65	-	75	2	Outwash	HH, WQ
MW-C2-004	X	X		492231	4951784	950	885	775	175	80	70	-	80	2	Outwash	HH, WQ
MW-E1-005	X	X		491081	4950114	950	890	850	100	75	65	-	75	2	Outwash	AT, HH, WQ
PW-E1-205			X	491081	4950114	950	890	850	100	100	80	-	100	4	Outwash	AT, HH, WQ
MW-A6-006	X	X		495024	4953338	930	860	750	180	85	75	-	85	2	Outwash	HH, WQ
MW-D3-007		X		492770	4951478	940	885	790	150	70	60	-	70	2	Outwash	HH, WQ
MW-B2-008	X	X		492072	4952683	950	885	805	145	80	70	-	80	2	Outwash	AT, HH, WQ
PW-B2-208			X	492072	4952683	950	885	805	145	145	125	-	145	4	Outwash	AT, HH, WQ
MW-E2-009		X		491798	4950771	950	885	810	140	80	70	-	80	2	Outwash	HH, WQ
PW-E2-209			X	491798	4950771	950	885	810	140	140	120	-	140	4	Outwash	AT, HH, WQ
MW-E4-010		X		493211	4950075	945	880	860	85	80	70	-	80	2	Outwash	AT, HH, WQ
MW-D5-011		X		494735	4951004	935	870	885	50	80	70	-	80	2	St. Peter	HH, WQ
MW-B4-012		X		493675	4952441	940	865	775	165	90	80	-	90	2	Outwash	HH, WQ
MW-C7-013		X		495968	4952027	925	855	855	70	85	75	-	85	2	St. Peter	HH, WQ

Notes:
Well ID Number - Prefix corresponds to type of well (MW = monitoring well; PW = pumping well); Center segment corresponds to Umore Park Grid System (shown on Figure 10); Suffix corresponds to serial number location (XX1 = location #1, XX2 = location #2, etc.) and relative screen placement (0XX = water table well, 1XX = submerged screen in middle portion of outwash, 2XX = submerged screen at base of outwash)
Pilot Boring - 'X' indicates a pilot boring will be advanced prior to well installation. For locations without pilot borings, stratigraphic information from the Geologic Assessment (ProSource, 2008) will be used
UTM - Universal transmercator system in meter; E = easting; N = northing
m - Meters
ft MSL - Feet relative to mean sea level
ft bgs - Feet below ground surface
HH - Hydraulic head monitoring
WQ - Water quality monitoring
AT - Aquifer testing

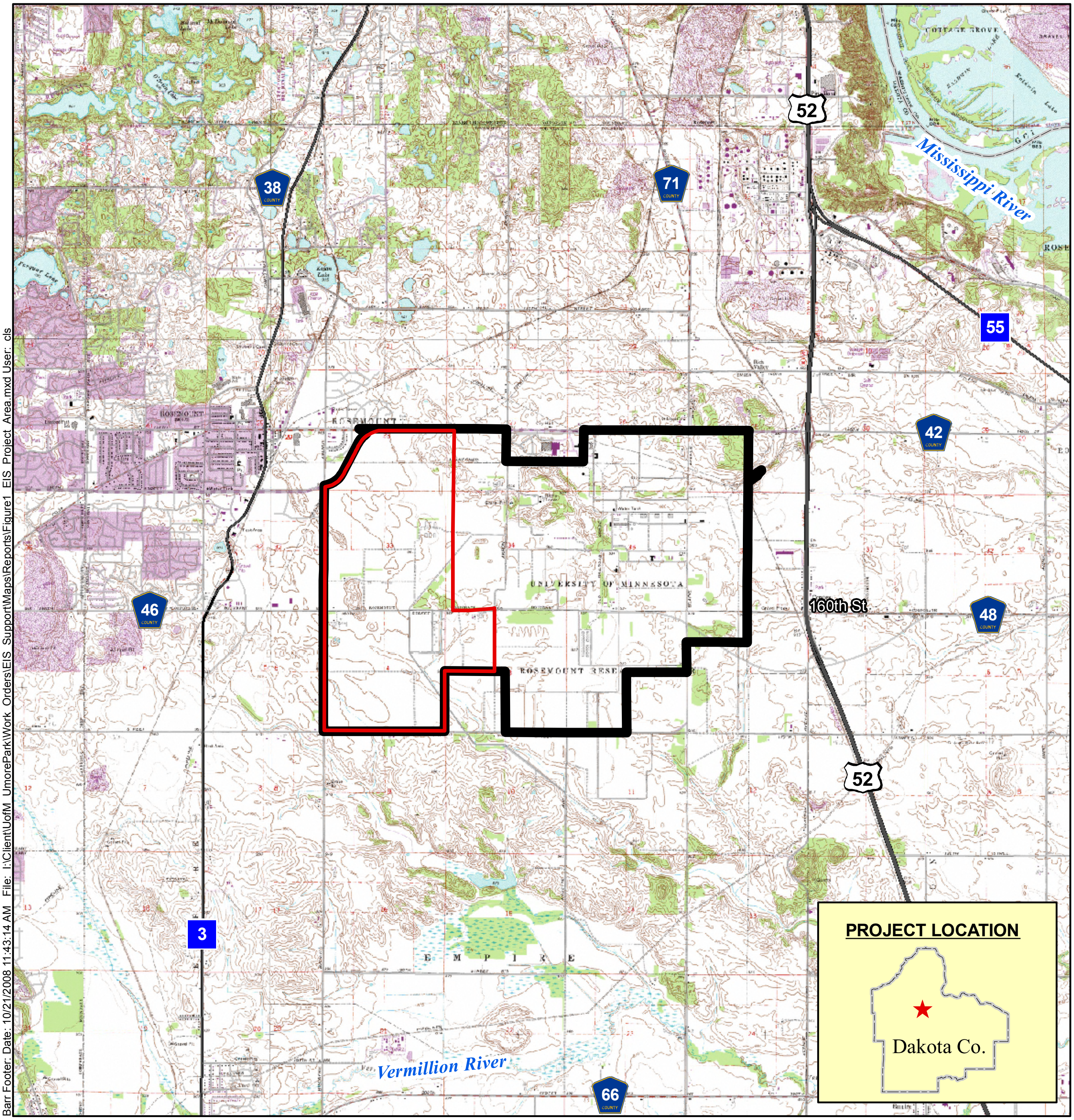
TABLE 2
Selected Existing Well Construction Summary
UMA Groundwater Assessment Work Plan
Dakota County, Minnesota

Well ID	Location		Approximate Ground Elevation (ft MSL)	Estimated Groundwater Elevation (ft MSL)	Approximate Well Depth (feet)	Screened Interval		Monitored Unit	Proposed Use
	UTM E (m)	UTM N (m)				Top (ft bgs)	Bottom (ft bgs)		
Wells Located on UMore Property									
PDC-E1-185278	490996	4950779	951	NA	310	145	310	PDC	GW Elevation Monitoring
PDC-D3-207605	492808	4951477	943	NA	206	NR	NR	PDC	GW Elevation Monitoring
PDC-C2-208402	492215	4951596	950	875	166	161	166	PDC	GW Elevation Monitoring
Q-B4-208403	493701	4953115	940	NA	188	172	188	Quaternary	GW Elevation Monitoring
Q-B3-208404	492923	4953129	940	NA	115	100	115	Quaternary	GW Elevation Monitoring
PDC-C7-227460	495755	4952362	922	NA	88	NR	NR	PDC	GW Elevation Monitoring
PDC-B7-425291	495665	4952591	930	NA	230	97	130	PDC	GW Elevation Monitoring
PDC-C7-425292	495654	4952117	926	NA	230	105	230	PDC	GW Elevation Monitoring
Wells Located off of UMore Property									
PDC-457126	493664	4954047	940	NA	245	NR	NR	PDC	GW Elevation Monitoring
Q-539518	497006	4950061	920	NA	68	NR	NR	Quaternary	GW Elevation Monitoring
PDC-540395	497022	4949955	920	NA	99	NR	NR	PDC	GW Elevation Monitoring
Q-T00020	497152	4951519	922	NA	63	NR	NR	Quaternary	GW Elevation Monitoring
Q-T00022	497161	4954121	882	NA	NR	NR	NR	Quaternary?	GW Elevation Monitoring
Q-698456	492136	4948292	800	NA	19	8.5	18.5	Quaternary	GW Elevation Monitoring
Q-698459	490784	4949593	950	NA	50.5	44.5	49.5	Quaternary	GW Elevation Monitoring
Q-698460	488720	4950502	850	NA	80.5	72	77.5	Quaternary	GW Elevation Monitoring
Q-698461	487651	4951463	950	NA	56	50	55	Quaternary	GW Elevation Monitoring
Q-698462	489252	4949992	950	NA	65.5	59.4	64.4	Quaternary	GW Elevation Monitoring

Notes:

Well ID Number - Prefix corresponds to monitored unit (Q = Quaternary; PDC = Prairie du Chien); Center segment corresponds to Umore Park Grid System (shown on Figure 10); Suffix corresponds to Minnesota unique well identification number
UTM - Universal Transverse Mercator system in meters; E = easting; N = northing
m - Meters
ft MSL - Feet relative to mean sea level
ft bgs - Feet below ground surface
PDC - Prairie du Chien
NR - Indicates no record or data incomplete based on review of available records

Figures



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UMore Mining Area (UMA)

UMore Park Boundary

Feet

6,000 0 6,000

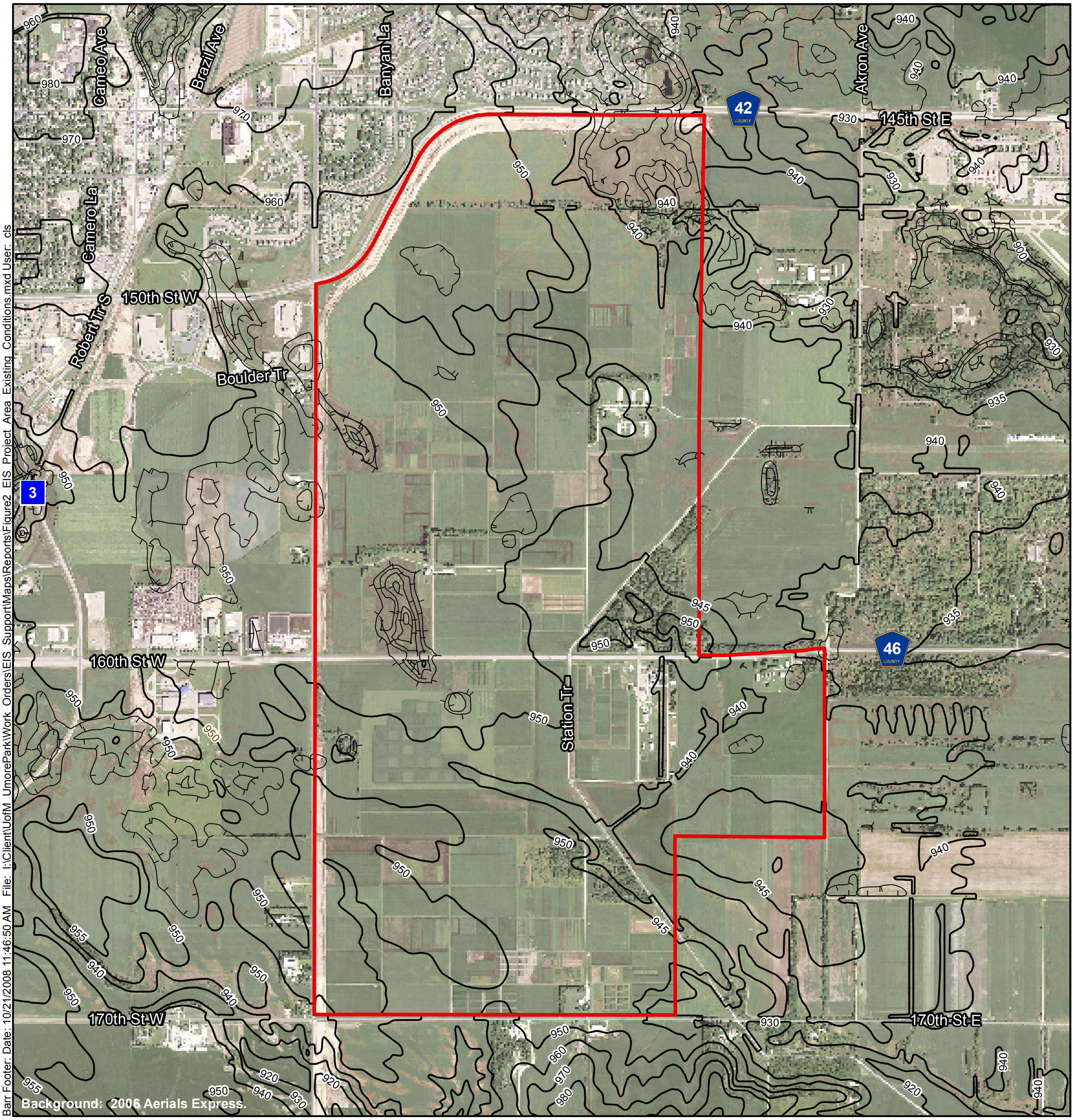
Figure 1

UMORE PARK AND
UMA LOCATION

UMore Mining Area
Groundwater Assessment
Dakota County, MN

Source: MnDOT, MN DNR, Dakota County, Barr, SEH, HKGi.
USGS topographic map background downloaded from the U.S.
Department of Agriculture, Natural Resources Conservation Service.

BARR



UMore Mining Area (UMA)

Ground Surface Contour

Depressional Ground Surface Contour

N

Feet

2,000 0 2,000

Figure 2

UMA EXISTING CONDITIONS

UMore Mining Area
Groundwater Assessment
Dakota County, MN

Source: Metropolitan Council, MnDOT, MN DNR, Dakota County, USGS, Barr, SEH.

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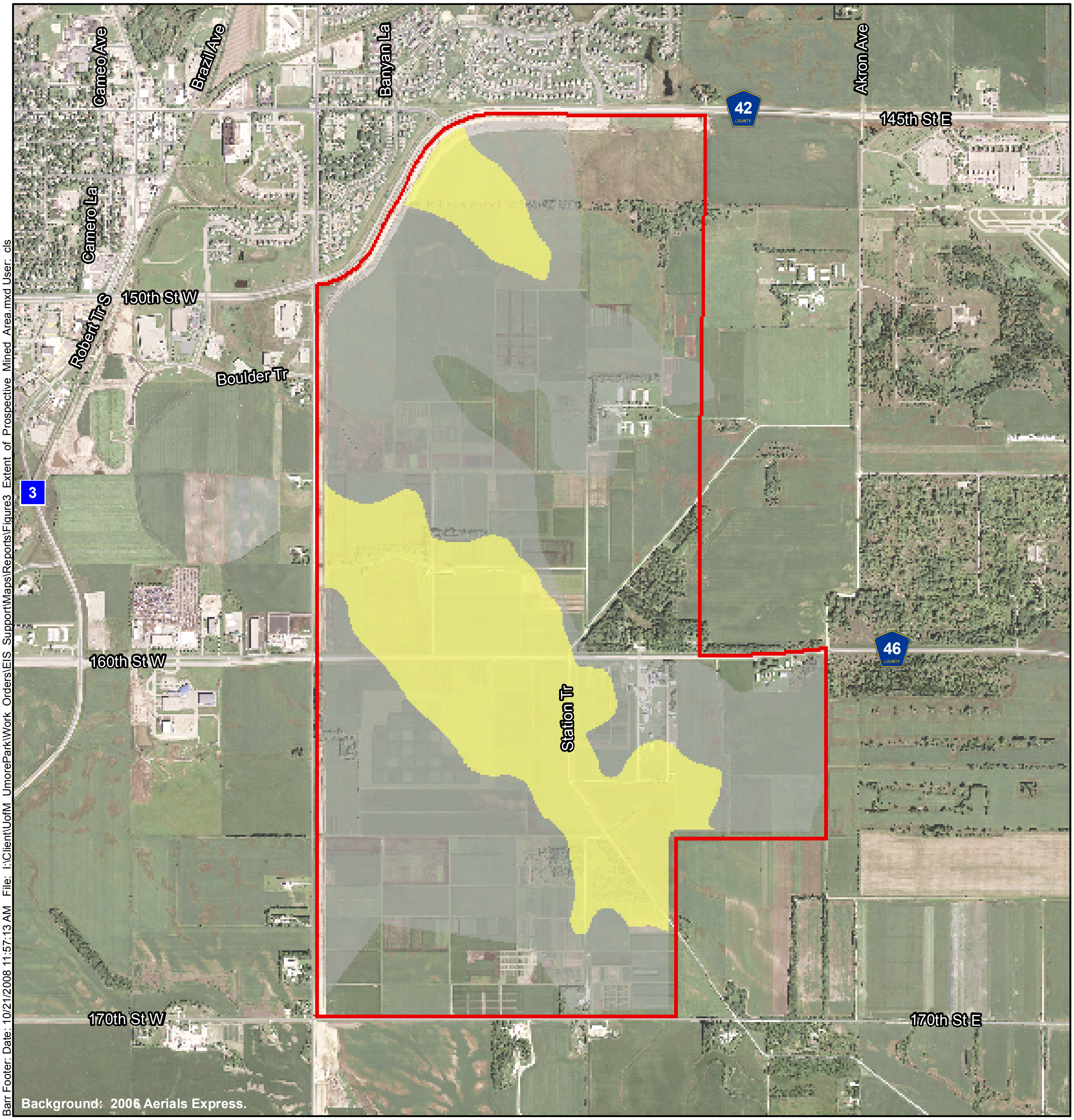

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UMore Mining Area (UMA)

Economic Gravel Deposit Below the Water Table (Approximate)

Gravel Deposit Areas (ProSource, 2008)

Feet

2,000 0 2,000

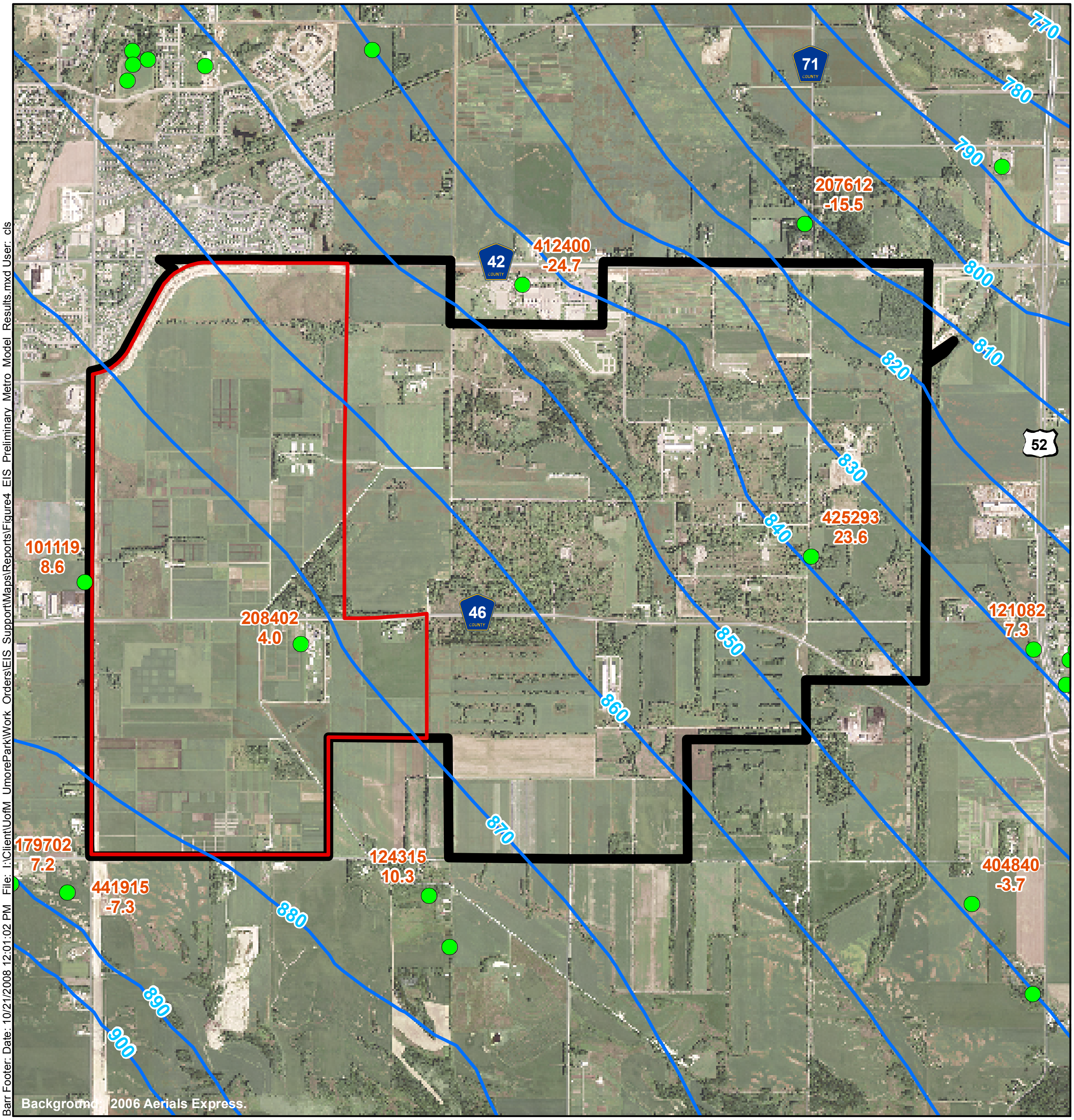
Figure 3

EXTENT OF PROSPECTIVE MINED AREAS

UMore Mining Area Groundwater Assessment Dakota County, MN

Source: ProSource, MnDOT, Dakota County, USGS, Barr, SEH.

UMP003333



Calibration Target (with Well ID No. & Residual Errors in Feet)

Groundwater Contours (ft MSL)

UMore Mining Area (UMA)

UMore Park Boundary

Feet

2,000 0 2,000 4,000

Figure 4

METRO MODEL PRELIMINARY OUTPUT

UMore Mining Area Groundwater Assessment Dakota County, MN

Source: Metropolitan Council, MnDOT, MN DNR, Dakota County, USGS, Barr, SEH, HKGi.
GW contours are from the new Metro Groundwater Model.

BARR

UMP003334

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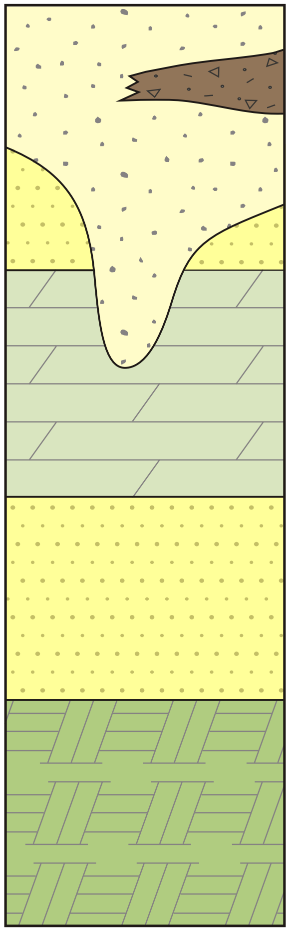
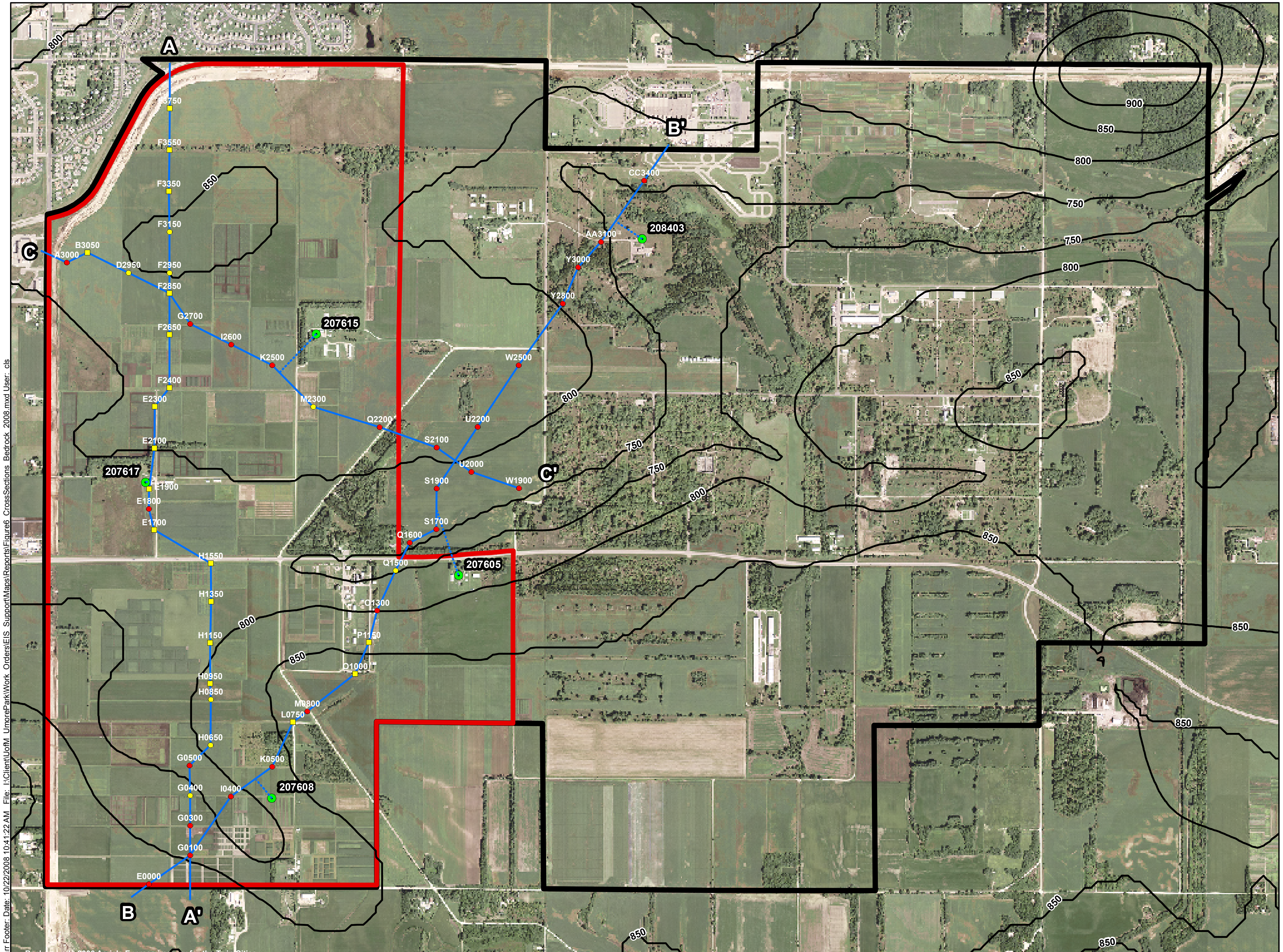


Formation Name and Graphic	Description	Site Nomenclature	Hydrogeologic Role
Unconsolidated Glacial Deposits	Unconsolidated sand and gravel	Outwash (sand & gravel deposit)	Surficial Aquifer
	containing fine grained diamicton (till-like)	Till	Leaky Confining Unit
	and lacustrine deposits.	Lacustrine - Lake bed silts & clays	Leaky Confining Unit
St. Peter	Fine to medium grained sandstone	St. Peter Sandstone	Aquifer (where saturated)
Shakopee and Oneota	Thin to medium-bedded crystalline dolomite	Prairie du Chien	Aquifer
Jordan	Fine to coarse sandstone	Jordan Sandstone	Aquifer
St. Lawrence	Dolomitic shale and siltstone	St. Lawrence	Regional Confining Unit

Figure 5

GENERALIZED STRATIGRAPHIC COLUMN
UMore Mining Area Groundwater Assessment
Dakota County, Minnnesota



Barr Footer: Date: 10/22/2008 10:41:22 AM File: I:\Client\UofM UmoreParkWork Orders\EIS Support\Maps\Reports\Figure6 CrossSections Bedrock 2008.mxd User: cls

Approximate Well Locations
Cross Section
Bedrock Contours*
UMore Park Boundary
UMore Mining Area (UMA)

Boring Locations
Phase I, Auger (ProSource, 2008)
Phase II, Auger (ProSource, 2008)
Phase II, Coring (ProSource, 2008)

Source: ProSource, SEH, Barr.

*Bedrock contours were generated from 30-meter DEM obtained from the Metropolitan Council. The Metropolitan Council DEM was interpolated from 50-foot bedrock contours obtained from the Minnesota Geological Survey. Contour Interval = 50 feet.

N

Feet
1,500 0 1,500

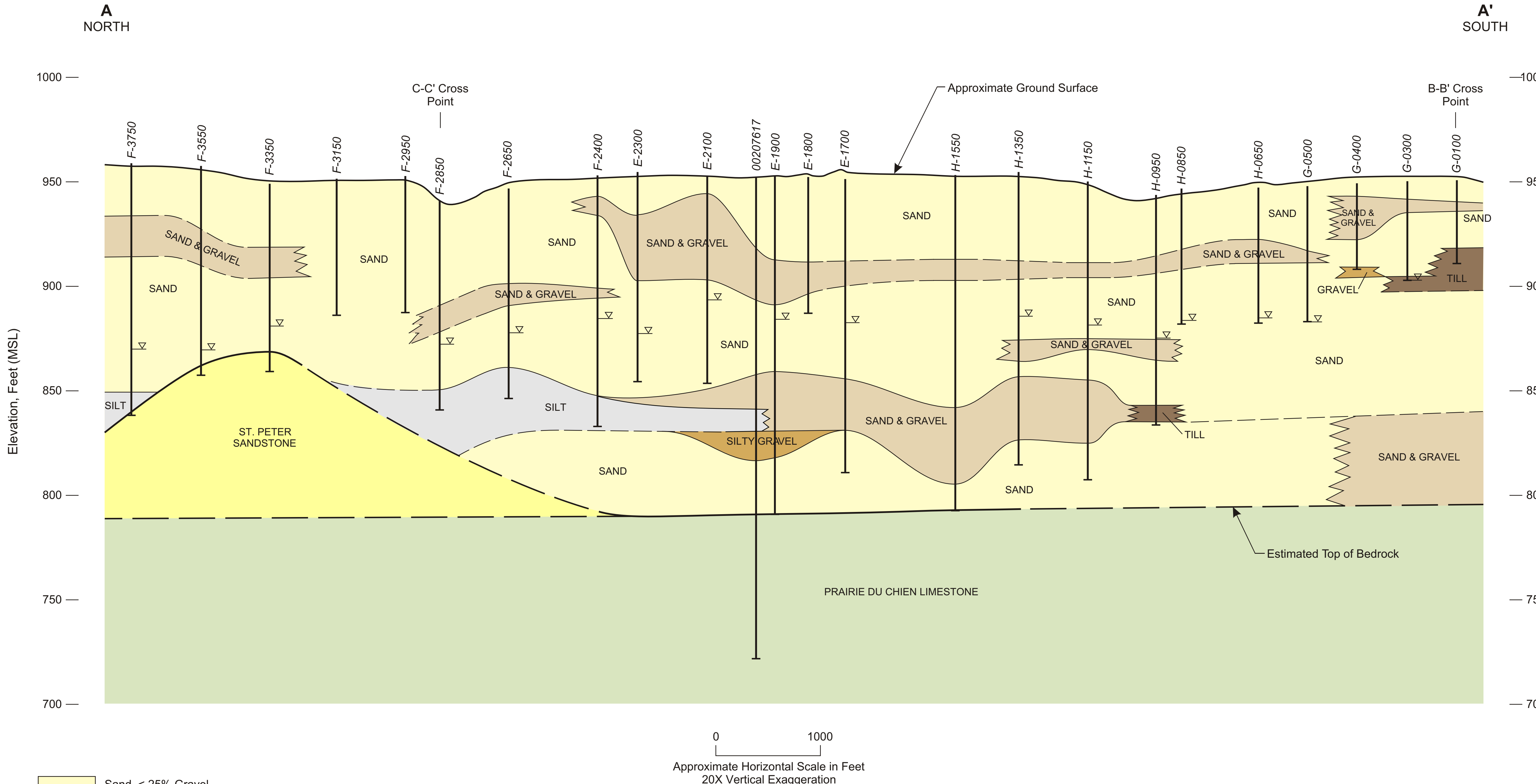
Figure 6

BEDROCK CONTOURS AND CROSS SECTION LOCATIONS

UMore Mining Area
Groundwater Assessment
Dakota County, MN

BARR

UMP003336



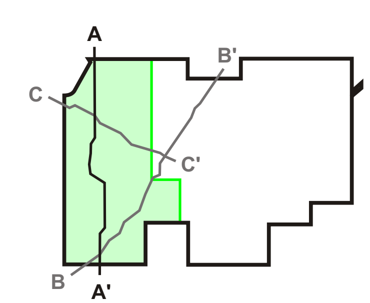
- Sand, < 25% Gravel
- Sand & Gravel, 25-40% Gravel
- Gravel, > 40% Gravel
- Glacial Diamicton
  - Till/Diamicton
- Lacustrine
  - Silt/Clay
- St. Peter Sandstone
- Prairie du Chien Dolomite

Approximate Groundwater Elevation (From ProSource gINT Lithology Table or CWI)

Boring (Top of boring elevation and boring depth is from ProSource gINT boring records or CWI)

NOTES:

1. Ground Surface derived from USGS National Elevation Dataset (NED) 10-meter Digital Elevation Model (DEM)
2. Geologic descriptions from ProSource (2008) and Minnesota County Well Index.
3. Isolated geologic units less than 10 feet thick are not shown.



Cross Section Location Map

Figure 7

CROSS SECTION A-A'
UMore Mining Area Groundwater Assessment
Dakota County, Minnesota

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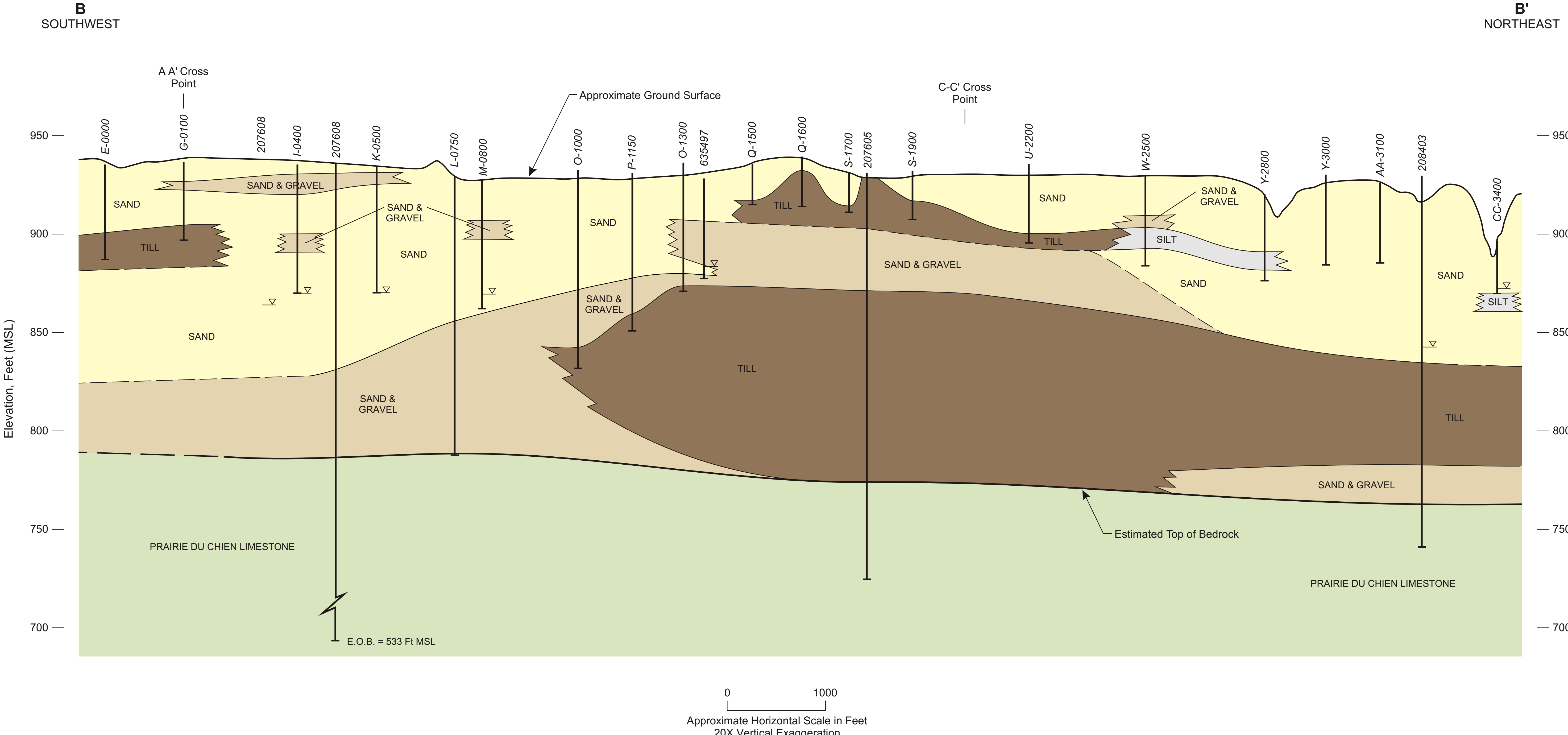


Sand, < 25% Gravel

Sand & Gravel, 25-40% Gravel

Gravel, > 40% Gravel

Glacial Diamicton
- Till/Diamicton

Lacustrine
- Silt/Clay

St. Peter Sandstone

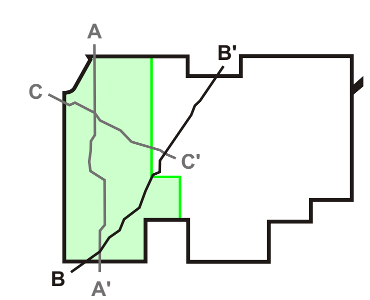
Prairie du Chien Dolomite

Approximate Groundwater Elevation (From ProSource gINT Lithology Table or CWI)

Boring (Top of boring elevation and boring depth is from ProSource gINT boring records or CWI)

NOTES:

1. Ground Surface derived from USGS National Elevation Dataset (NED) 10-meter Digital Elevation Model (DEM)
2. Geologic descriptions from ProSource (2008) and Minnesota County Well Index.
3. Isolated geologic units less than 10 feet thick are not shown.



Cross Section Location Map

Figure 8

CROSS SECTION B-B'
UMore Mining Area Groundwater Assessment
Dakota County, Minnesota

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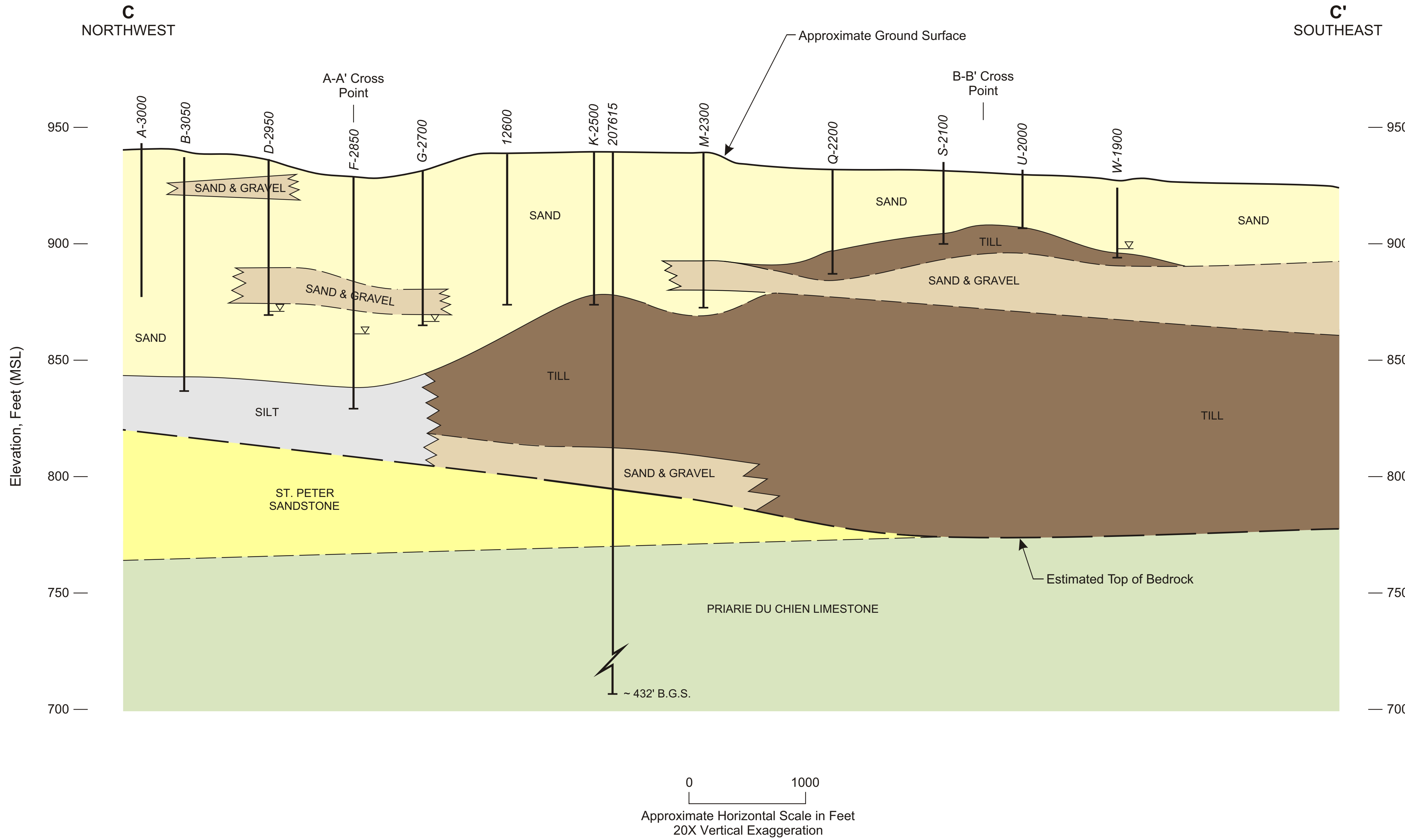
UMP003338



Sand, < 25% Gravel

Sand & Gravel, 25-40% Gravel

Gravel, > 40% Gravel

Glacial Diamicton
- Till/Diamicton

Lacustrine
- Silt/Clay

St. Peter Sandstone

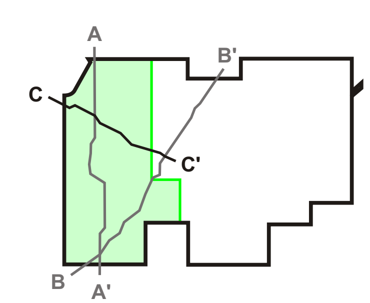
Prairie du Chien Dolomite

Approximate Groundwater Elevation (From ProSource gINT Lithology Table or CWI)

Boring (Top of boring elevation and boring depth is from ProSource gINT boring records or CWI)

NOTES:

1. Ground Surface derived from USGS National Elevation Dataset (NED) 10-meter Digital Elevation Model (DEM)
2. Geologic descriptions from ProSource (2008) and Minnesota County Well Index.
3. Isolated geologic units less than 10 feet thick are not shown.



Cross Section Location Map

Figure 9

CROSS SECTION C-C'
UMore Mining Area Groundwater Assessment
Dakota County, Minnesota

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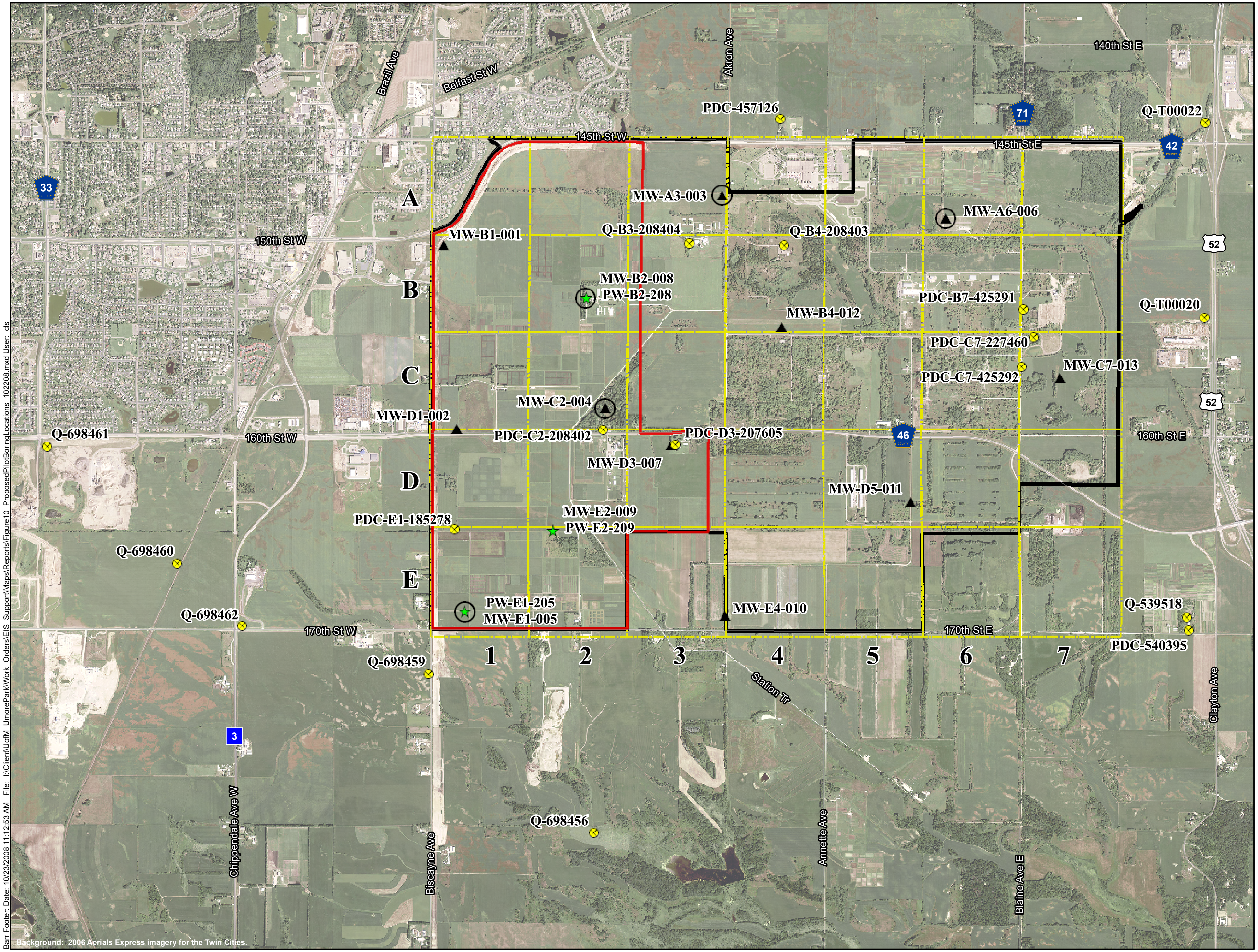

Pilot Boring Location
Monitoring Well Location
Pumping/Monitoring Well Nest Location
Existing Well
UMore Mining Area (UMA)
UMore Park Boundary
Site Location Grid

Source: Metropolitan Council, MnDOT, Dakota County, Barr, SEH, HKGi, Minnesota Geological Survey.

N

Feet
2,500 0 2,500

Figure 10

PILOT BORING/
WELL LOCATIONS

UMore Mining Area
Groundwater Assessment
Dakota County, MN

BARR

Barr Footer: Date: 10/23/2008 11:12:53 AM File: I:\Client\UofM_UmorePark\Work_Orders\EIS_Support\Maps\Reports\Figure10_ProposedPilotBoringLocations_102208.mxd User: cls