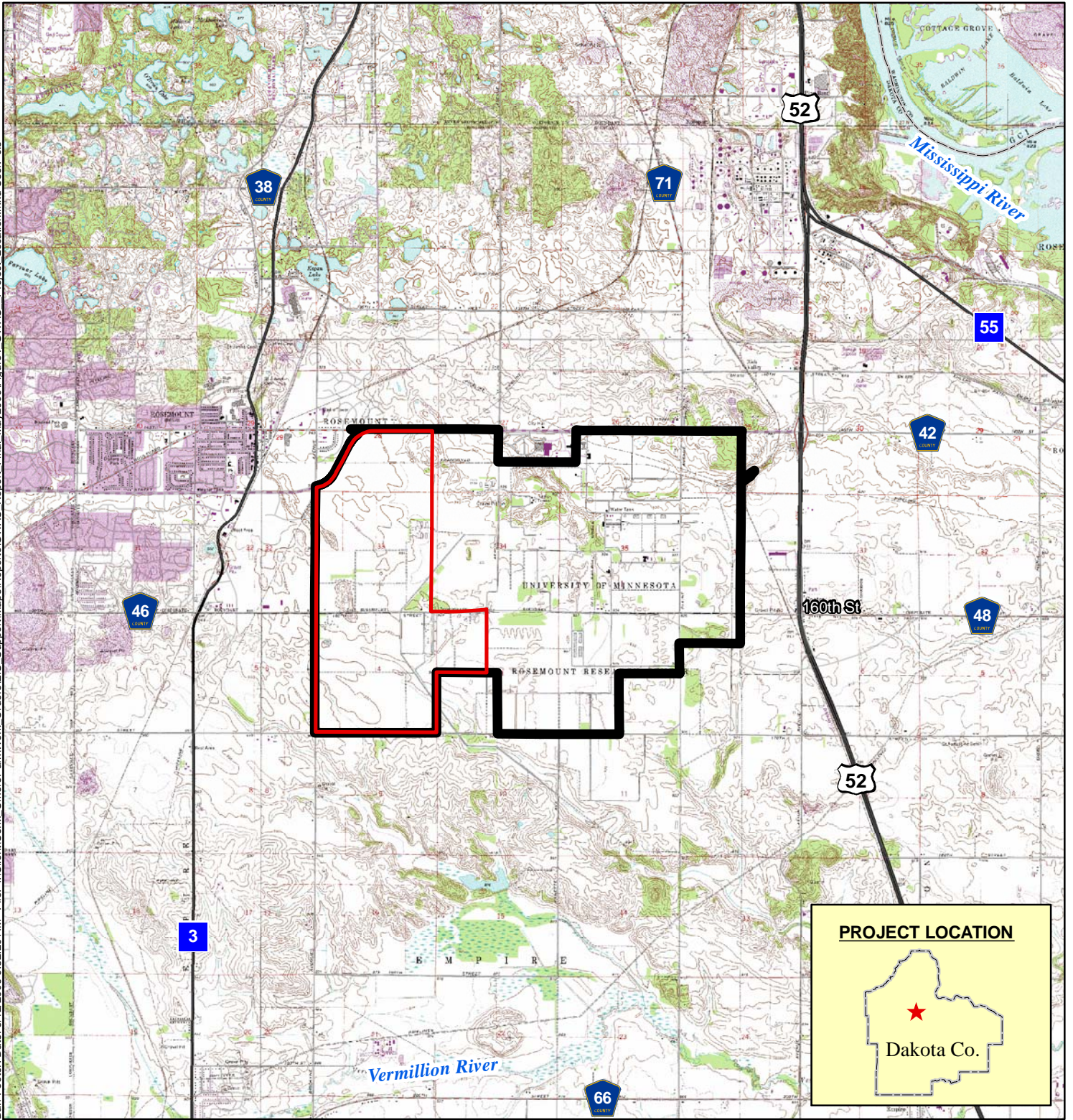


## Figures



- Umore Mining Area (UMA)
- Umore Park Boundary

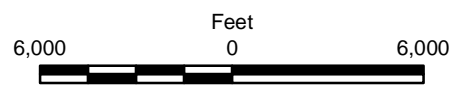


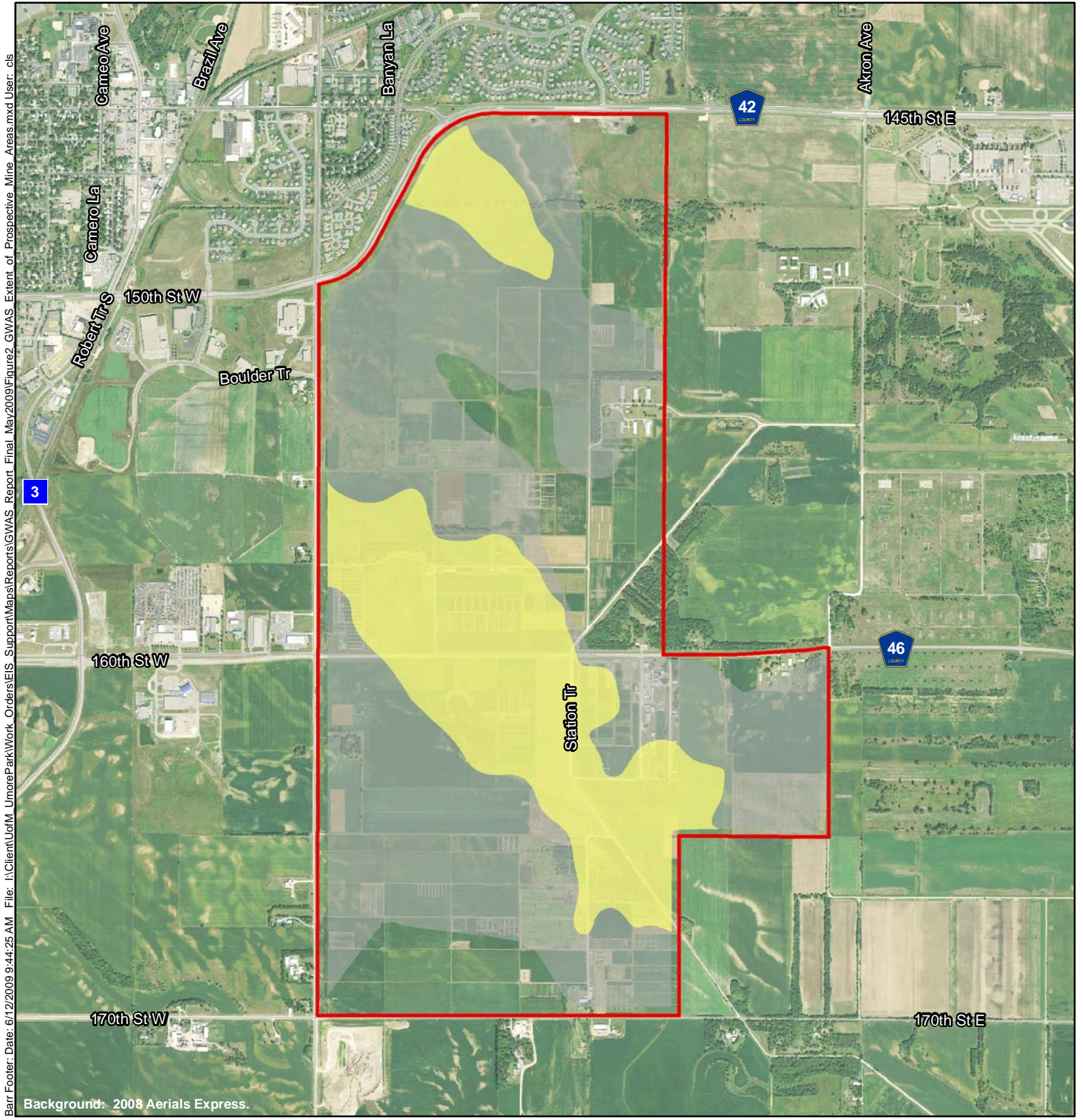
Figure 1

**UMORE PARK AND  
UMA LOCATION**

Groundwater Assessment Report  
Umore Mining Area  
Dakota County, MN







Barr Footer: Date: 6/12/2009 9:44:25 AM File: I:\Client\UofM\_UmorePark\Work\_Orders\EIS\_Support\Maps\Reports\GWAS\_Report\_Final\_May2009\Figure2\_GWAS\_Extent\_of\_Prospective\_Mine\_Areas.mxd User: ds

- UMore Mining Area (UMA)
- Economic Gravel Deposit Below the Water Table (Approximate)
- Gravel Deposit Areas (ProSource, 2008)

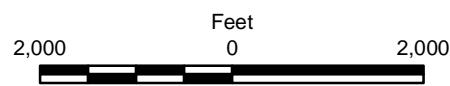


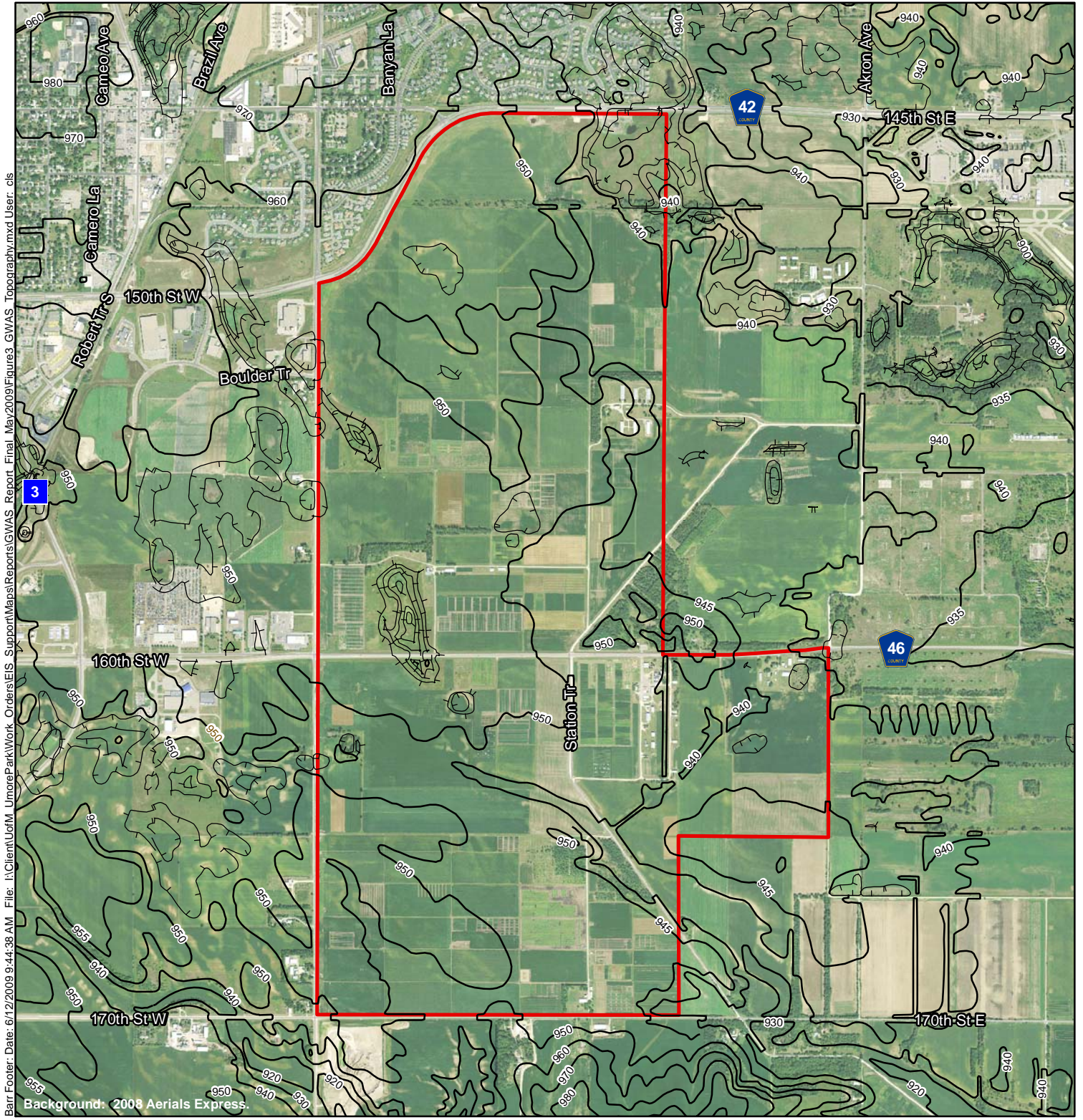
Figure 2

**EXTENT OF PROSPECTIVE MINE AREAS**

Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN







- UMore Mining Area (UMA)
- Ground Surface Contour
- Depressional Ground Surface Contour

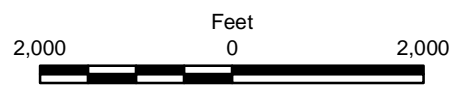


Figure 3

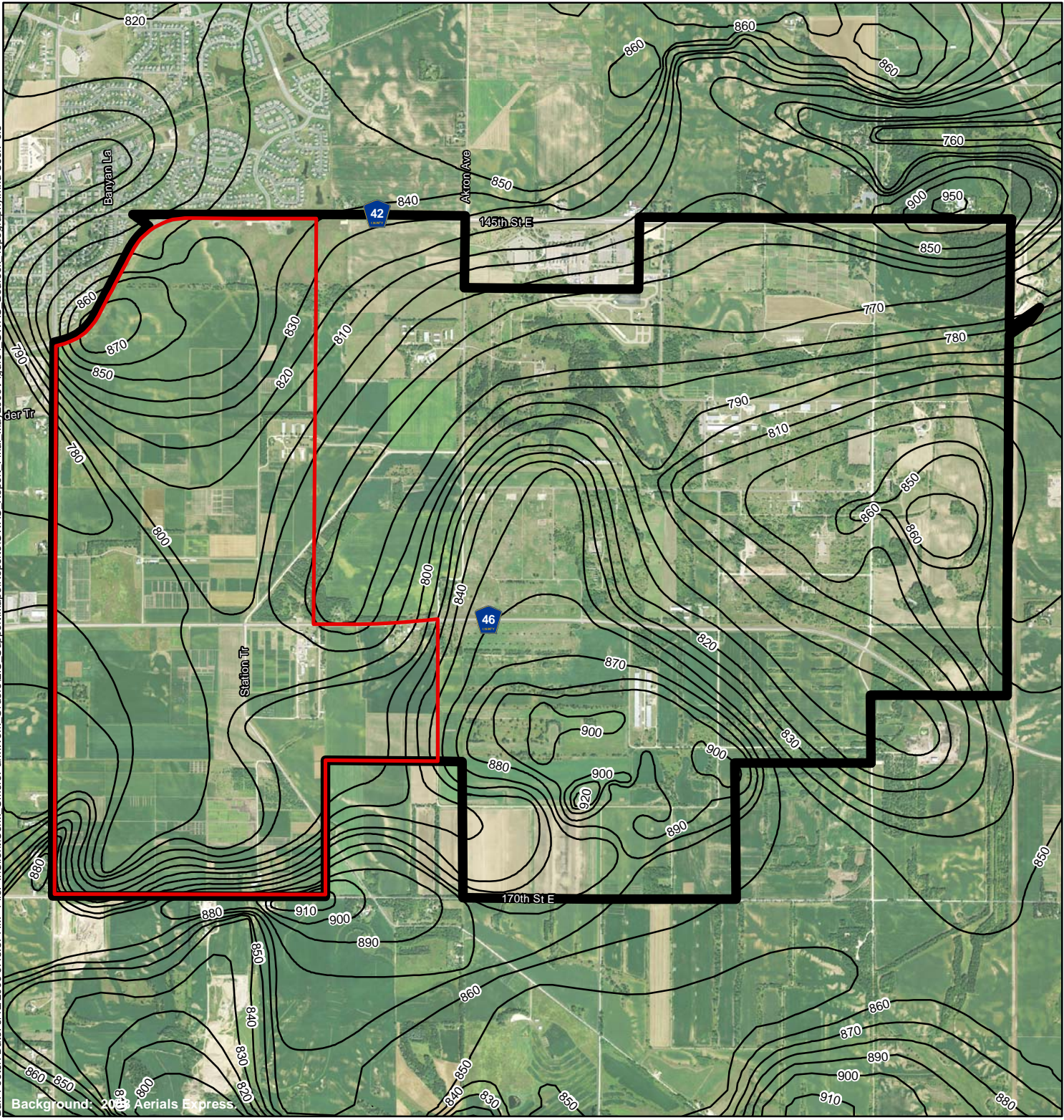
TOPOGRAPHY IN THE UMA

Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN





Barr Footer: Date: 6/12/2009 9:45:57 AM File: I:\Client\UofM\_UmorePark\Work\_Orders\EIS\_Support\Maps\Reports\GWAS\_Report\_Final\_May2009\Figure4\_GWAS\_Bedrock\_Topography.mxd User: cls






-  UMore Mining Area (UMA)
-  UMore Park Boundary
-  Bedrock Contour



Figure 4

LOCAL BEDROCK TOPOGRAPHY

Groundwater Assessment Report  
UMore Mining Area  
Dakota County, MN



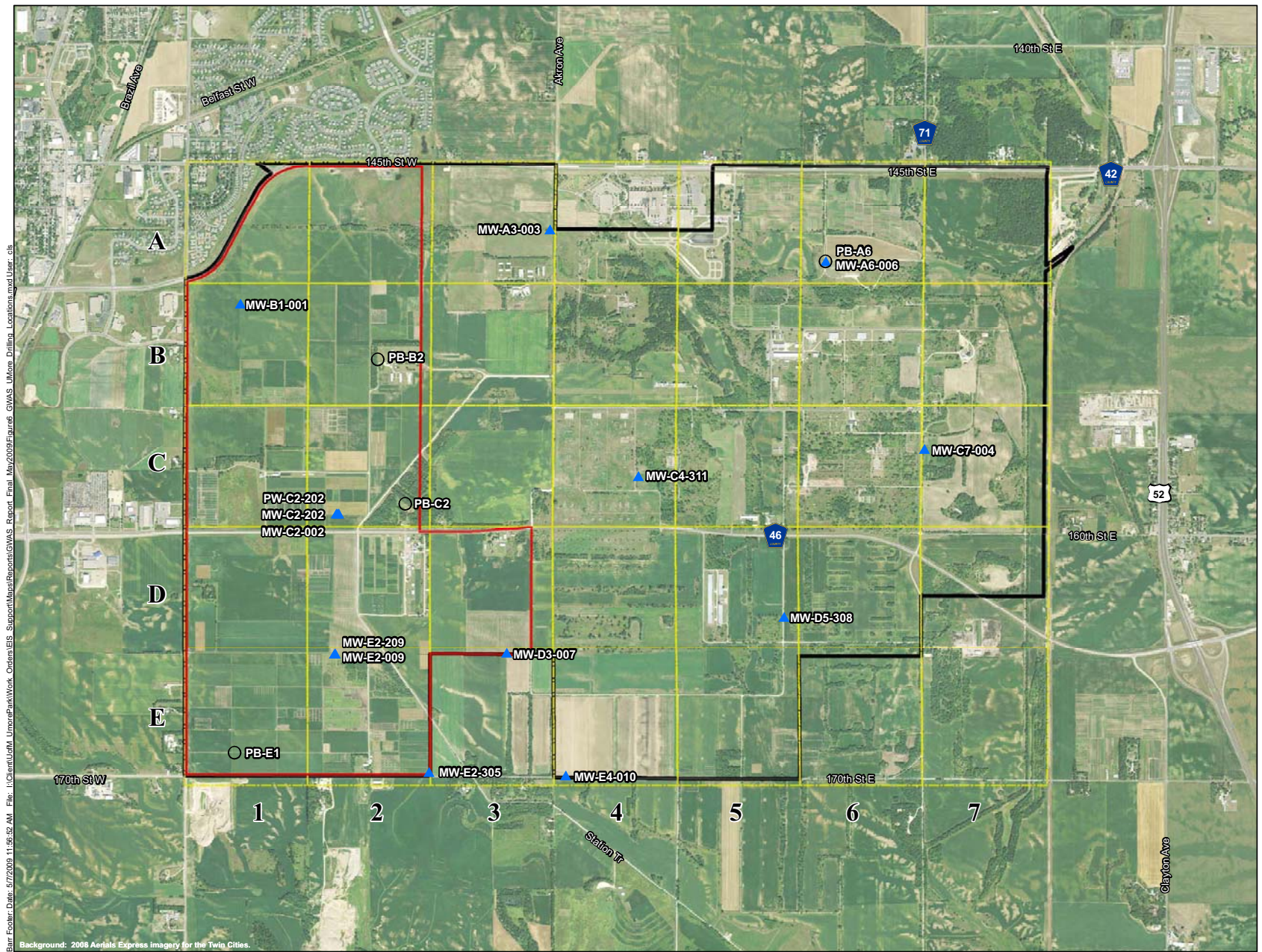


Formation Name and Graphic	Description	Site Nomenclature	Hydrogeologic Role
Unconsolidated Glacial Deposits	Unconsolidated sand and gravel containing fine grained diamicton and lacustrine deposits.	Outwash (sand & gravel deposit) Diamicton or Till Lacustrine - Lake bed silts & clays	Surficial Aquifer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

Figure 5

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





- ▲ Monitoring Well Location
  - Pilot Boring Location
  - ▭ UMore Mining Area (UMA)
  - ▭ UMore Park Boundary
  - ▭ Site Location Grid
- Source: MnDOT, Barr, SEH, HKGI.



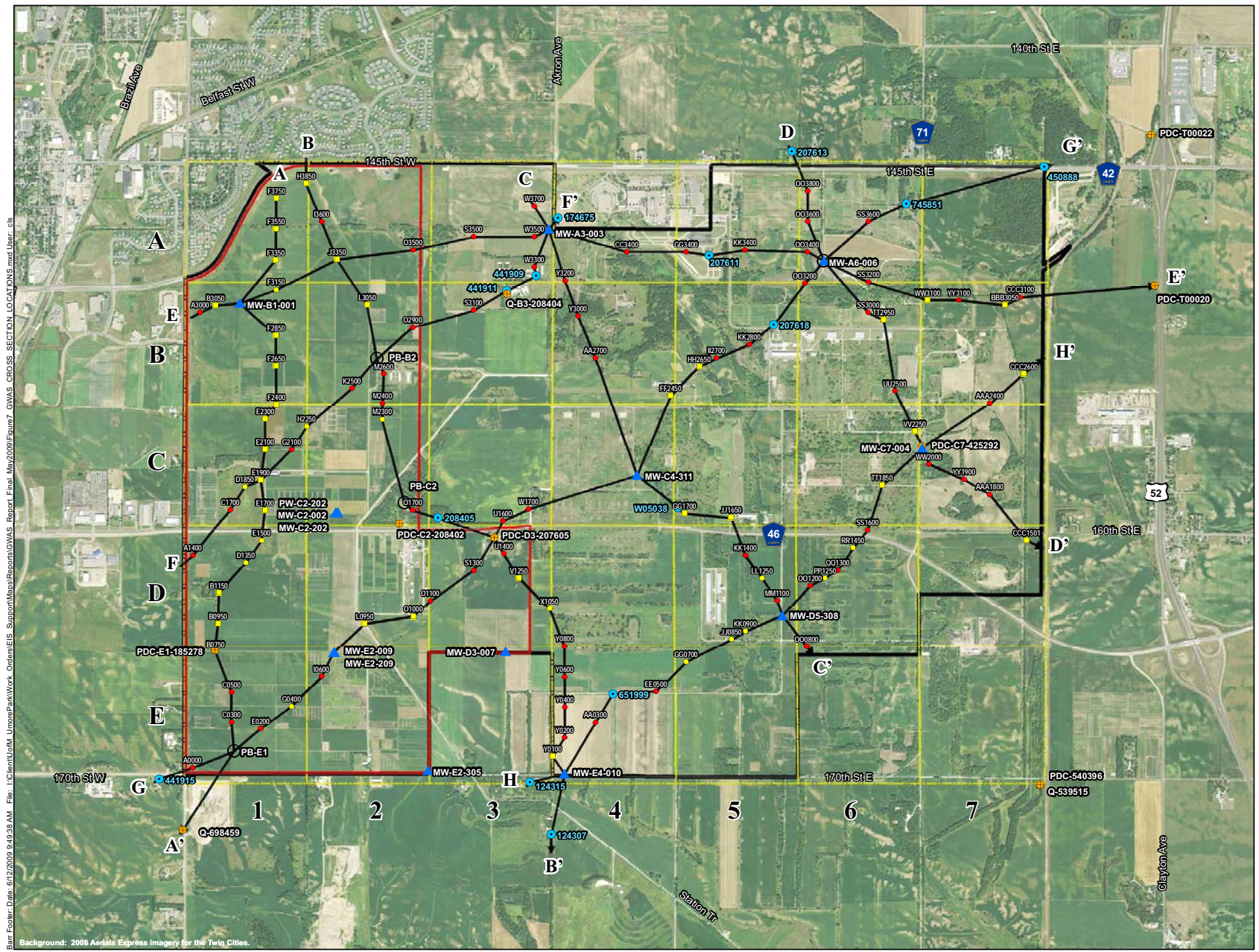
Figure 6  
 DRILLING LOCATIONS  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN



Barr Footer: Date: 5/7/2009 11:56:52 AM. File: I:\Client\UM UMorePark\Work Orders\GIS Support\Map\Reports\GWAS UMore Drilling Locations.mxd User: cls

Background: 2008 Aerials Express imagery for the Twin Cities.





- Existing Well
  - ▲ Monitoring Well Location
  - Pilot Boring Location
  - Dakota Co. Wells (from Dak. Co. WR Dept. 10/23/08)
  - Boring Locations (from ProSource)
    - Phase I, Auger
    - Phase II, Auger
    - Phase II, Coring
  - Cross Section
  - ▭ UMore Mining Area (UMA)
  - ▭ UMore Park Boundary
  - ▭ Site Location Grid
- Source: MnDOT, ProSource, Dakota County, Barr, SEH, HKGI.

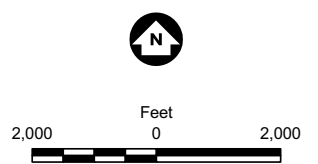
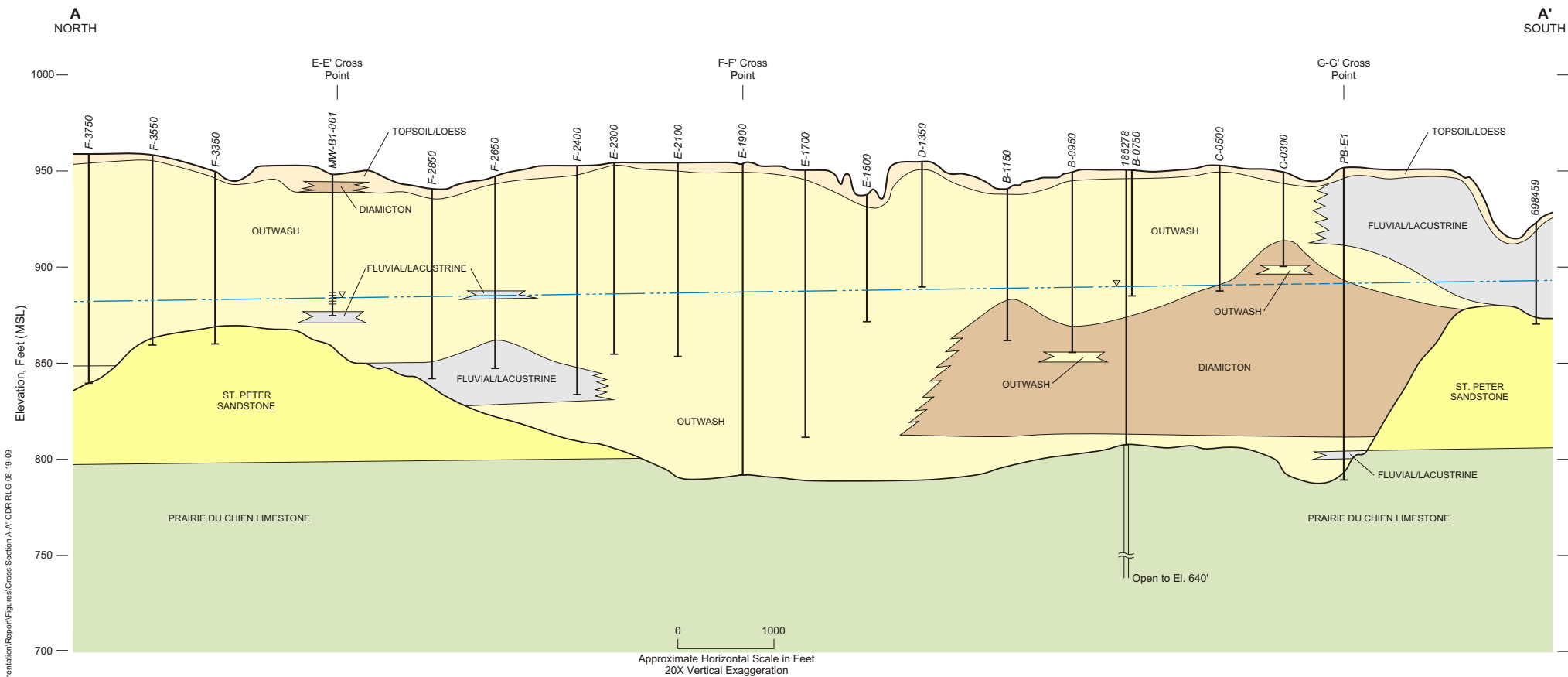


Figure 7  
 CROSS SECTION LOCATIONS  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN







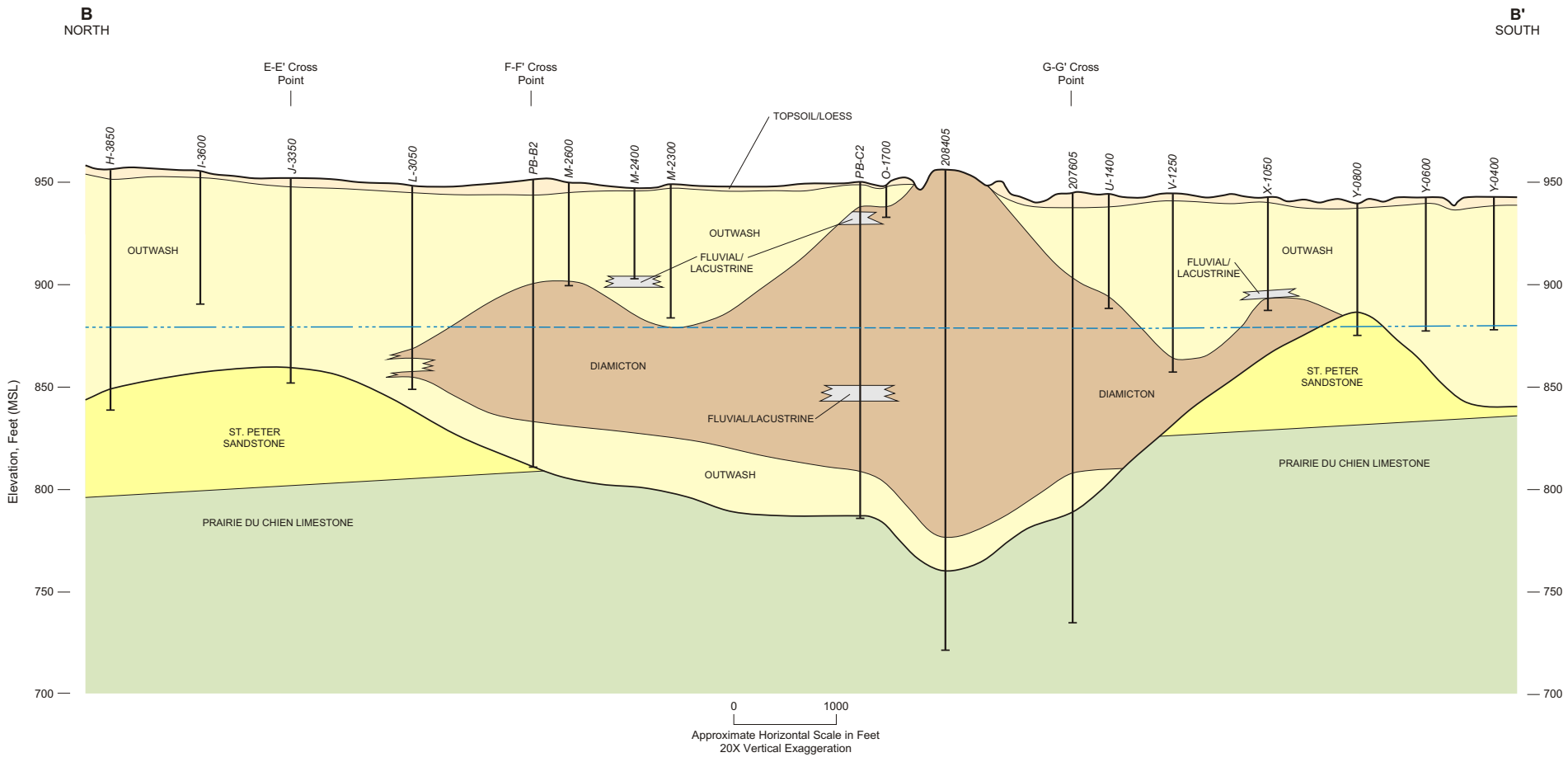
P:\Mpl\23198505\WorkFiles\GW Assessment Invest\W042 and #3\Implementation\Report\Figures\Cross Section A-A' CDR RLG 06-19-09

Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> <li>Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 8  
CROSS SECTION A-A'  
UMore Mining Area Groundwater Assessment  
Dakota County, Minnesota



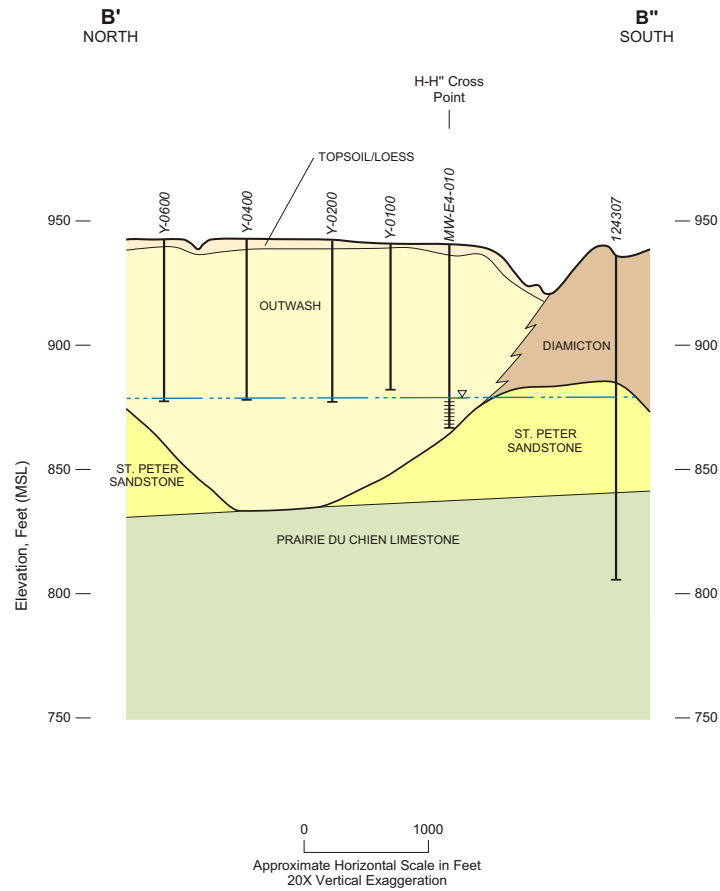
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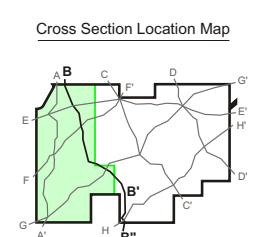
Legend		Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes	
	Approximate Water Table Elevation (Dashed where inferred)		Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt		<ol style="list-style-type: none"> <li>Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>	
	Approximate Groundwater Elevation (04-03-09)		Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)			OL, ML
	Soil Boring		Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)			SP, SW, GP
	Well Screen		Fluvial(low energy)/Lacustrine	Sandy Silt, Silt or Interbedded Clays			CL, SC
	Open Hole Interval (for pre-existing wells)		St. Peter Sandstone	Fine Grained Sandstone (Bedrock)			ML, SM, SM/CL
			Prairie du Chien	Dolomite (Bedrock)			NA
							NA

**Figure 9a**  
**CROSS SECTION B-B'**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota





Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial (low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA



**Notes**

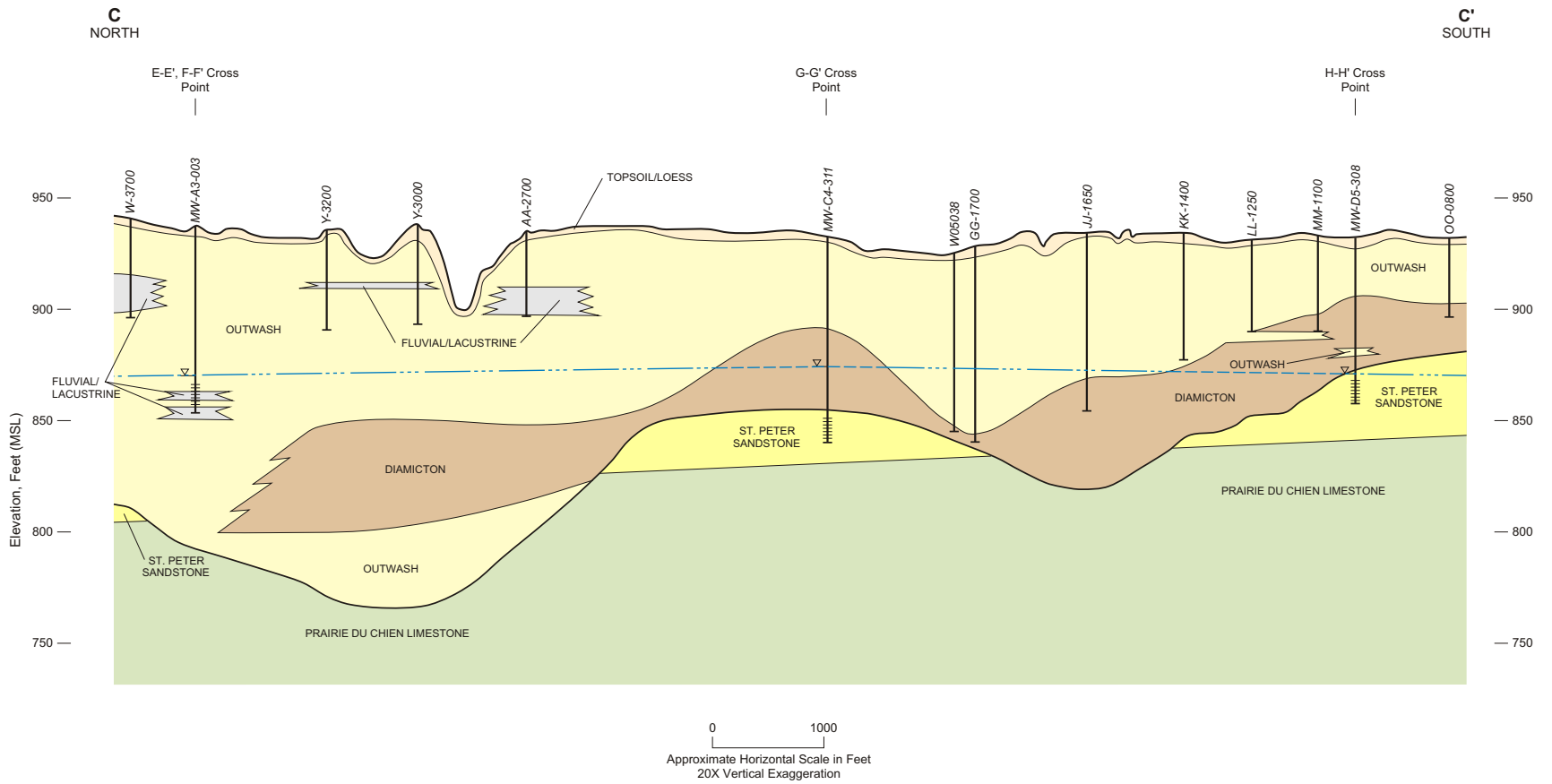
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

**Figure 9b**

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



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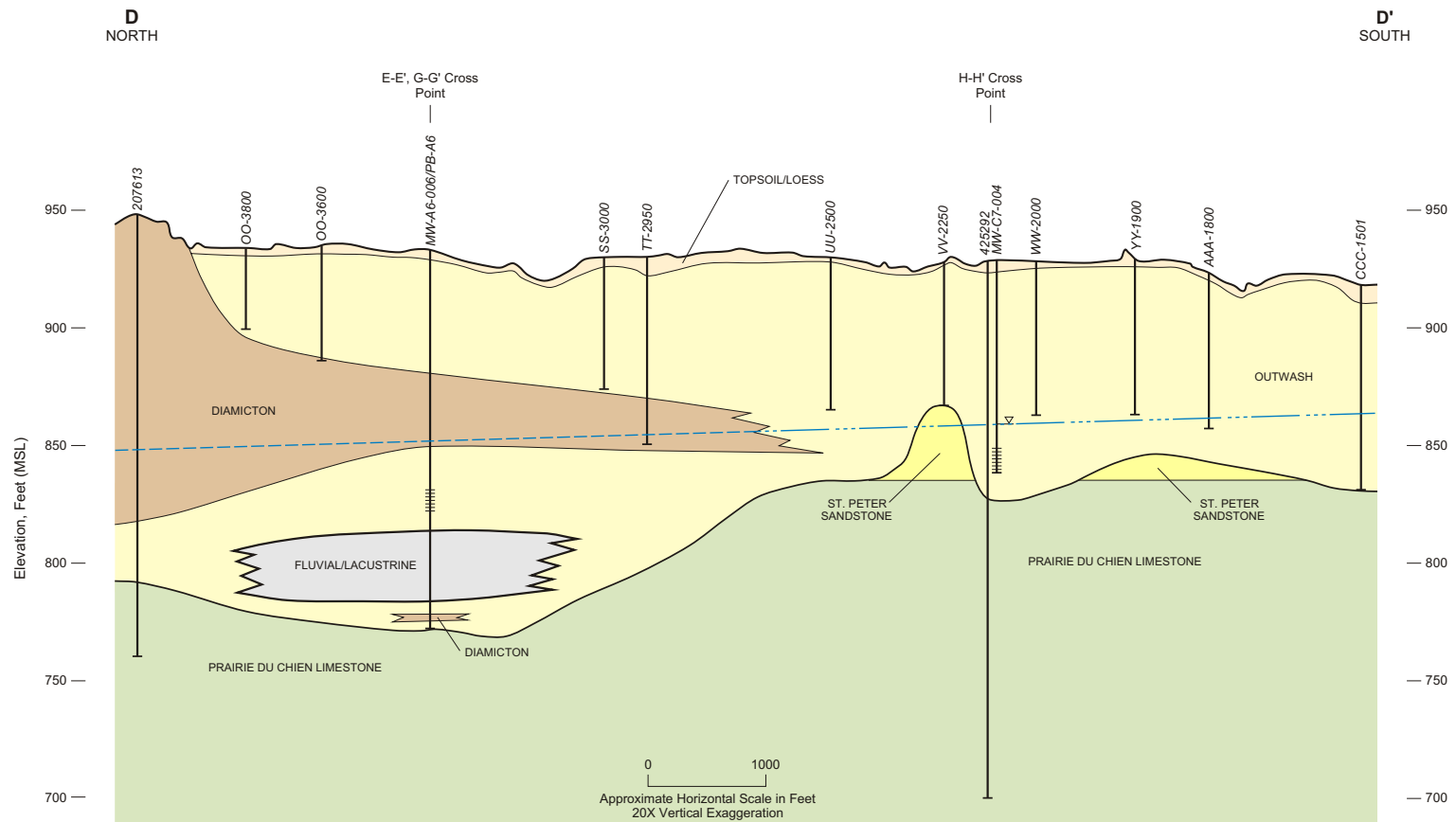


0 1000  
Approximate Horizontal Scale in Feet  
20X Vertical Exaggeration

Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> <li>Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 10  
CROSS SECTION C-C'  
UMore Mining Area Groundwater Assessment  
Dakota County, Minnesota



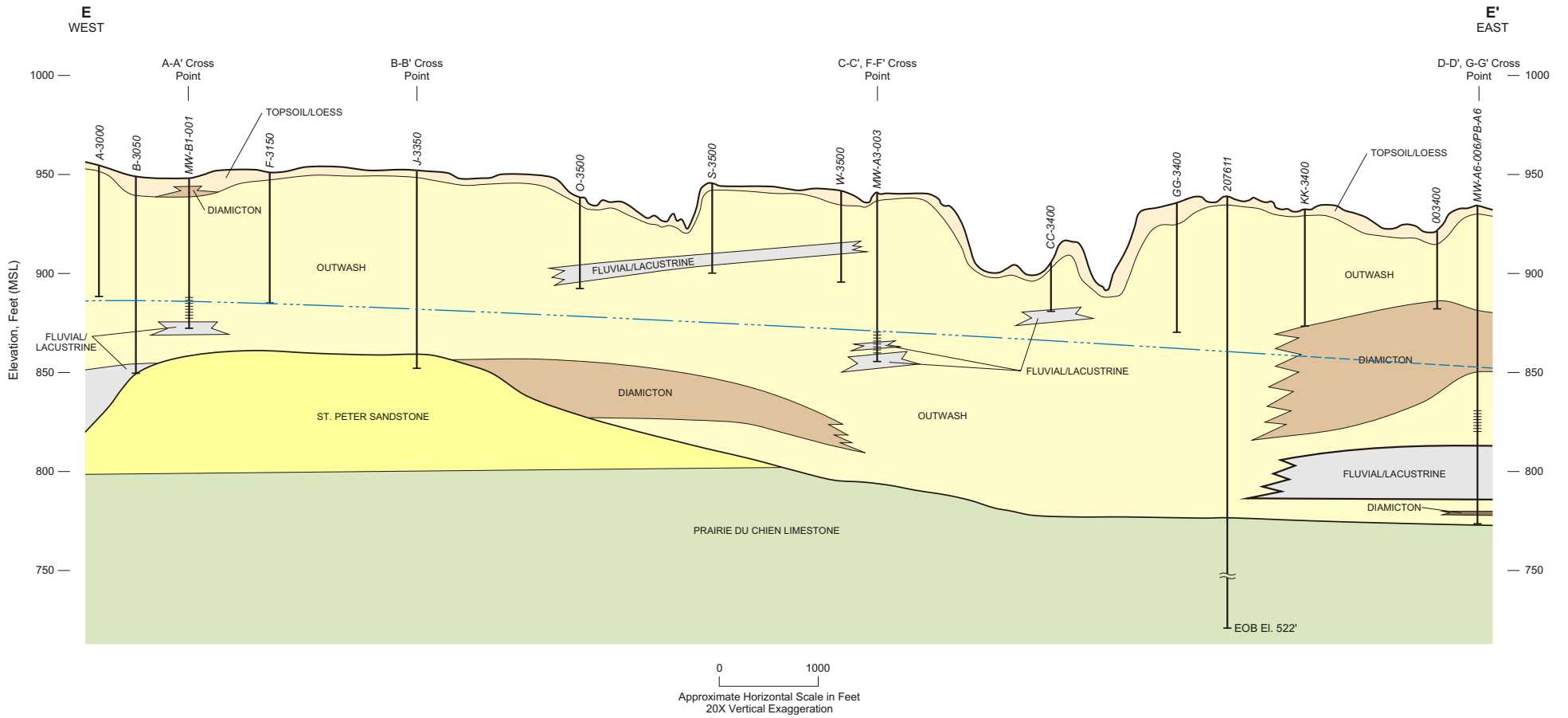


Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> <li>1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 11  
**CROSS SECTION D-D'**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota



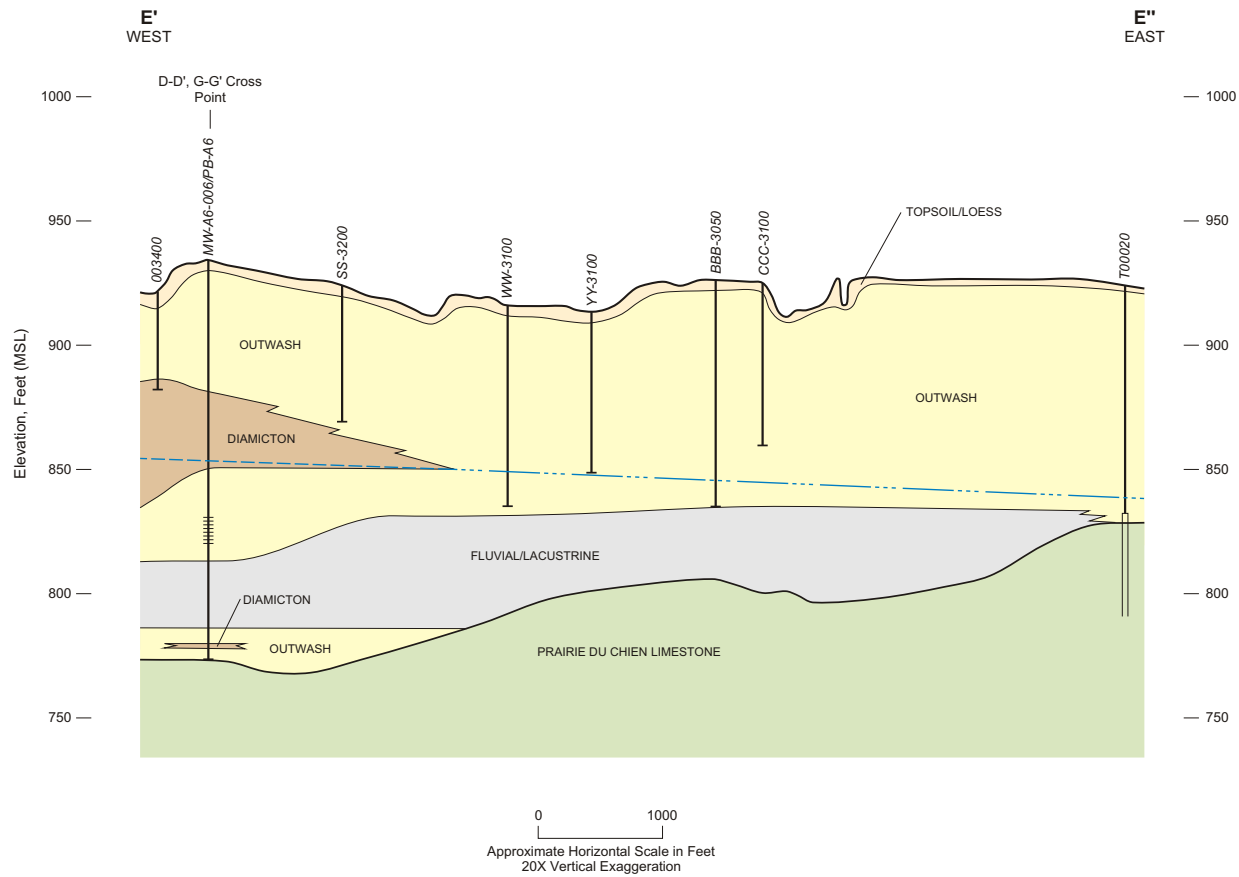
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Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> <li>Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

**Figure 12a**  
**CROSS SECTION E-E'**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota

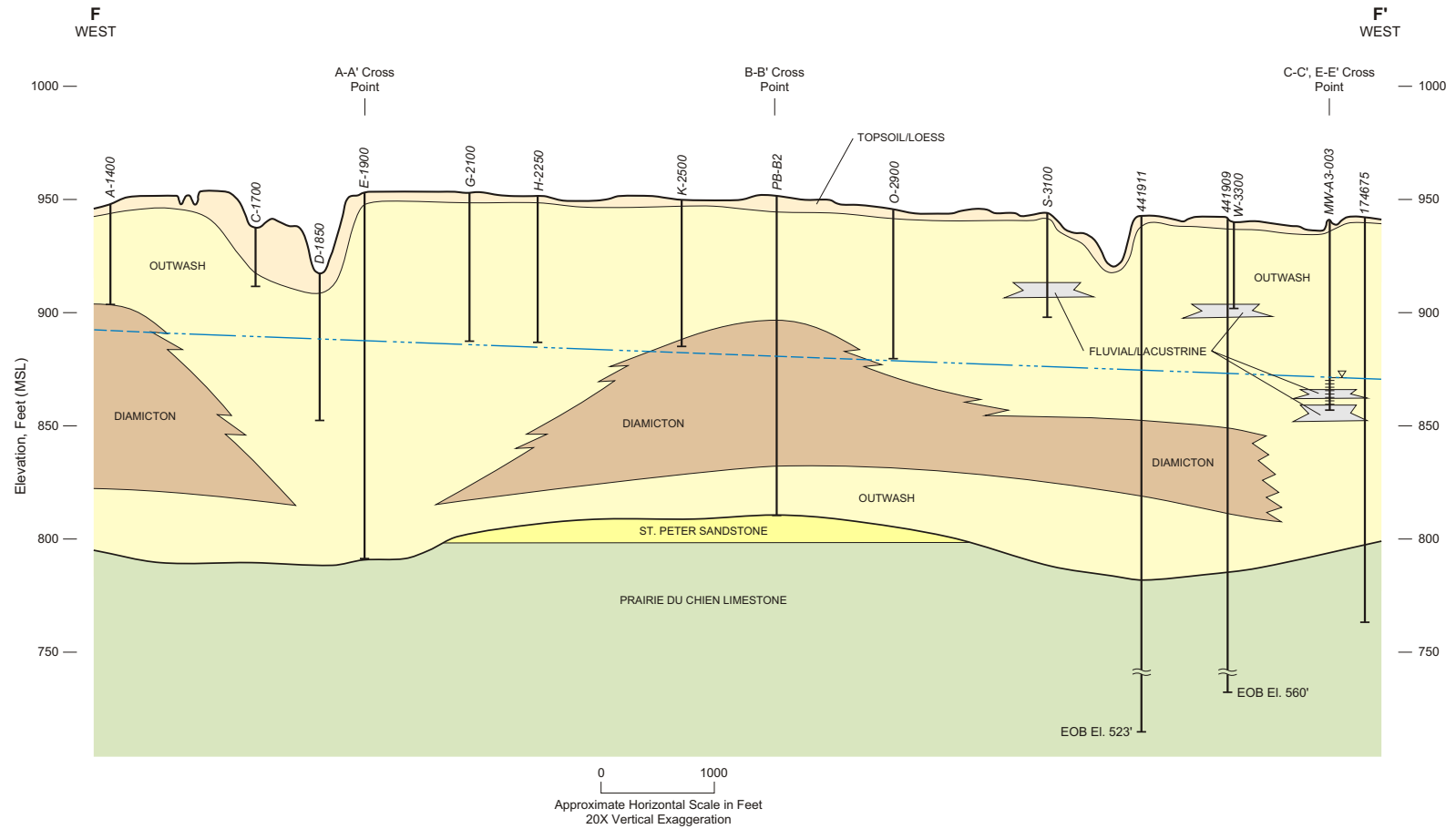




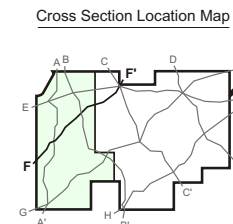
Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> <li>Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 12b  
CROSS SECTION E'-E''  
UMore Mining Area Groundwater Assessment  
Dakota County, Minnesota



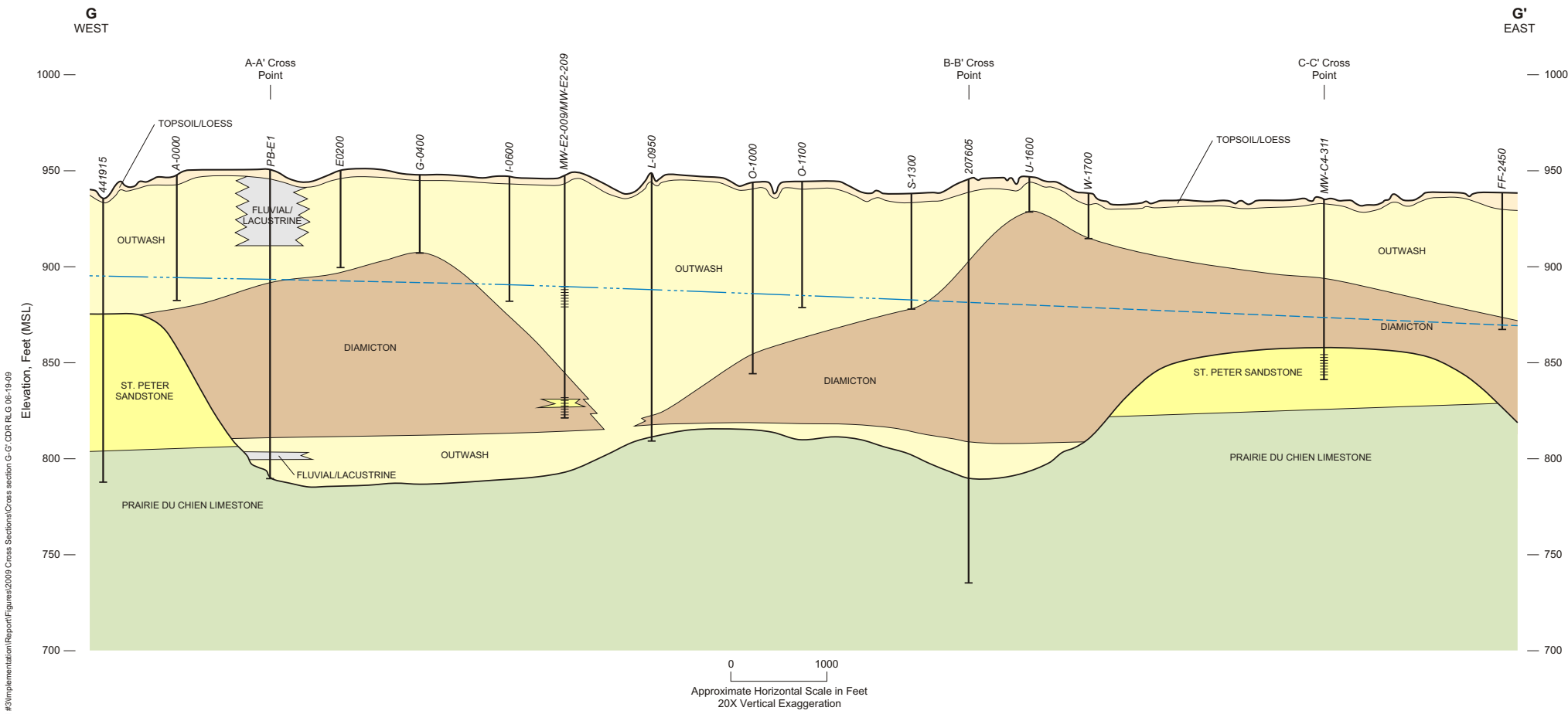


Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA



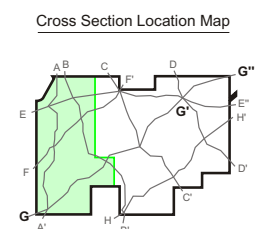
- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
  2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

**Figure 13**  
**CROSS SECTION F-F'**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota



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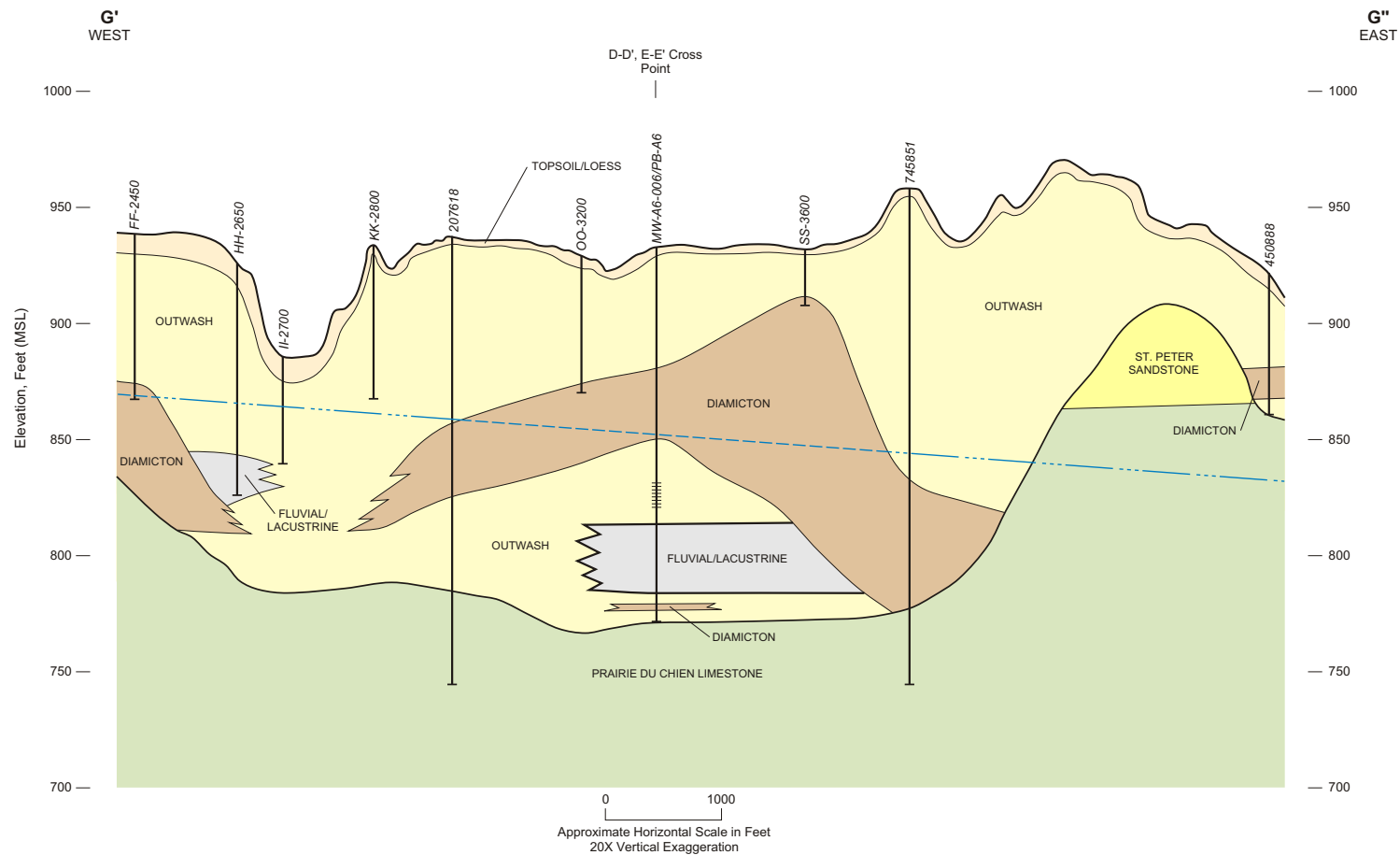
Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial(low energy)/Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA



- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
  2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

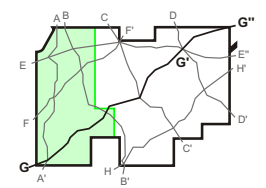
**Figure 14a**  
**CROSS SECTION G-G'**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota





Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA

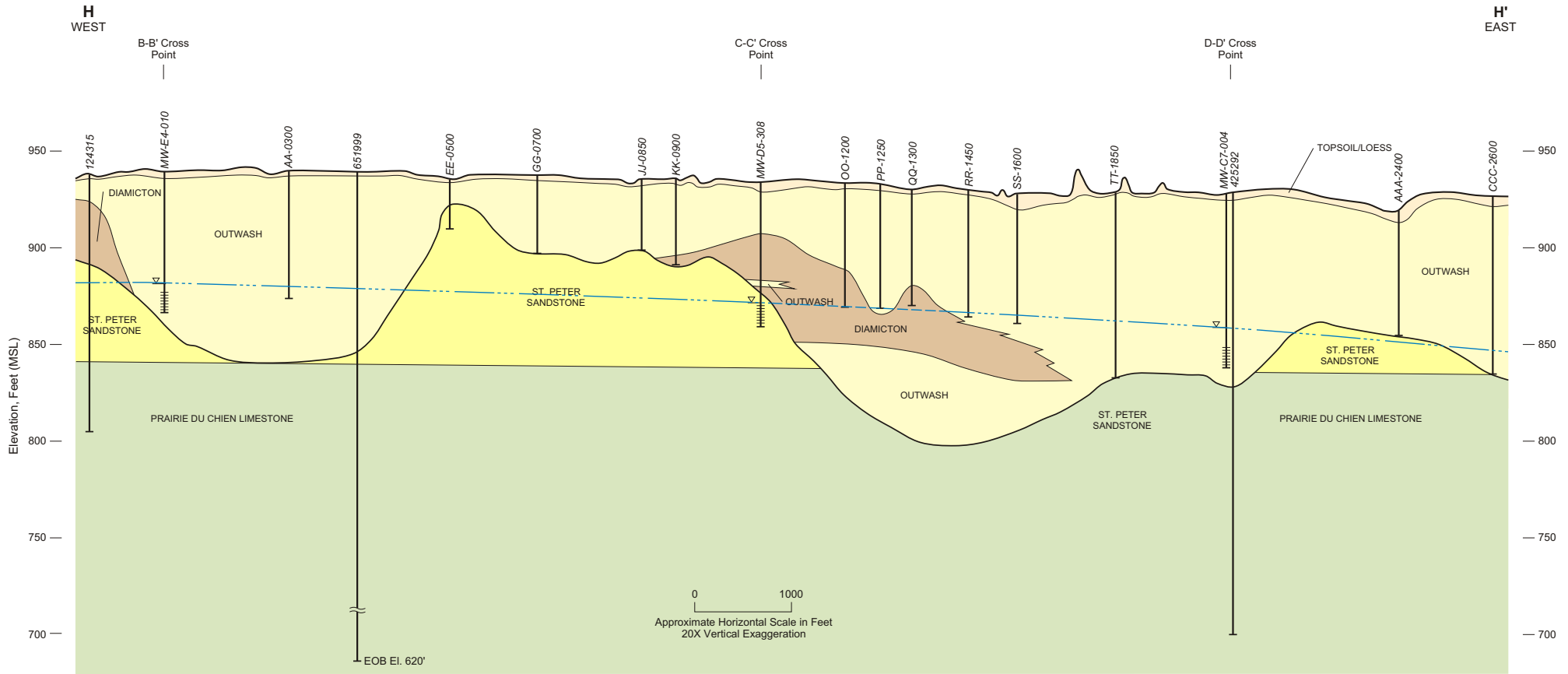
**Cross Section Location Map**



- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
  2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

**Figure 14b**  
**CROSS SECTION G'-G''**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota

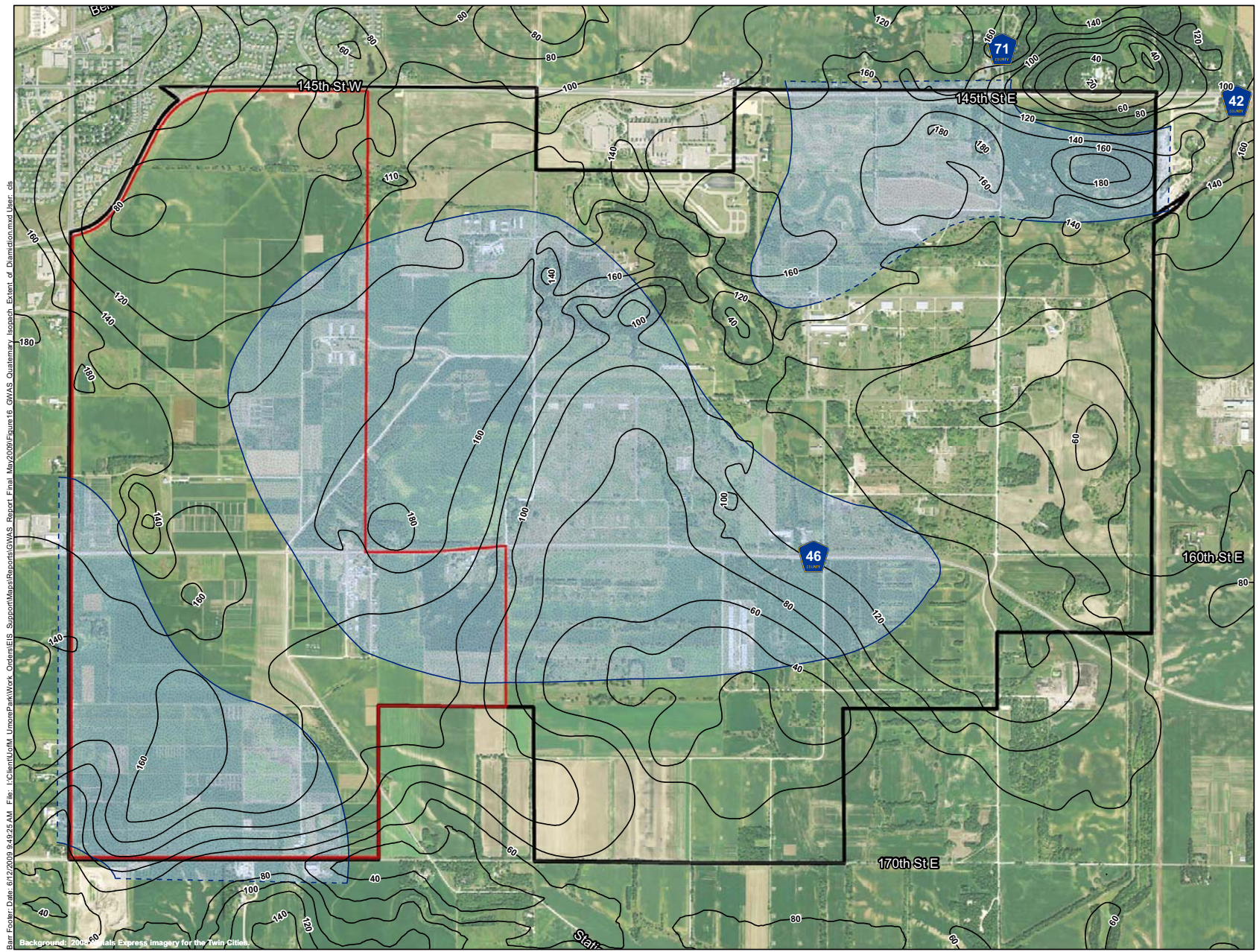
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Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> <li>Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.</li> <li>The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.</li> </ol>
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

**Figure 15**  
**CROSS SECTION H-H'**  
 UMore Mining Area Groundwater Assessment  
 Dakota County, Minnesota





UMore Mining Area (UMA)  
 UMore Park Boundary  
 — Quaternary Deposit Isopach  
 (Thickness in feet)  
 Approximate Extent of Diamicton  
 (below water table)

Source: MnDOT, Barr, SEH, HKGi,  
 Geologic Logs from Assessment,  
 ProSource (2008), and County Well Index

Note: Where shaded, diamicton comprises at least half of the saturated Quaternary deposits.



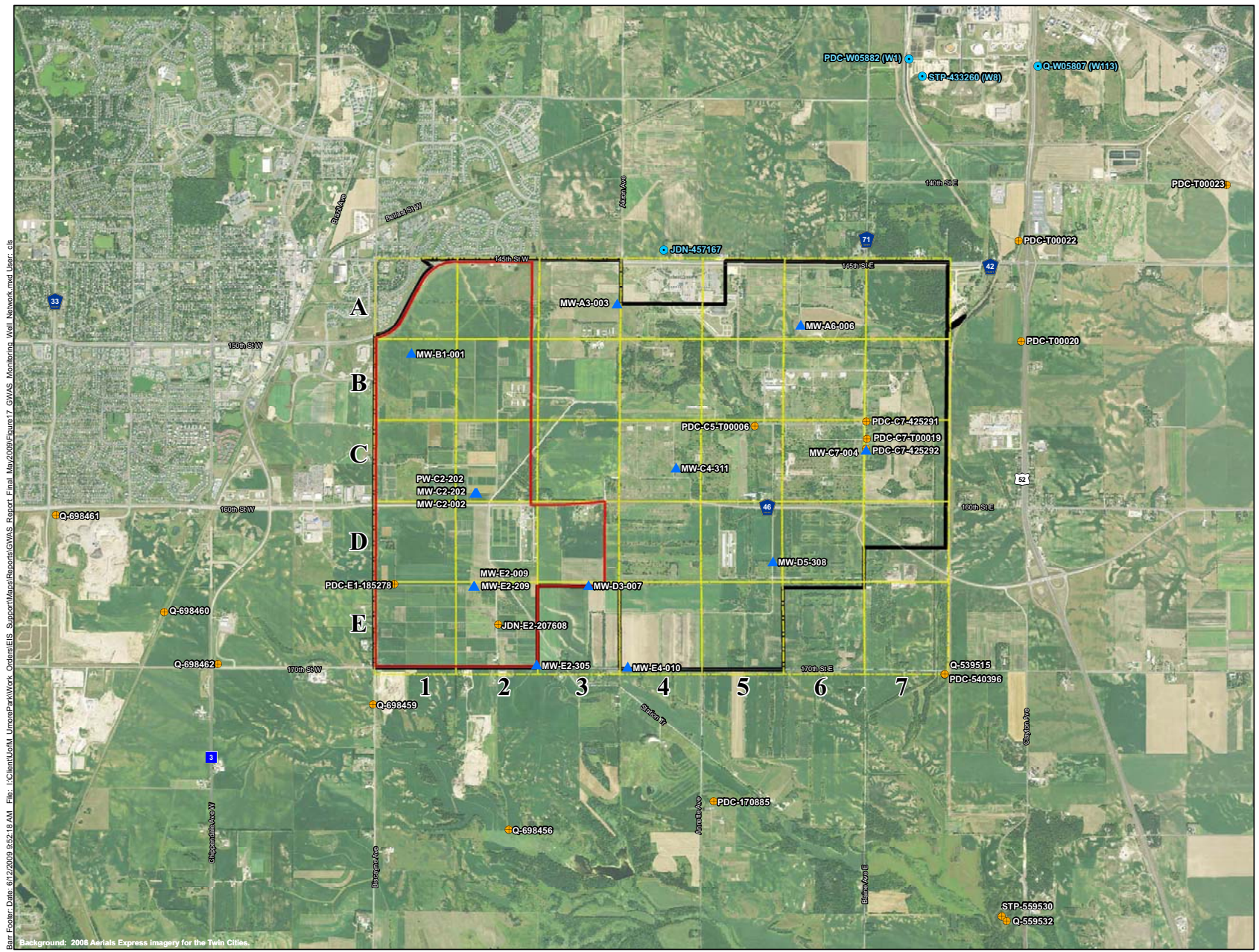
Figure 16

**QUATERNARY ISOPACH AND  
 EXTENT OF DIAMICTON**  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN



Barr Footer: Date: 6/12/2009 9:49:25 AM File: I:\Client\UoM\_UmorePark\Work Orders\EIS\_Support\Map\Reports\GWAS\_Report\_Final\_May2009\Figure16\_GWAS\_Quaternary\_Isopach\_Extent\_of\_Diamicton.mxd User: ds





- Existing Well
  - ▲ Monitoring Well Location
  - Dakota Co. Wells (from Dak. Co. WR Dept. 10/23/08)
  - ▭ UMore Mining Area (UMA)
  - ▭ UMore Park Boundary
  - ▭ Site Location Grid
- Source: MnDOT, Barr, Dakota County, SEH, HKGI.

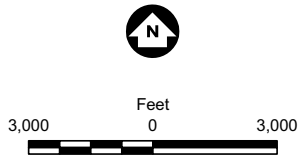


Figure 17  
 MONITORING WELL NETWORK  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN



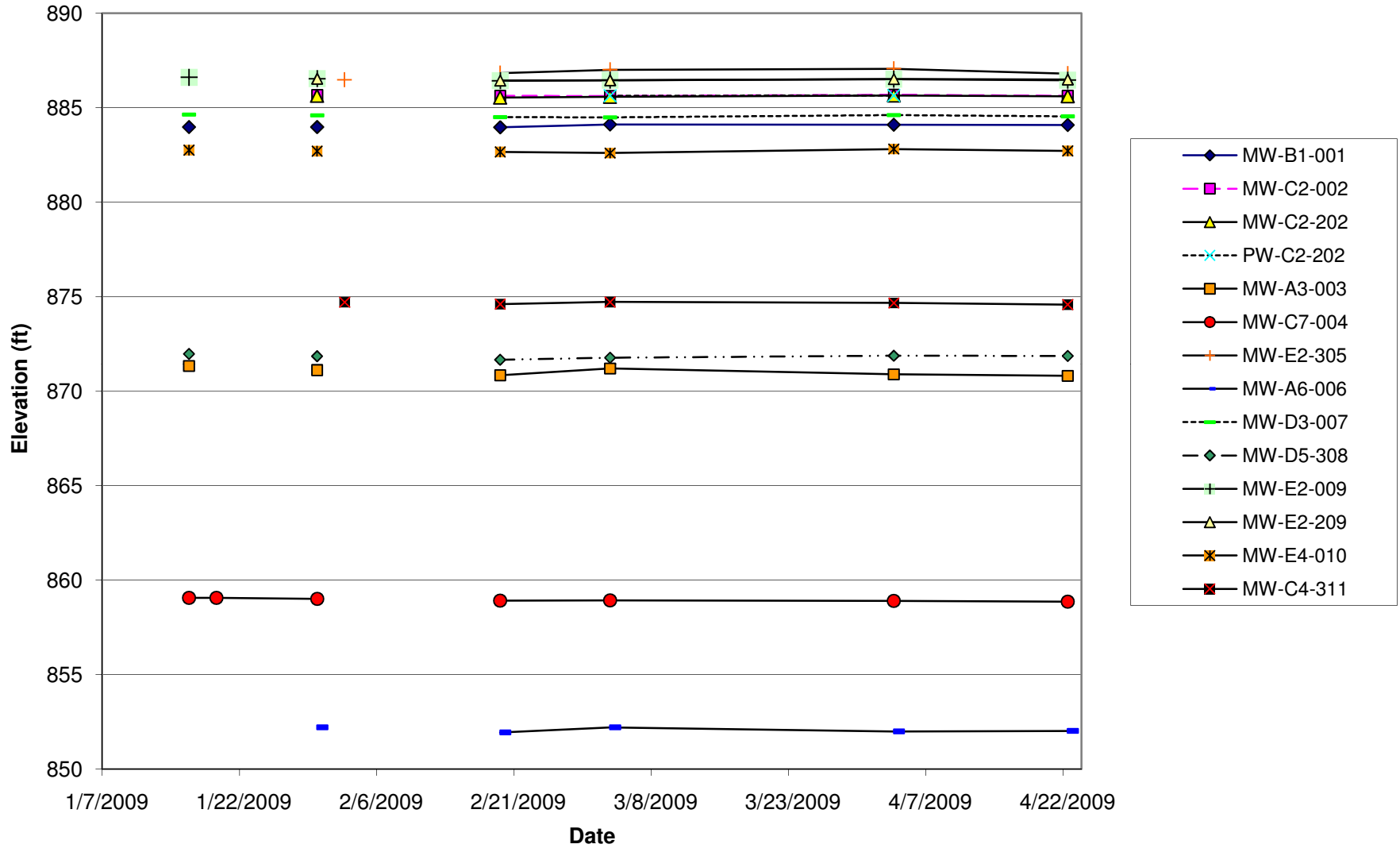
Barr Footer: Date: 6/12/2009 8:52:18 AM. File: I:\Client\UofM\UmorePark\Work Orders\GIS\Support\MapReports\GWAS Report\_Final\_May2009\Figure17\_GWAS\_Monitoring\_Well\_Network.mxd User: cbs

Background: 2008 Aerials Express imagery for the Twin Cities.

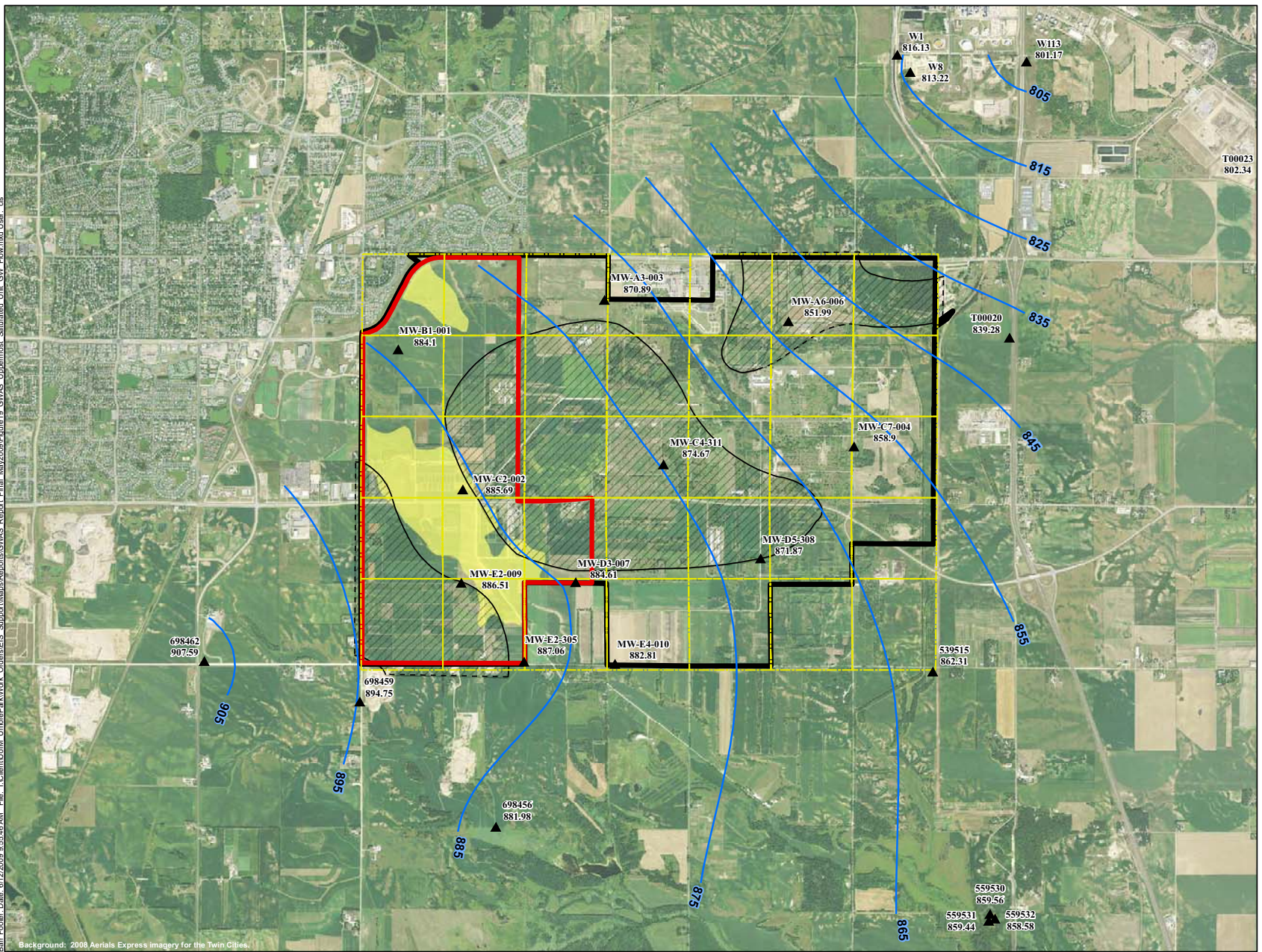


Figure 18

Groundwater Elevation Hydrographs  
Groundwater Assessment Report  
UMore Mining Area  
Dakota County, Minnesota



Barr Footer Date: 6/12/2009 9:55:46 AM File: I:\Client\UoM\UmorePark\Work\_Corridor\GIS\_Support\Maps\Reports\GWAS\_Report\_Final\_May2009\Figure19\_GWAS\_Uppermost\_Saturated\_Unit\_GW\_Flow.mxd User: cbs



- ▲ Monitoring Wells
- Groundwater Elevation Contours
- ▭ Umore Park Boundary
- ▭ Umore Mining Area (UMA)
- ▭ Site Location Grid
- ▨ Approximate Extent of Diamicton
- Economic Gravel Deposit Below the Water Table (Approximate)

Source: Metropolitan Council, MndOT, Dakota County, Barr, ProSource, SEH, HKGI.

Water levels used for this map are from wells completed in the uppermost saturated unit and within 25 feet of the water table. Most of the wells used are completed in Quaternary deposits or the St Peter formation, except W1, which is completed in the Prairie du Chien formation, and T00020, which is completed across Quaternary deposits and the Prairie du Chien formation. Well MW-C4-311 completed in St. Peter Sandstone confirmed by diamicton.

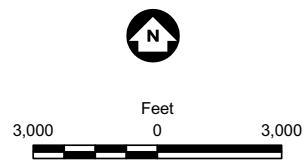


Figure 19  
GROUNDWATER FLOW MAP  
(UPPERMOST SATURATED UNIT)  
APRIL 3, 2009

Groundwater Assessment Report  
Umore Mining Area  
Dakota County, MN







P:\Mpl\23.MN19\2319B05\WorkFiles\GW Assessment Invest\W042 and #3\Implementation\Report\Figures\Conceptual Cross Section 2.CDR.RL.G.06-12-09

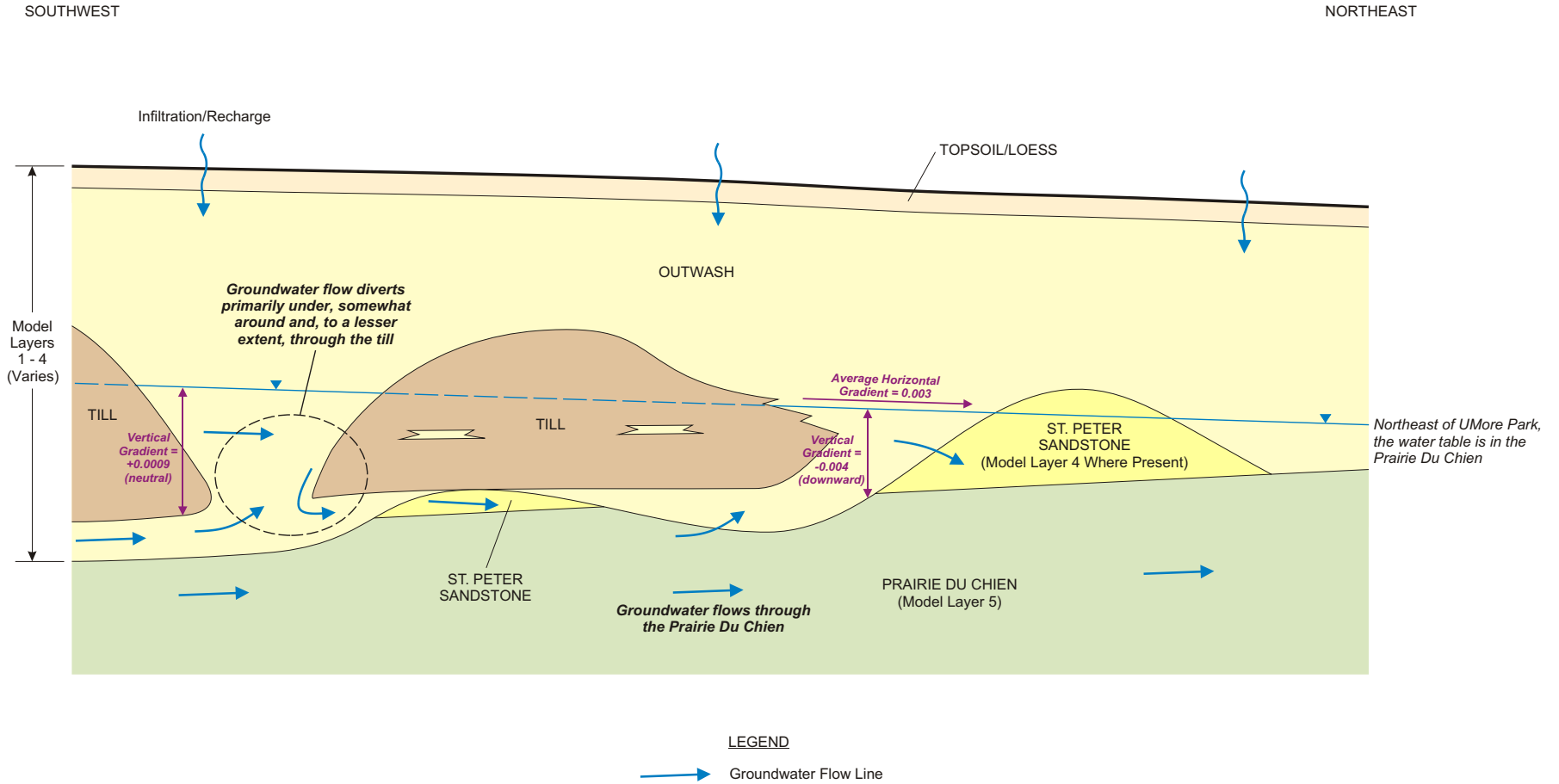


Figure 21  
 CONCEPTUAL CROSS SECTION  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, Minnesota



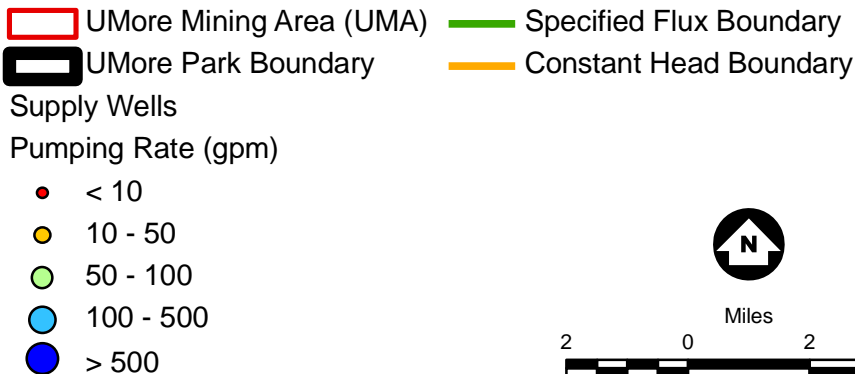
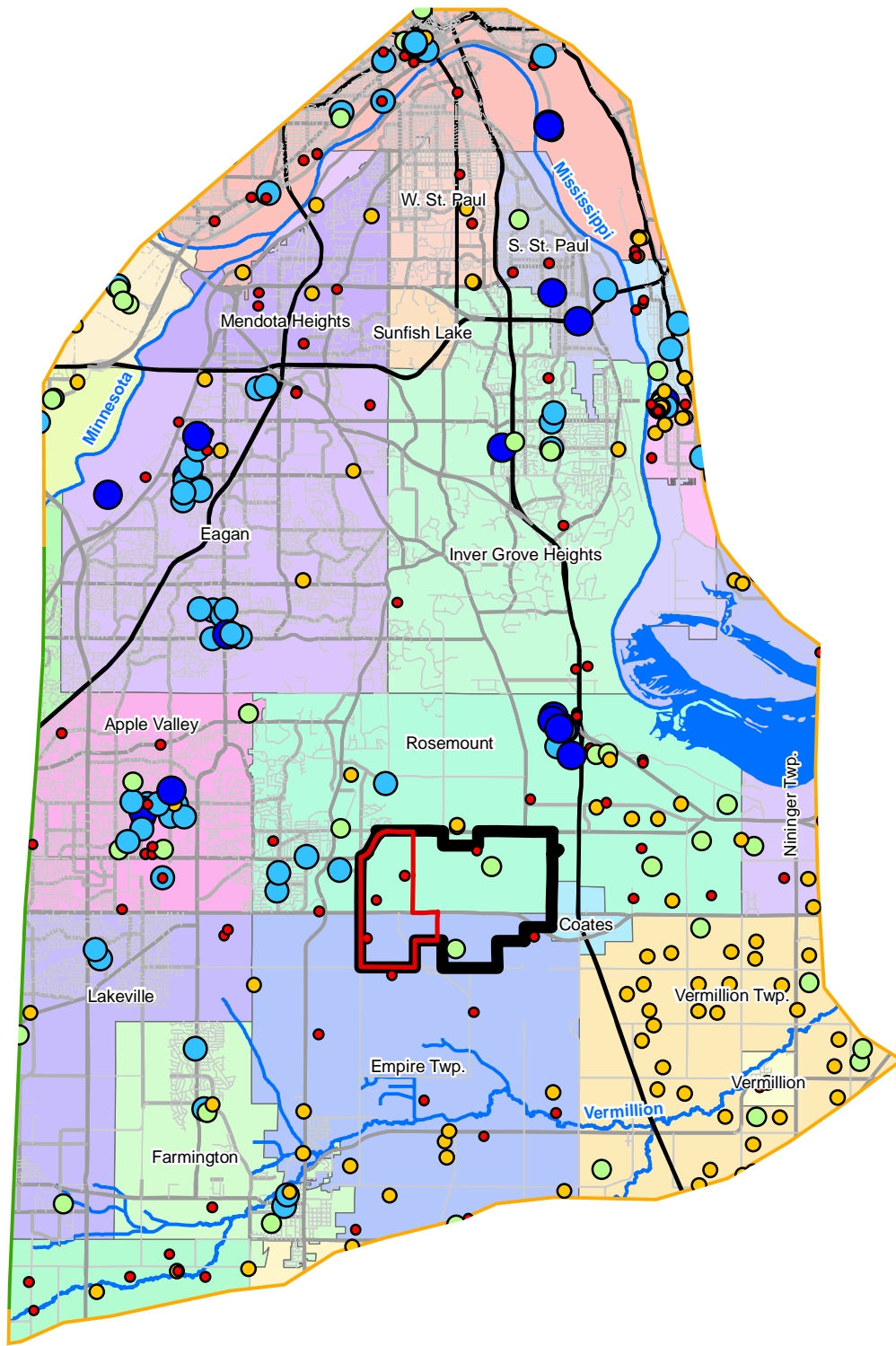


Figure 22

MODEL DOMAIN AND  
BOUNDARY CONDITIONS

Groundwater Assessment Report  
Umore Mining Area  
Dakota County, MN

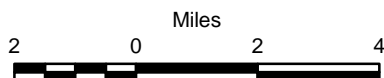
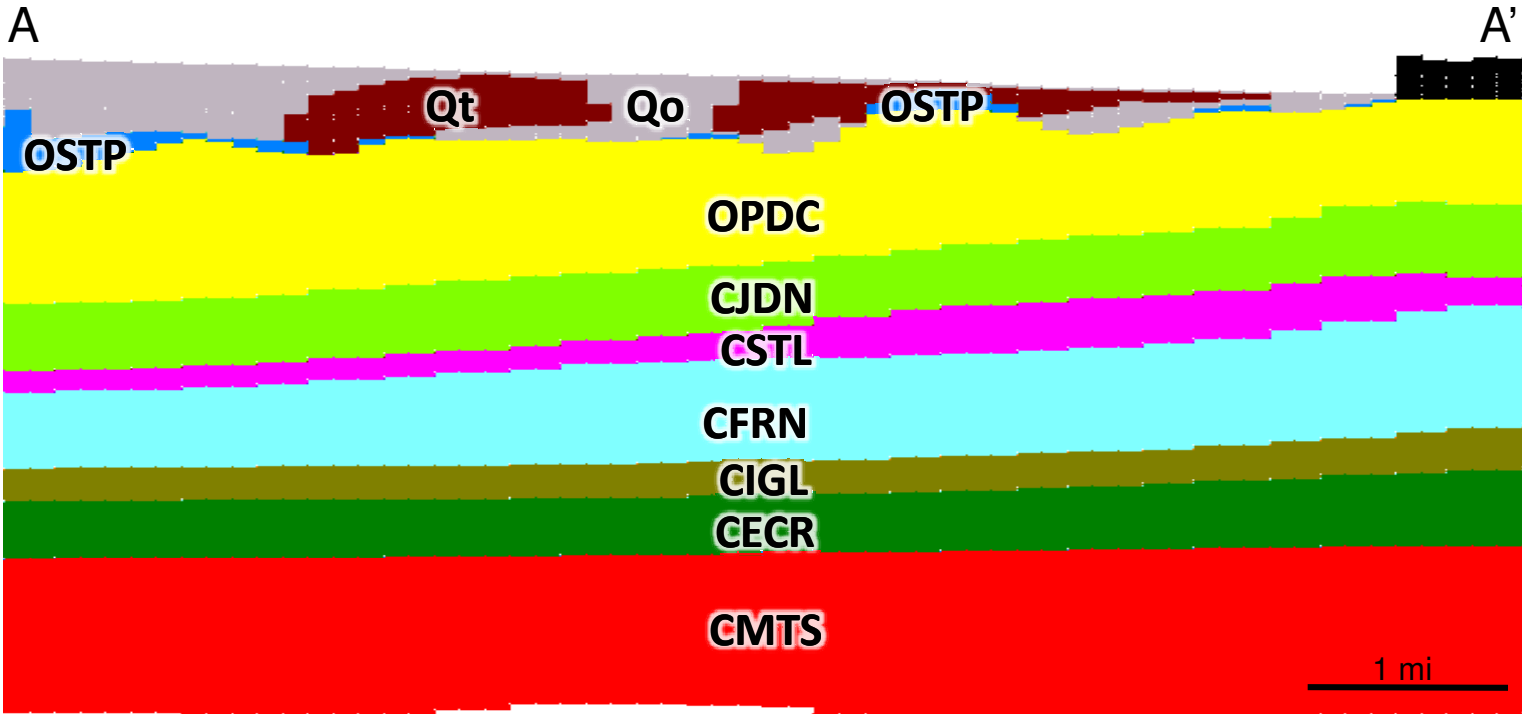


Figure 23  
Groundwater Model Cross Section



- Till (Qt)
- Outwash / Quaternary Undifferentiated (Qo)
- St Peter Sandstone (OSTP)
- Prairie du Chien Group (OPDC)
- Jordan Sandstone (CJDN)
- St. Lawrence Formation (CSTL)
- Franconia Formation (CFRN)
- Ironton and Galesville Sandstone (CIGL)
- Eau Claire Formation (CECR)
- Mt. Simon Sandstone (CMTS)

Vertical exaggeration = ~18x

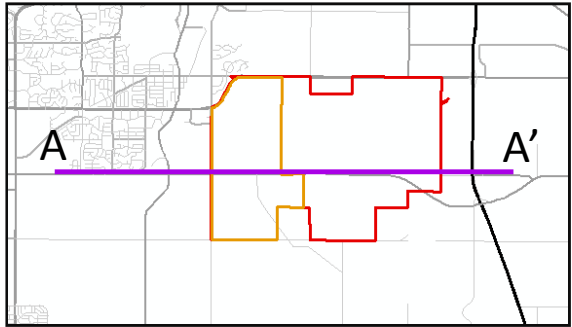


Figure 24  
Observed vs Computed Hydraulic Head Values

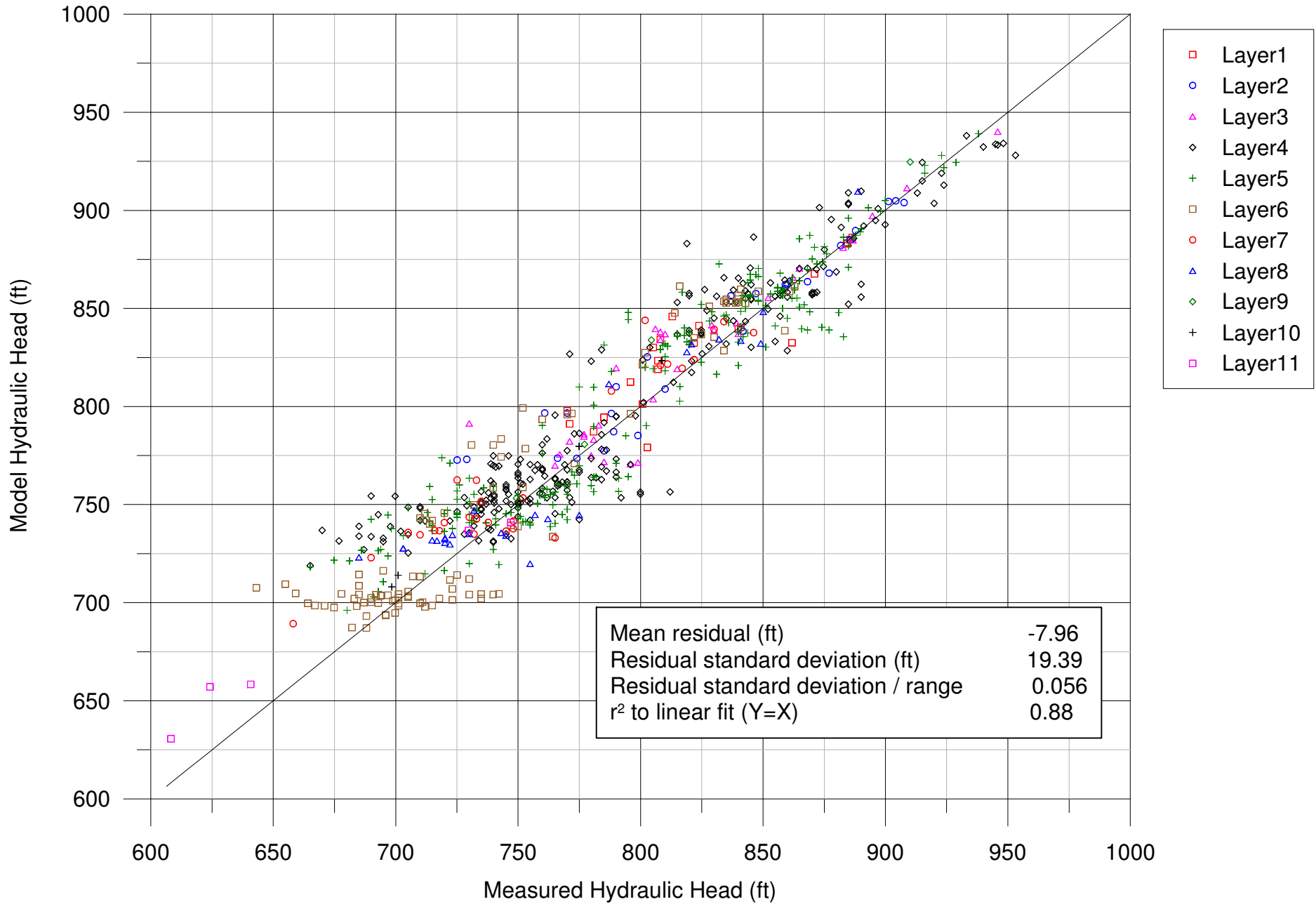
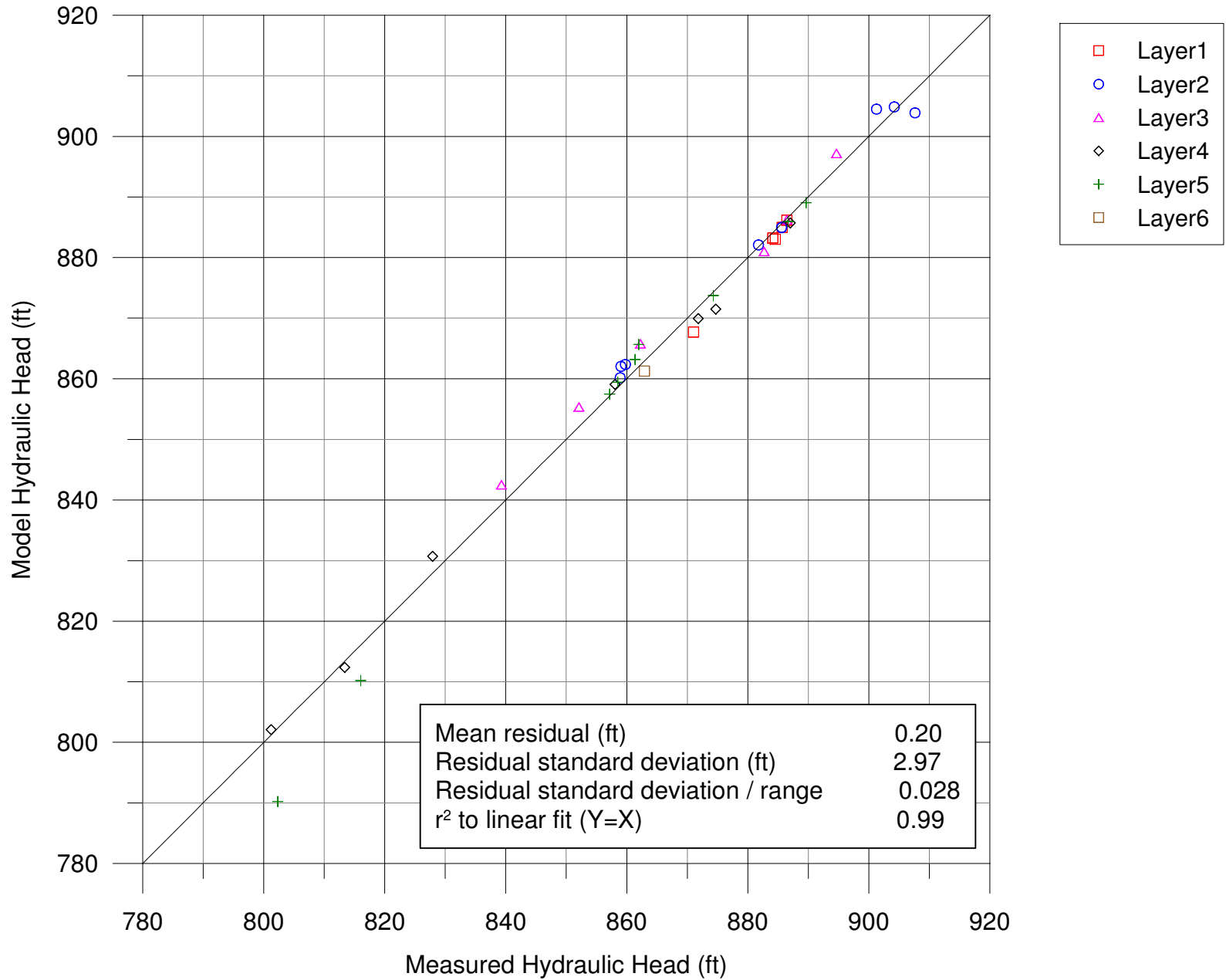
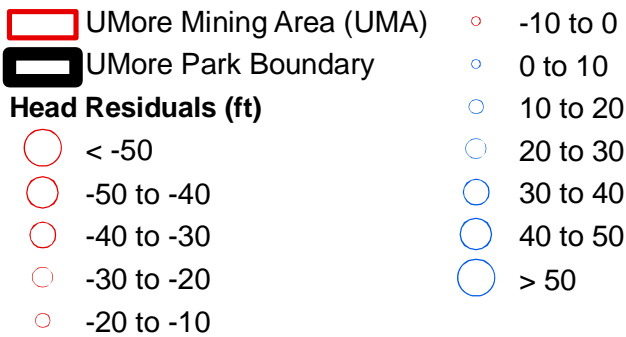
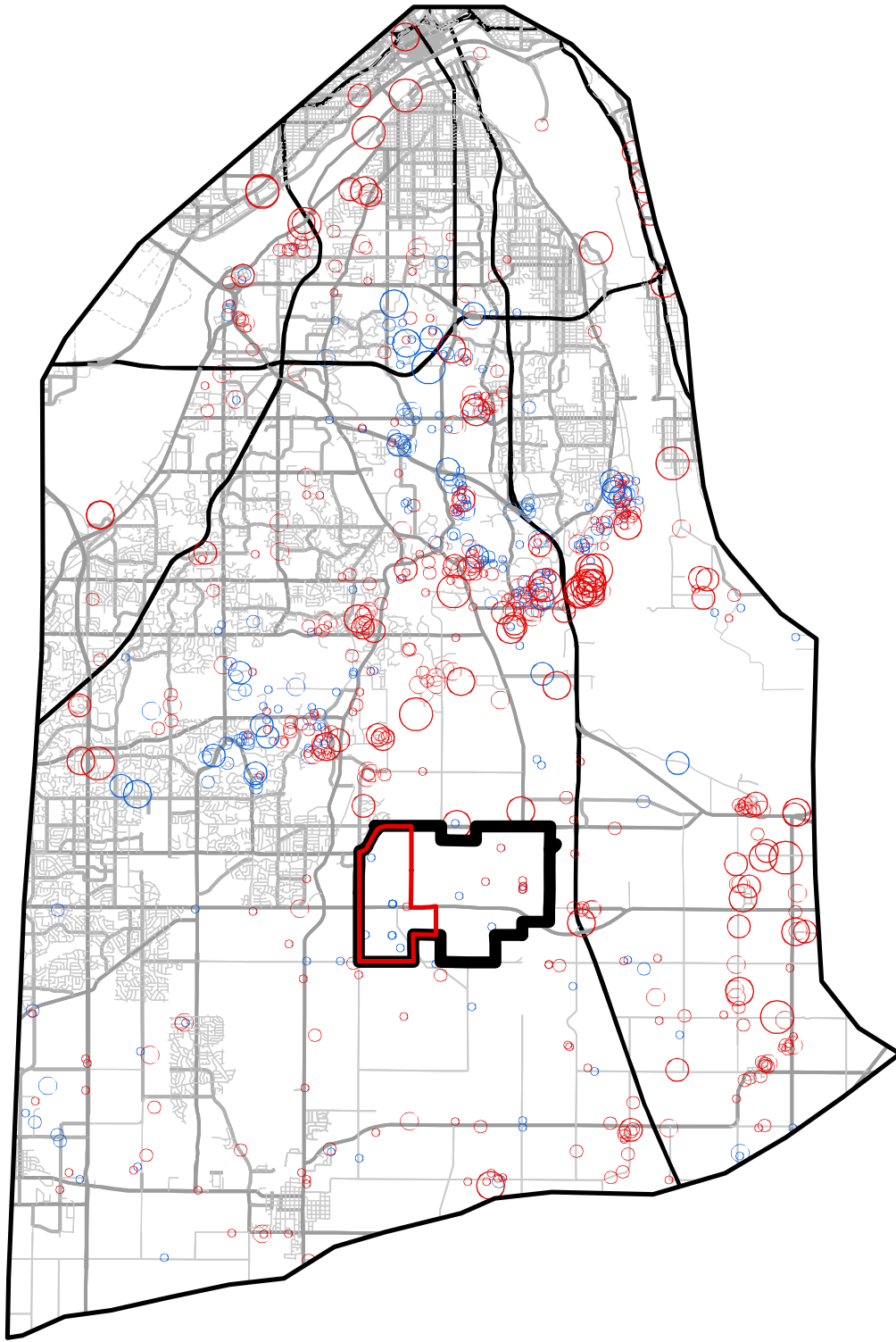




Figure 25  
 Observed vs. Computed Hydraulic Head Values  
 Measurements taken as part of this study





Miles



Residuals calculated as: measured value - model value

Source: MnDOT, MN DNR, Barr, SEH.

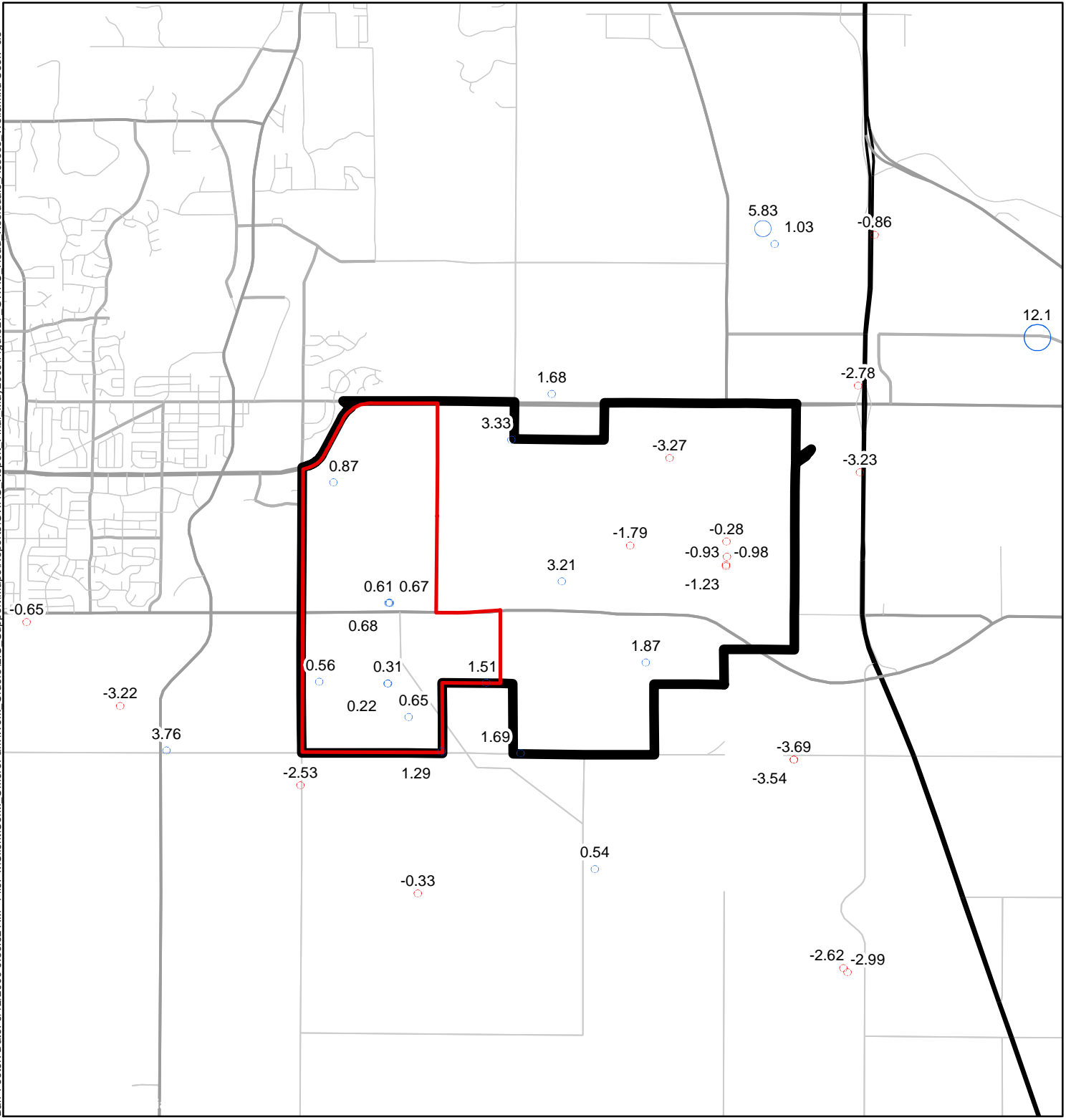
Figure 26

HEAD RESIDUALS

Groundwater Assessment Report  
Umore Mining Area  
Dakota County, MN





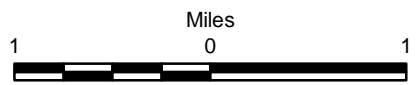


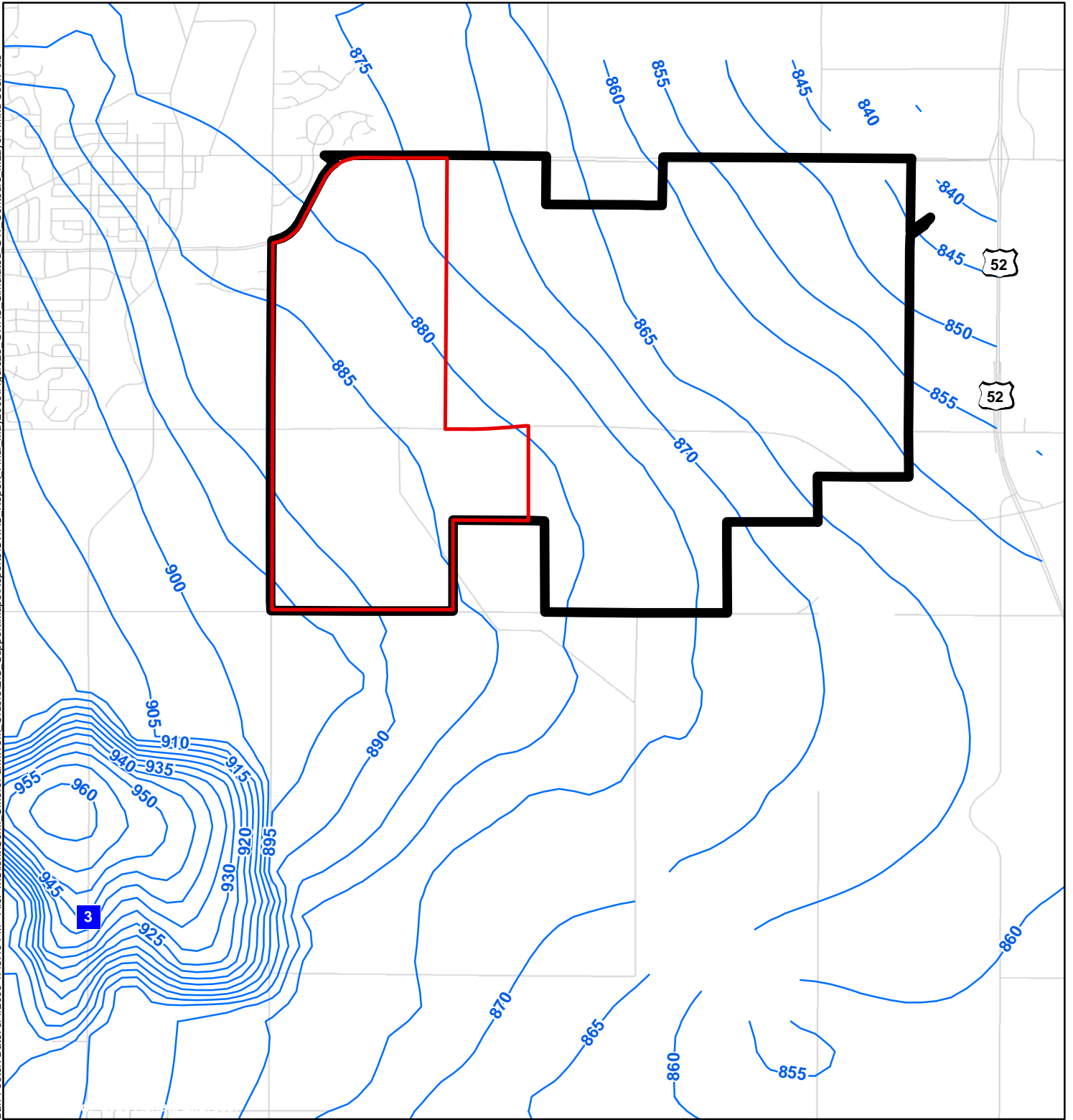
- UMore Mining Area (UMA)
  - UMore Park Boundary
  - Head Residuals (ft)**
  - < -10
  - 5 to -10
  - 5 to 0
  - 0 to 5
  - 5 to 10
  - > 10
- Residuals caclulated as: measured value - model value




Figure 27

**HEAD RESIDUALS,  
ASSESSMENT WELLS**

Groundwater Assessment Report  
UMore Mining Area  
Dakota County, MN





-  UMore Mining Area (UMA)
-  UMore Park Boundary
-  Head Contour (Contour Interval = 5 ft)

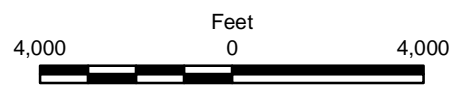


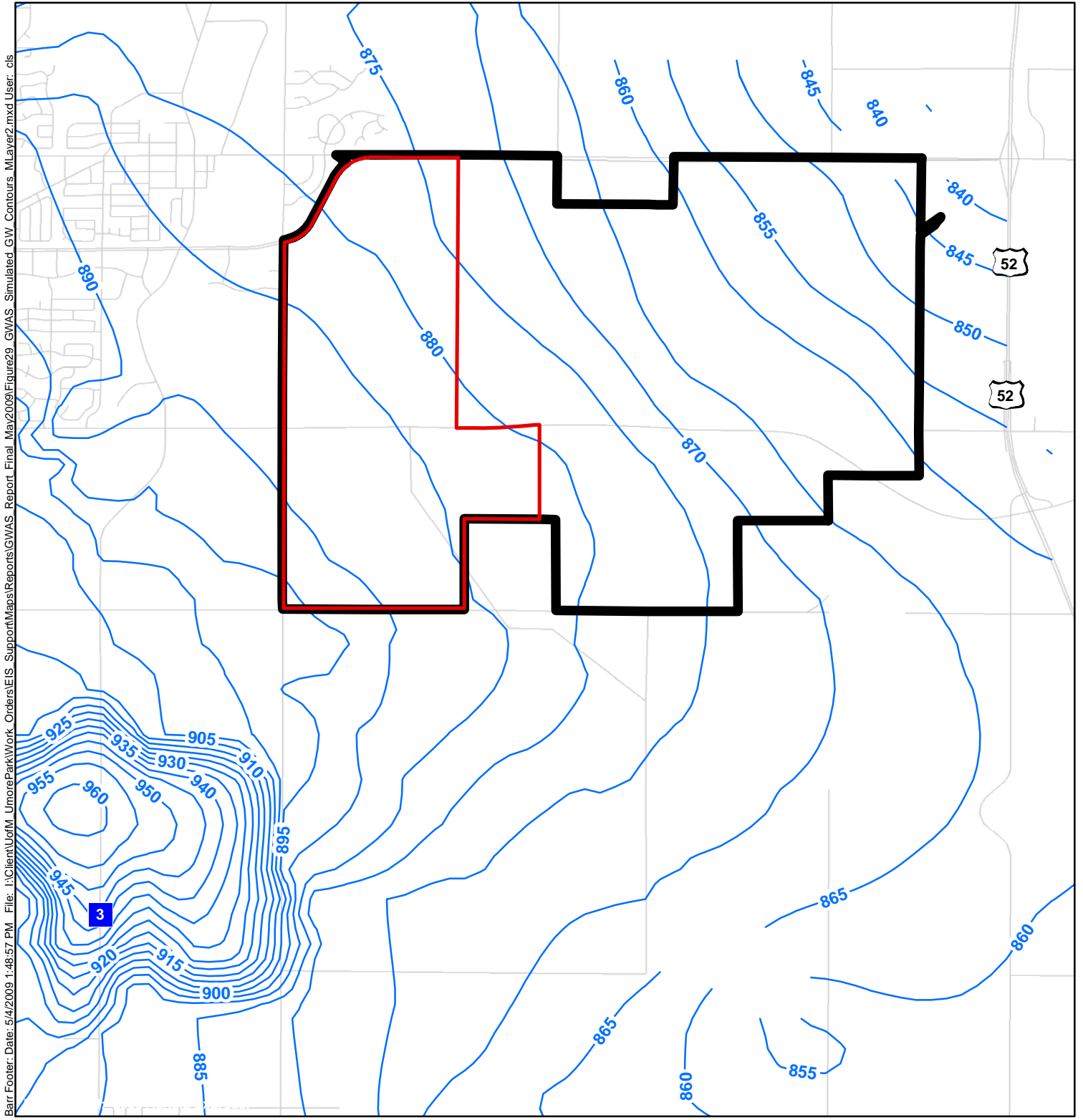
Figure 28

SIMULATED GROUNDWATER  
CONTOURS  
MODEL LAYER 1  
QUATERNARY

Groundwater Assessment Report  
UMore Mining Area  
Dakota County, MN







Barr Footer: Date: 5/4/2009 1:48:57 PM File: I:\Client\UoM\UmorePark\Work\_Orders\GIS\_Support\Maps\Reports\GWAS\_Report\_Final\_May2009\Figure29\_GWAS\_Simulated\_GW\_Contours\_MLayer2.mxd User: cls

- UMore Mining Area (UMA)
- UMore Park Boundary
- Head Contour (Contour Interval = 5 ft)

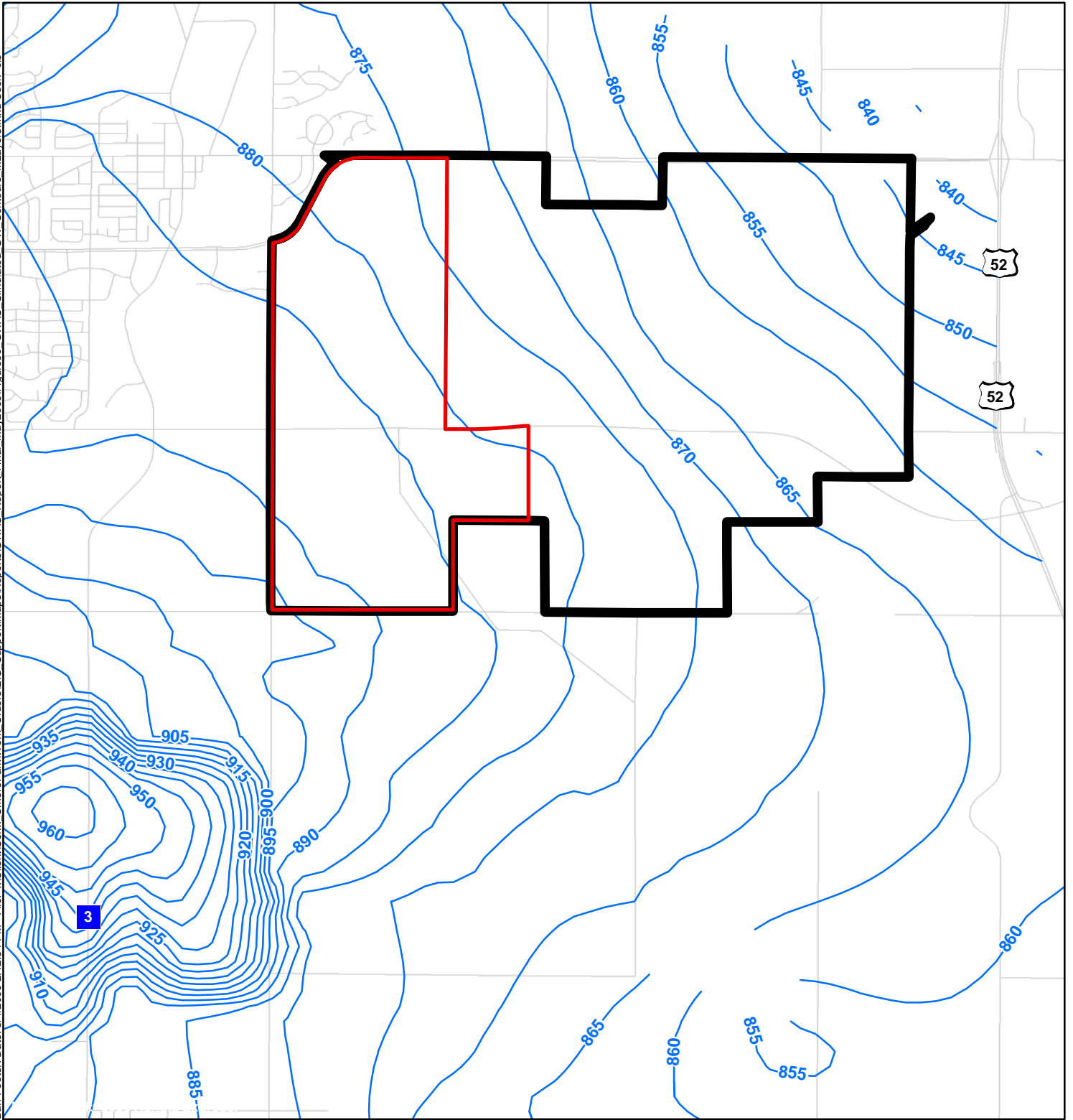





Figure 29

SIMULATED GROUNDWATER  
CONTOURS  
MODEL LAYER 2  
QUATERNARY

Groundwater Assessment Report  
UMore Mining Area  
Dakota County, MN





-  Umore Mining Area (UMA)
-  Umore Park Boundary
-  Head Contour (Contour Interval = 5 ft)

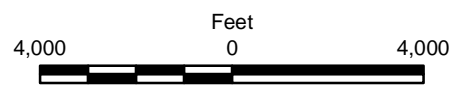


Figure 30

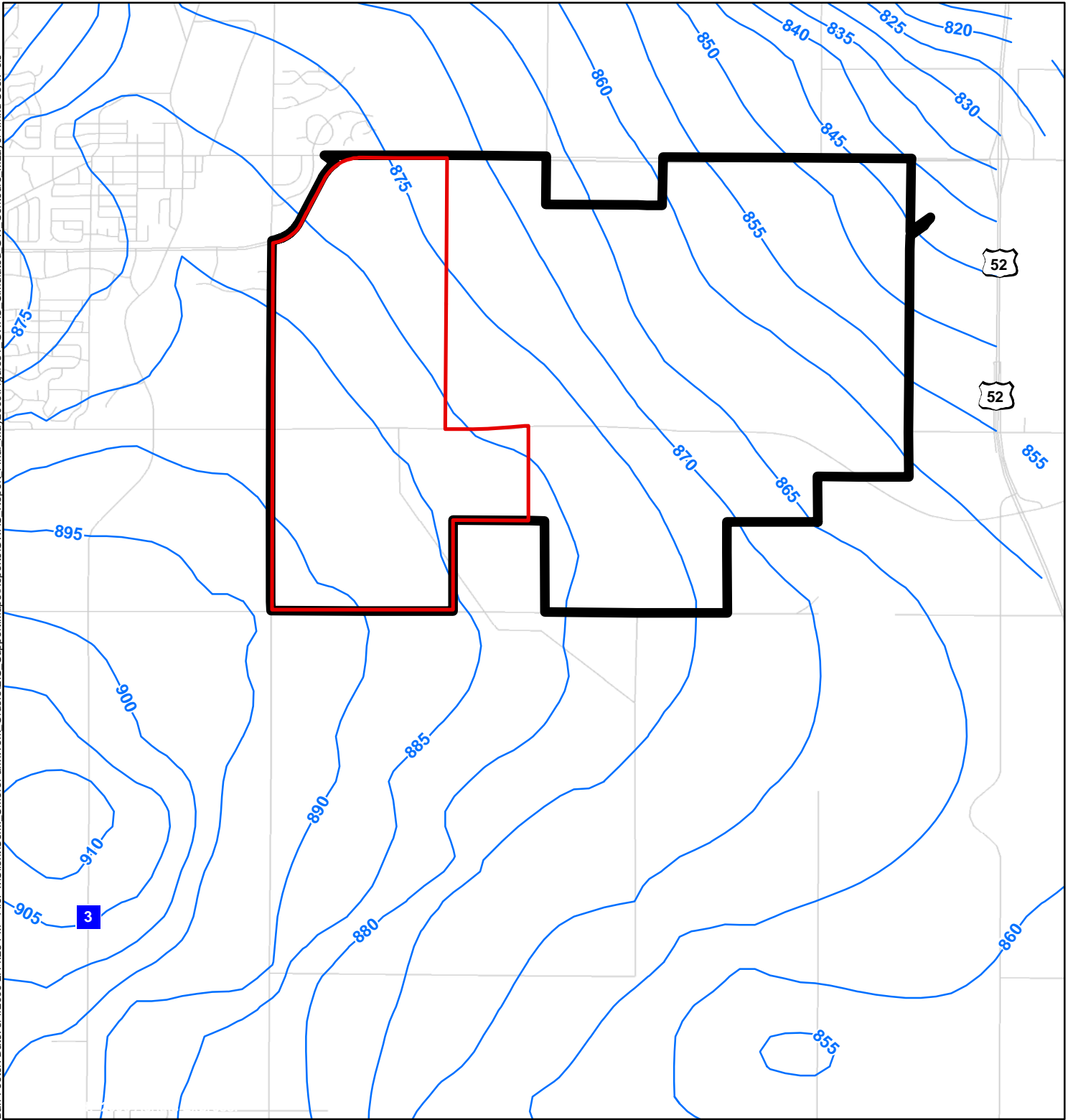
SIMULATED GROUNDWATER  
CONTOURS  
MODEL LAYER 3  
QUATERNARY




Groundwater Assessment Report  
Umore Mining Area  
Dakota County, MN





Barr Footer: Date: 5/4/2009 2:14:23 PM File: I:\Client\UoM - UmorePark\Work - Orders\GIS - Support\Maps\Reports\GWAS - Report.Final\_May2009\Figure31\_GWAS - Simulated GW - Contours\_MLayer4.mxd User: cls



-  Umore Mining Area (UMA)
-  Umore Park Boundary
-  Head Contour (Contour Interval = 5 ft)

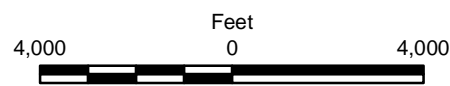
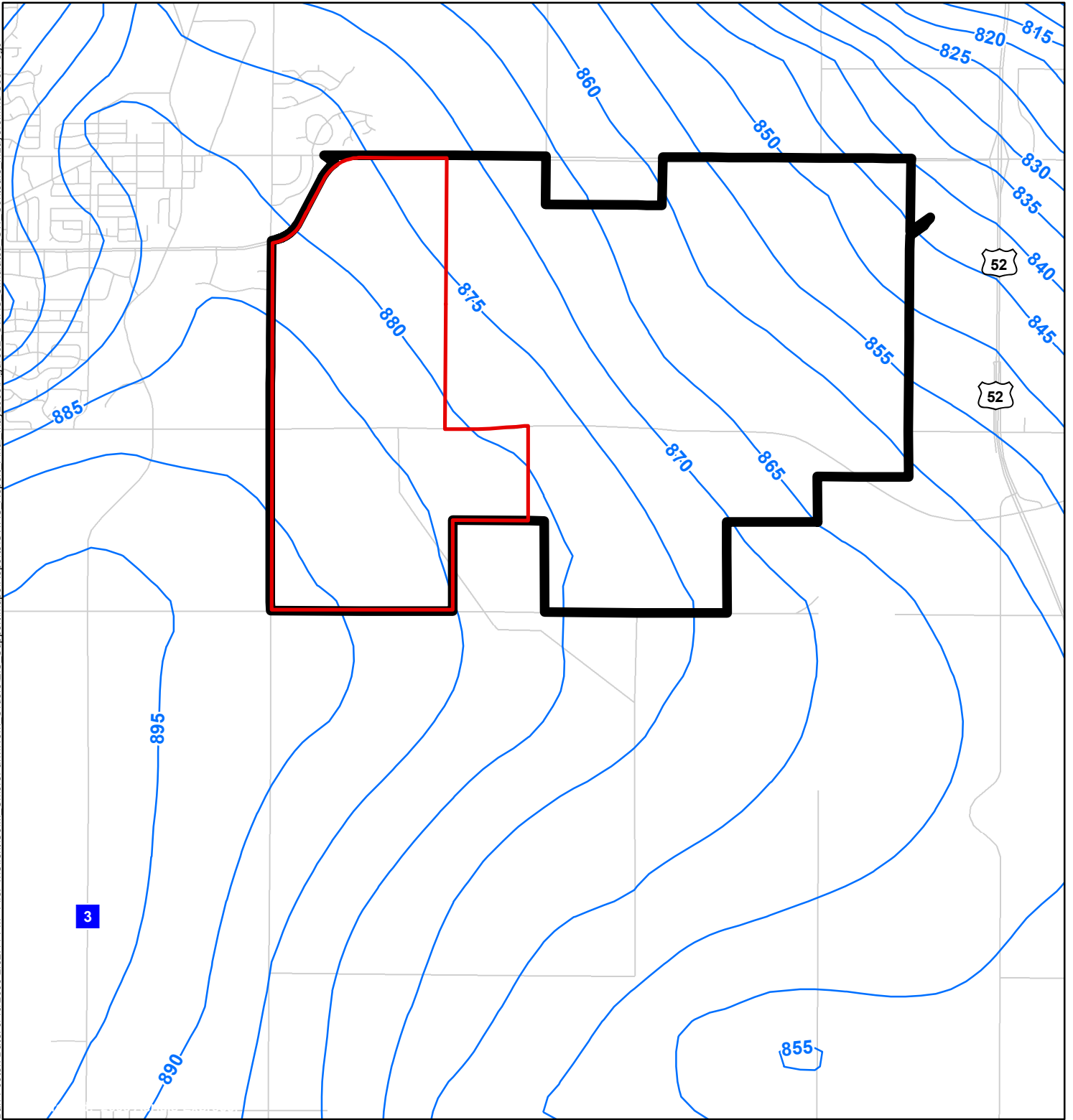


Figure 31

SIMULATED GROUNDWATER  
CONTOURS  
MODEL LAYER 4  
QUATERNARY & ST. PETER  
SANDSTONE (WHERE PRESENT)

Groundwater Assessment Report  
Umore Mining Area  
Dakota County, MN








-  UMore Mining Area (UMA)
-  UMore Park Boundary
-  Head Contour (Contour Interval = 5 ft)



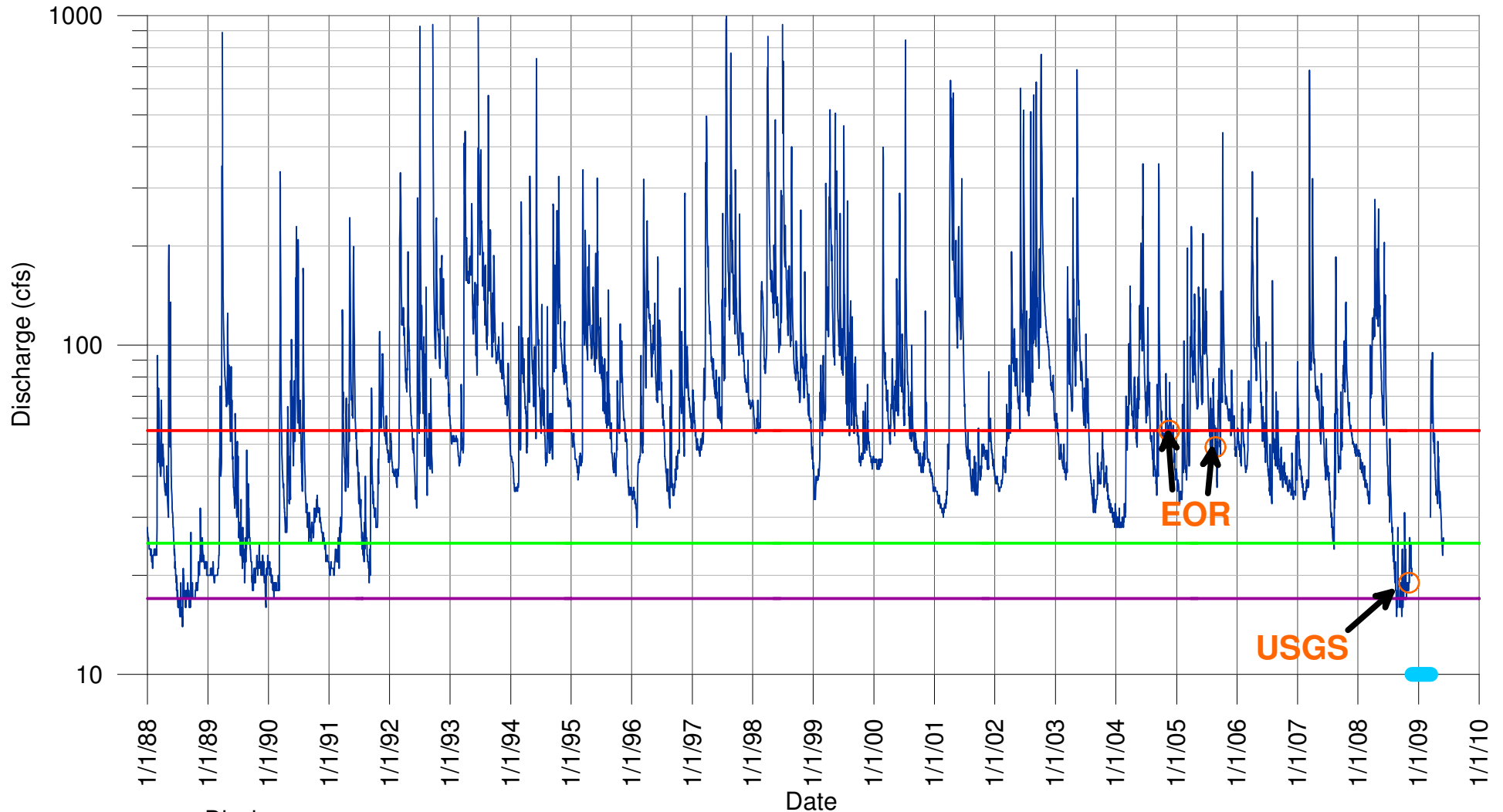
Figure 32

SIMULATED GROUNDWATER  
CONTOURS  
MODEL LAYER 5  
PRAIRIE DU CHIEN GROUP  
(WHERE PRESENT)

Groundwater Assessment Report  
UMore Mining Area  
Dakota County, MN



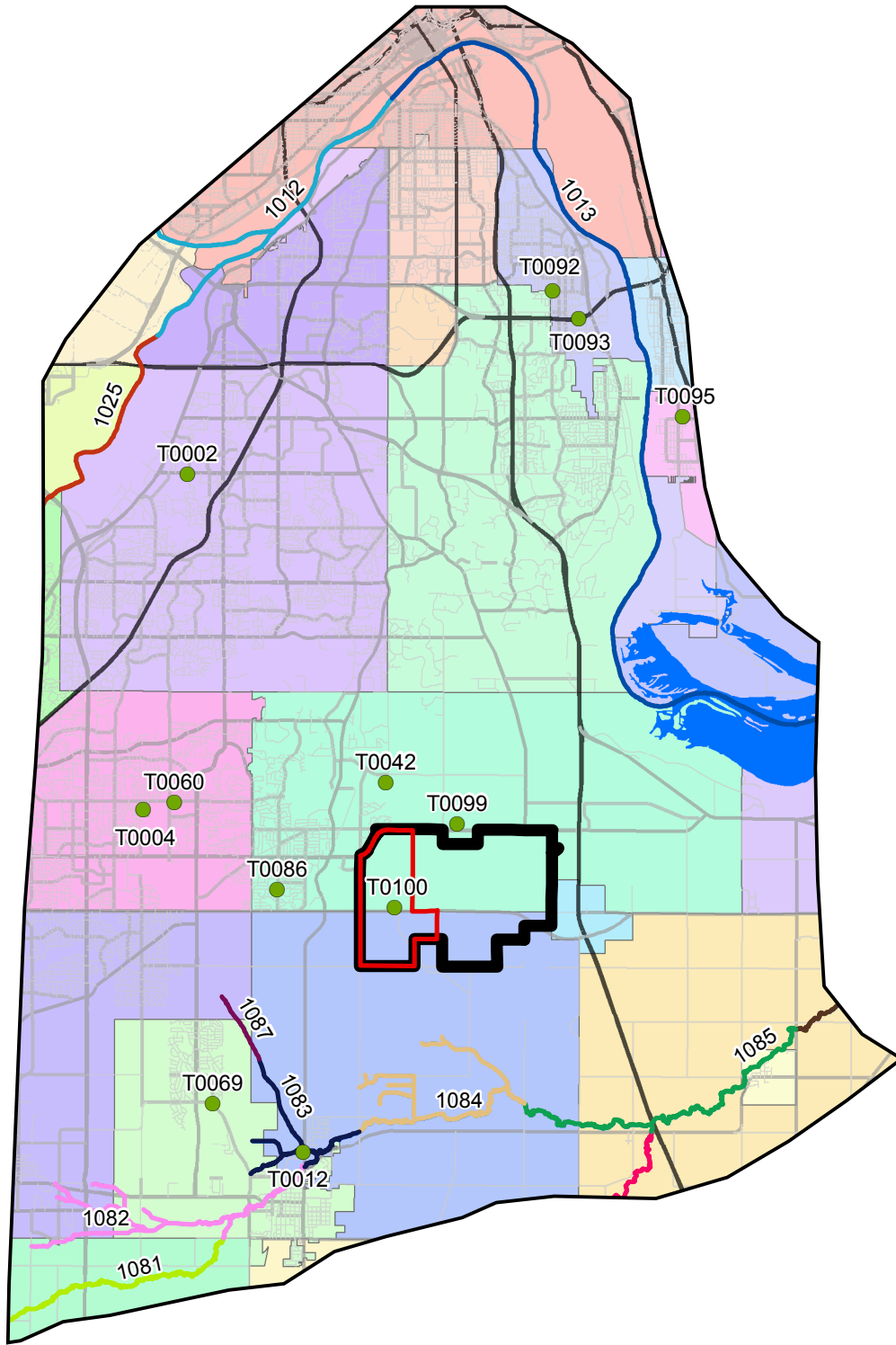
**Figure 33**  
**Daily Mean Stream Discharge**  
**Vermillion River near Empire, MN**  
**USGS Station 05345000**



- Discharge
- Median (record shown)
- 10th Percentile (record shown)
- 1st Percentile (record shown)
- Flow at station affected by ice

EOR data collected on November 17, 2004 and August 22-24, 2005 (EOR, 2007)  
 USGS data collected on November 3, 2008 (Cowdery, 2009)








-  UMore Mining Area (UMA)
-  UMore Park Boundary
-  Transmissivity Targets

Figure 34

BASEFLOW REACHES & TRANSMISSIVITY TARGETS

Groundwater Assessment Report  
UMore Mining Area  
Dakota County, MN

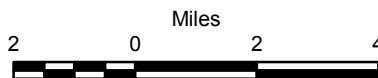
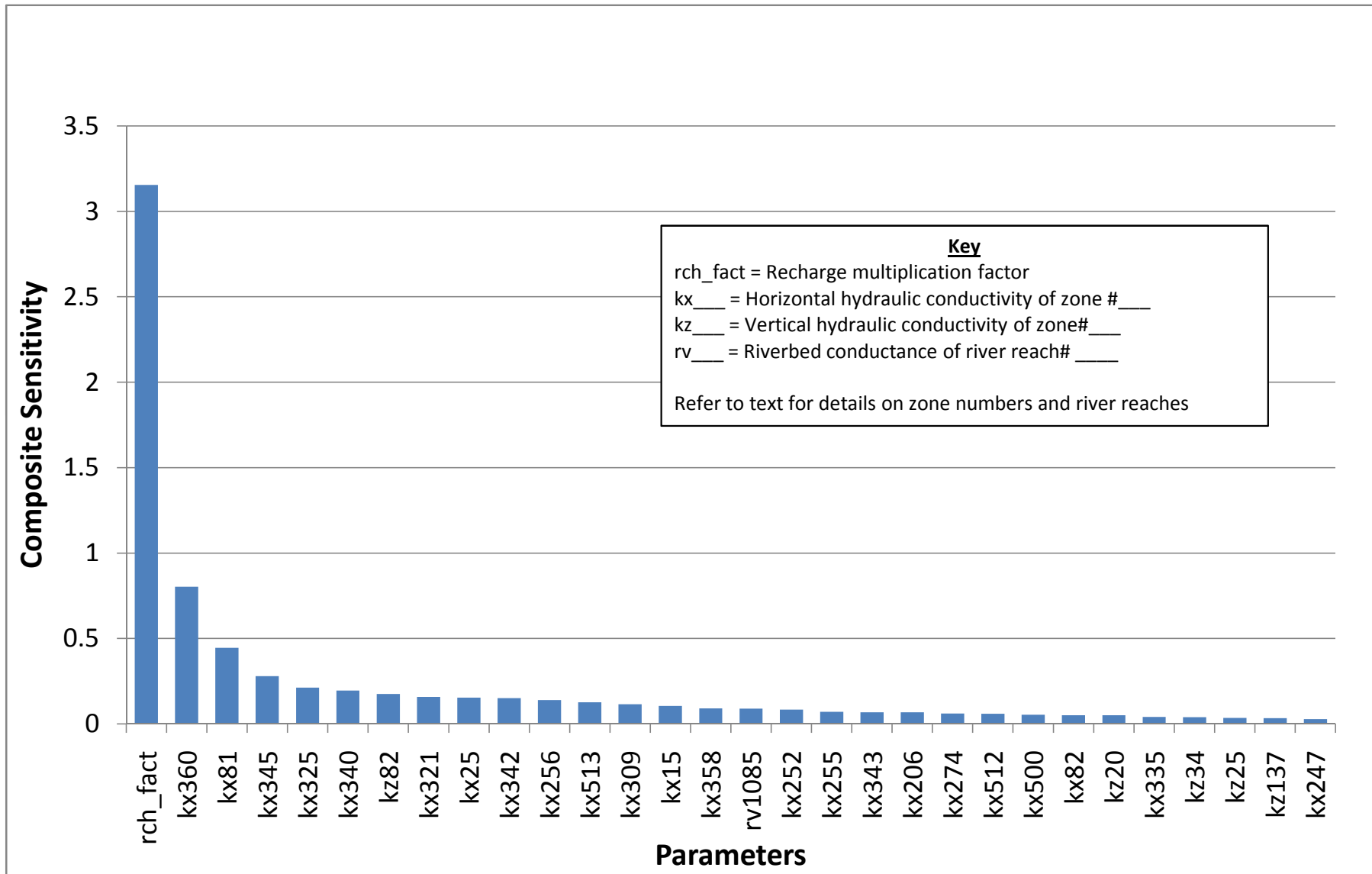
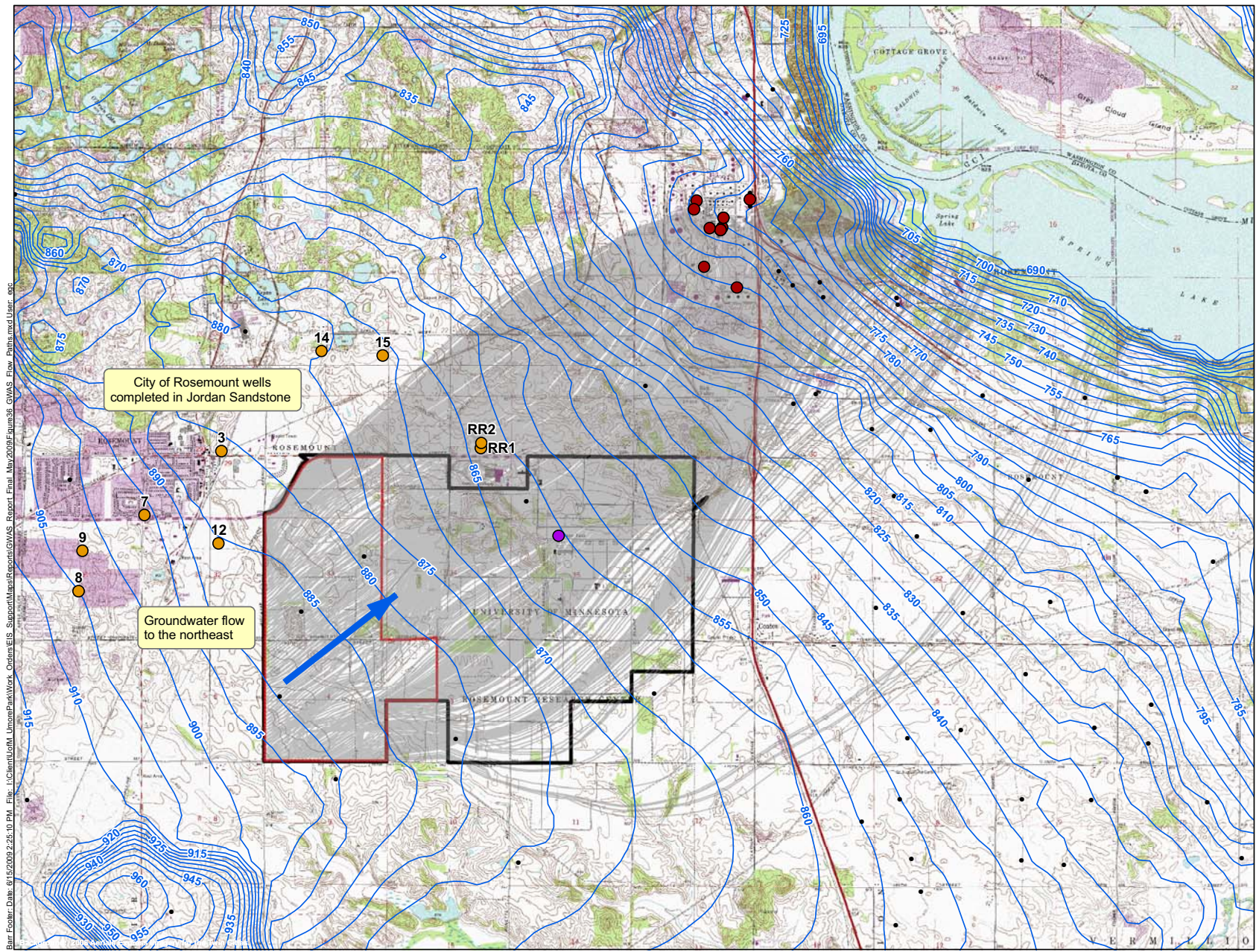


Figure 35  
Parameter Sensitivities







- Wells**
- Flint Hills Resources
  - U of M (CJDN-CSTL)
  - City of Rosemount (CJDN)
  - Additional Supply Wells In Model
- Flow Lines
- Groundwater Contours (ft)
- UMore Mining Area (UMA)
- UMore Park Boundary
- Source: MnDOT, Barr, Dakota County, SEH, HKGI, USGS topographic map background downloaded from the U.S. Department of Agriculture, Natural Resources Conservation Service.

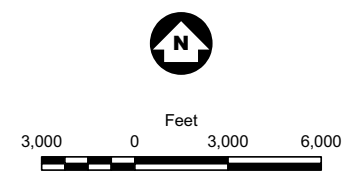
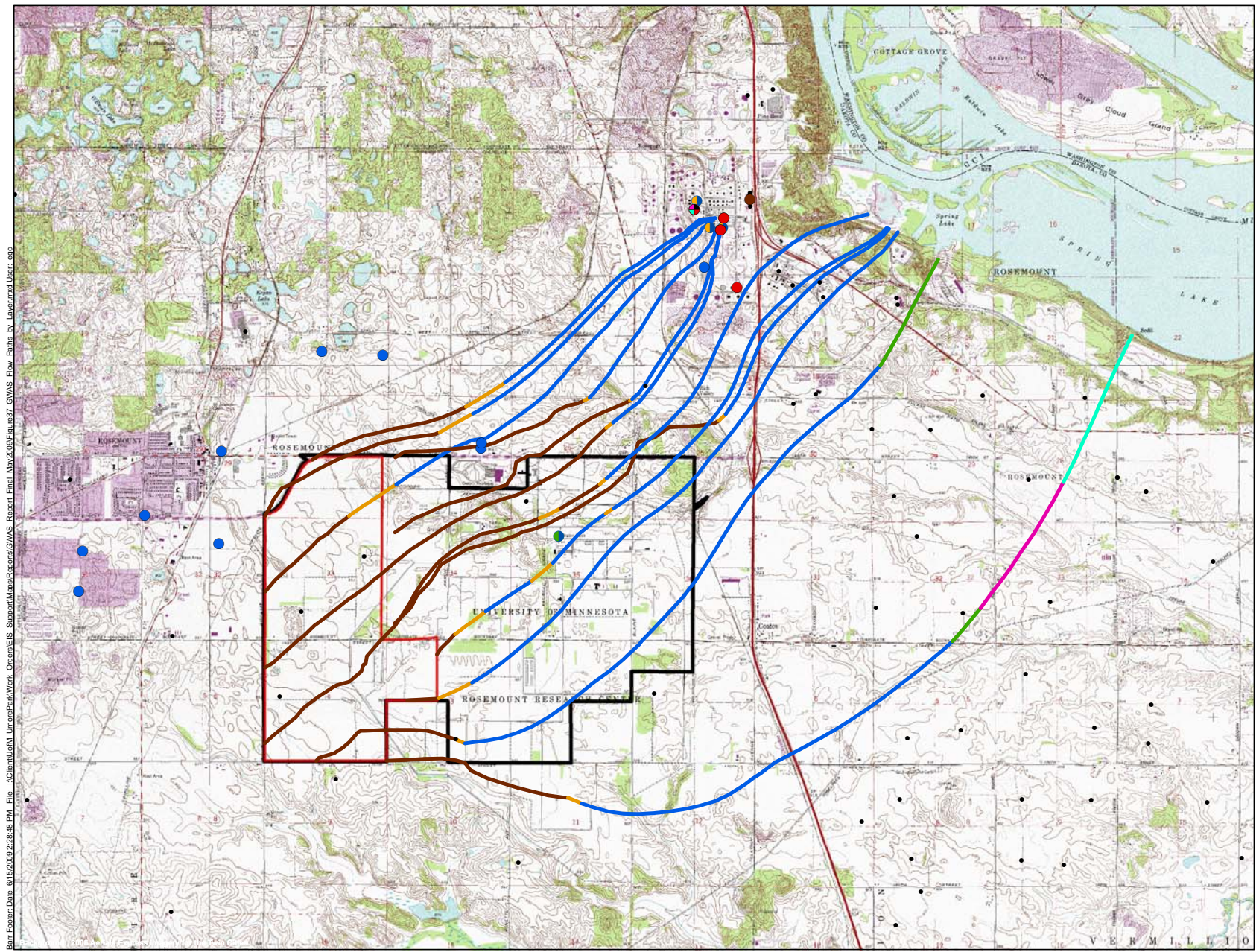


Figure 36  
 MODEL-DERIVED  
 FLOW PATHS FROM  
 UMA BOUNDARY  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN



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- Wells of interest by aquifer unit**
- Quaternary
  - OPDC - CJDN
  - CJDN
  - CJDN - CSTL
  - CFRN - CMTS
  - CMTS
  - Additional Supply Wells In Model
- Wells of Interest by Aquifer Unit**
- Quaternary - OSTP
  - OPDC
  - CJDN
  - CSTL
  - CFRN
  - CIGL
  - UMore Mining Area (UMA)
  - UMore Park Boundary

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



Figure 37

SELECTED FLOW PATHS  
 BY LAYER

Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN



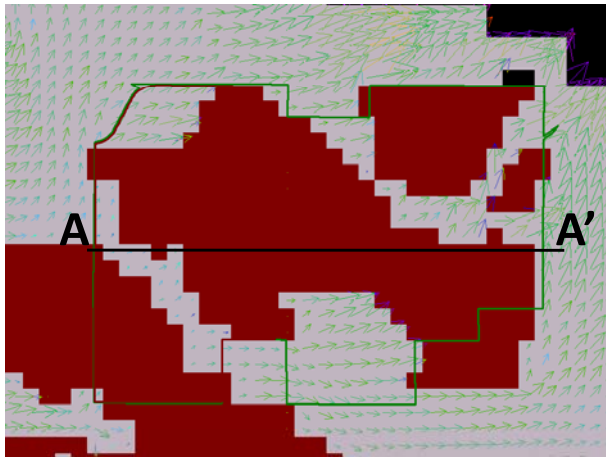
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Figure 38

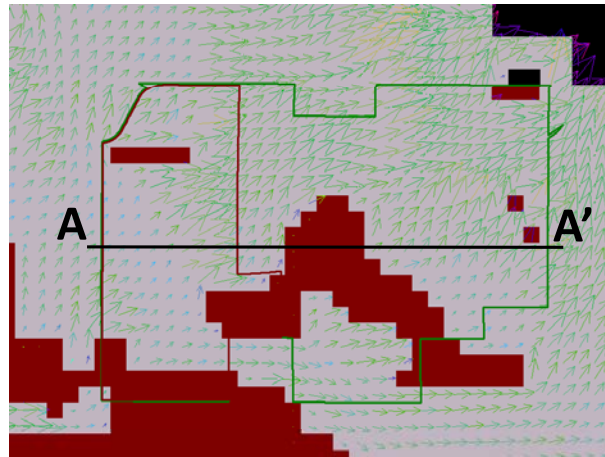
Groundwater Flow Vectors  
 Groundwater Assessment Report  
 UMore Mining Area  
 Dakota County, MN

Model Layer 2



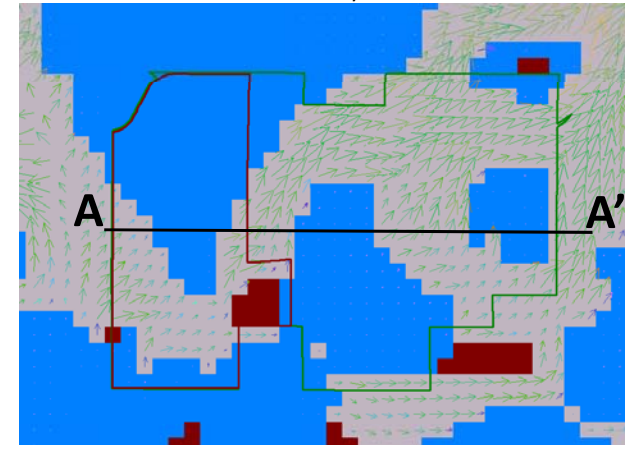
- Groundwater flow around till to northwest and southeast.
- Groundwater flow towards till flows under till through lower outwash and bedrock.
- Vectors within the till are too small to be visible at this scale.

Model Layer 3

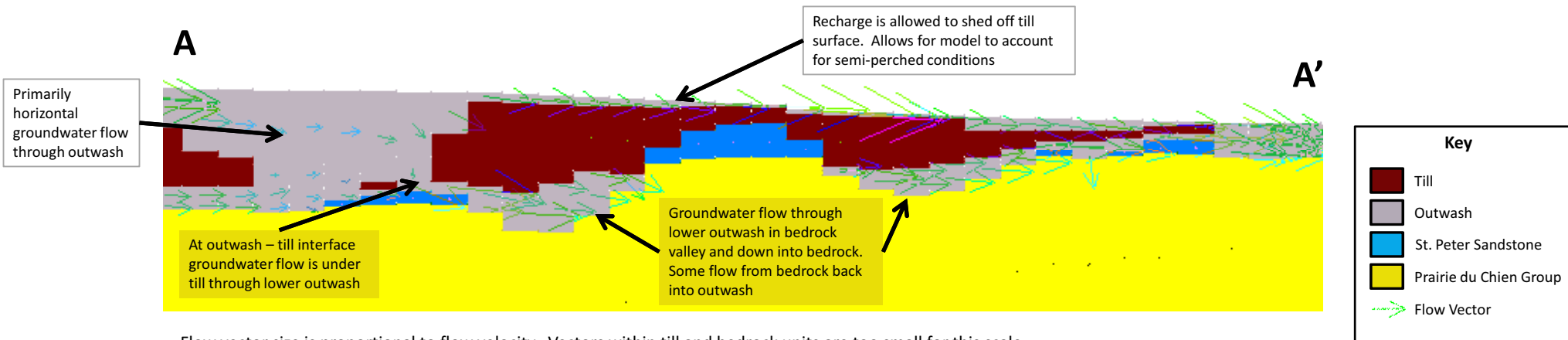


- Groundwater flow in north-central part of site is under till within lower outwash unit.

Model Layer 4



- Active groundwater flow through outwash filled bedrock valley.
- Vectors within the St. Peter Sandstone are too small to be visible at this scale.



Flow vector size is proportional to flow velocity. Vectors within till and bedrock units are too small for this scale. Flow vectors vertically exaggerated.

Key	
<span style="display:inline-block; width:15px; height:15px; background-color:darkred;"></span>	Till
<span style="display:inline-block; width:15px; height:15px; background-color:grey;"></span>	Outwash
<span style="display:inline-block; width:15px; height:15px; background-color:blue;"></span>	St. Peter Sandstone
<span style="display:inline-block; width:15px; height:15px; background-color:yellow;"></span>	Prairie du Chien Group
<span style="display:inline-block; width:15px; height:15px; border-bottom: 1px dashed green;"></span>	Flow Vector