Hydrogeologic Assessment of the Drinking Water Source and Wells for the City of Montrose

DELINEATIONS – WELLHEAD PROTECTION AREA AND DRINKING WATER SUPPLY MANAGEMENT AREA

VULNERABILITY ASSESSMENTS – WELLS AND DRINKING WATER SUPPLY MANAGEMENT AREA

August 4, 2021

Hydrogeologic Assessment of the Drinking Water Source and Wells for the City of Montrose

Public Water Supply ID: 1860016

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I hereby certify that this plan, document or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Geologist under the laws of the State of Minnesota.

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Glossary of Terms

Data Element. A specific type of information required by the Minnesota Department of Health to prepare a wellhead protection plan.

Drinking Water Supply Management Area (DWSMA). The area delineated using identifiable landmarks that reflects the scientifically calculated wellhead protection area boundaries as closely as possible (Minnesota Rules, part 4720.5100, subpart 13).

Drinking Water Supply Management Area Vulnerability. An assessment of the likelihood that the aquifer within the DWSMA is subject to impact from land and water uses within the wellhead protection area. It is based upon criteria that are specified under Minnesota Rules, part 4720.5210, subpart 3.

Emergency Response Area (ERA). The part of the wellhead protection area that is defined by a one-year time of travel within the aquifer that is used by the public water supply well (Minnesota Rules, part 4720.5250, subpart 3). It is used to set priorities for managing potential contamination sources within the DWSMA.

Inner Wellhead Management Zone (IWMZ). The land that is within 200 feet of a public water supply well (Minnesota Rules, part 4720.5100, subpart 19). The public water supplier must manage the IWMZ to help protect it from sources of pathogen or chemical contamination that may cause an acute health effect.

Wellhead Protection (WHP). A method of preventing well contamination by effectively managing potential contamination sources in all or a portion of the well's recharge area.

Wellhead Protection Area (WHPA). The surface and subsurface area surrounding a well or well field that supplies a public water system, through which contaminants are likely to move toward and reach the well or well field (Minnesota Statutes, section 103I.005, subdivision 24).

Well Vulnerability. An assessment of the likelihood that a well is at risk to human-caused contamination, either due to its construction or indicated by criteria that are specified under Minnesota Rules, part 4720.5550, subpart 2.

Acronyms

CWI - County Well Index

DNR - Minnesota Department of Natural Resources

EPA - United States Environmental Protection Agency

FSA - Farm Security Administration

MDA - Minnesota Department of Agriculture

MDH - Minnesota Department of Health

MGS - Minnesota Geological Survey

MLAEM - Multi Layer Analytic Element Model

MnDOT - Minnesota Department of Transportation

MnGEO - Minnesota Geospatial Information Office

MPCA - Minnesota Pollution Control Agency

NRCS - Natural Resource Conservation Service

SWCD - Soil and Water Conservation District

UMN - University of Minnesota

USDA - United States Department of Agriculture

USGS - United States Geological Survey

Summary

Protection Areas - The recharge area for the wells is known as the wellhead protection area, or WHPA, and represents the area that contributes water to the city's wells within a 10-year period. The area that contributes water within a one-year period is known as the emergency response area, or ERA. Practical reasons require the designation of a management area that fully envelops the wellhead protection area, called the drinking water supply management area, or DWSMA. Each of these areas is shown in Figure 1.

Geology and Groundwater Flow – The city of Montrose has three primary wells screened in a sand and gravel aquifer that is buried beneath a layer of clay-rich sediment. Such aquifers are known generically as Quaternary Buried Artesian Aquifers (QBAA). The depths of the wells are represented in Table 1. Regionally, groundwater flow is from the southwest to the northeast (Figure 2).

Table 1 - Water Supply Well Information

Local Well ID	Unique Number	Use/ Status	Casing Diameter (inches)	Casing Depth (feet)	Well Depth (feet)	Date Constructed/ Reconstructed	Aquifer	Well Vulnerability
Well #4	700302	Primary	12	155	175	7/15/2004	QBAA	Not Vulnerable
Well #5	700301	Primary	12	155	175	7/15/2004	QBAA	Not Vulnerable
Well #6	843402	Primary	12	145	161	9/18/2019	QBAA	Not Vulnerable

Well Vulnerability - The vulnerability of each well has been assessed based on 1) well construction details, especially conformance with standards required by the state well code, 2) the geologic sensitivity of the aquifer, and 3) past monitoring results. All wells meet construction standards.

Table 2 - Isotope and Water Quality Results

Well Name (Unique Number)	Tritium	Nitrate (mg/L)	Chloride (mg/L)	Bromide (mg/L)	Chloride/ Bromide Ratio
Montrose Well #4 (700302)	< 0.8 11/30/2012	< 0.05 4/7/2014	< 1 7/30/2013	0.0288 7/30/2013	< 35
Montrose Well #5 (700301)	-	< 0.5 4/7/2014	1.57 7/30/2013	0.0246 7/30/2013	63.8
Montrose Well #6 (843402)	-	< 0.05 9/18/2019	-	-	-

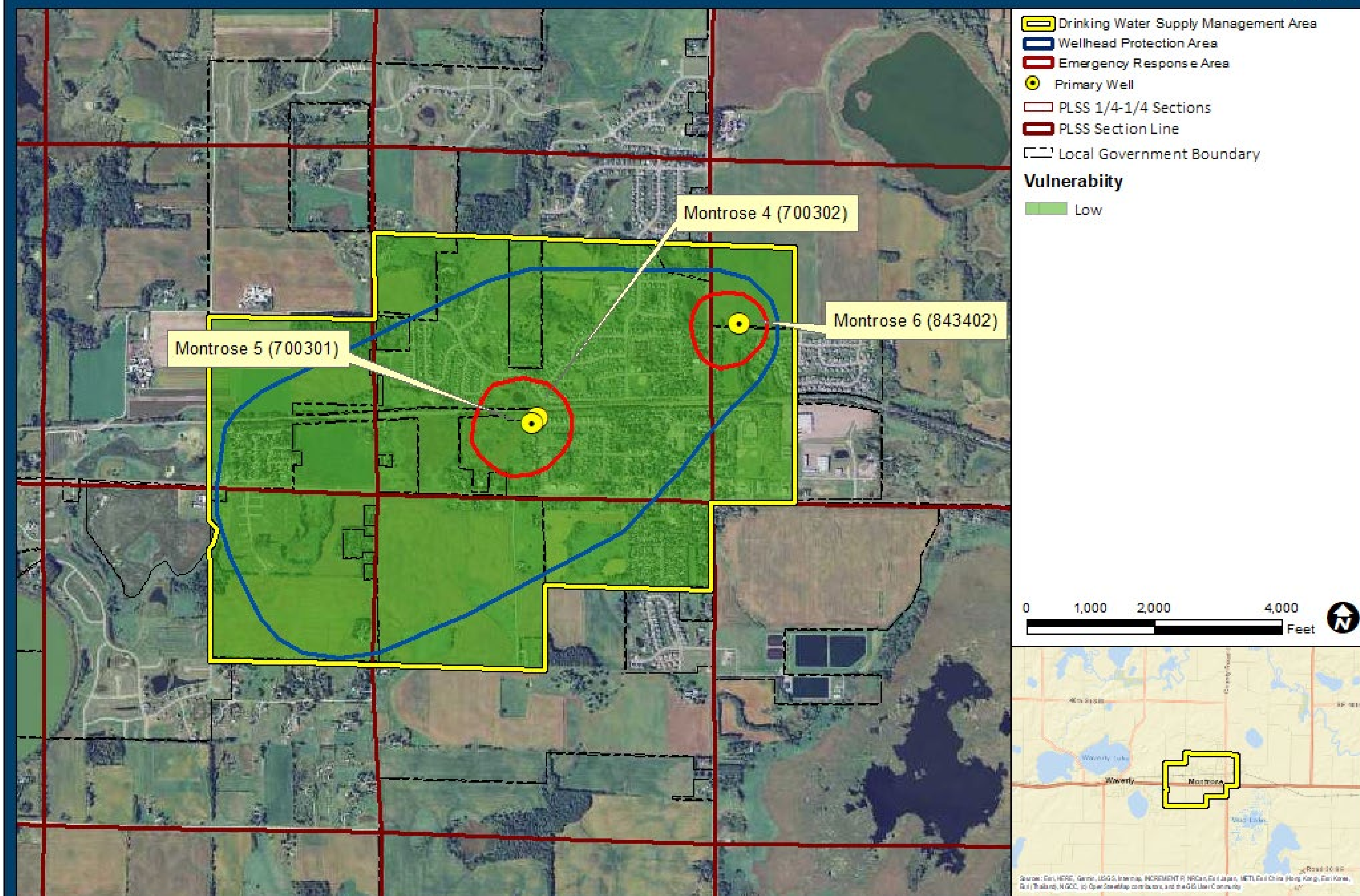
DWSMA Vulnerability - The vulnerability of the city's aquifer throughout the DWSMA is based on the geologic sensitivity ratings of wells and their monitoring data. Based on this information MDH has assigned a low vulnerability to the DWSMA. This suggests that the clay-rich sediments that overlie the city's aquifer prevent water and contaminants from moving quickly from the land surface into the city's aquifer and implies a time of travel of decades or longer. The principal threats to this aquifer are unsealed abandoned wells that penetrate through this clay layer. Such wells are 145 feet or greater in depth in the Montrose area.

Water Quality Concerns - At present, none of the contaminants for which the Safe Drinking Water Act has established health-based standards has been found above maximum allowable levels in the city's water supply, nor are any present at one-half of those levels.

Recommendations - Recommendations have been generated to improve future delineations and vulnerability assessments and should be considered for inclusion as management strategies in the city's wellhead protection plan. These activities include: well locating, water quality monitoring and aquifer testing. Further details can be found in Section 2.7 of this report.

Wright County
Minnesota

Figure 1
Drinking Water Supply Management Area and Vulnerability
City of Montrose



Technical Report

Discussion

The Minnesota Department of Health (MDH) developed Part I of the wellhead protection (WHP) plan at the request of the city of Montrose (PWSID 1860016). The work was performed in accordance with the Minnesota Wellhead Protection Rule, parts 4720.5100 to 4720.5590.

This report presents delineations of the wellhead protection area (WHPA) and drinking water supply management area (DWSMA), and the vulnerability assessments for the public water supply wells and DWSMA. Figure 1 shows the boundaries for the WHPA and the DWSMA. The WHPA is defined by a 10-year time of travel. Figure 1 also shows the emergency response area (ERA), which is defined by a one-year time of travel. Definitions of rule-specific terms used are provided in the “Glossary of Terms.”

In addition, this report documents the technical information required to prepare this portion of the WHP plan in accordance with the Minnesota Wellhead Protection Rule. Additional technical information is available from MDH.

Table 1 lists all the wells in the public water supply system. Only wells listed as primary are required to be included in the WHP plan.

Assessment of the Data Elements

MDH staff met with representatives of the city of Montrose on November 30, 2016, for a scoping meeting that identified the data elements required to prepare Part I of the WHP plan. Subsequently, wellhead protection activities were paused while Montrose installed a new public water supply well and treatment plant. MDH and Minnesota Rural Water Association staff met again with the city of Montrose on April 08, 2021, to discuss updates to wellhead protection planning efforts in light of the addition of Well #6 to the city’s water system. Appendix A presents the assessment of these data elements relative to the present and future implications of planning items specified in Minnesota Rules, part 4720.5210.

General Descriptions

Description of the Water Supply System

The city of Montrose obtains its drinking water supply from three primary wells. Table 1 summarizes information regarding them.

Description of the Hydrogeologic Setting

The city of Montrose draws groundwater from a glacial sand and gravel aquifer found approximately 145 feet below the land surface. The aquifer is overlain by a layer of clay-rich sediments and is designated as a Quaternary Buried Artesian Aquifer (QBAA). For this report, an estimated aquifer thickness of 24 feet is used (Barry 2018). The true thickness is unknown due to the lack of wells that fully-penetrate the aquifer. Regionally, groundwater flows from southwest to northeast.

A description of the hydrogeologic setting for the aquifer used to supply drinking water is presented in Table 3.

Table 3 - Description of the Local Hydrogeologic Setting

Attribute	Descriptor	Data Source
Aquifer Material	Unconsolidated sand and gravel	CWI
Porosity Type and Value	20 percent	Fetter, 2001
Aquifer Thickness	Aquifer thickness is regionally variable and uncertain due to the lack of fully penetrative borehole data in the surrounding area. The Montrose city wells draw from a sand and gravel aquifer approximately 24 feet thick.	CWI, Figures 4 and 5
Stratigraphic Top Elevation	Approximately 840 feet AMSL depending on regional deposition of sand, gravel, and clay layers.	CWI, Figures 4 and 5
Stratigraphic Bottom Elevation	Approximately 816 feet AMSL depending on regional deposition of sand, gravel, and clay layers.	CWI, Figures 4 and 5
Hydraulic Confinement	Confined	CWI

Attribute	Descriptor	Data Source
Transmissivity	Range of Values: 1,632 - 6,600 ft^2/day	The range of transmissivity values was derived using specific capacity data obtained from well records. See Table 4 for the reference value.
Hydraulic Conductivity	Range of Values: 68 - 275 ft/day	The range of K values was obtained from the range of transmissivity values.
Groundwater Flow Field	Groundwater flow is southwest to northeast through Montrose with an approximate compass direction of 66^o and gradient of 0.0018517 (Figure 2).	Defined by using static water level elevations from well records in the CWI database.

The distribution of the aquifer and its stratigraphic relationships with adjacent geologic materials are shown in Figures 3, 4, and 5. They were prepared using well record data contained in the CWI database. The geological maps and studies used to further define local hydrogeologic conditions are provided in the "Selected References" section of this report.

Delineation of the Wellhead Protection Area

Delineation Criteria

The boundaries of the WHPA for the city of Montrose are shown in Figure 1. Table 4 describes how the delineation criteria specified under Minnesota Rules, part 4720.5510, were addressed.

Table 4 - Description of WHPA Delineation Criteria

Criterion	Description	How the Criterion was Addressed
Flow Boundary	Other High-Capacity Wells	High-capacity wells within two miles of the city wells were included in the groundwater models.
Daily Volume of Water Pumped	See Table 5	Pumping information was obtained from the DNR, Appropriations Permit Number 1984-3186, and was converted to a daily volume pumped by a well.
Groundwater Flow Field	See Figure 2	The groundwater flow field was determined from local well data and input explicitly into MLAEM and capture zones were calculated based on the flow field. Oneka was used to evaluate the uncertainty of the wells' capture areas based on the simplified conceptual model and regional flow, recharge and local well data.
Aquifer Transmissivity (T)	Reference Value: 2,688 ft^2/day	The aquifer test plan was approved on 05/27/2021, and T was determined from specific capacity data. Uncertainty regarding aquifer transmissivity was addressed as described in Section 2.4.6.
Time of Travel	10 years	The public water supplier selected a 10-year time of travel.

Pumping data was obtained from the DNR Permit and Reporting System (MPARS) for the public water supply's Appropriation Permit Number 1984-3186. These values, confirmed by the public water supplier, were used to identify the maximum volume of water pumped annually by each well over the previous five-year period, as shown in Table 5. An estimate of the pumping for the next five years is also shown. The maximum daily volume of discharge used as an input parameter in the model was calculated by dividing the greatest annual pumping volume by 365 days.

Table 5 - Annual Volume of Water Discharged from Water Supply Wells

Well Name	Unique Number	2015	2016	2017	2018	2019	Daily Volume (cubic meters)
Well #4	700302	20.913	**22.206**	22.035	21.379	19.935	230
Well #5	700301	22.680	21.883	23.136	**27.255**	23.856	283
Well #6	843402	**-**	-	-	-	-	281

(Expressed as millions of gallons. Bolding indicates greatest annual pumping volume.)

In addition to the wells used by the public water supplier, Table 6 shows other high-capacity wells included in the delineation to account for their pumping impacts on the capture areas for the public water supply wells. Pumping data was obtained from the DNR MPARS database.

Table 6 - Other Permitted High-Capacity Wells

Unique Number	Well Name	DNR Permit Number	Aquifer	Use	Annual Volume of Water Pumped (gallons)[1]	Daily Volume (cubic meters)
218012	Waverly 1	1975-3023	QBAA	Municipal/Public Water Supply	10.414	108
182086	Waverly 2	1975-3023	QBAA	Municipal/Public Water Supply	9.932	103
258207	12 Hi MHP	1992-3191	QBAA	Public Water Supply	7.886	82

[1] = Expressed as millions of gallons

Method Used to Delineate the Wellhead Protection Area

The WHPA for the city of Montrose's wells were determined using a combination of two methods. The first method involved calculating the groundwater capture zones deterministically using representative aquifer parameters that were input into MLAEM, a groundwater modeling code (Strack, 1989). The second method used the stochastic analytical groundwater flow method Oneka (Barnes and Soule, 2002). The resulting WHPA boundaries are a composite of the capture zones calculated using these two approaches (Figure 1). The input files and related information are available at MDH upon request.

MLAEM: The MLAEM Code was selected because it is a quantitative method capable of simulating both simple and complex groundwater flow processes, including the influence of vertical infiltration and the pumping influence of multiple high-capacity wells, if necessary. Here, it produces a conservative estimate because aquifer recharge is not used as an input parameter. It is appropriate to use MLAEM for this particular delineation because no flow boundaries were directly observed in drillers' logs in the area around the primary public water supply wells, at least in the areas defined by a one-year and a 10-year time of travel.

Oneka Model: Oneka was used to assess the probability of impacts that local variations in hydrogeologic conditions may have on a well capture zone. This model treats the aquifer properties and the available water level measurements as variable input parameters. The locations of wells, water levels, and the aquifer geometry were evaluated using information from the CWI database. For the solution, Oneka finds the flow field that best fits the network of water level elevations by varying the values of the aquifer thickness and transmissivity. Oneka then evaluates the probability of the capture of a given point based on the number of times it is included in the capture areas generated by the total number of solutions. The output from the model is a capture zone probability map for the specified time of travel (10 years).

The combined output from the MLAEM and Oneka models were composited to create the final WHPA (Figure 1).

Results of Model Calibration and Sensitivity Analysis

Model calibration is a procedure that compares the results of a model based on estimated input values to measured or known values. This procedure can be used to define model validity over a range of input values, or it helps determine the level of confidence with which model results may be used. As a matter of practice, groundwater flow models are usually calibrated using water elevation or flux.

There is nothing to calibrate for the MLAEM delineation because it is based on calculating flowpath lines using equations that reflect 1) a constant pumping rate, 2) direction of groundwater flow, 3) hydraulic gradient, 4) aquifer thickness, 5) aquifer permeability, and 6) aquifer porosity. As such, it is a simple calculation of the portion of the aquifer that contributes water, based on the width of the flow field that is affected by pumping.

The Oneka Model is used to support the MLAEM results by using an iterative process which provides the best fit for the ranges of values assigned to its input parameters. This helps to define the subset of values for which the delineation results are most likely to reflect local hydrogeologic conditions and, therefore, provide the best calibration results.

Model sensitivity is the amount of change in model results caused by the variation of a particular input parameter. Because of the simplicity of the MLAEM, the direction and extent of the modeled capture zone may be very sensitive to any of the input parameters:

- The pumping rate directly affects the volume of the aquifer that contributes water to the well. An increase in pumping rate leads to an equivalent increase in the volume of aquifer within the capture zone, proportional to the porosity of the aquifer materials. However, the pumping rate is based on the results presented in Table 5 and, therefore, is not a variable factor that will influence the delineation of the WHPA.
- The direction of groundwater flow determines the orientation of the capture area. Variations in the direction of groundwater flow will not affect the size of the capture zone but are important for defining the areas that are the source of water to the well. The ambient groundwater flow field defined in Figure 2 provides the basis for determining the extent to which each model run reflects the conceptual understanding of the orientation of the capture area for a well.
- A hydraulic gradient of zero produces a circular capture zone, centered on the well. As the hydraulic gradient increases, the capture zone changes into an elliptical shape, with the well centered on the down-gradient focal point. The hydraulic gradient was

determined by using water level elevations that were taken from wells that have verified locations (Figure 2). Generally, the accuracy of the hydraulic gradient determination is directly proportional to the amount of available data that describes the distribution of hydraulic head in the aquifer.

- The aquifer thickness, hydraulic conductivity, and porosity influence the size and shape of the capture zone. A decrease in porosity causes a linear, proportional increase in the areal extent of the capture zone; whereas thickness and hydraulic conductivity each factor into the transmissivity, which defines the relative proportions of the capture zone width to length. A decrease in thickness or hydraulic conductivity decreases the length of the capture zone and increases the distance to the stagnation point, making the capture zone more circular in shape and centered around the well.

Addressing Model Uncertainty

Using computer models to simulate groundwater flow involves representing a complicated natural system in a simplified manner. Local geologic conditions may vary within the capture areas of the public water supply wells, but the amount of existing information needed to accurately define this degree of variability is often not available for portions of the WHPA. In addition, the current capabilities of groundwater flow models may not be sufficient to represent the natural flow system exactly. However, the results are valid within a range defined by the reasonable variation of input parameters for this delineation setting.

The MLAEM Code, used as it was in this delineation, has limited capabilities in addressing these kinds of uncertainties, other than by using multiple runs in which the following six input parameters are varied: 1) constant pumping rate, 2) hydraulic gradient, 3) direction of ambient flow, 4) aquifer thickness, 5) aquifer permeability, and 6) porosity. The uncertainty associated with the MLAEM results from 1) the model limitations mentioned above and 2) the fact that the model cannot be calibrated.

The steps employed for this delineation to address model uncertainty were:

1. Pumping Rate - For each well, a maximum historical (five-year) pumping rate or an engineering estimate of future pumping, whichever is greater (Minnesota Rules, part 4720.5510, subpart 4).
2. Ambient Flow Field - A composite of capture zones created from angles of flow that are 10 degrees greater and 10 degrees lesser than the representative angle of ambient flow (Minnesota Rules, part 4720.5510, subpart 5, B(2).

Capture areas were developed for a range of groundwater flow directions, aquifer permeabilities, and times of travel of one and ten years (Figure 6). As the model code uses constant input values for each run, several runs were required to include all variations in input parameters. Table 7 documents the variables used to address MLAEM uncertainty.

Table 7 - Model Parameters Used in MLAEM Base Case and Uncertainty Runs

<table>
<tr><th>File Name</th><th>Well Name</th><th>Discharge (cubic meters per day)</th><th>Hydraulic Conductivity (meters per day)</th><th>Gradient</th><th>Flow Angle</th><th>Porosity (%)</th><th>Aquifer Thickness (meters)</th></tr>
<tr><td rowspan="9">Montrose.dat</td><td rowspan="3">Well #4 (700302)</td><td rowspan="3">230</td><td rowspan="3">34</td><td rowspan="3">0.001852</td><td>14</td><td rowspan="3">20</td><td rowspan="3">7.32</td></tr>
<tr><td>24</td></tr>
<tr><td>34</td></tr>
<tr><td rowspan="3">Well #5 (700301)</td><td rowspan="3">283</td><td rowspan="3">34</td><td rowspan="3">0.001852</td><td>14</td><td rowspan="3">20</td><td rowspan="3">7.32</td></tr>
<tr><td>24</td></tr>
<tr><td>34</td></tr>
<tr><td rowspan="3">Well #6 (843402)</td><td rowspan="3">281</td><td rowspan="3">34</td><td rowspan="3">0.001852</td><td>14</td><td rowspan="3">20</td><td rowspan="3">7.32</td></tr>
<tr><td>24</td></tr>
<tr><td>34</td></tr>
</table>

For the Oneka Model, uncertainty related to water levels reported on well records is based on the accuracy of the ground elevation assigned to the well using topographic maps and the transient variability of the water levels in the aquifer over time. Water levels that are probably inaccurate were identified using data from 1) the CWI database, and 2) DNR observation well measurements. Only water levels that fit the flow field (Figure 2) were used for the Oneka analysis.

The Oneka Model helps to address uncertainties related to aquifer parameters as variations of the flow field. A 10-year capture zone probability map (Figure 6) was generated for the public water supply wells; the values used for the Oneka Model are shown in Table 7. The Oneka results fit well with the capture zones calculated by MLAEM. The probability map for the public water supply wells shows that uncertainty of the capture zone increases as the distances from the public water supply wells increase (Figure 6).

Table 8 - Ranges of Values Used for the Oneka Model

Well Number	File Name	Hydraulic Conductivity (meters/day)	Thickness (meters)	Porosity (%)
Well #4 (700302)	Montrose.one	20.7 - 83.7	7.32	20
Well #5 (700301)	Montrose.one	20.7 - 83.7	7.32	20
Well #6 (843402)	Montrose.one	20.7 - 83.7	7.32	20

Delineation of the Drinking Water Supply Management Area

The boundaries of the Drinking Water Supply Management Area (DWSMA) were defined by the city of Montrose using the following features (Figure 1):

- Center-lines of highways, streets, roads, or railroad rights-of-ways
- Public Land Survey coordinates
- Property or fence lines

Vulnerability Assessments

The Part I wellhead protection plan includes the vulnerability assessments for the city of Montrose's wells and DWSMA. These vulnerability assessments are used to help define potential contamination sources within the DWSMA and select appropriate measures for reducing the risk that they present to the public water supply.

Assessment of Well Vulnerability

The vulnerability assessments for each well used by the city of Montrose are listed in Table 1 and are based upon the following conditions:

1. The geologic conditions at the well sites include a cover of clay-rich geologic materials over the aquifer that is sufficient to retard or prevent the vertical movement of contaminants.
2. None of the human-caused contaminants regulated under the federal Safe Drinking Water Act have been detected at levels indicating that the wells themselves serve to draw contaminants into the aquifer from pumping.
3. Water samples were collected from Montrose Wells 4, 5, and 6 were analyzed for tritium (Well #4), nitrate, chloride, and bromide (Table 2). No tritium or nitrate was detected, and the groundwater age classification based on the tritium result is mostly premodern (MDNR and MDH, 2020). This confirms the non-vulnerable nature of the wells (Alexander and Alexander, 1989) . In addition, the chloride and bromide results confirm that the wells have not been impacted by land-use activities (Mullaney et. al, 2009).

Assessment of Drinking Water Supply Management Area Vulnerability

The DWSMA vulnerability is shown in Figure 1 and is based upon the following information:

1) Isotopic and water chemistry data from wells located within the DWSMA indicate that the aquifer contains water that has no detectable levels of tritium or human-caused contamination.
2) Review of the geologic logs contained in the CWI database, geological maps, and reports indicate that the aquifer exhibits a low geologic sensitivity throughout the DWSMA and is isolated from the direct vertical recharge of surface water.

Therefore, given the information currently available, it is prudent to assign a low vulnerability rating to the DWSMA, in accordance with the Minnesota Wellhead Protection Rule (parts 4720.5100 to 4720.5590) (Barry 2018).

Recommendations

The following recommendations have been generated to inform the next amendment of the city of Montrose's Wellhead Protection Plan.

1. Well Locating: This delineation is based on very little well data. If wells are constructed within two-miles of the city or one mile of the DWSMA, their locations should be verified. This information may allow a better understanding of the extent and thickness of the city's aquifers and could result in a more refined WHPA in the future.
2. Water Quality Monitoring: The standard assessment monitoring package (which includes tritium, stable isotopes, and general chemistry suite) should be analyzed at all primary wells during year six, contingent on funding assistance from MDH for sampling and analysis. The city may need to collect the samples and ship them to MDH. Information generated by this sampling will be used to refine vulnerability assessments for the next amendment.
3. Aquifer Testing: Performing an aquifer test at the city wells might help to refine the hydraulic conductivity of the aquifer near the wells and confirm any potential geologic barriers for the next amendment. There are specific water system requirements for conducting a successful aquifer test, these should be discussed with the MDH hydrologist before committing to this option to ensure all requirements can be met. Any costs that might be associated with this activity could be eligible for a Source Water Protection Implementation Grant if this measure is included in the city's wellhead protection plan.

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Figures

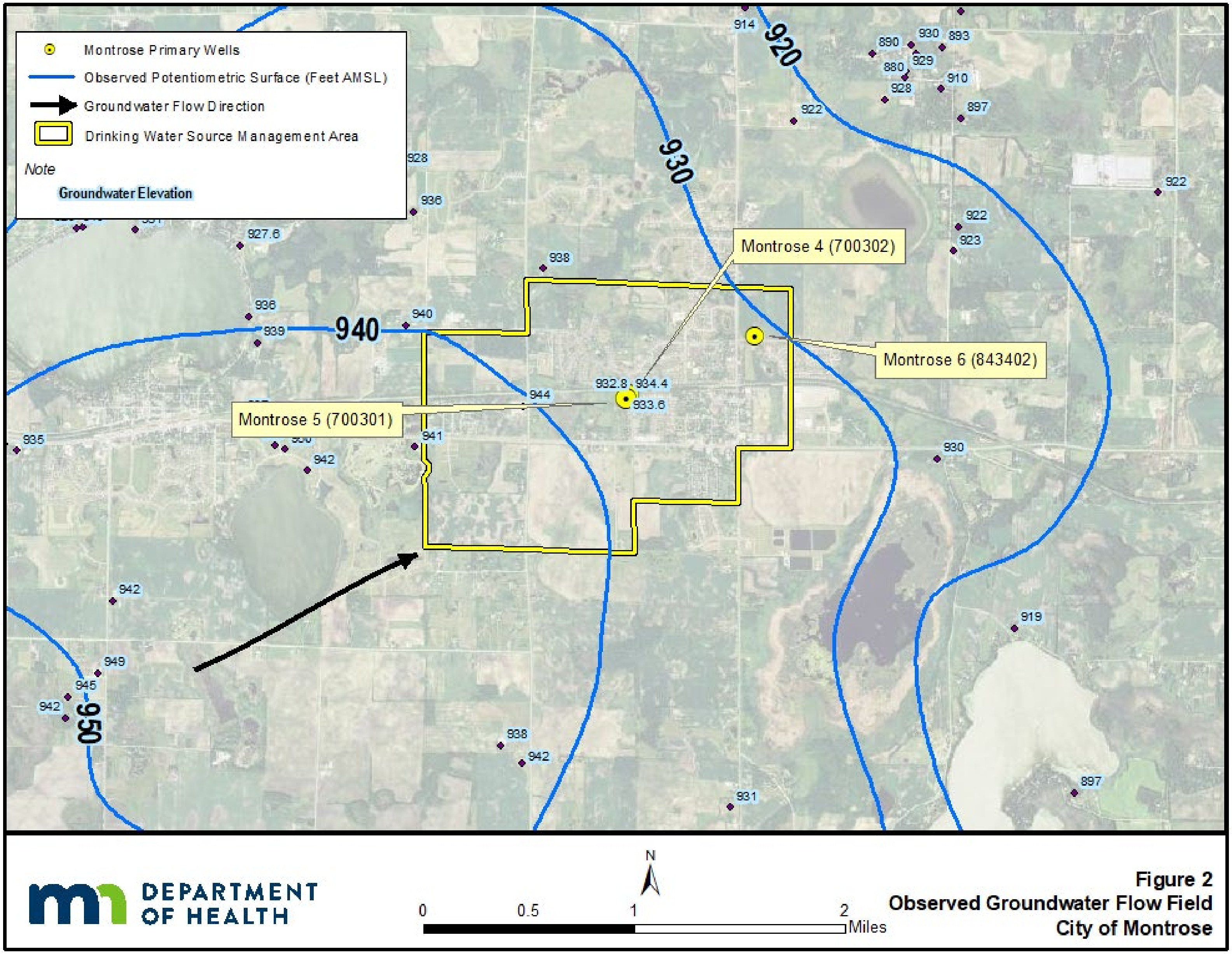
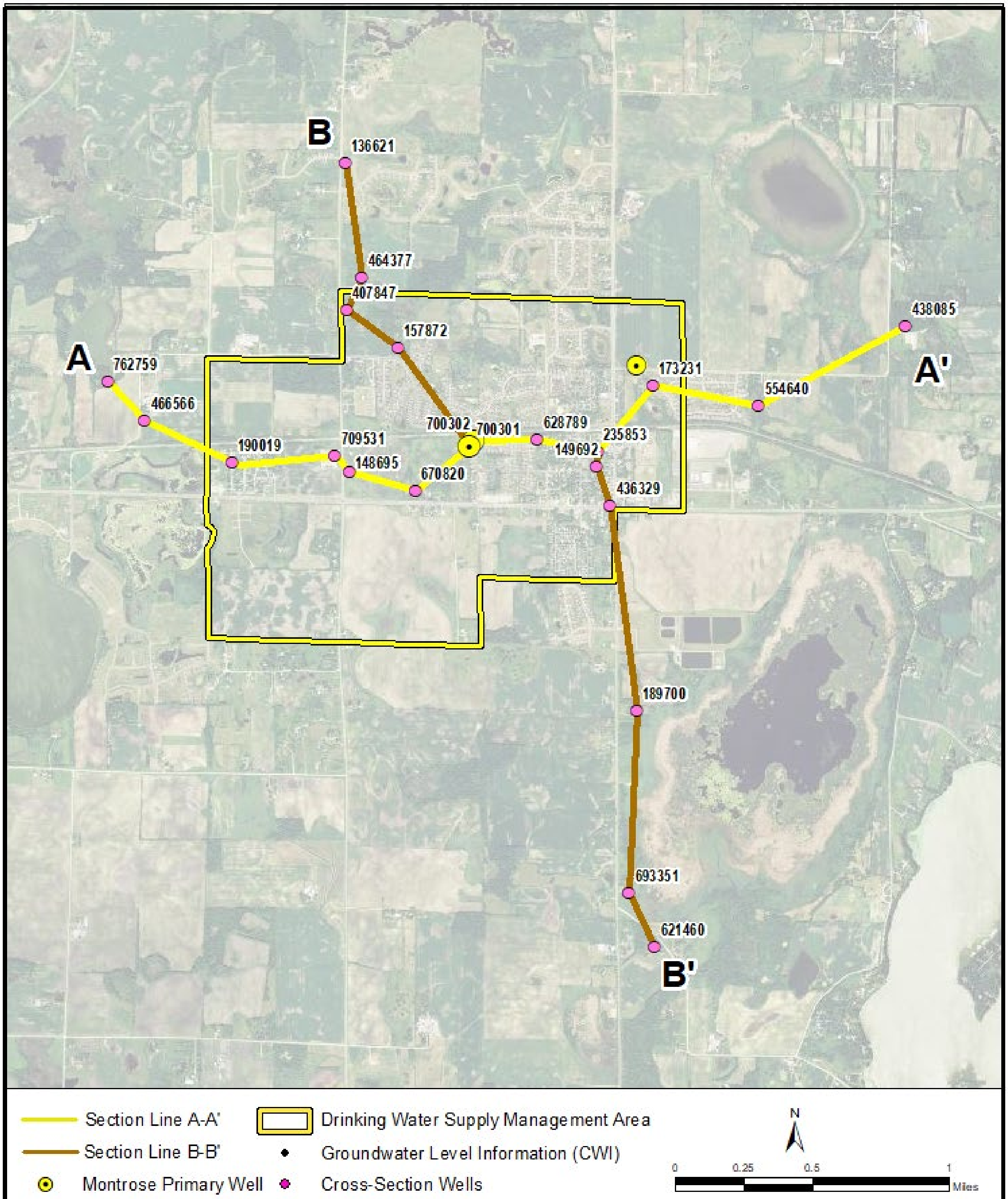
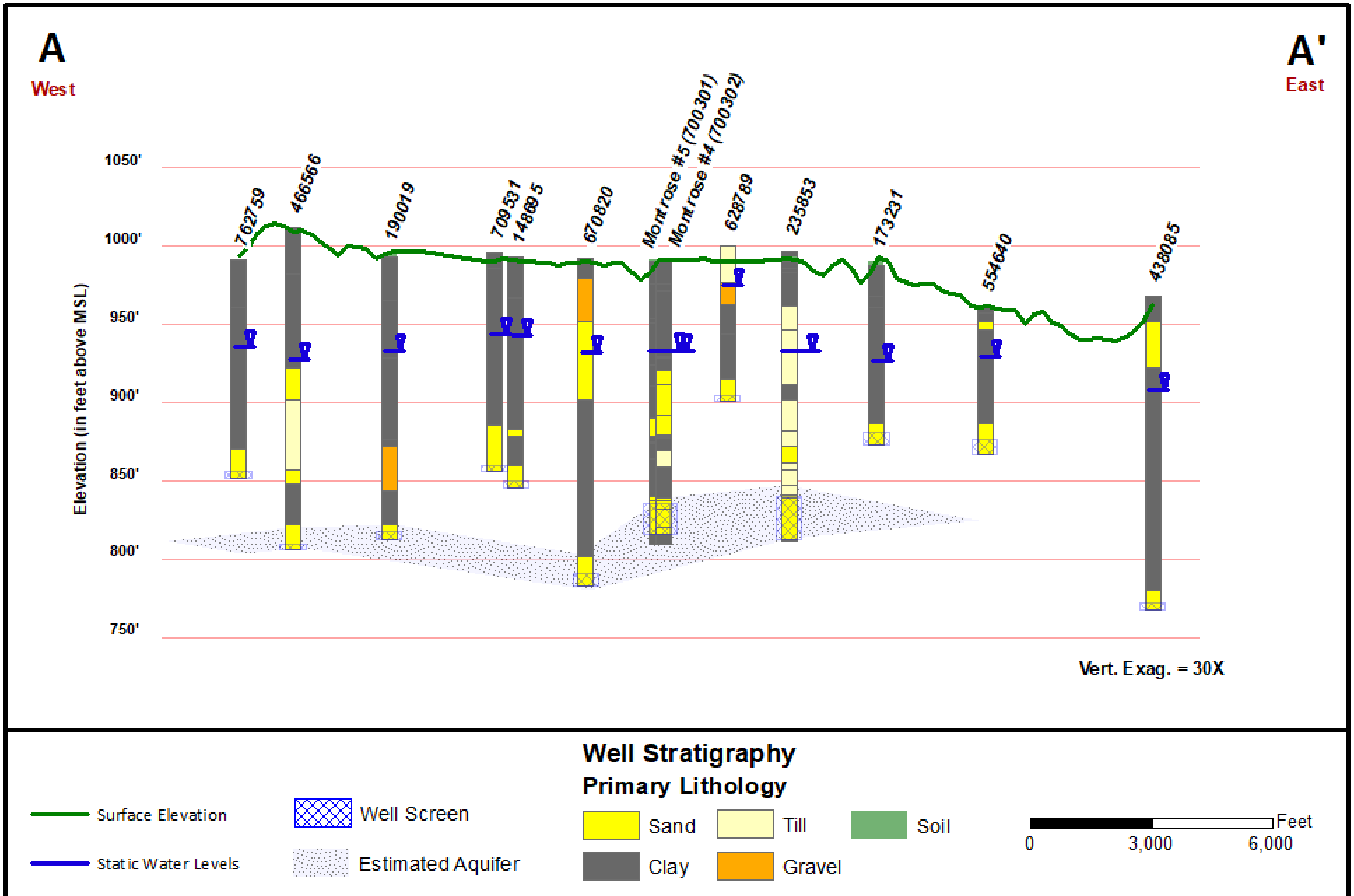


Figure 2
Observed Groundwater Flow Field
City of Montrose



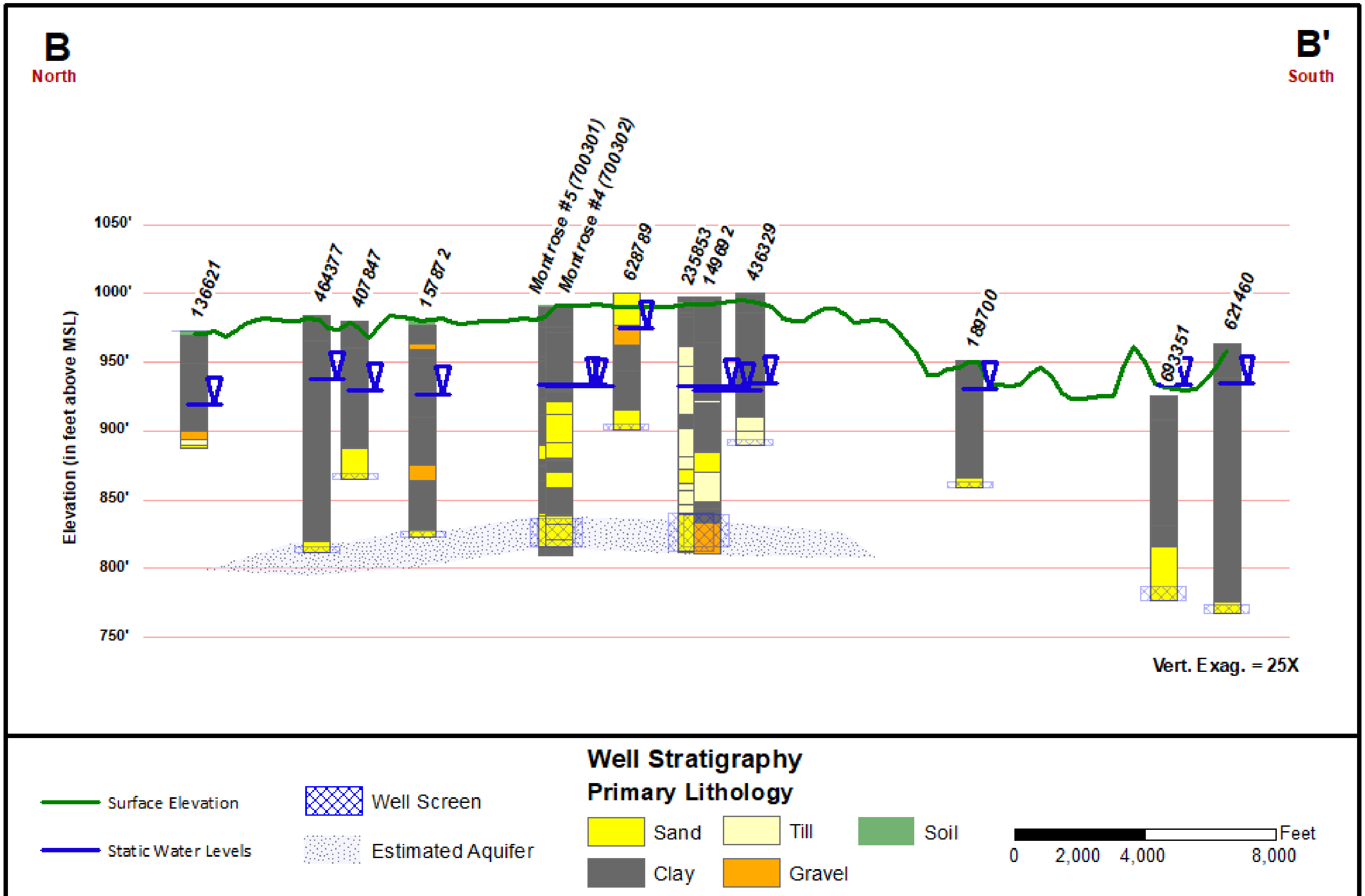
DEPARTMENT OF HEALTH

Figure 3
Trends of Geologic Cross-Sections
City of Montrose



DEPARTMENT OF HEALTH

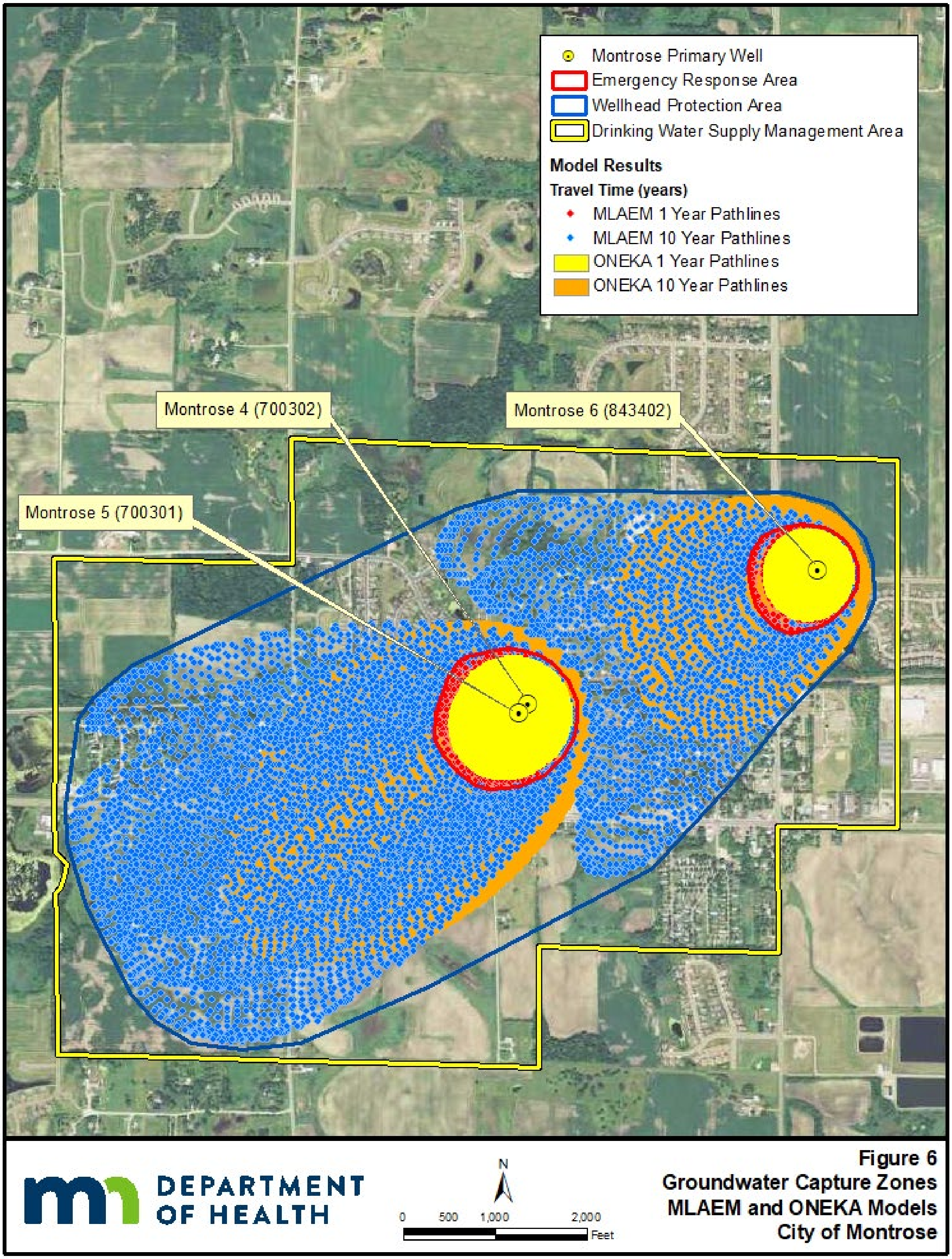
Figure 4
Geologic Cross-Section A-A'
City of Montrose



DEPARTMENT OF HEALTH

Figure 5
Geologic Cross-Section B-B'
City of Montrose

Map showing uncertainty analysis



Appendix A: Data Elements Assessment

Data Type	Data Element	Use of the Well(s)	Delineation Criteria	Quality and Quantity of Well Water	Land and Groundwater Use in DWSMA	Data Source
Climate	Precipitation					
Geology	Maps and geologic descriptions	M	H	H	H	USGS, MGS, DNR
Geology	Subsurface data	M	H	H	H	MGS, MDH
Geology	Borehole geophysics	M	H	H	H	Not Available
Geology	Surface geophysics	L	L	L	L	Not Available
Soils	Maps and soil descriptions					
Soils	Eroding lands					
Water Resources	Watershed units					
Water Resources	List of public waters					
Water Resources	Shoreland classifications					
Water Resources	Wetlands map					
Water Resources	Floodplain map					
Land Use	Parcel boundaries map	L	H	L	L	Wright County
Land Use	Political boundaries map	L	H	L	L	MnGEO
Land Use	Public Land Survey map	L	H	L	L	MnGEO
Land Use	Land use map and inventory					
Land Use	Comprehensive land use map					
Land Use	Zoning map					
Public Utility Services	Transportation routes and corridors	L	L	L	L	MnDOT, MnGEO
Public Utility Services	Storm/sanitary sewers and PWS system map					
Public Utility Services	Oil and gas pipelines map					
Public Utility Services	Public drainage systems map or list					
Public Utility Services	Records of well construction, maintenance, and use	H	H	H	H	City of Montrose, CWI, MDH
Surface Water Quantity	Stream flow data					
Surface Water Quantity	Ordinary high water mark data					
Surface Water Quantity	Permitted withdrawals					

Data Type	Data Element	Use of the Well(s)	Delineation Criteria	Quality and Quantity of Well Water	Land and Groundwater Use in DWSMA	Data Source
Surface Water Quantity	Protected levels/flows					
Surface Water Quantity	Water use conflicts					
Groundwater Quantity	Permitted withdrawals	H	H	H	H	DNR
Groundwater Quantity	Groundwater use conflicts	H	H	H	H	DNR
Groundwater Quantity	Water Levels	H	H	H	H	MDH, MGS, DNR
Surface Water Quality	Stream and lake water quality management classifications					
Surface Water Quality	Monitoring data summary					
Groundwater Quality	Monitoring data	H	H	H	H	MDH
Groundwater Quality	Isotopic data	H	H	H	H	MDH
Groundwater Quality	Tracer studies	H	H	H	H	Not Available
Groundwater Quality	Contamination site data	M	M	M	M	Not Available
Groundwater Quality	Property audit data from contamination sites					
Groundwater Quality	MPCA and MDA spills/release reports	M	M	M	M	Not Available

Definitions Used for Assessing Data Elements

- High (H): the data element has a direct impact
- Moderate (M): the data element has an indirect or marginal impact
- Low (L): the data element has little if any impact
- Shaded: the data element was not required by MDH for preparing this delineation

Acronyms used in this report are listed after the Glossary of Terms.