Hydrogeologic Assessment of the Drinking Water Source and Wells for the City of Maple Plain

DELINEATIONS – WELLHEAD PROTECTION AREA AND DRINKING WATER SUPPLY MANAGEMENT AREA

VULNERABILITY ASSESSMENTS – WELLS AND DRINKING WATER SUPPLY MANAGEMENT AREA

October 3, 2023

Hydrogeologic Assessment of the Drinking Water Source and Wells for the City of Maple Plain

Public Water Supply ID: 1270021

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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

MnDOT - Minnesota Department of Transportation

MnGEO - Minnesota Geospatial Information Office

MODFLOW - Three-Dimensional Finite-Difference Groundwater Model

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 time period. The area that contributes water within a one-year time period is known as the emergency response area (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 Maple Plain has two primary wells screened in sandstone bedrock aquifers that are buried beneath a layer of clay-rich sediment. Wells #3 and #4 are 534 and 392 feet deep, respectively (Table 1). Regionally, groundwater flow is to the south/southeast.

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 #1	207090	Emergency	10	238	418	1939	Tunnel City-Wonewoc	Not Vulnerable
Well #2	207407	Emergency (Out Long Term)	16	241	435	1959	Tunnel City-Wonewoc	Not Vulnerable
Well #3	112238	Primary	18	534	534	1978	Mt. Simon	Not Vulnerable
Well #4	824078	Primary	18 x 12	343	392	2017	Wonewoc	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 aquifers, and 3) past monitoring results. Both wells meet current state Well Code specifications (Minnesota Rules 4725) and the wells themselves do not provide a pathway for contaminants to enter the aquifer used by the public water supplier. Both wells are considered non-vulnerable to contamination. Well #3 (112238) is grouted. Well #4 (824078) was constructed using the cable tool method, which minimize the risk of the well acting as a conduit for flow of surface water and contaminants into the buried aquifer. Also, water samples from the wells lacked detectable tritium (detection indicates the presence of young water), so they are not considered vulnerable at this time (Table 2). This is reinforced by the low chloride/bromide ratios presented below.

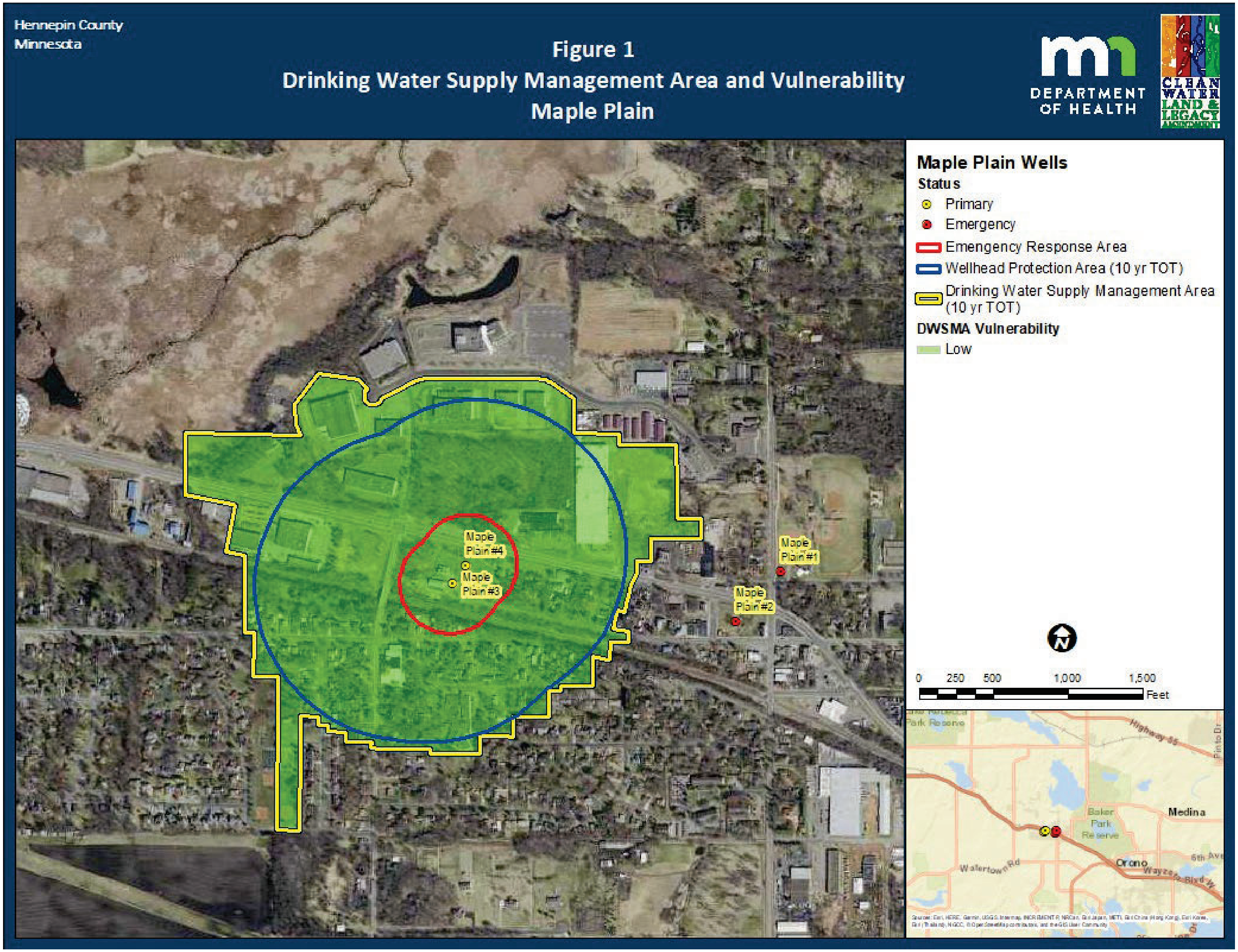
Table 2 - Isotope and Water Quality Results

Unique Number (Well Name)	Tritium	Nitrate (mg/L)	Chloride (mg/L)	Bromide (mg/L)	Chloride/ Bromide Ratio
112238 (Well #3)	< 0.8 (05/03/2021) < 1 (07/09/1991)	< 0.05 (05/03/2021)	8.63 (05/03/2021)	0.0491 (05/03/2021)	176 (05/03/2021)
824078 (Well #4)	<0.8 (05/03/2021)	< 0.05 (05/03/2021)	1.15 (05/03/2021)	0.0177 (05/03/2021)	65 (05/03/2021)

DWSMA Vulnerability - The vulnerability of the city's aquifers 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 aquifers prevent water and contaminants from moving quickly from the land surface into the city's aquifers and implies a time of travel of decades or longer. The principal threats to these aquifers are unsealed abandoned wells that penetrate through this clay layer. Such wells are 270 feet or greater in depth in the Maple Plain 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. Maple Plain currently treats for radium which is above the safe drinking water standard in the source aquifer.

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 and water quality monitoring. Further details can be found in the Recommendations section of this report.


Hennepin County
Minnesota
Figure 1
Drinking Water Supply Management Area and Vulnerability
Maple Plain
DEPARTMENT OF HEALTH
CLEAN WATER LAND & LEGACY
Maple Plain #4
Maple Plain #3
Maple Plain #1
Maple Plain #2
Maple Plain Wells
Status
Primary
Emergency
Emergency Response Area
Wellhead Protection Area (10 yr TOT)
Drinking Water Supply Management Area (10 yr TOT)
DWSMA Vulnerability
Low
0 250 500 1,000 1,500
Feet
Highway 55
Medina
Baker Park Reserve
Orono
Watertown Rd
Wayzata Blvd W
6th Ave

Technical Report

Discussion

This document describes the amendments to Part 1 of the wellhead protection (WHP) plan for The city of Maple Plain (PWSID 1270021). The purpose for amending the plan is to address the changes that have occurred since the plan was last approved, in order to update the WHP measures that are needed to protect public drinking water. In addition, the locations of the city's wells were adjusted for greater accuracy. The amended areas are somewhat smaller (Figure 7) because an updated groundwater flow model, more accurate than the ones used in the previous delineations, was used. 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. An inner wellhead management zone (IWMZ), which is the area within a 200-foot radius around the well, serves as the wellhead protection area for emergency wells and is not displayed in this report. 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 Maple Plain on March 30, 2021, for a scoping meeting that identified the data elements required to prepare Part I of the WHP plan. 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 Maple Plain obtains its drinking water supply from two primary wells. Table 1 summarizes information regarding them.

Description of the Hydrogeologic Setting

The city of Maple Plain draws groundwater from the Wonewoc and the Mt Simon aquifers. The description of the hydrologic setting for the aquifer used to supply drinking water is presented in Tables 3a and 3b.

The distribution of the aquifer and its stratigraphic relationships with adjacent geologic materials are shown in Figures 3, 4a and 4b. 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.

Table 3a - Description of the Local Hydrogeologic Setting at Maple Plain Well 3 (112238), Mt. Simon aquifer

Attribute	Descriptor	Data Source
Aquifer Material	Sandstone	Well Logs
Primary Porosity	0.20	Estimated and used in Metro Model 3
Aquifer Thickness (ft)	105	Well Log (Well #3 [112238])
Stratigraphic Top Elevation	545	Well Log (Well #3 [112238])
Stratigraphic Bottom Elevation	440	Well Log (Well #3 [112238])
Hydraulic Confinement	Confined	Well Log (Well #3 [112238])
Transmissivity (T)	Reference Value: 770 ft^2/day Range: 380 to 1160 ft^2/day	The aquifer test plan was approved on January 25, 2021, and T was determined from a specific capacity test at Well #3 (112238).
Hydraulic Conductivity	Reference Value: 7.4 ft/day Range: 3.7 to 11 ft/day	The values were obtained from the transmissivity range and aquifer thickness at and T was determined from a specific capacity test at Well #3 (112238).
Groundwater Flow Field	Flow to the east.	Calibrated Groundwater Model.

Table 4a - Description of the Local Hydrogeologic Setting at Maple Plain Well #4 (824078), Wonewoc Aquifer

Attribute	Descriptor	Data Source
Aquifer Material	Sandstone	Well Logs
Primary Porosity	0.20	Estimated and used in Metro Model 3
Aquifer Thickness (ft)	49	Well Log Well #4 (824078)
Stratigraphic Top Elevation	678	Well Log Well #4 (824078)
Stratigraphic Bottom Elevation	629	Well Log Well #4 (824078)
Hydraulic Confinement	Confined	Well Log Well #4 (824078)
Transmissivity (T)	Reference Value: 4,150 ft^2/day Range: 2,075 to 6,227 ft^2/day	The aquifer test plan was approved on January 25, 2021, and T was determined from a specific capacity test at Well #4 (824078).
Hydraulic Conductivity	Reference Value: 81.4 ft/day Range: 40.7 to 122.1 ft/day	The values were obtained from the transmissivity range and aquifer thickness at and T was determined from a specific capacity test at Well #4 (824078).
Groundwater Flow Field	Flow to the south/southeast.	Calibrated Groundwater Model.

Delineation of the Wellhead Protection Area

Delineation Criteria

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

Table 5 - Description of WHPA Delineation Criteria

Criterion	Description	How the Criterion was Addressed
Flow Boundary	Mississippi, Minnesota, and Crow Rivers	The rivers provide boundary conditions to the original regional model that extends to these natural boundaries. They were included in the original regional model and set the regional groundwater flow.
Flow Boundary	Other High-Capacity Wells	There are no other high-capacity wells within two-miles that pump in the same aquifer as the public water supplier and that may have an impact on the public water supplier's well capture zone. Other high-capacity wells, located further away, were included in the regional model.
Daily Volume of Water Pumped	See Table 5	Pumping information was obtained from the DNR, Appropriations Permit Number 1977-6403, and was converted to a daily volume pumped by a well.
Groundwater Flow Field	See Figures 2a and 2b	The model calibration process addressed the relationship between the calculated versus observed groundwater flow field.

Criterion	Description	How the Criterion was Addressed
Aquifer Transmissivity (T)	Reference Value: ft^2/day	The aquifer test plans were approved on May 19, 2021. The transmissivities were determined from specific capacity tests at Well #3 (112238) and at Well #4 (824078). Uncertainty regarding aquifer transmissivity was addressed as described in Addressing Model Uncertainty section.
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 1977-6403. 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 6 - Annual Volume of Water Discharged from Water Supply Wells

Well Name	Unique Number	2016	2017	2018	2019	2020	(Year) Pumping	Daily Volume (cubic meters)
Well #1	207090	0	148,000	19,000	119,000	0	Not Applicable	Not Applicable
Well #2	207407	0	0	0	0	0	Not Applicable	Not Applicable
Well #3	112238	57,465,551*	49,296,000	28,582,000	25,243,500	35,100,000	57,465,551	595.9
Well #4	824078	0	5,969,000	27,054,000*	26,585,000	21,5712,000	27,054,000	280.5

(Expressed as gallons. *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 7 - Other Permitted High-Capacity Wells

Unique Number	Well Name	DNR Permit Number	Aquifer	Use	5-Year Average Annual Volume of Water Pumped	Daily Volume (cubic meters)
448765	Independence #2	1976-6030	Quaternary Buried Artesian Aquifer	Municipal/Public Water Supply	9,748,900	9.87
100219	Independence #1	1976-6030	Quaternary Buried Artesian Aquifer	Municipal/Public Water Supply	966,620	0.97

Method Used to Delineate the Wellhead Protection Area

The WHPA for the city of Maple Plain's wells was determined using a modified version of an existing regional MODFLOW model (Metro Model 3) that was developed by Barr Engineering Company for the Metropolitan Council. Original model construction detail, data files, and calibration results are outlined in the Metropolitan Council report (2014).

MODFLOW was developed by the United States Geological Survey and is publicly available. The specific software code used for this delineation was MODFLOW-2005 (Harbaugh, 2005). The program has been thoroughly documented, is widely used by consultants, government agencies, and researchers and consistently accepted in regulatory proceedings. MODFLOW is also an extremely versatile program capable of simulating groundwater flow in up to three dimensions while offering a variety of boundary condition options, confined or unconfined aquifer conditions and allowing for vertical discretization through the use of layering.

The regional Metro Model 3 consists of nine layers that represent the major aquifers and aquitards within the eleven-county metropolitan area. These layers represent, from top to bottom, the following units: (1) surficial aquifer of glacial deposits, (2) St. Peter Sandstone or Quaternary Buried Artesian Aquifer, (3) Prairie du Chien Group, (4) Jordan Sandstone, (5) St. Lawrence Formation (aquitard), (6) Tunnel City Group, (7) Wonewoc, (8) Eau Claire Formation (aquitard), and (9) Mt. Simon Sandstone. The regional groundwater model was calibrated to steady-state water levels and river base flows.

A local-scale model was extracted from the regional Metro Model (Appendix B, Figure B-1). All modeling for this amendment was completed using GMS (Aquaveo, 2015), a pre- and post-processor for MODFLOW. The model grid consists of 454 rows, 310 columns, and nine layers. It has variable areal grid spacing ranging from 12 meters near the city's well and grading to 50 meters at the boundaries of the model domain. Constant head boundary conditions were specified at the boundaries of the model (Appendix B, Figure B-2). River boundaries represent cells where water is flowing both into and out of the aquifer and were used to simulate the many lakes and rivers within the model domain.

Prior to its use in the delineations, the following modifications were incorporated in the local model:

- Local areas of modified horizontal conductivity were included in the model to reflect the reference transmissivity value in Tables 3a and 3b.
- The flow rate for the Maple Plain wells were updated to match wellhead protection rule requirements. Modeled rates are shown in Table 5.
- The average modeled flow rates for high-capacity wells located within two-miles were modified to reflect the period from 2015 to 2019 (Table 6).

To determine the WHPA, the groundwater flow model was used along with a particle tracking program called MODPATH (Pollock, 2012). MODPATH is used to evaluate advective transport of simulated particles moving through the simulated flow system. A series of 50 particles were launched at each well. A porosity of 20 percent was used and a reverse time of travel was calculated at 10 years.

Representative aquifer parameters were used in the base case model scenario. Additional modeling scenarios were then simulated using reasonable estimations of parameters to demonstrate model sensitivity and to reflect uncertainty conditions, which are addressed in the next section. The model parameters for all model runs are listed in Table 6.

The capture zones of all model scenarios were composited to create the final WHPA (Figures 1a and 1b).

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 and/or flux. The sensitivity analysis quantifies the differences in model results produced by the natural variability of a particular parameter. Uncertainty analysis addresses the effects of poor data quality (lack of local detailed information or deficiencies in the data) on the model results. Together, sensitivity and uncertainty analyses are commonly used to evaluate the effects that natural variability and uncertainties in the hydrogeologic data have on the size and shape of the capture zones. Regarding the WHPA delineation, these analyses are used to document that the delineation is optimal, conservative, and protective of public health based on existing information.

Modeled heads were compared to observed heads for Wonewoc wells and Mt. Simon. The local calibration dataset includes water level information from all Wonewoc and Mt. Simon wells within the model domain. The graph of modeled versus observed hydraulic heads are included as Figure B-3 in Appendix B. A quantitative measure by which to evaluate the success obtained during calibration is to compute the normalized mean square of the residuals (RMS). The normalized RMS is the ratio on the RMS and the maximum observed head difference of the calibration dataset. A calibration is acceptable if the normalized RMS is less 15 percent (Anderson et al., 2015). The RMS of the calibration dataset (i.e., Wonewoc and Mt. Simon wells) is 14.43 feet with a normalized RMS of 3.25 percent (Figure B-3, Appendix B). The calibration is therefore acceptable, and no additional calibration is needed.

Sensitivity Analysis

Model sensitivity is the amount of change in model results caused by the variation of a particular input parameter. Because of the relative simplicity of this particular MODFLOW model, 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 and an expanded capture zone, proportional to the porosity of the aquifer materials.

How Addressed and Results – The pumping rate is based on the results presented in Table 5 and is not considered a variable factor that will influence the delineation of the WHPA. The modeled pumping rate is based on the largest annual pumping during the last five years of record, as shown in Table 5. The sensitivity of the delineation to this parameter is assumed to be minimal when compared with the other parameters discussed below.

- The **direction of groundwater flow** determines the orientation of the capture zone. 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 contributing water to the well.

How Addressed and Results – General flow direction was determined based on the calibrated regional and local models. The local model calibration was verified for static water levels of similarly screened wells within the local model. Overall, the sensitivity of the WHPA to the direction of groundwater flow should not be significant, given the current knowledge of the hydraulic head distribution in the aquifer.

- The **hydraulic gradient** (along with aquifer hydraulic conductivity) determines the rate at which water moves through the aquifer materials.

How Addressed and Results – The flow fields shown in Figures 2a and 2b provide the basis for determining the extent to which each model run reflects the conceptual understanding of the orientation of the capture area for each well. The regional model has been calibrated to hydraulic heads. The sensitivity of the WHPA to the hydraulic gradient should not be significant given the current knowledge of the hydraulic head distribution in the aquifer.

- The **horizontal hydraulic conductivity** influences the size and shape of the capture zone. A decrease in 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 on the well.

How Addressed and Results – Additional scenarios were modeled by increasing/reducing the reference horizontal hydraulic conductivity by a factor of two. The sensitivity of the delineated capture zone to a change in horizontal hydraulic conductivity is minimal as depicted in Figure 5.

- The **aquifer porosity** influences the size and shape of the capture zone.

  How Addressed and Results – Decreasing the porosity causes a linear, proportional increase in the areal extent of the capture zone. A literature value of 20 percent was used for the delineation and this value was not varied (Fetter, 2001).

- The **aquifer thickness** influences the size and shape of the capture zone.

  How Addressed and Results – Aquifer thicknesses used in this model were obtained from the stratigraphic information at the regional Metro Model whose layering closely follows the overall stratigraphy through the region. Near the city wells, aquifer thickness was obtained the well logs.

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 area of the public water supply well, 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 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. Multiple model runs were conducted for the range of horizontal conductivity values used in the sensitivity analysis.

For each run, the capture areas were delineated for times of travel of one and 10 years (Figure 5). The different resulting capture zones were combined to make the final WHPA.

Delineation of the Drinking Water Supply Management Area

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

- Public Land Survey coordinates.
- Property or fence lines.

Vulnerability Assessments

The Part I wellhead protection plan includes the vulnerability assessments for the city of Maple Plain'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 s for each well used by the city of Maple Plain are listed in Table 1 and are based upon the following conditions:

1. Well construction meets current State Well Code specifications (Minnesota Rules, part 4725), meaning that the wells themselves should not provide a pathway for contaminants to enter the aquifer used by the public water supplier.
2. 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.
3. 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 as a result of pumping.
4. Water samples were collected from wells #3 and #4 (112238 and 824078) on 05/03/2021 and were analyzed for tritium, nitrate, chloride and bromide (Table 2). No tritium or nitrate was detected in the sample, confirming the non-vulnerable nature of the well (Alexander and Alexander, 1989). In addition, the chloride and bromide results confirm that the well has 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 and 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.
3. Radium, which is a naturally occurring contaminant, has been detected in the water from public water supply Well #3 (Unique Number 112238, 7.3 pCi/L). Maple Plain treats the source water for radium to safe drinking water standards. The presence of a naturally occurring contaminant does not indicate that there is a direct pathway between the aquifer and potential contamination sources that occur at or near the land surface.

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).

Recommendations

The following recommendations have been generated to inform the next amendment of the city of Maple Plain'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 the overlying clay confining units and result in a more refined WHPA in the future.
2. Water Quality Monitoring: The standard assessment monitoring package should be analyzed during year six, including the primary wells and river, 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.

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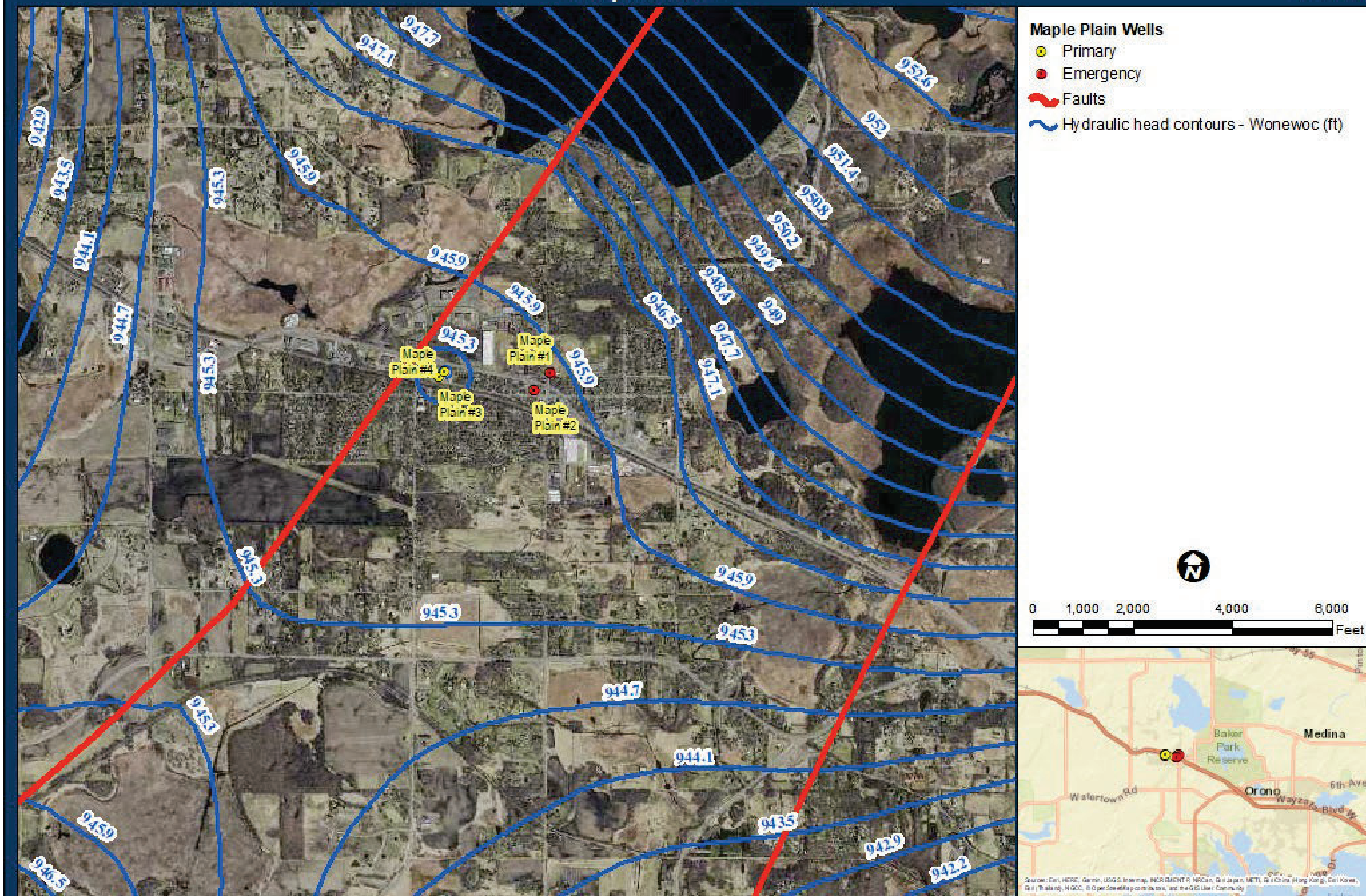
Figures

Hennepin County
Minnesota

Figure 2a
Ambient Groundwater Flow Field
Wonewoc
Maple Plain

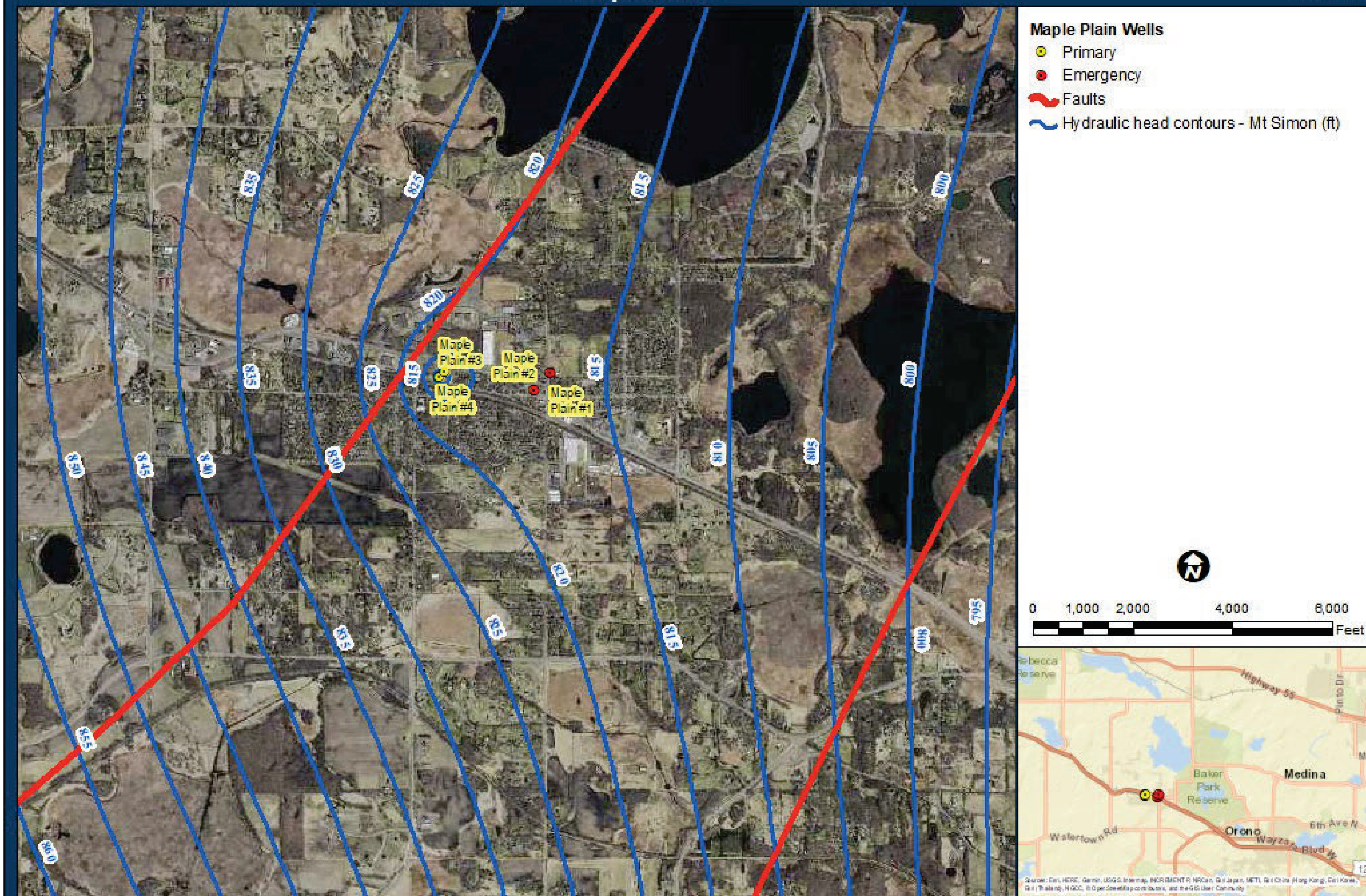
DEPARTMENT OF HEALTH

CLEAN WATER LAND & LEGACY



Hennepin County
Minnesota

Figure 2b
Ambient Groundwater Flow Field
Mt. Simon
Maple Plain

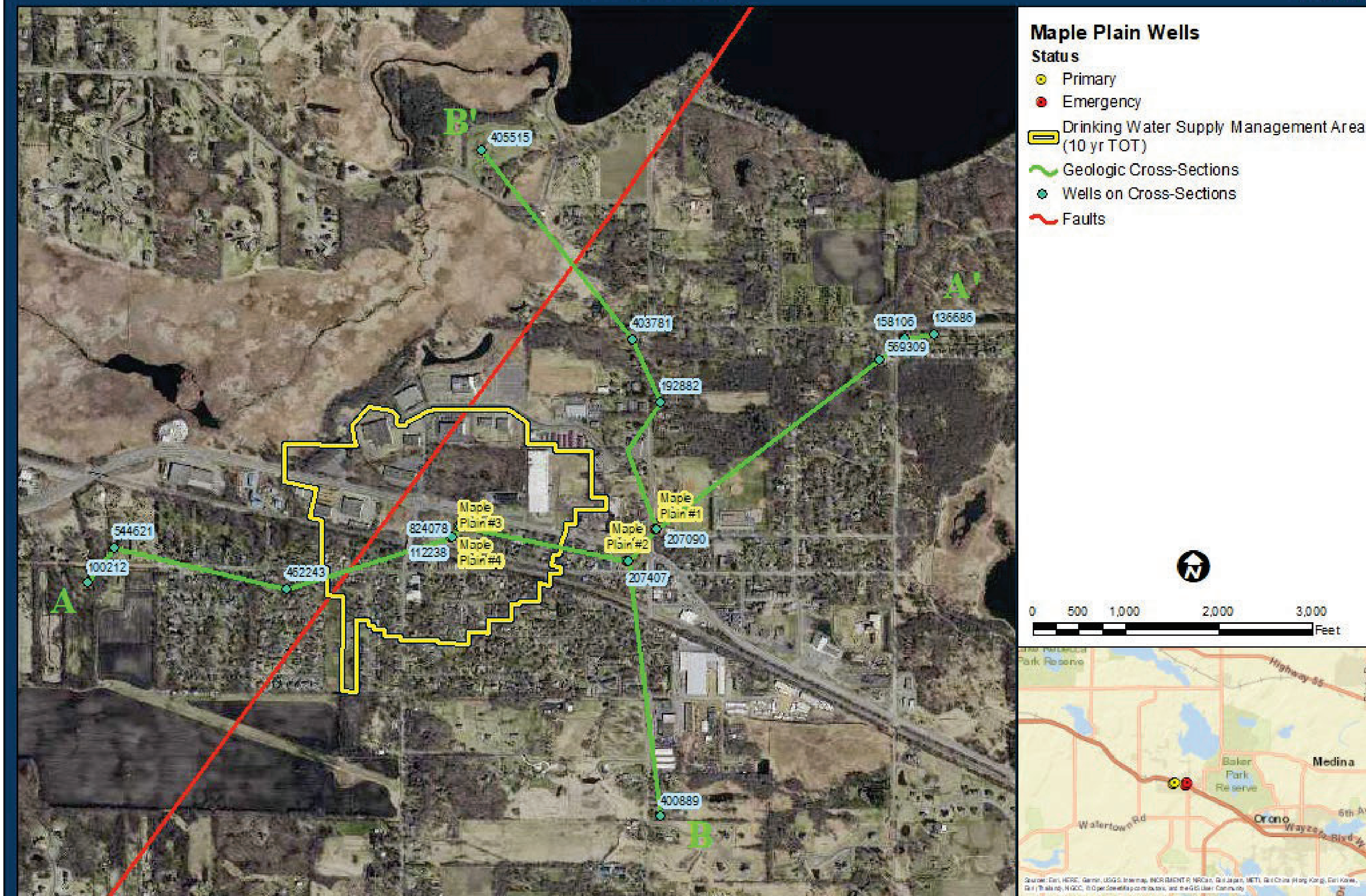


Hennepin County
Minnesota

Figure 3
Trends of Geologic Cross-Sections
Maple Plain

DEPARTMENT OF HEALTH

CLEAN WATER LAND & LEGACY AMENDMENT

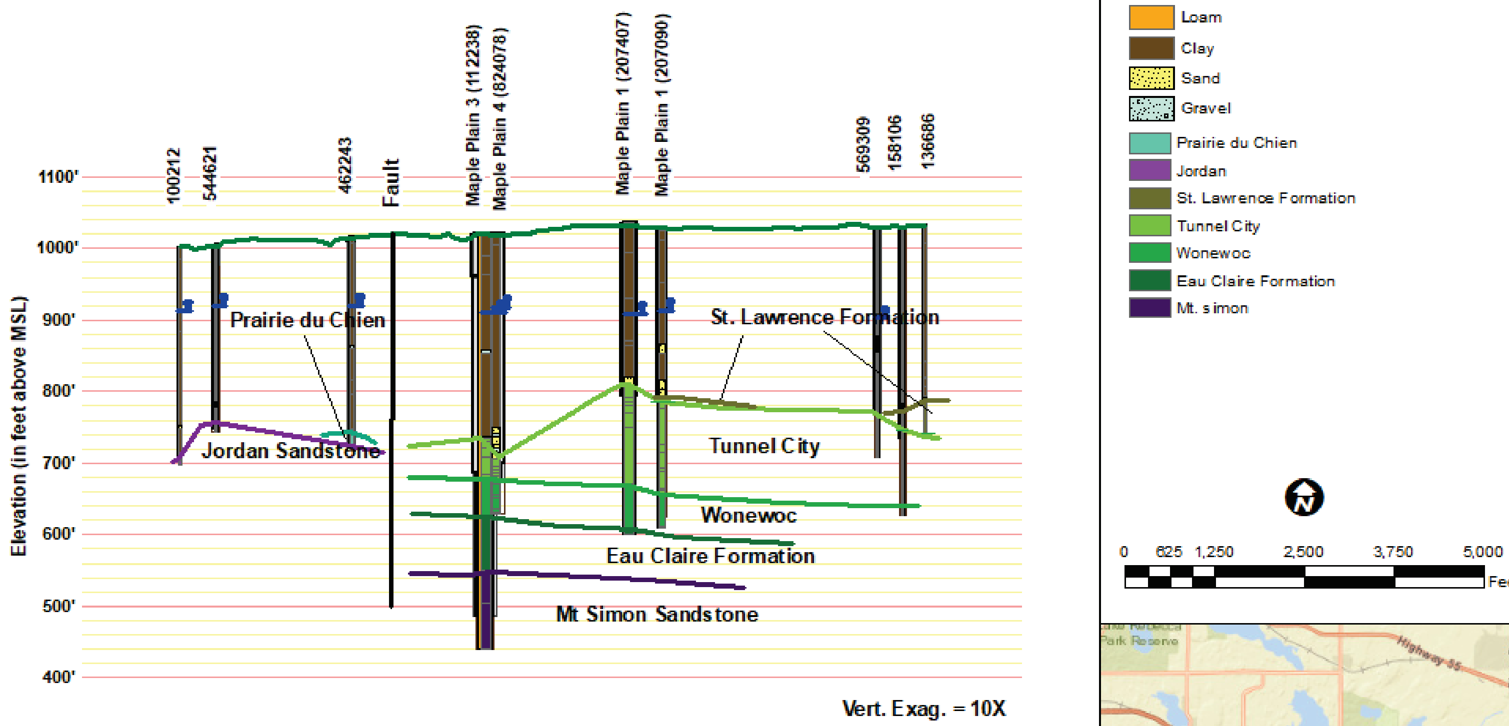


Hennepin County
Minnesota

Figure 4a
Geologic Cross-Section A-A'
Maple Plain

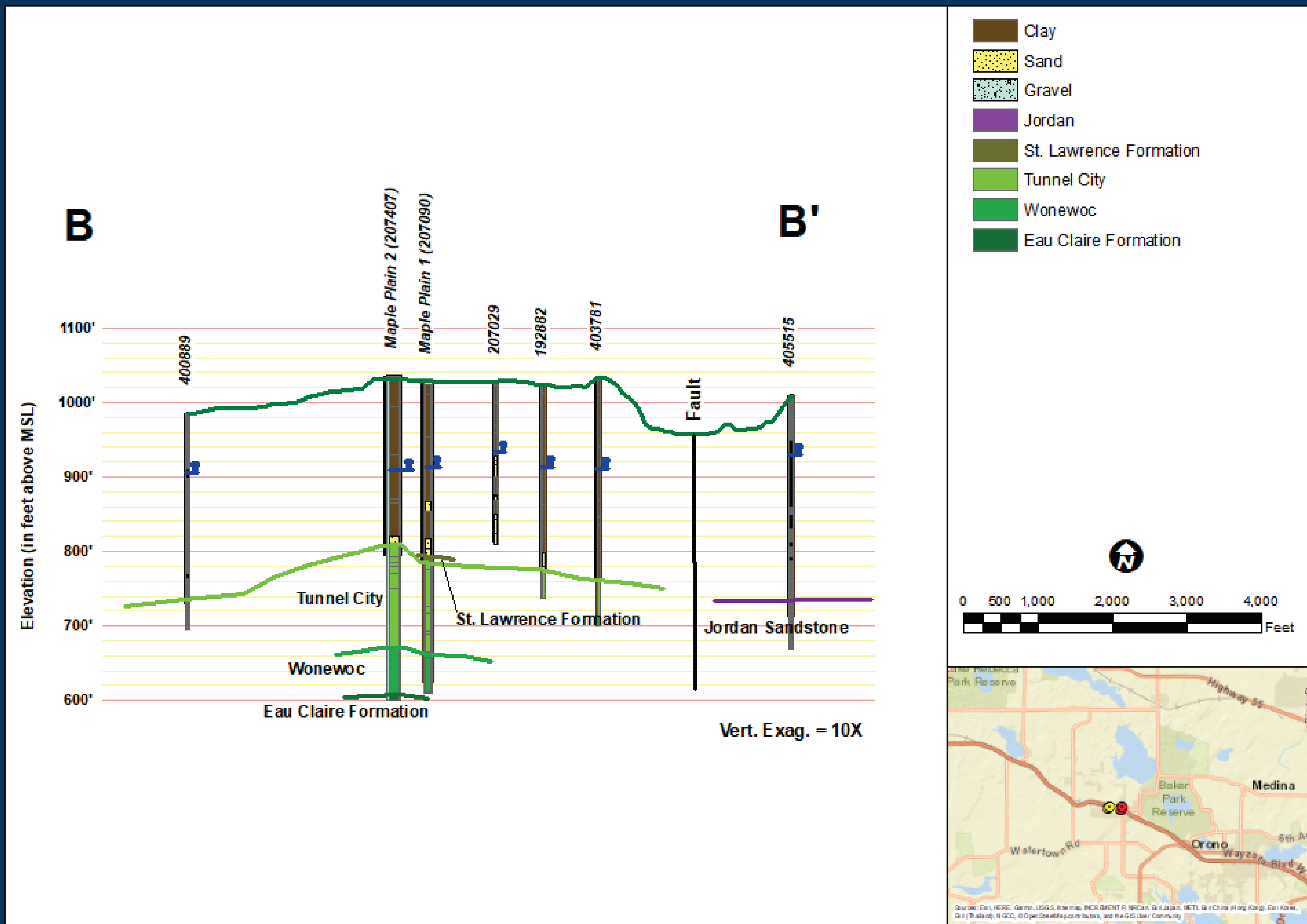
DEPARTMENT OF HEALTH

CLEAN WATER LAND & LEGACY



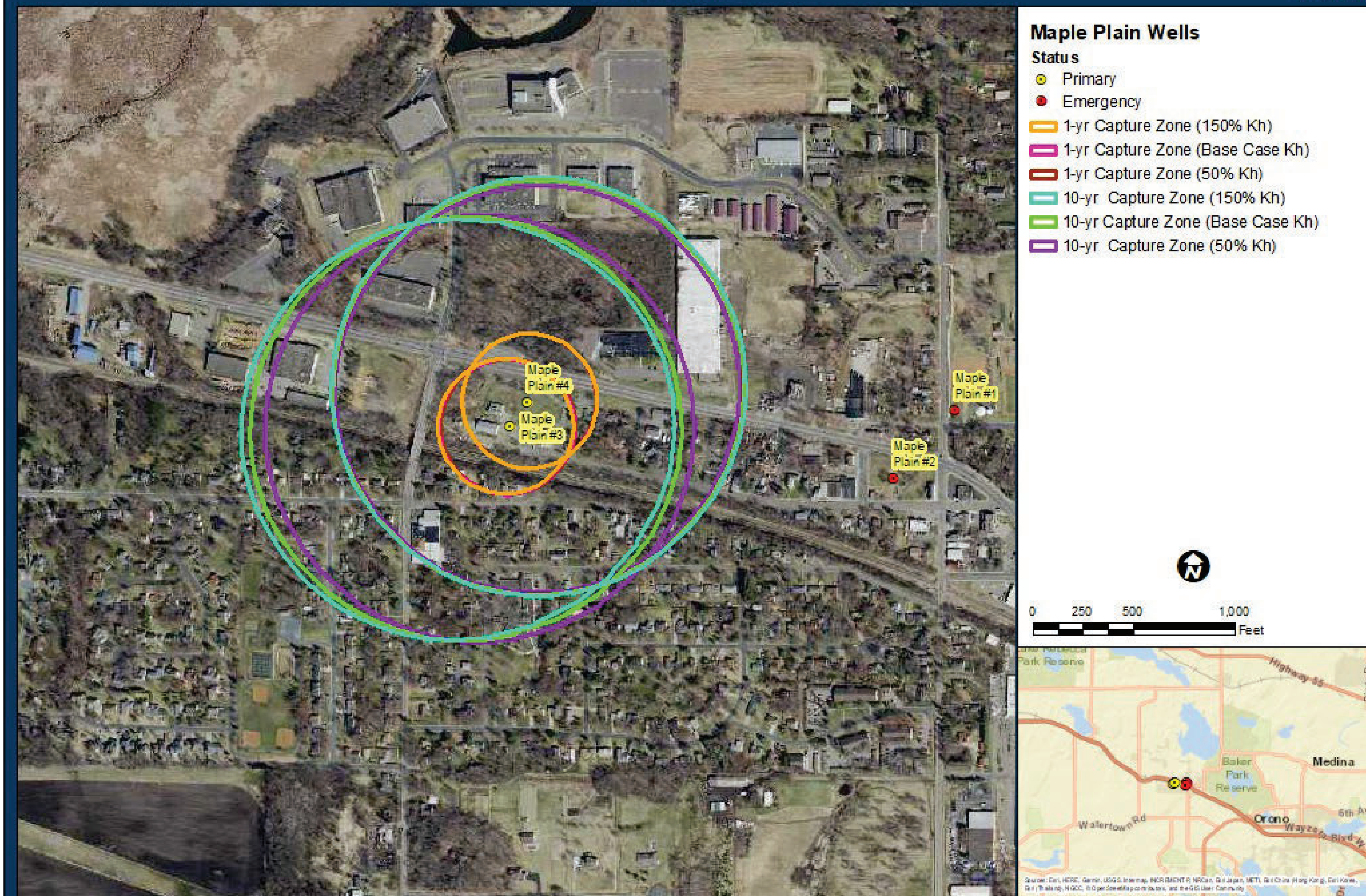
Hennepin County
Minnesota

Figure 4b
Geologic Cross-Section B-B'
Maple Plain



Hennepin County
Minnesota

Figure 5
Capture Zones from MODFLOW Used in the Delineations of the WHPA and ERA
Maple Plain



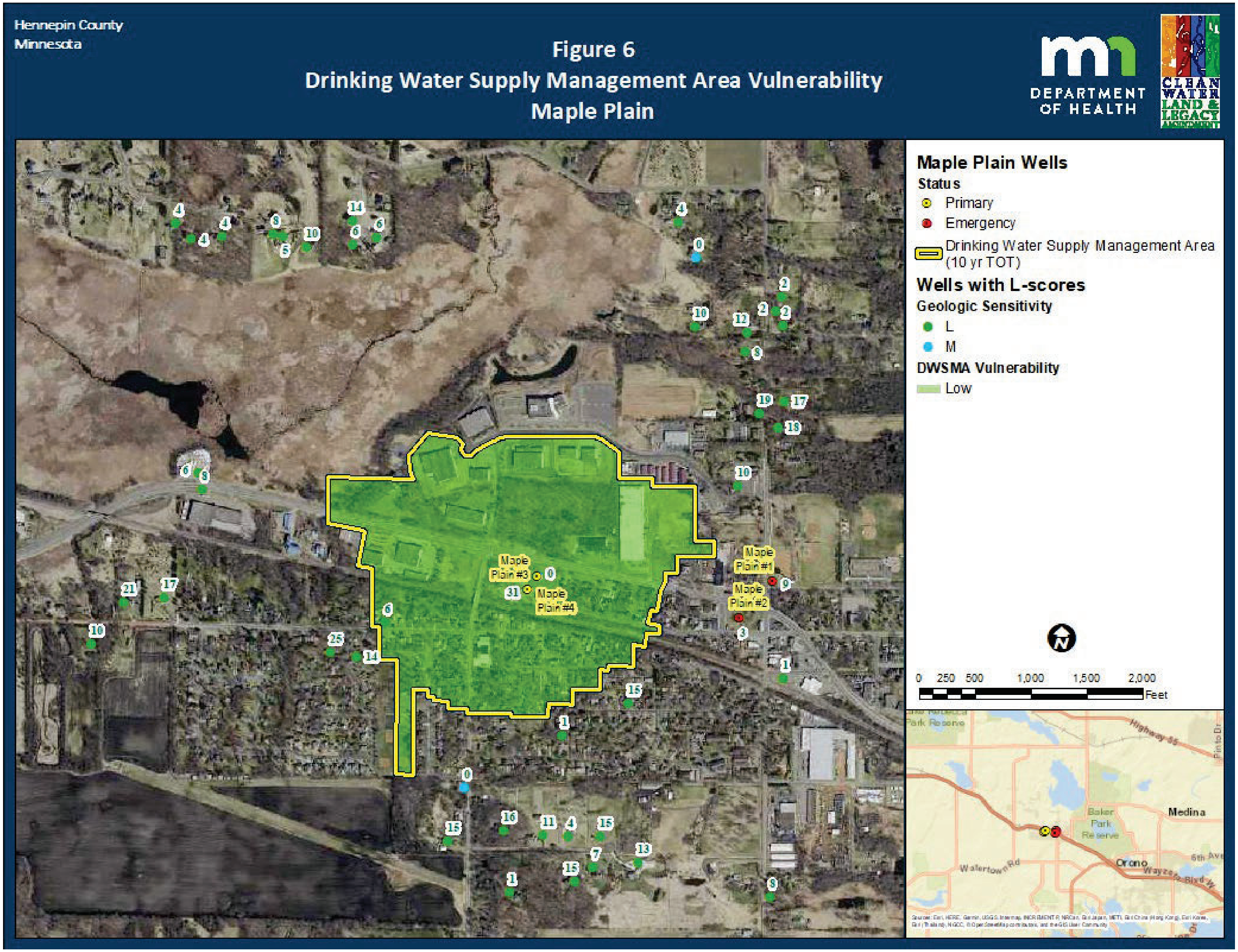
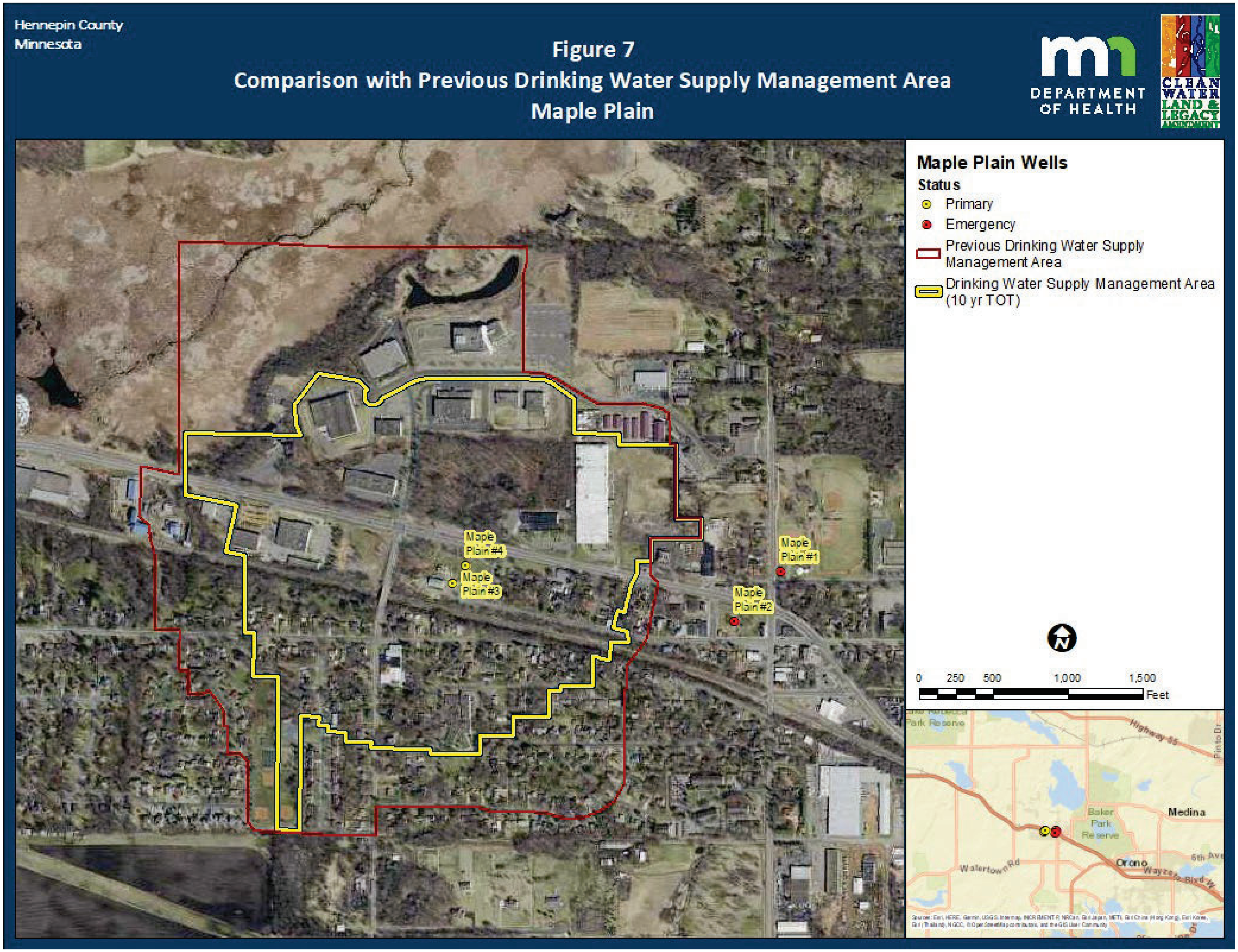


Figure 6
Drinking Water Supply Management Area Vulnerability
Maple Plain


Hennepin County
Minnesota
Figure 7
Comparison with Previous Drinking Water Supply Management Area
Maple Plain
DEPARTMENT OF HEALTH
CLEAN WATER LAND & LEGACY
Maple Plain #1
Maple Plain #2
Maple Plain #3
Maple Plain #4
Maple Plain Wells
Status
Primary
Emergency
Previous Drinking Water Supply Management Area
Drinking Water Supply Management Area (10 yr TOT)
0 250 500 1,000 1,500
Feet
Park Reserve
Highway 55
Medina
Baker Park Reserve
Watertown Rd
Orono
6th Ave
Wayzata Blvd W
Pinto Dr

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	MGS, DNR, USGS, Consultant Reports
Geology	Subsurface data	M	H	H	H	MGS, MDH, MPCA, DNR, MDA
Geology	Borehole geophysics	M	H	H	H	None available
Geology	Surface geophysics	L	L	L	L	None 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	Hennepin County
Land Use	Political boundaries map	L	H	L	L	MnGEO, City
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, 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	No relevant data found
Groundwater Quantity	Water Levels	H	H	H	H	No relevant data found
Surface Water Quality	Stream and lake water quality management classifications					
Surface Water Quality	Monitoring data summary					
Groundwater Quality	Monitoring data	H	H	H	H	MPCA, MDH, MDA, USGS
Groundwater Quality	Isotopic data	H	H	H	H	MPCA, MDH, MDA, USGS, Hennepin County, UMN
Groundwater Quality	Tracer studies	H	H	H	H	No relevant data found
Groundwater Quality	Contamination site data	M	M	M	M	MPCA, MDA
Groundwater Quality	Property audit data from contamination sites					
Groundwater Quality	MPCA and MDA spills/release reports	M	M	M	M	MPCA, MDA

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.”

Appendix B: Local MODFLOW Model

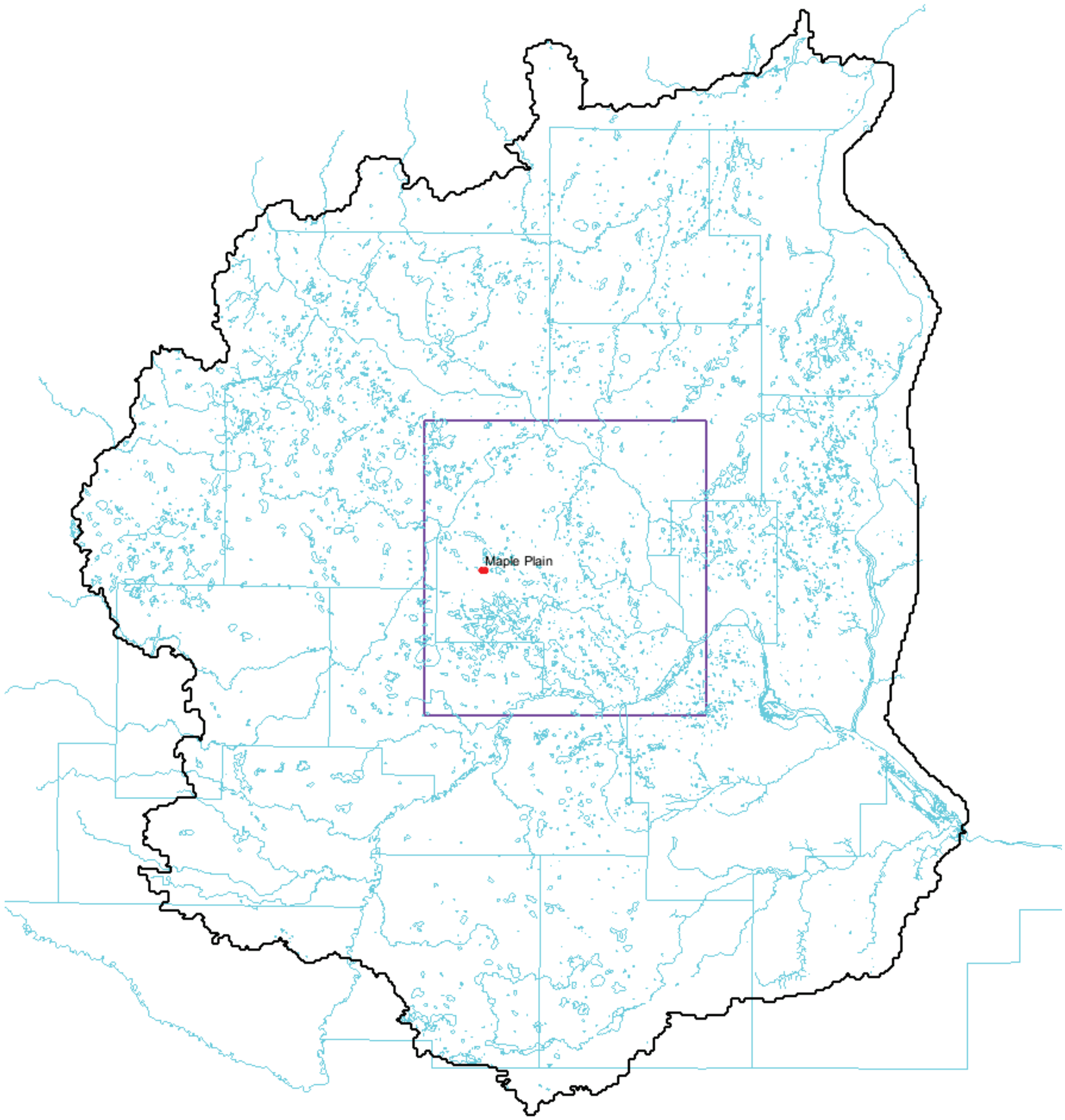


Figure B1 – Local Model/Regional Model Relationship

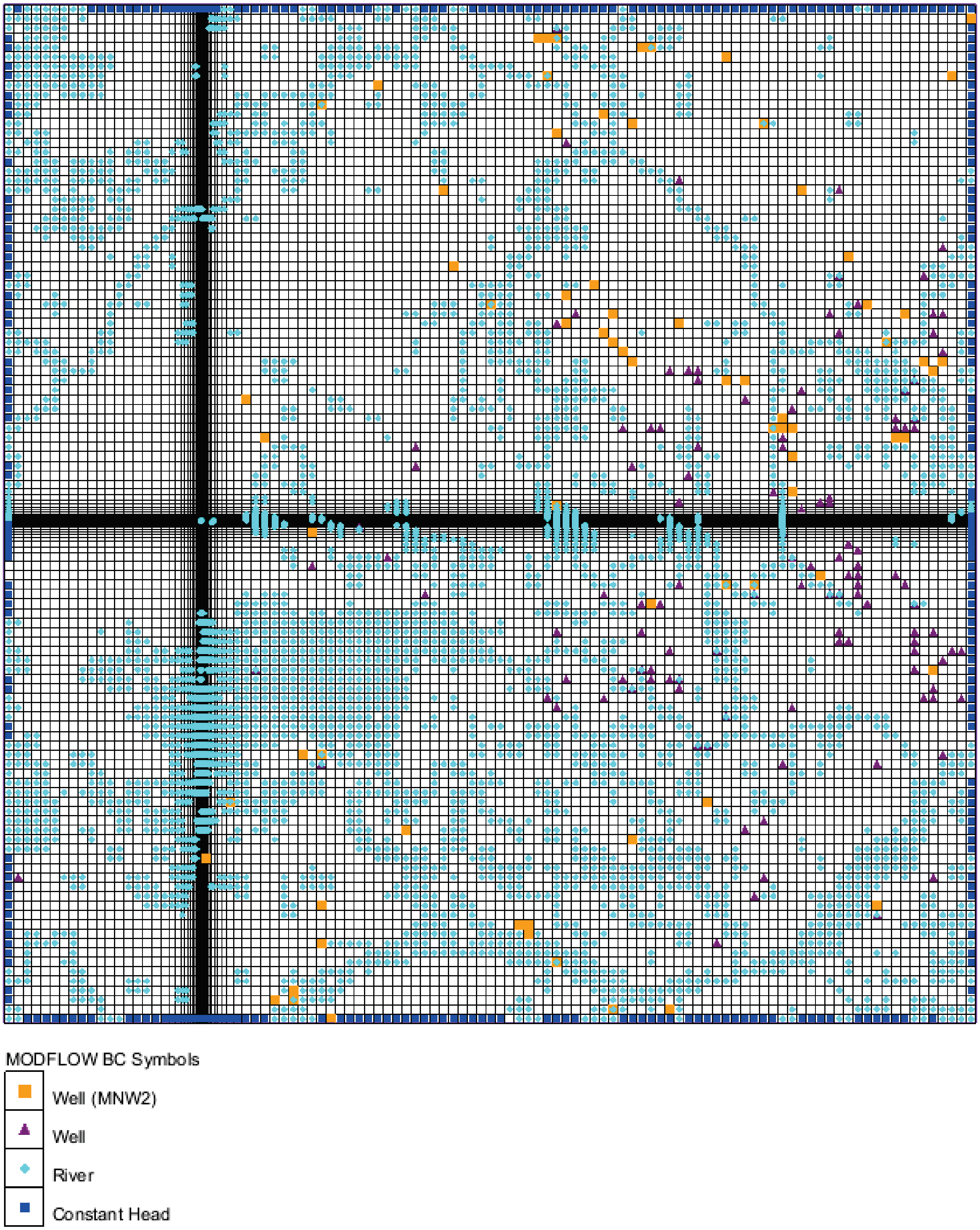
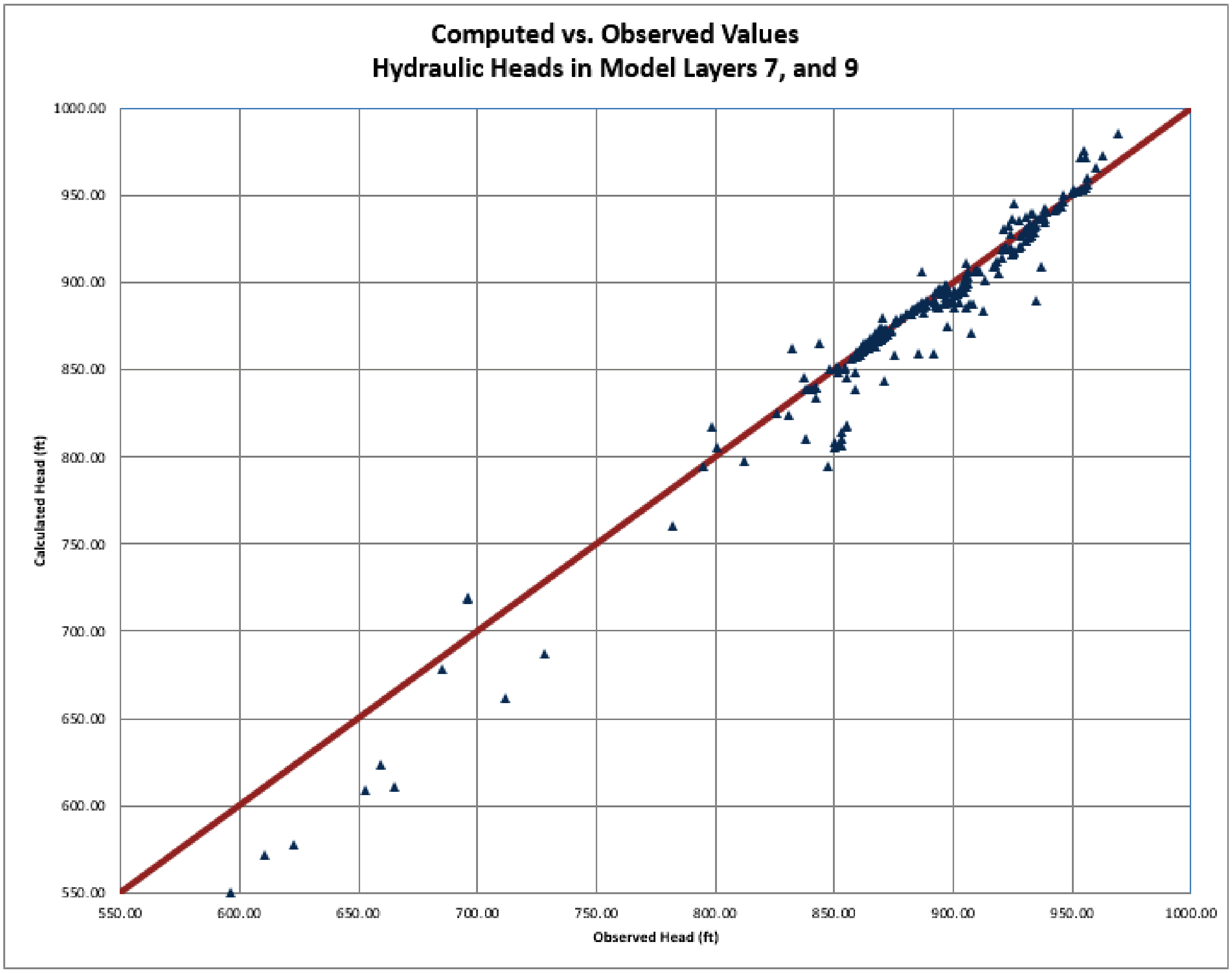


Figure B-2 – Model Layout – Local MODFLOW Model



5.43	= Mean Residual
7.50	= Mean Absolute Residual
14.43	= Root Mean Squared Residual
3.25%	= Normalized RMS

Figure B-3 – Computed vs. Observed Hydraulic Heads in Wonewoc/Mt. Simon Aquifers