CITY OF RICHFIELD
WELLHEAD PROTECTION PLAN
PART I (AMENDMENT)

February 27, 2018

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CITY OF RICHFIELD

WELLHEAD PROTECTION PLAN – PART 1 (AMENDMENT)

FEBRUARY 27, 2018

WELLHEAD PROTECTION AREA AND DRINKING WATER SUPPLY MANAGEMENT AREA DELINEATION AND VULNERABILITY ASSESSMENTS

I hereby certify that this plan, specification, 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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Date: FEBRUARY 27, 2018 License # 45625

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EXECUTIVE SUMMARY

This report documents the amended delineation of the wellhead protection area (WHPA) and drinking water supply management area (DWSMA) and the vulnerability assessments for the wells and DWSMA for the City of Richfield (PWSID 1270045) drinking water supply wells (Table 1). The amended plan covers the wells listed in Table 1. Well logs are presented in Appendix A. The delineation was performed in accordance with rules (Minnesota Rules 4720.5100 to 4720.5590) for preparing and implementing wellhead protection measures for public water supply wells. The rules are administered by MDH, and the results described in this report were prepared by Stantec.

The City of Richfield currently obtains its drinking water supply from six active wells completed in the Prairie du Chien and Jordan aquifers and one additional well completed in the Wonewoc and Mt. Simon aquifers. The WHPA and DWSMA delineations and vulnerability assessments for the City's wells was initially prepared in December 2005 by Bolton and Menk in the report *Part 1 Wellhead Protection Plan* (included within Appendix F). Since the time that plan was completed, the Minnesota Department of Health (MDH) has updated their guidance for delineating wellhead protection areas in setting where aquifers (such as the Jordan sandstone) are overlaid by fractured bedrock formations that can rapidly transmit water (and contaminants). Also, the 10-year delineation update deadline has passed, necessitating an update to the City's wellhead protection delineations. As such, a full update is being undertaken to bring the Part 1 plan up to date.

A computer groundwater modeling platform was utilized for this project. The porous-flow portion of the wellhead protection areas (WHPAs) for Richfield's wells was delineated using a modified version of the Metropolitan Councils Metro Model 3, recently released in 2014. This model is a steady state MODFLOW model built using Groundwater Vistas. The model was updated to reflect current pumping and geological conditions in and near the area around the Richfield well field. The model was used to delineate one-year and ten-year porous-flow capture zones for Richfield's wells (Figure 1).

A fracture flow analysis was then undertaken using current MDH methodology to predict the area of the Prairie du Chien aquifer that overlies the Jordan aquifer that is capable of rapidly transmitting water to the 10-year Prairie du Chien and Jordan capture zones. This fracture flow delineation was created by utilizing MDH guidance developed for fracture flow settings. The calculated area is shown in Figure 2.

The porous-flow and fracture-flow areas calculated were combined to create the composite groundwater contribution area shown in Figure 3. Figure 4 shows the vulnerability of the underlying Prairie du Chien-Jordan aquifer within this groundwater contribution area. A surface water contribution area was calculated, showing the area where the stormwater drainage system carries water that infiltrates into the highly-vulnerable portion of the groundwater contribution area. Figure 5 shows this mapped surface water contribution area.

The combined groundwater and surface water contributions areas for the Wellhead Protection Area (WHPA) for the amended plan. The drinking water supply management area (DWSMA) was determined for the WHPA by using property parcels and roadways as boundaries. Figure 6 shows the boundaries of both the WHPA and the DWSMA.

The amount of geologic protection documented in well logs from the water supply wells and regional information, along with water quality information was used to determine well vulnerability. All of Richfield's wells are considered vulnerable to contamination, with the exception of Well 7. Elevated

tritium levels were the main reasons for the vulnerable classifications. Tritium is harmless in water, but indicates that some portion of the water is less than 60 years old. High geologic sensitivity also contributed to the vulnerability of the wells in this area. Richfield's wells appear to meet the construction standards of the State Well Code, however, and the wells themselves are not considered a likely avenue for contamination to reach the aquifer from which they pump.

The groundwater contribution area has a mixed vulnerability to contamination from contamination at or near the land surface, ranging from low to high. Figure 4 shows the vulnerability of the Prairie du Chien-Jordan aquifers. The high vulnerability areas are based on the relative lack of continuous layers of confining materials (e.g. clay or shale) that could impede vertical infiltration of contaminants. Moderate vulnerability areas contain some confining materials, but are not believed to be thick enough to offer significant protection to the aquifers. Low vulnerability areas have at least 10 feet or more of confining materials to protect the aquifers.

The vulnerability of the surface water contribution area is shown in Figure 7. Since overland flow of surface water (and associated contaminants) can be rapid, the entire area is designated as highly vulnerable.

Groundwater and surface water vulnerability will be used to define the scope of activities required to complete the amendment to Part 2 of the Wellhead Protection Plan.

CHAPTER ONE
DATA ELEMENTS and ASSESSMENT (4720.5200)

PART 1. REQUIRED DATA ELEMENTS

This section contains required data elements that were outlined in the Scoping Decision Notice provided to Richfield by the MDH. Appendix E contains a table assessing the data elements required for this plan. Below is a summary of each data element.

A. Physical Environment Data Elements

Geology, soils, and water resources data elements are provided in *Part 1 Wellhead Protection Plan, City of Richfield (Bolton and Menk, 2005)*. See Appendix F for the 2005 report files. Geologic cross-sections for the Richfield Well Field are provided in Appendix D, as taken from the original Part 1 Wellhead Protection Plan.

The below table represents updated precipitation data from the Richfield area in inches, as calculated by the Minnesota Climatology Working Group's online gridded precipitation database. The database correlates available surrounding precipitation data points to determine approximate precipitation values in the area of interest.

Richfield Precipitation (inches), Minnesota Climatology Gridded Database

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2016	0.31	1.10	2.11	3.30	2.36	4.05	4.95	8.45	6.00	3.57	2.81	2.11	41.12
2015	0.31	0.31	0.70	2.28	4.16	4.97	7.84	3.25	4.29	2.72	4.33	2.03	37.19
2014	1.35	1.38	0.73	6.33	4.12	11.89	2.58	2.67	2.06	1.59	0.85	0.88	36.43
2013	0.83	1.27	2.03	4.87	6.16	5.57	4.33	1.98	1.36	3.32	0.53	1.46	33.71
2012	0.41	1.83	1.43	3.03	9.47	3.94	4.10	1.58	0.35	1.25	0.71	1.59	29.69
2011	1.00	1.11	2.18	2.96	4.48	4.97	4.99	3.07	0.40	0.84	0.21	0.97	27.18
2010	0.52	0.78	0.83	2.58	2.60	5.79	3.60	5.50	5.52	1.85	2.12	2.86	34.55
2009	0.54	1.04	1.55	1.40	0.49	3.17	1.49	7.21	0.55	5.58	0.46	1.98	25.46
2008	0.15	0.45	2.24	3.26	2.35	2.97	2.75	3.17	2.10	1.84	1.22	1.19	23.69
2007	0.87	1.39	3.65	1.61	2.45	2.07	2.68	8.48	5.89	4.51	0.10	1.66	35.36

Average annual precipitation over the 10-year period from 2007 to 2016 was 32.4 inches, which is close to the 1981-2010 mean of 32.3 inches for the same study area. Precipitation is accounted for as recharge in the *Twin Cities Metropolitan Area Regional Groundwater Flow Model Version 3.00* (Metropolitan Council, 2014).

B. Land Use Data Elements

1. **Land use** – Land use was generally not considered for the Part 1 wellhead protection activities. Land use will be covered in greater detail in the updated Part 2 plan, where the role of land use on water quality will be closely reviewed.
2. **Public utility services** – The only public utilities that play a role in the Part 1 Wellhead Protection Plan are the municipal water supply wells in Richfield and other nearby public water supply wells for surrounding communities that utilize the same aquifers. Table 2 shows the modeled rates of the wells operated by Richfield. All high capacity wells in the DNR SWUDs database were already included in the MODFLOW model.

However, all permitted high capacity wells within two miles of the Richfield wells have been modified in the model to reflect current conditions. Table 3 shows the modeled rates of these high capacity wells. High capacity wells beyond two miles retain the original pumping rates assigned to them in the Metropolitan Council's 2014 modeling effort. Well usage is also addressed in Part 2 of this chapter.

C. Water Quantity Data Elements

1. **Surface water quantity** – The Minnesota River and Mississippi River are the major discharge features located within the domain of the model developed for this project. Numerous smaller discharge features have been added to the model domain and are explained in greater detail in the Metropolitan Council's technical report for the Metropolitan Model (May 2014).

2. **Groundwater quantity** - Review of groundwater appropriations permits in the State Water Use Data System (SWUDS) database was performed to identify high capacity wells in the area that might affect delineation of the wellhead protection area. Most high capacity wells as of 2014 were included in the Metropolitan Council's model. High capacity wells within two miles of the Richfield wells were updated in the model for the purposes of this delineation effort and are listed in Table 3. The City of Richfield wells were modeled at the rate outlined in the wellhead protection rules, based on historical or projected within with 5 years of the current date. Modeled Richfield well rates are shown in Table 2.

D. Water Quality Data Elements

1. **Surface water quality** – Major surface water features in the area, such as the Minnesota River and Mississippi River, which are in direct hydraulic connection with the Prairie du Chien and Jordan aquifers, serve as flow boundaries within select layers of the Metropolitan Model. The Prairie du Chien and Jordan aquifers are also in connection with more localized streams and lakes, as documented in the Met Council model report (May 2014). Since these major rivers are points of drainage from the aquifers, the quality of water in these rivers does not play a large role in Richfield's water quality. More pertinent is the quality of storm water that infiltrates into the capture zones for the City's wells. Surface water quality will be addressed in greater detail in the updated Part 2 plan.

2. **Groundwater quality** – Results of routine monitoring of the Richfield wells are contained within the files of the Minnesota Department of Health. Historical monitoring has shown that the water quality within the Jordan aquifer in Richfield is generally of excellent quality. Nitrates levels in Richfield's wells remain below the detection limits, indicating that nitrates-contaminants from turf fertilization is not impacting groundwater quality. Due to the urban setting, it is believed that very few properties have septic systems or have agricultural land uses.

   Sampling of tritium has taken place at Richfield Wells 1 and 2. Tritium is an isotope of hydrogen that was released into the atmosphere during the above-ground testing of nuclear weapons in the early 1950s. While harmless, the presence of tritium in aquifers indicates that some portion of the water was in contact with the atmosphere within the past 60 years. A tritium level of 1 tritium unit (TU) or greater is an indication that these aquifers are somewhat vulnerable to contamination. The tritium levels range between 5.8 TU (in Well 1) to 12.7 TU (in Well 2). Wells 3-7 have not been sampled for tritium to date. It is believed that Wells 3-6 will show tritium, due to also being open to the

Prairie du Chien aquifer. Additionally, Well 7 has not been sampled, as it is believed that the deeper Wonewoc and Mt. Simon aquifers are sufficiently protected by confining layers. Sampling Well 7 in the future may help to back up this assumption and demonstrate that the well integrity is not allowing younger water to leak into the well casing from overlying units.

PART 2. ASSESSMENT OF DATA ELEMENTS USED TO DELINEATE THE WELLHEAD PROTECTION AREA

A. Use of the Wells – The wells shown in Table 1 serve as the sole drinking water source for residents of the City of Richfield. Pumping from the wells is rotated based on water demand and seasonal usage.

Table 2 shows a comparison of the usage of the City of Richfield wells for the past five years versus a projected pumping rate 5 years into the future. The greatest amount of pumping from any of these years is used to represent the pumping rate for that well in the groundwater model. This is done for the purpose of developing a delineation that is conservative and takes into account the potential volume each well may be pumped in the near future.

Other high capacity wells being included within the model, but not being delineated in the plan, are modeled using an average pumping rate taken from a 5-year period. This is explained in greater detail in the Metropolitan Council's 2014 technical report for the Metropolitan Model. High capacity wells within two miles of the Richfield wells are shown in Table 3. These wells were modeled based on an average rate from the years 2011-2015. These pumping volumes modify the volumes originally modeled by the Metropolitan Council

B. Wellhead Protection Area Delineation Criteria

1. **Time of travel** – The minimum time-of-travel for porous-flow aquifer delineations is 10-years, which is what was used for the Prairie du Chien, Jordan, Wonewoc, and Mt. Simon aquifers. For the fracture-flow delineation, a 5-year fixed radius with a 5-year upgradient extension is used to represent an approximate 10-year capture zone for flow within the fractured Prairie du Chien aquifer. A 1-year-year time-of-travel zone was also delineated for both porous-flow and fracture-flow systems and represents the Emergency Response Area.

2. **Hydrologic flow boundaries** – The Minnesota River and Mississippi River represents the major flow boundaries for the Prairie du Chien and Jordan aquifers in the Hennepin County area. Hydrologic flow boundaries included in the groundwater model are documented in greater detail in the technical report for the Metropolitan Model (Metropolitan Council, 2014).

3. **Daily volume** – Projected annual pumping volumes for the Richfield wells are shown in Table 2. The maximum projected annual pumping volumes were converted to cubic meters per day in order to be applied to the groundwater model.

4. **Groundwater flow field** – The groundwater flow field was calculated by the groundwater flow model. Original model calibration and ambient flow-field simulation results are described in the technical report for the Metropolitan Model (Metropolitan Council, 2009). Model calibration remains relatively unchanged, since the only significant updates to the model are updates to the wells and their pumping rates, and small-scale changes to hydraulic conductivity near the Richfield well field. These changes were not enough to significantly impact calibration results.

5. **Aquifer transmissivity** – Aquifer transmissivity for regional model was established by the Metropolitan Council's calculations for the 2014 update to the Metropolitan Model. To refine transmissivity for the Richfield area, the nearest available high-quality aquifer test data from the City of Edina's wells was utilized. Transmissivity for the Prairie du Chien-Jordan aquifer was calculated based on a 24-hour aquifer pumping and recovery tests conducted on Edina Well No. 3 in 1995. The results of the test indicated transmissivity values of 9,265 ft^2/day for the Prairie du Chien aquifer and 5,440 ft^2/day for

the Jordan aquifer. An additional aquifer pumping test conducted on Edina Well No. 10 was used to calculate transmissivity of the Mt. Simon aquifer. Calculated transmissivity for the Mt. Simon was 2,190 ft^2/day. The Wonewoc aquifer is lacking in nearby aquifer test data, so the hydraulic conductivity already within the Metropolitan Model was retained for the purposes of this delineation effort.

Aquifer test plans were submitted to the MDH proposing the above values for use in the amended plan delineations. Since there is uncertainty over how much the hydraulic conductivity changes between Edina and Richfield, conductivity was varied by 50% in the model (both increased and decreased) to account for the plausible range in values.

C. Quality and Quantity of Water Supplying the Public Water Supply Well - Water in the City of Richfield water distribution system is regularly sampled and analyzed for contaminants regulated under the federal Safe Drinking Water Act. Routine monitoring by the Public Water Supply Program at MDH does not indicate contamination that may pose a public health risk. No contaminants of significant concern have been detected in the City's wells, however the relatively high tritium concentration does indicate the Prairie du Chien and Jordan aquifers are somewhat vulnerable to contamination.

The Prairie du Chien and Jordan aquifers appears to have sufficient transmissivity and recharge to remain a long-term source of drinking water for the residents of Richfield. The deeper Mt. Simon aquifer is now restricted in usage for the Twin Cities metropolitan area, except under situations where no other viable alternative exists. This is done to limit the amount of pumping from the Mt. Simon, as this deep aquifer is slowly recharged and is in danger of being pumped beyond its ability to be recharged. Existing wells, such as Richfield Well. No. 7 are still allowed to utilize the Mt. Simon aquifer, but no new wells (or increases in discharge to existing wells) are currently being allowed for the Mt. Simon.

No significant changes in water demand are expected, as the City has essentially reached its maximum growth. Annual pumping has decreased every year between 2012 and 2016, as greater water conservation efforts help to reduce pumping demand. Monitoring of water levels within the aquifer in the region will help observe the long-term sustainability of the aquifers as surrounding communities continue to develop. Water level data collected in the Richfield wells will contribute to the understanding of groundwater sustainability.

D. The Land Uses in the Drinking Water Supply Management Area – Land uses in the DWSMA (Drinking Water Supply Management Area) for the Richfield wells is primarily residential and commercial. A portion of the MSP International Airport is also included within the DWSMA. Land uses will be discussed in greater detail in the amended Part 2 Wellhead Protection Plan, which will include the contaminant source inventory for parcels within the DWSMA.

CHAPTER TWO
WELLHEAD PROTECTION AREA AND DRINKING WATER SUPPLY MANAGEMENT AREA DELINEATION (4720.5205)

A. Physical setting and subsurface hydrogeology – The Richfield municipal wells draw water from the Prairie du Chien, Jordan, Wonewoc, and Mt. Simon aquifers. Groundwater flow and the hydrogeologic setting are described in *Part 1 Wellhead Protection Plan, City of Richfield (Bolton and Menk, 2005).* A discussion of hydrogeologic conditions across the full model domain is presented in the report *Twin Cities Metropolitan Area Regional Groundwater Flow Model Version 3.00* (Metropolitan Council, 2014).

B. Delineation of the Wellhead Protection Area

1. Porous Flow Delineation Method

The delineation of the porous-flow aquifer capture zones was conducted utilizing the modified Metropolitan Model. Original model construction detail, data files, and calibration results are outlined in the Metropolitan Council report (2014). Modifications to the model included:

- Refinement of the model grid was done to reduce model grid size from 500 x 500 meters to 31.25 x 31.25 meters around the Richfield municipal wells.
- Updating modeled flow rates for Richfield municipal wells to match wellhead protection rule requirements. Modeled rates are shown in Table 2.
- Updating average modeled flow rates for nearby high capacity wells (both municipal and private) to reflect the period from 2011 to 2015.
- The modeling of some high capacity wells was modified to better reflect the actual construction of the well. It is common practice for local well drillers, who are constructing a Jordan aquifer well, to drill a few feet below the Jordan aquifer into the St. Lawrence aquifer. This is done to ensure that the full interval of the Jordan is open to the well. The borehole that is open to the St. Lawrence formation often yields very little water and often becomes back-filled over time with sediment and debris. When the well is recorded in the County Well Index database, however, it is often classified as a "Jordan-St. Lawrence" well, even though the well is truly a Jordan aquifer well. County Well Index classifications were used in simulating some of the wells in the Metropolitan Model, showing the wells being open to Layer 5 (the St. Lawrence). This can result in the model simulating a higher-than-expected water volume from the St. Lawrence layer. For the purposes of this modeling effort, Jordan aquifer wells which are open to a few feet of the St. Lawrence formation were modeled as only being in Layer 4 (the Jordan aquifer).
- The Prairie du Chien (layer 3) and Jordan Aquifer (layer 4) parameters around the Richfield wells was adjusted to match local values, as determined from nearby aquifer tests. Horizontal hydraulic conductivity was adjusted to 20.4 m/d and 16.5 m/d, respectively, in the Prairie du Chien and Jordan aquifers. Hydraulic conductivity was also adjusted to 2.47 m/d in the area around Richfield Well 7 for the Mt. Simon aquifer, based on the aquifer pumping test information. Wonewoc aquifer conductivity values were unchanged in the model.

- A global porosity of 0.20 was chosen to represent the Jordan, Wonewoc, and Mt. Simon aquifers across the model domain. A porosity of 0.056 was chosen to represent the Prairie du Chien aquifer.
- The thickness of the Mt. Simon aquifer was increased to 271 feet in the Richfield area to reflect the aquifer thickness observed at Well 7.

Calibration of the modified Metropolitan Model was checked using target wells located in Layer 3 (Prairie du Chien aquifer), Layer 4 (Jordan aquifer), and Layer 9 (Mt. Simon). Calibration results are presented in Appendix B for the area in the immediate vicinity of the City of Richfield. Calibration results showed a Root Mean Squared Error of 11.5m and a calculated mean deviation of 0.316. In general, calibration results are consistent with the original Metro Model 3.00.

The delineations were created using particle tracking analysis in MODPATH. A circle of particles was established at a radius of 40 meters from each wellhead and tracking backwards (upgradient) with 120 particle lines per well. MODPATH was set to have four release points between 0.2 and 0.8 offset. The path line groupings were then outlined to develop capture zones for 1-year and 10-year time-of-travel delineations. Figure 1 shows the outlined result of the delineation effort. Model files and generated path lines are provided as supplemental data in Appendix F.

2. Fracture Flow Delineation Method – Prairie du Chien Aquifer

Since the Prairie du Chien aquifer, which overlies the Jordan aquifer, is capable of rapidly transmitting water through its secondary porosity features (fractures and solution cavities) and can transmit water to the underlying Jordan aquifer, an additional delineation effort was required for the Jordan aquifer wells (Wells 1 and 2), along with wells that are also directly open to both the Prairie du Chien aquifer and the Jordan aquifer (Wells 3-6). The Minnesota Department of Health has developed a guidance for delineating the fracture flow component to the delineation of wells in this type of setting. The methodology is outlined in greater detail in *Guidance for Delineating Wellhead Protection Areas in Fractured and Solution-Weathered Bedrock in Minnesota* (Minnesota Department of Health, December 2011).

While the calculated porous delineation of the Jordan aquifer can account for the full 10-year volume of water pumped from Richfield Wells 1 and 2, anecdotal evidence (including tritium data) suggest that recharge from the overlying Prairie du Chien aquifer results in relatively recent water reaching the Jordan aquifer. As such, completing a fracture flow delineation for the Prairie du Chien aquifer is required for these two wells.

The modified MODFLOW model was analyzed to determine an estimation of recharge from the Prairie du Chien aquifer into the Jordan aquifer across the 10-year capture zone. This was done using a mass-balance calculation in Groundwater Vistas, determine the sum of the cell-by-cell flows within the delineated area. A summary of the results is provided in Table 5. This summary shows that the model is calculating a recharge from the overlying Prairie du Chien aquifer to the Jordan aquifer of 1027.0 m^3/day. Wells 1 and 2 have a combined average pumping rate of 4605.7 m^3/day. This indicates that approximately 22% of the water entering the 10-year capture zone is coming from the overlying Prairie du Chien.

The next step of the process was to delineate a fixed radius capture zone for the Prairie du Chien aquifer around Wells 1 and 2. Table 5 shows the values used to create the fixed radius calculation for each well, using the MDH's GIS-based calculation tool for fracture flow delineations. Since Wells 1 and 2 are in close proximity, a combined delineation for both wells was performed, with a central coordinates providing the basis for drawing the fixed

radii. This calculation takes into account aquifer thickness, aquifer porosity, and the combined calculated contribution from the Prairie du Chien (1027.0 m^3/day). A 1-year fixed radius and a 5-year fixed radius (with a 5-year upgradient extension) was calculated. The results are shown in Table 5.

For Wells 3, 4, 5, and 6, which are open to both the Prairie du Chien and Jordan aquifers, a separate calculation was performed for those wells. The difference is that this second set of calculations (with all four wells grouped together) assumed that 100% of the water being pumped by these wells was coming from the Prairie du Chien formation. While the reality is that the pumping is likely split between both the Prairie du Chien and the Jordan aquifers, attributing 100% of the pumping volume to the Prairie du Chien is a conservative approach which addresses the uncertainty over how much water each aquifer produces. Table 5 shows the calculated radii for this grouping of wells.

Since the fixed radii of the multi-well groupings overlapped each other, the calculated areas had to be increased accordingly (since two sets of wells cannot share the same capture area). The next step was to apportion a volume of the overlap area of each well, by calculating the volume of the shared area and determining the percentage of the shared area that should be added to each well's delineated area. Table 5 shows this calculation and shows the resulting modified fixed radius and modified upgradient extension area.

Upgradient extensions were varied 10 degrees in either direction of the flow gradient (300 degrees from North), to account for possible uncertainties regarding flow direction. The fixed radius delineations and their upgradient extensions were combined to create a composite fracture-flow delineation area for the Prairie du Chien bedrock, as shown in Figure 2. This is the area that, combined with the 10-year porous flow area delineated in Figure 1, will serve as the groundwater capture zone for the Richfield wells. The composite groundwater capture area is shown on Figure 3. All parcels that are either partially or wholly contained within this area make up the groundwater contribution area.

3. Surface Water Contribution Area

Portions of the Prairie du Chien and Jordan aquifers within the groundwater capture zones for Richfield's wells are highly vulnerable to contamination. (See Chapter Three.) Figure 4 displays the vulnerability of the groundwater capture zone. Within some of these highly vulnerable parcels, there is a potential for contaminated stormwater or surface water to infiltrate into the aquifer. To account for this possibility, an additional surface water contribution area was required for the amended Wellhead Protection Plan.

The groundwater capture zone for Richfield's wells is highly developed and surface water is controlled through a series of storm water pipes and channels. Some of the stormwater flow is carried to ponds or streams where it flows outside of the groundwater contribution area or it infiltrates into low vulnerability areas. Some of the stormwater flows into highly vulnerable parcels where it infiltrates in a series of ponds or lakes. Infiltration points in highly vulnerable areas include Legion Lake, Wood Lake, Norby's Pond, Christian Park Pond, Diamond Lake, Grass Lake, and Taft Lake. Stormwater pipes and overland flow that drains into these infiltration areas were delineated. This area is displayed on Figure 5 as the surface water contribution area.

The composite of the groundwater capture zone and the surface water contribution area formed the delineation of the Wellhead Protection Area (WHPA) shown in Figure 6.

C. Uncertainties relating to the accuracy of the calculated wellhead protection area boundaries

Using computer models to simulate ground-water flow necessarily involves representing a complicated natural system in a simplified manner. These simplifications are a result of incomplete knowledge or understanding of part of the natural system and the limitations of mathematical models implemented in groundwater modeling computer codes. The necessary simplifications give rise to uncertainty in the model results. A reasonable attempt to account for the most significant causes of model uncertainty was made in the delineation of the WHPA. The technical report for the Metropolitan Model (Metropolitan Council, 2014) outlines some of the model uncertainties that exist within the original MODFLOW model. Wherever possible, locally obtained values of hydraulic conductivity were used to more accurately represent conditions in and around the Richfield wells.

Additional areas of uncertainty not accounted for in the original 2003 delineation analysis were considered for this amended delineation. The chief area of uncertainty was the portion of water entering the Jordan aquifer porous flow capture zones through the overlying Prairie du Chien aquifer. The MDH guidance for calculating wellhead protection areas in fracture flow and solution-weathered settings is designed to account for a large amount of that uncertainty. The additional areas, added to the delineation around the wellhead (and extended in the upgradient direction), add a higher degree of confidence that the delineation accounts for areas within both the Prairie du Chien and Jordan aquifers that supply water to the municipal wells over a 10-year period.

Additionally, the lack of high-quality aquifer pumping test data from the Richfield wells (that meets the MDH's criteria for a wellhead protection aquifer test) necessitated using data from nearby Edina wells to estimate aquifer transmissivity and hydraulic conductivity. Since these values can vary somewhat across the metro area, there is uncertainty whether the aquifers in Richfield have comparable values. To account for this uncertainty, separate modeling runs were completed with the Metropolitan Model where the hydraulic conductivity in the Prairie du Chien, Jordan, and Mt. Simon aquifers was both increased and decreased by 50%. This produced a range of capture zones to account for potential conductivity variations. The porous flow delineations shown in Figure 1 are a composite of all three sets of conductivity values used, the calculated value from the Edina wells (Model Run 5), the 50% increased value (Model Run 6), and the 50% decreased value (Model Run 7).

D. Delineation of the DWSMA

The Wellhead Protection area (WHPA) is shown on Figure 6. This area includes all of the porous-flow wellhead protection areas, the fracture-flow wellhead protection area, and the surface water contribution area. The Drinking Water Supply Management Area (DWSMA) was delineated using a combination of parcel boundaries, street and road centerlines, and municipal boundaries. Any parcel of land either wholly or partially within one of the delineation areas was included within the DWSMA.

The DWSMA represents the area of land that will be considered during the creation of the updated management plan for Part 2. The vulnerability of the DWSMA is discussed in Chapter 3 of this report.

CHAPTER THREE
VULNERABILITY ASSESSMENT

This chapter documents the vulnerability assessments of the wells and drinking water supply management area (DWSMA) for the City of Richfield wells listed in Table 1. This assessment was performed in accordance with rules (Minnesota Rule 4720.5210) for preparing and implementing wellhead protection measures for public water supply wells.

The vulnerabilities of the wells were determined by evaluating available information on the 1) geology, 2) well construction, 3) pumping rates, and 3) chemical composition of the well water and comparing these results with the criteria in Minnesota Rule 4720.5550.

The vulnerability of the DWSMA was determined by evaluating available information on 1) the lateral continuity of protective geologic materials overlying the aquifer and 2) the chemical and isotopic composition of well water from the aquifer. The primary source of information for the DWSMA vulnerability assessment is outlined in *Part 1 Wellhead Protection Plan, City of Richfield (Bolton and Menk, 2005)*. DWSMA vulnerability was calculated using a combination of the Hennepin County Geologic Atlas, bedrock geology, surface geology, and mapped clay layers.

A. Well vulnerability assessment - A vulnerability score was calculated for each well based on factors such as well construction, geology at the well site, and chemical data; higher scores correlate to greater perceived vulnerability. A numeric cutoff (of 45 points) is used to identify vulnerable from non-vulnerable wells (MDH, 1997). Vulnerable wells are also identified based on the presence of contamination, such as nitrate-nitrogen in excess of 10 mg/l, or young (post-1953) water, as indicated by the presence of 1 tritium unit or greater in the well water. The completed well vulnerability assessment worksheets are provided in Appendix C.

With the exception of Well 7, all municipal wells were determined to be vulnerable, based on a combination of the geologic "L" score and the presence of tritium. These classifications did not change since the original 2005 classifications, since none of the determining factors that are considered for this analysis had changed. Well use, well construction, and geology remain the same. With the exception of Well 7, all wells that scored 45 points or more were still considered vulnerable due to the presence of tritium in nearby wells with the same type of construction (casing depth and overall well depth). Well 7 is considered non-vulnerable since it is completed in the deeper Wonewoc and Mt. Simon aquifers and is protected by the St. Lawrence and Eau Claire formations, which contain fine-grained shales that help to protect these aquifers.

There is nothing that was discovered in the well vulnerability assessment that indicates that the wells themselves are a likely avenue for contamination to reach the aquifer. The wells appear to meet construction standards set forth in the State Well Code. Well vulnerability in Richfield is mostly indicative of overall aquifer vulnerability.

B. Drinking Water Supply Management Area Vulnerability Assessment - The vulnerability of groundwater underlying the land parcels located within the groundwater contribution area for Richfield was evaluated primarily on the basis of the geologic sensitivity, as determined from the Hennepin County Geologic Atlas (Minnesota Geologic Survey, 1989) and well records in County Well Index. The original analysis of aquifer vulnerability from the original Part 1 Wellhead Protection Plan was mostly retained. Appendix D contains the geologic cross-sections prepared for the original plan that indicated aquifer vulnerability. These cross-sections were based on data from well logs located in and around the original DWSMA. Since the revised management area is smaller in size, these cross-sections still provide adequate coverage across the new groundwater contribution area. In areas where the cross-sections differed from the

County Atlas, the vulnerability of the aquifer were adjusted accordingly.

For the purposes of this study, only the vulnerability of the Prairie du Chien and Jordan aquifers was considered for the groundwater contribution area. The capture zone for these aquifers encompasses the capture zones for the lower-vulnerability Wonewoc and Mt. Simon aquifer. Therefore, the vulnerability of the Prairie du Chien and Jordan aquifers take precedence.

The groundwater vulnerability levels range from "high" to "low," as shown in Figure 4. In the high vulnerability areas, there is very little geologic protection (e.g. layers of clay or shale) between the land surface and the aquifer. Infiltration of contaminants to these areas could occur in a relatively short span of time (days to years). In areas where geologic protection existed, but didn't exceed 10 feet of continuous thickness, a moderate vulnerability designation was applied. Where continuous geologic protection of 10 or more feet was found, a low vulnerability designation was applied.

Figure 4 also shows a number of wells within and around the groundwater contribution area, with "L-Scores" assigned to each well. For each number of the assigned L-Score, there are at least 10 feet of confining material. This data is used to support the vulnerability designations shown in Figure 4. In some instances, however, the L-Score is not a definitive determination of vulnerability. In some of the moderate vulnerability areas, the L-Score may register as "0" even though confining bedrock materials (e.g. basal St. Peter, Glenwood formation) are present, or confining clays are present but not at a continuous thickness of 10 feet or more. Likewise, some wells in highly vulnerable areas may show the presence of confining units. But without other nearby wells to help define the extent of those confining units, a lower vulnerability area often cannot be drawn with great confidence.

Figure 7 shows the vulnerability of the surface water contribution area. Since flow of surface waters in these areas can be rapid (especially in man-made stormwater sewers), any contaminants in stormwater can also rapidly reach the ponds and lakes within the highly-vulnerable portions of the groundwater contribution area, where they can be infiltrated. Therefore, the entire surface water contribution area is considered to be highly vulnerable.

The implications of the assigned vulnerability level will be addressed in greater detail in the amended Part 2 Wellhead Protection Plan. In general, the higher vulnerability rankings will necessitate a more thorough inventory of potential contamination sources within the affected parcels. Areas with lower vulnerability will focus more on management of wells that penetrate the protective geologic layers.

C. Recommendations – Assessing vulnerability requires periodic sampling for age dating compounds and potential contaminants to ensure that the water meets established standards and that the designated vulnerability levels are appropriate. The following steps could help in establishing more accurate vulnerability designations for future plan updates:

a. Request that the MDH re-sample wells for tritium before the fifth year of plan implementation. Only Wells 1 and 2 have been sampled for tritium, in 2009 and 1991, respectively. Consider collecting new samples from Wells that have not previously been sampled (Wells 3, 4, 5, 6, and 7). While Well 7 is assumed to be non-vulnerable due to the depth of the aquifers it pulls from, it may still be vulnerable if there are well-construction problems or defects in the casing joints. These issues could allow young water from upper aquifers to enter this well. A tritium sample from Well 7 could help to confirm whether this well is truly non-vulnerable.

b. Request that the MDH collect samples of well water and surface water to analyze for stable isotopes in order to evaluate the potential mixture of groundwater and surface water. This information will help determine of surface waters are hydraulically connected to the aquifer(s) and thus are a potential risk to the City's wells. This sampling should be conducted by the fifth year of the plan implementation, so the data is available for the next plan amendment.

REFERENCES

Bolton and Menk, *Part 1 Wellhead Protection Plan, City of Richfield, Minnesota,* BMI Project No. M23.36246, December 2005.

Metropolitan Council, *Twin Cities Metropolitan Area Regional Groundwater Flow Model Version 3.00*, *May 2014*.

Minnesota Department of Health, *Assessing Well and Aquifer Vulnerability for Wellhead Protection*, February 1997.

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Minnesota Geological Survey, *Geologic Atlas of Hennepin County, Minnesota*, County Atlas Series C-4, N.H. Balaban, Editor, University of Minnesota, St. Paul. 1989.

Minnesota Geological Survey, *Bedrock Geology and Structure of the Seven-County Twin Cities Metropolitan Area, Minnesota*, 2000.

TABLES

Table 1 - Richfield Water Supply Well Information

Well Name	Unique Number	UTM E Corrected Coordinate	UTM N Corrected Coordinate	Aquifer	Casing Diameter (in)	Casing Depth (feet)	Well Depth (feet)	Year Constructed	Well Vulnerability*
Well 1	206353	478069	4970739	Jordan	24x16	343	437	1961	Vulnerable
Well 2	206354	478068	4970589	Jordan	24x16	343	435	1961	Vulnerable
Well 3	206361	478937	4970731	Prairie du Chien-Jordan	24x16	226	425	1962	Vulnerable
Well 4	206276	478967	4970420	Prairie du Chien-Jordan	24x16	208	405	1962	Vulnerable
Well 5	206280	479110	4970164	Prairie du Chien-Jordan	24x16	226	408	1963	Vulnerable
Well 6	206279	479502	4970074	Prairie du Chien-Jordan	24x16	225	422	1963	Vulnerable
Well 7	133362	478872	4970760	Wonewoc-Mt. Simon	24x20x16	631	1066	1977	Non-Vulnerable

* vulnerability status based on review of well construction, geologic materials encountered during drilling, well use, and water quality.

Table 2: Modeled Richfield Well Pumping Rates

Well Name	Unique Number	Recorded Pumping Volumes (MG/Y)					Predicted 2021 Pumping (MG/Y)	Modeled Pumping Rate (MG/Y)	Modeled Pumping Rate (m^3/day)
		2012	2013	2014	2015	2016			
Well 1	206353	237.9	207.6	203.6	211.6	185.9	225.0	237.9	2468.9
Well 2	206354	205.9	194.5	173.5	161.6	199.2	180.0	205.9	2136.8
Well 3	206361	180.6	145.6	188.0	180.9	166.2	180.0	188.0	1951.0
Well 4	206276	37.9	58.5	53.1	87.7	49.5	75.0	87.7	910.1
Well 5	206280	181.9	182.3	184.0	167.5	155.9	180.0	184.0	1909.5
Well 6	206279	237.7	217.3	199.5	172.8	188.7	225.0	237.7	2466.8
Well 7	133362	88.0	88.7	69.9	64.6	73.2	75.0	88.7	920.5
Total		1169.9	1094.5	1071.6	1046.7	1018.6	1140.0	1229.9	12763.7

Table 3 - Permitted High Capacity Wells Within Two Miles of Richfield's Municipal Wells

Unique Number	Well Name	DNR Permit Number	Aquifer	Well Use	UTM E Coord	UTM N Coord	Reported Pumping Volumes (MG/Y)*					Average Withdrawal 2011-2015 (MG/Y)	Modeled Withdrawal (m^3/day)
							2011	2012	2013	2014	2015		
208325	US Dept. of Veterans Affairs	1986-6150	OPDC	Cemetery	482437	4968883	0.0	0.8	24.1	27.8	17.4	14.0	145.5
208326	US Dept. of Veterans Affairs	1986-6150	OPDC	Cemetery	482417	4968836	25.7	34.1	24.1	28.8	23.5	27.2	282.7
251279	Woodlawn Terrace	1985-6054	OPDC	Private Waterworks	477282	4968370	1.5	1.7	1.7	1.7	1.7	1.7	17.2
505073	Micron Molding Inc.	2002-6085	OPDC	Processing	477858	4967328	3.8	3.0	2.3	2.6	2.9	2.9	30.3
672551	Aggregate Industries	2003-3011	OPDC	Processing	477508	4971098	3.4	3.6	3.4	3.7	4.5	3.7	38.6

*Obtained from DNR MPARS Database

Table 4 – Aquifer Parameters, City of Richfield

Parameter	Value	Data Source
Aquifer Name	Prairie du Chien	Richfield Well Logs, County Well Index
Aquifer Material	Dolomite	Hennepin County Geologic Atlas
Primary Porosity	0.056	Standard MDH porosity for WHP delineations
Aquifer Thickness	122-132 feet	Richfield Well Logs, County Well Index
Stratigraphic Top Elevation	622-641 feet	Richfield Well Logs, County Well Index
Stratigraphic Bottom Elevation	495-509 feet	Richfield Well Logs, County Well Index
Hydraulic Confinement	Confined	Hennepin County Geologic Atlas
Transmissivity (T)	9,260 ft^2/day	Edina Well 3 Aquifer Test
Hydraulic Conductivity	67.0 ft/day	Edina Well 3 Aquifer Test
Groundwater Flow Field	Southeast Flow Direction	Hennepin County Geologic Atlas

Parameter	Value	Data Source
Aquifer Name	Jordan	Richfield Well Logs, County Well Index
Aquifer Material	Sandstone	Hennepin County Geologic Atlas
Primary Porosity	0.20	Standard MDH porosity for WHP delineations
Aquifer Thickness	73-104 feet	Richfield Well Logs, County Well Index
Stratigraphic Top Elevation	495-509 feet	Richfield Well Logs, County Well Index
Stratigraphic Bottom Elevation	400-425 feet	Richfield Well Logs, County Well Index
Hydraulic Confinement	Confined	Hennepin County Geologic Atlas
Transmissivity (T)	5,440 ft^2/day	Edina Well 3 Aquifer Test
Hydraulic Conductivity	54.0 ft/day	Edina Well 3 Aquifer Test
Groundwater Flow Field	Southeast Flow Direction	Hennepin County Geologic Atlas

Table 4 (continued) – Hydrogeologic Parameters, City of Richfield

Parameter	Value	Data Source
Aquifer Name	Wonewoc	Richfield Well Logs, County Well Index
Aquifer Material	Sandstone	Hennepin County Geologic Atlas
Primary Porosity	0.20	Standard MDH porosity for WHP delineations
Aquifer Thickness	70 feet	Richfield Well Logs, County Well Index
Stratigraphic Top Elevation	205 feet	Richfield Well Logs, County Well Index
Stratigraphic Bottom Elevation	135 feet	Richfield Well Logs, County Well Index
Hydraulic Confinement	Confined	Hennepin County Geologic Atlas
Transmissivity (T)	115 ft^2/day	Metro Model 3
Hydraulic Conductivity	1.6 ft/day	Metro Model 3
Groundwater Flow Field	Southeast Flow Direction	Hennepin County Geologic Atlas

Parameter	Value	Data Source
Aquifer Name	Mt. Simon	Richfield Well Logs, County Well Index
Aquifer Material	Sandstone	Hennepin County Geologic Atlas
Primary Porosity	0.20	Standard MDH porosity for WHP delineations
Aquifer Thickness	270 feet	Richfield Well Logs, County Well Index
Stratigraphic Top Elevation	50 feet	Richfield Well Logs, County Well Index
Stratigraphic Bottom Elevation	-220 feet	Richfield Well Logs, County Well Index
Hydraulic Confinement	Confined	Hennepin County Geologic Atlas
Transmissivity (T)	2,190 ft^2/day	Edina Well 10 Pumping Test
Hydraulic Conductivity	8.1 ft/day	Edina Well 10 Pumping Test, Richfield Well Log
Groundwater Flow Field	Northwest Flow Direction	Hennepin County Geologic Atlas

Table 5 - Calculation of Fixed Radius For Prairie Du Chien Fracture Flow Assessment

		1-Year Calculated Fixed radius	5-Year Calculated Fixed radius
Well Nos. 1 and 2 (Centroid 478069, 4970664)	Pumping Rate (Q) from mass balance:	1,027.0 m^3/day	1,027.0 m^3/day
	Water Producing Zone Thickness (L):	38.7 m	38.7 m
	Effective Porosity (n):	0.056	0.056
	Original (Calculated) Radius:	234.6 m	524.0 m
	Original (Calculated) Area for Wells 1 and 2:	172,967.4 m^2	862,467.7 m^2
	New Area for Wells 1 and 2:	172,967.4 m^2	949,176.3 m^2
	New Radius:	234.6 m	549.7 m
Well Nos. 3, 4, 5, 6 (Centroid 479129, 4970347)	Pumping Rate (Q) from pumping total:	7,237.4 m^3/day	7,237.0 m^3/day
	Water Producing Zone Thickness (L):	33.8 m	33.8 m
	Effective Porosity (n):	0.056	0.056
	Original (Calculated) Radius:	666.5 m	1,488.3 m
	Original (Calculated) Area for Wells 3, 4, 5, 6:	1,395,631.3 m^2	6,958,653.8 m^2
	New Area for Wells 3, 4, 5, 6:	1,395,631.3 m^2	7,658,245.3 m^2
	New Radius:	666.5 m	1,561.3 m
	Total Overlap Area:	0.0 m^2	786,300.0 m^2
	Apportioned Overlap Area to Well#4 (206932):	0.0 m^2	86,708.6 m^2
	Apportioned Overlap Area to Well#5 (497387):	0.0 m^2	699,591.4 m^2
	Angle of Flow Direction:	300 +/- 10 degrees	300 +/- 10 degrees

FIGURES

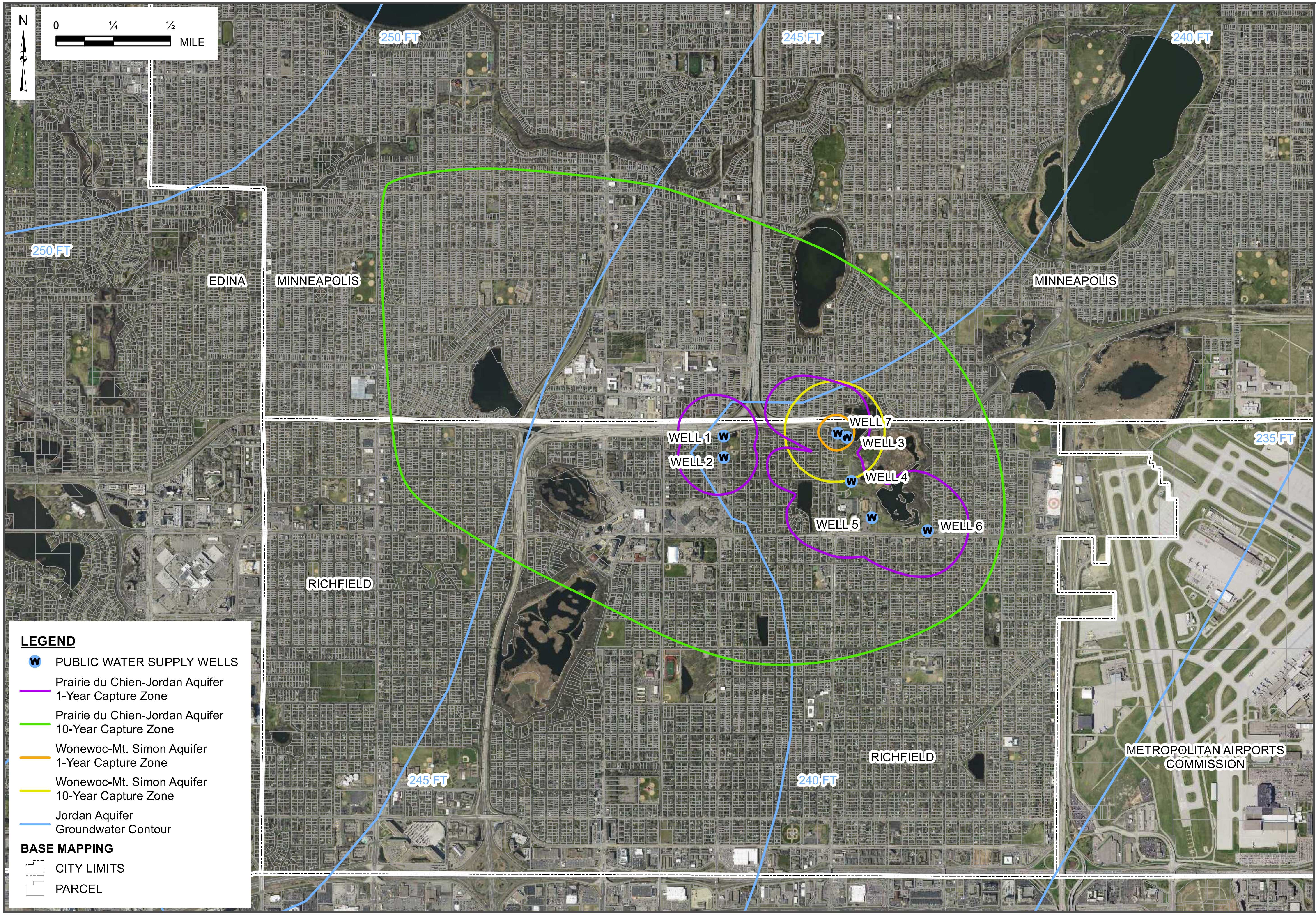

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FIGURE 1 - POROUS FLOW MODELING WELL CAPTURE ZONES

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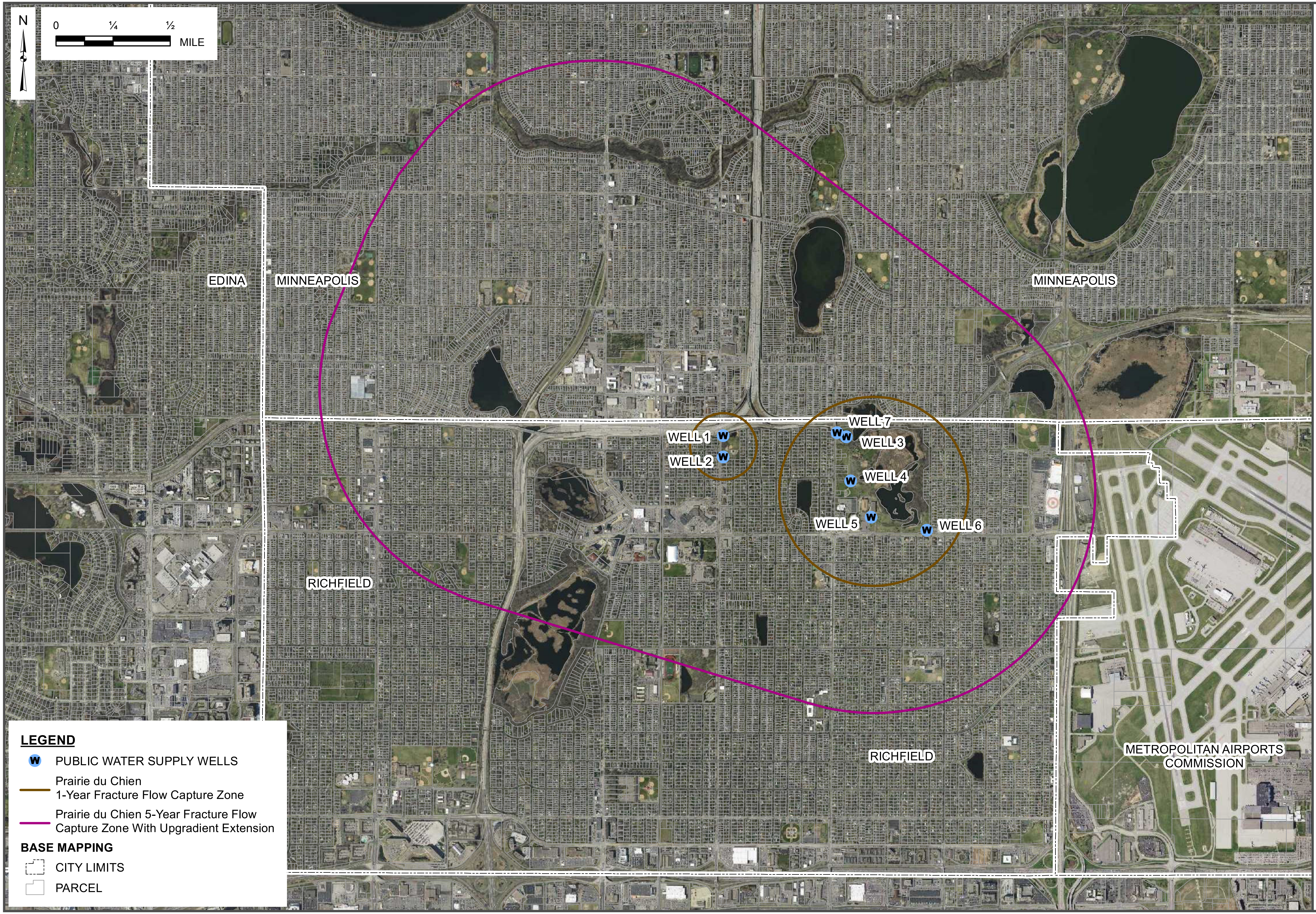

FIGURE 2 - FRACTURE FLOW CALCULATED WELL CAPTURE ZONES

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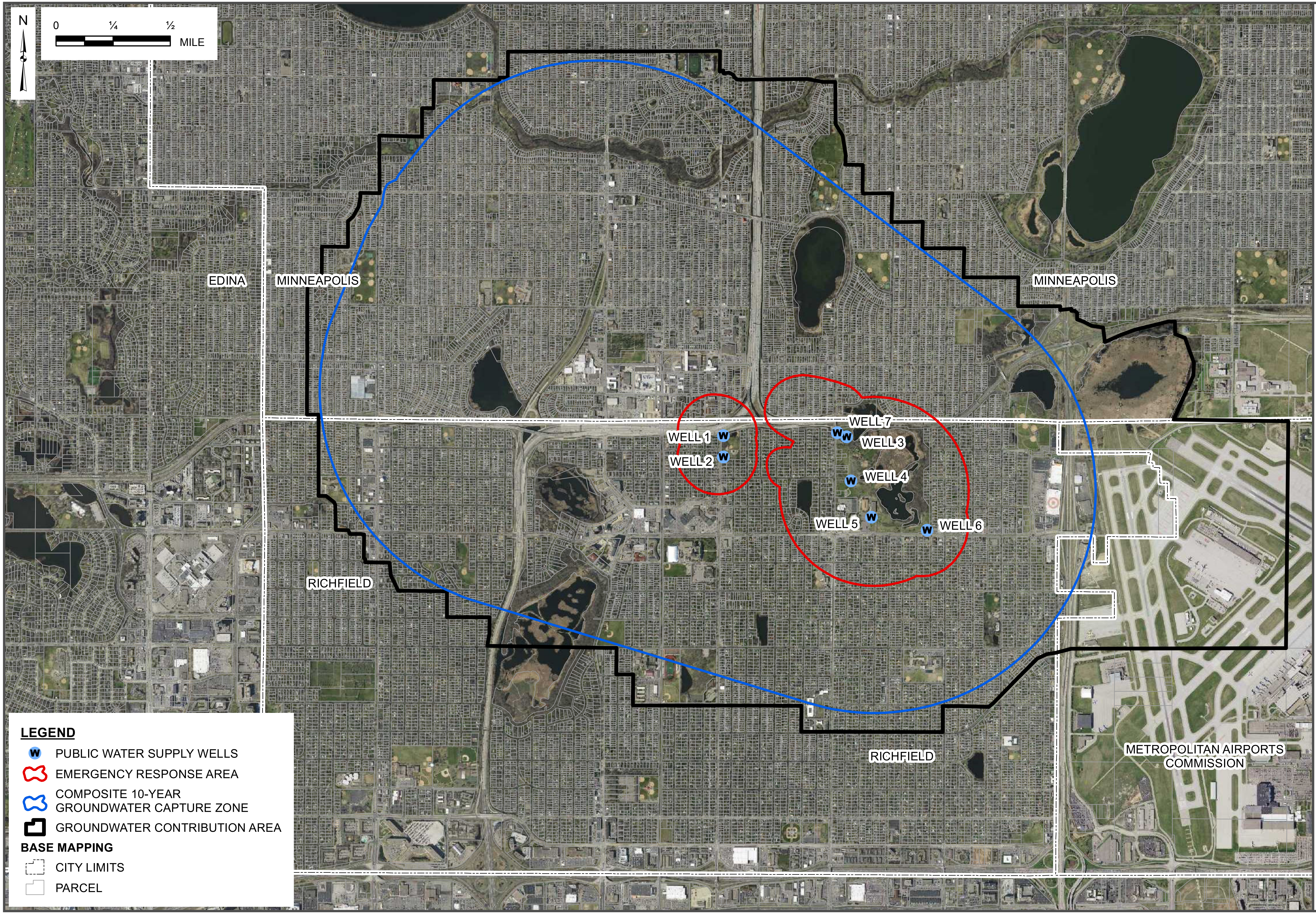

FIGURE 3 - GROUNDWATER CONTRIBUTION AREA DELINEATION

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N

0 ¼ ½ MILE

505671 - 4
236161 - 0
242103 - 1
137353 - 1
505672 - 6
200603 - 0
226216 - 0
505673 - 0
223904 - 1
200582 - 5
200581 - 0
122226 - 0
223902 - 1
180930 - 0
200571 - 0
551810 - 1
200576 - 1
200578 - 2
191309 - 2
200573 - 0
190081 - 0
EDINA
MINNEAPOLIS
MINNEAPOLIS
200579 - 1
200583 - 0
125924 - 2
223906 - 9
200584 - 3
509058 - 0
257414 - 1
223950 - 0
672551 - 0
200585 - 0
655955 - 1
WELL 7
206291 - 19
206275 - 1
206353 - 1
206361 - 3
WELL 1
133362 - 10
WELL 3
206354 - 0
206336 - 2
WELL 2
206405 - 11
206345 - 1
206321 - 1
206276 - 0
WELL 4
206310 - 8
206342 - 1
206318 - 2
206358 - 4
206278 - 0
233257 - 0
206374 - 2
206373 - 0
206347 - 3
244677 - 0
206332 - 1
206348 - 0
206324 - 2
WELL 5
206279 - 0
WELL 6
206286 - 2
272021 - 0
248536 - 0
272502 - 1
206326 - 5
206328 - 5
206331 - 3
206281 - 6
433288 - 0
218196 - 0
218197 - 0
218199 - 0
206330 - 0
206327 - 0
609005 - 1
206375 - 5
RICHFIELD
206377 - 5
165600 - 10
165599 - 0
206192 - 6
206234 - 0
206230 - 13
206235 - 0
206199 - 4
206254 - 0
206194 - 2
206236 - 4
223281 - 16
223251 - 13
METROPOLITAN AIRPORTS COMMISSION
206206 - 0
206188 - 0
251279 - 0
RICHFIELD
206269 - 5
206227 - 1
206267 - 15
206189 - 3
223218 - 3
223258 - 5
206273 - 23
223260 - 6
206264 - 6
206272 - 8
272567 - 4
206262 - 6
222919 - 0
206271 - 1
206222 - 8
276826 - 8
204969 - 18
248815 - 19
205572 - 0
247949 - 0
205576 - 13

LEGEND

- PUBLIC WATER SUPPLY WELLS
- WELL WITH L-SCORE
- EMERGENCY RESPONSE AREA
- COMPOSITE 10-YEAR GROUNDWATER CAPTURE ZONE
- GROUNDWATER CONTRIBUTION AREA

GROUNDWATER VULNERABILITY

- LOW
- MODERATE
- HIGH

BASE MAPPING

- CITY LIMITS
- PARCEL

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FIGURE 4 - GROUNDWATER CONTRIBUTION AREA VULNERABILITY

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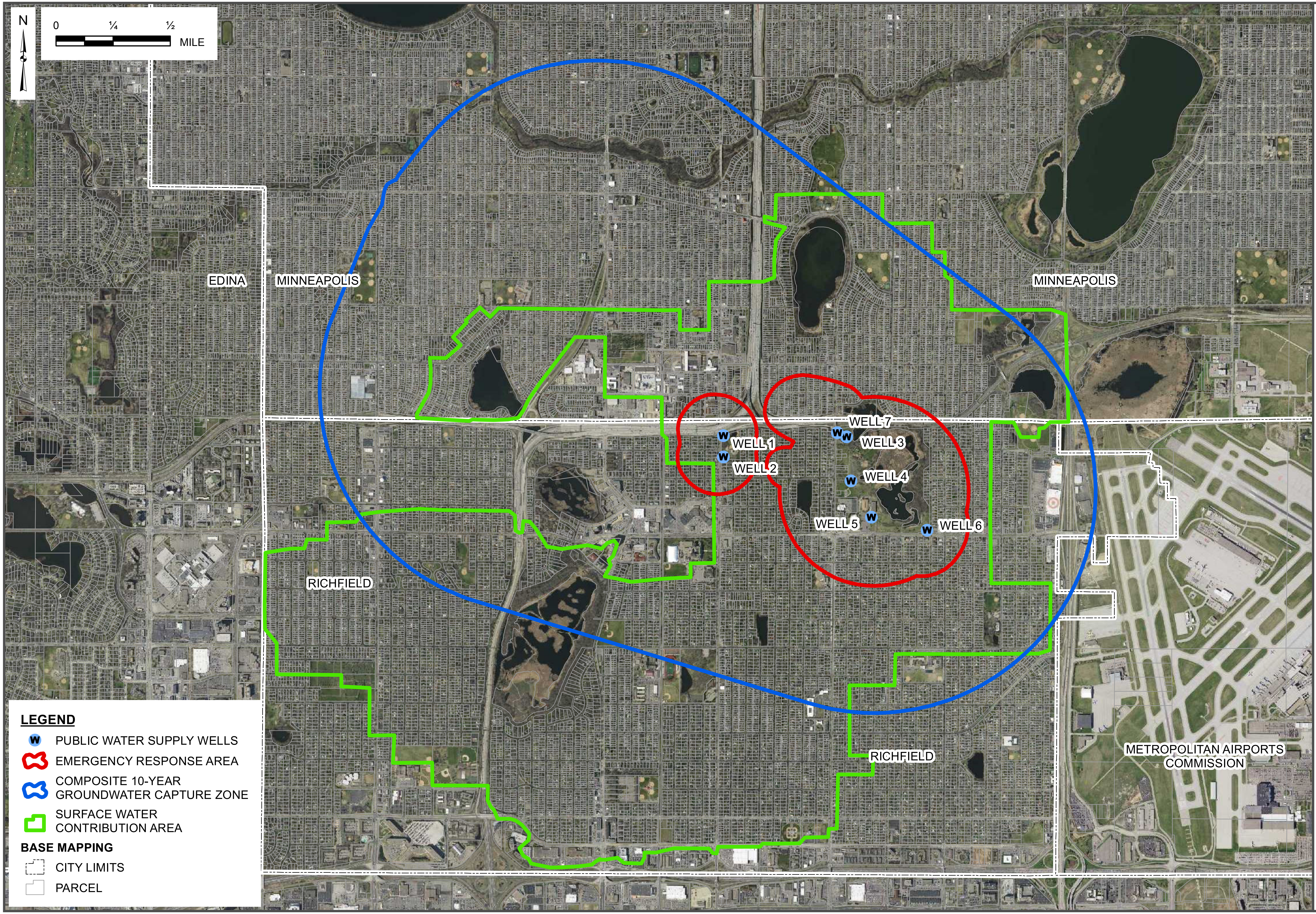

FIGURE 5 - SURFACE WATER CONTRIBUTION AREA

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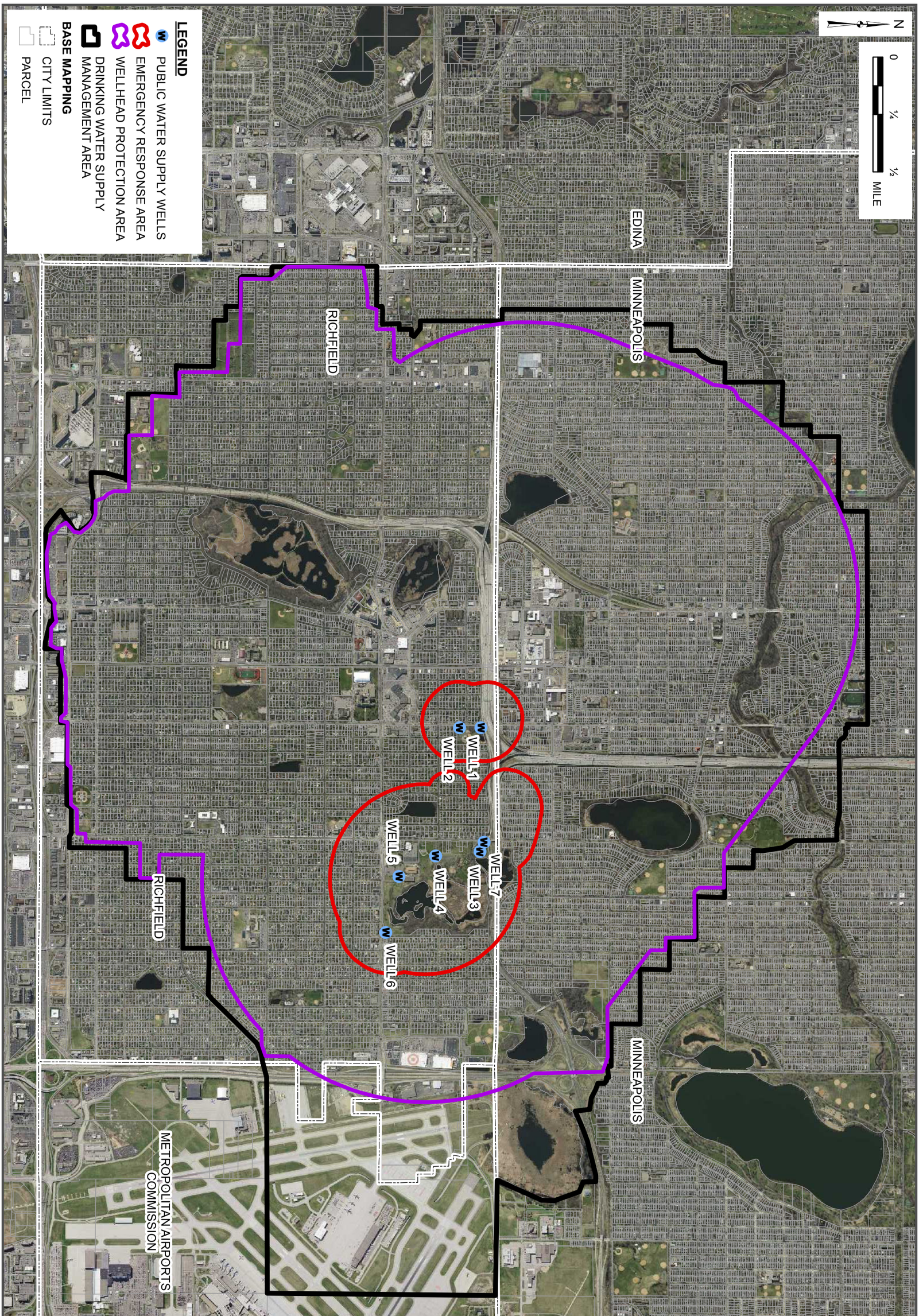

FIGURE 6 - WHPA AND DWSMA DELINEATION

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V:\1938\active\193803363\GIS\Projects\Part 1 Figure 6 - WHPA and DWSMA.mxd

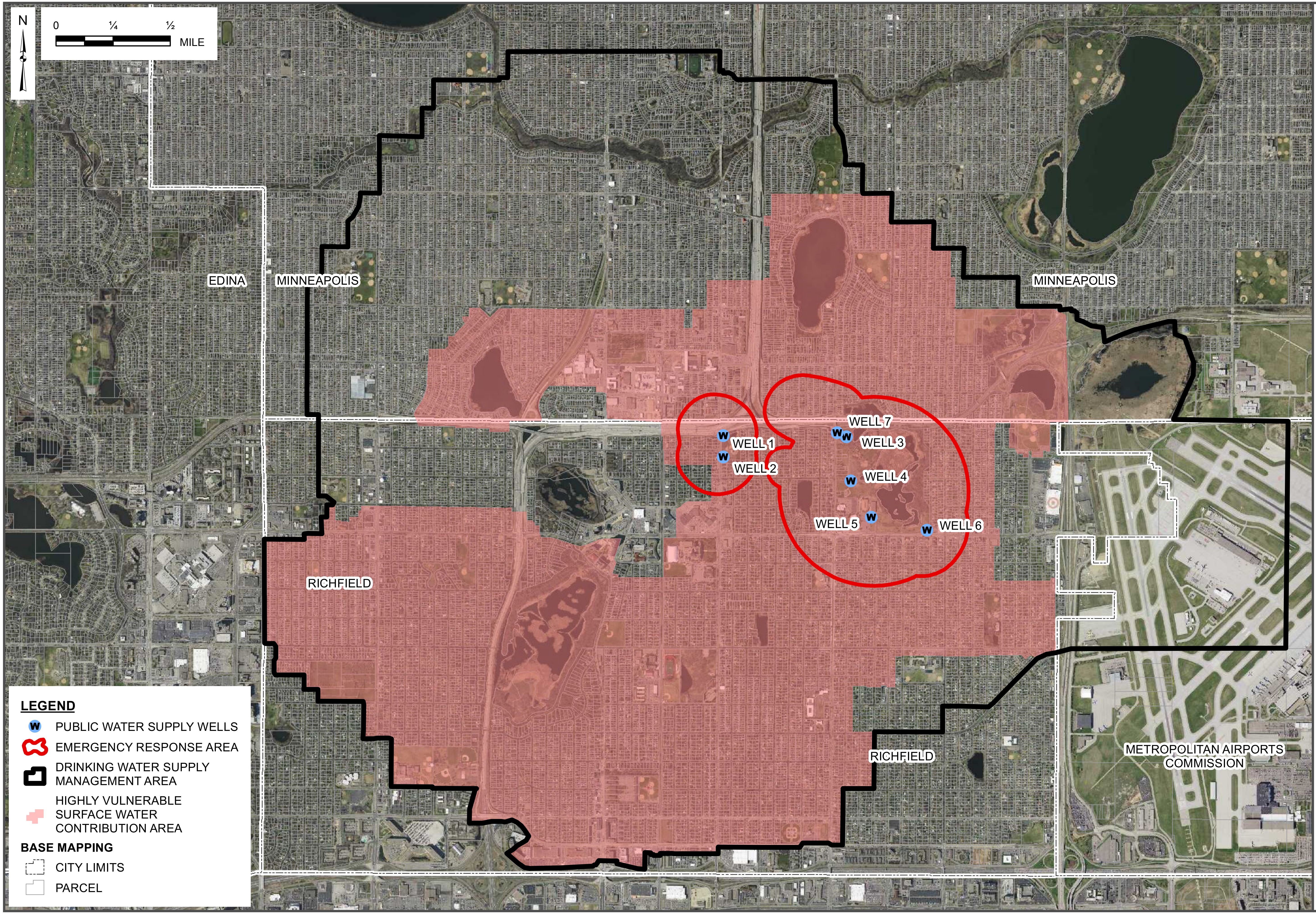

FIGURE 7 - SURFACE WATER CONTRIBUTION AREA VULNERABILITY

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APPENDIX A

CITY OF RICHFIELD WELL LOGS

Unique No. 00206353
County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2016/08/26
Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	27	ABBCBB

Well Depth		Depth Completed		Date Well Completed
437	ft.	437	ft.	1961/06/27

Well Name RICHFIELD 1

Drilling Method Cable Tool

Well Owner's Name RICHFIELD 1

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

in. t 435 ft

Casing Diameter **Weight(lbs/ft)**

24 in. t 156 ft

16 in. t 343 ft

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
TOP SOIL			0	1
CLAY, SAND, GRAVEL			1	78
HARDPAN			78	93
SAND ROCK, GRAVEL, ROC			93	123
SANDROCK, GRAVEL			123	135
SANDROCK & GRAVEL			135	153
SANDROCK, SHALE, GRAV			153	199
SHAKOPEE LIMEROCK			199	208
SHAKOPEE LIMEROCK			208	330
JORDAN SANDROCK			330	418
JORDAN SANDROCK, SHAL			418	433
SHALE			433	435

Screen N

Open Hole From 343 ft. to 435 ft.

Make Type

Static Water Level 43 ft. from Land surface Date 1961/06/27

PUMPING LEVEL (below land surface)

89 ft. after hrs. pumping 1506 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☑ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)	
G	0	31	Y	

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☑ Not Installed Date Installed N

Mfr nam

Model HP 0 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

M.G.S. NO. 246. COPIED FROM U.S.G.S.

63RD AND NICOLLET - NICOLLET PARK.

USGS Quad Minneapolis South Elevation 833

Aquifer: CJDN Alt Id: 62-0691

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012

License Business Name

Name of Driller JOHNSON, R.

Report Copy

Unique No. 00206354

County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 1031

Update Date 2014/03/10

Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	27	ABCBCA

Well Depth		Depth Completed		Date Well Completed
435	ft.	435	ft.	1961/09/07

Well Name RICHFIELD 2

Drilling Method Cable Tool

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Well Owner's Name RICHFIELD 2

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
TOP SOIL			0	1
SAND			1	36
SAND, GRAVEL, CLAY			36	58
CLAY	BROW		58	67
HARDPAN			67	77
CAVING SANDROCK			77	156
SANDROCK, SHALE			156	197
SHAKOPEE LIMEROCK			197	329
JORDAN SANDROCK			329	408
JORDAN SANDROCK, SHAL			408	433
SHALE			433	435

Casing Diameter **Weight(lbs/ft)**

24 in. t 158 ft

16 in. t 343 ft

Screen N

Open Hole From 343 ft. to 435 ft.

Make Type

Static Water Level 43 ft. from Land surface Date 1961/09/07

PUMPING LEVEL (below land surface)

65 ft. after hrs. pumping 533 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☑ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☐ Yes ☐ No

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed

Mfr nam

Model HP 0 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

M.G.S. NO. 247. SOUTH WELL IN NICOLLET PARK.

BLASTED & BAILED & AIR DEVELOPED.

USGS Quad Minneapolis South Elevation 838

Aquifer: CJDN Alt Id: 62-0691

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012

License Business Name

Name of Driller

Report Copy

HE-01205-06 (Rev. 9/96)

Unique No. 00206361

County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2016/01/05

Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	26	BBBCAA

Well Depth 425 ft. **Depth Completed** 425 ft. **Date Well Completed** 1962/09/00

Well Name RICHFIELD 3

Drilling Method Cable Tool

Well Owner's Name RICHFIELD 3

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

in. t 425 ft

Casing Diameter **Weight(lbs/ft)**

24 in. t 211 ft

16 in. t 226 ft

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
PIPE ABOVE GROUND FILL			0	15
FILL			15	18
PEAT			18	22
SAND			22	85
SAND & GRAVEL			85	110
SANDY CLAY			110	175
HARDPAN			175	211
SANDROCK			211	213
SHAKOPEE LIMEROCK			213	340
JORDAN SANDROCK			340	425
ST. LAWRENCE			425	425

Screen N

Make Type

Open Hole From 226 ft. to 425 ft.

Static Water Level 56 ft. from Land surface Date 1962/09/00

PUMPING LEVEL (below land surface)

97 ft. after hrs. pumping 2500 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☐ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)	
G		402	S	

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☑ Not Installed Date Installed N

Mfr nam

Model HP 0 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

LOCATED AT 62ND AND PORTLAND, LEGION PARK.

WELL WAS BLASTED AND 100.5 YDS OF SANDROCK REMOVED AND THEN WAS AIR DEVELOPED.

USGS Quad Minneapolis South Elevation 835

Aquifer: OPCJ Alt Id: 62-0691

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012

License Business Name

Name of Driller

Report Copy

Unique No. 00206276
County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 1031

Update Date 2016/01/05
Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	26	BCBABC

Well Depth		Depth Completed		Date Well Completed
405	ft.	405	ft.	1962/09/30

Well Name RICHFIELD 4

Drilling Method Cable Tool

Well Owner's Name RICHFIELD 4

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
PEAT SOIL			0	3
FINE SAND & GRAVEL			3	118
SAND & CLAY-MIXED			118	192
SHAKOPEE ROCK			192	324
JORDAN SAND			324	405

Casing Diameter			Weight(lbs/ft)
16	in. t	208 ft	
24	in. t	193 ft	

Screen N

Make Type

Open Hole From 193 ft. to 405 ft.

Static Water Level 33 ft. from Land surface Date 1962/09/30

PUMPING LEVEL (below land surface)

130 ft. after 115 hrs. pumping 2400 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☐ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)	
G	0	193	16	Y

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☑ Not Installed Date Installed N

Mfr nam

Model HP 0 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

M.G.S. NO. 229. IN LEGION PARK.

CREVICE AT 252-254 FT. & 268-269 FT.

200' E. OF INTERSECTION OF 64TH AND PORTLAND.

USGS Quad Minneapolis South Elevation 826

Aquifer: OPCJ Alt Id: 62-0691

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 27010

License Business Name

Name of Driller HOLLEN, G.

Report Copy

Unique No. 00206280
County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2016/03/29
Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	26	BCDBDC

Well Depth 408 ft. **Depth Completed** 408 ft. **Date Well Completed** 1963/03/01

Well Name RICHFIELD 5

Drilling Method Cable Tool

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Well Owner's Name RICHFIELD 5

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
GLACIAL DRIFT			0	204
SHAKOPEE-ONEOTA DOLO			204	327
JORDAN SANDSTONE			327	398
SHALEY SANDSTONE			398	408

Casing Diameter **Weight(lbs/ft)**

24 in. t 210 ft

16 in. t 226 ft

Screen N

Open Hole From 225 ft. to 408 ft.

Make Type

Static Water Level 36 ft. from Land surface Date 1963/03/01

PUMPING LEVEL (below land surface)

132 ft. after 12 hrs. pumping 2500 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☐ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)
G			

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☑ Not Installed Date Installed N

Mfr nam

Model HP 0 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

LINEAR PIPE GROUTED.

WELL DEVELOPED BY SHOOTING & BAILING; 112 YDS. SANDSTONE REMOVED.

M.G.S NO. 248. IN LEGION PARK.

300' N. OF 66TH IN FRONT OF ICE ARENA.

USGS Quad Minneapolis South Elevation 828

Aquifer: OPCJ Alt Id: 62-0691

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 27118

License Business Name

Name of Driller BERTHIAUME, M

Report Copy

Unique No. 00206279
County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2016/01/05
Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	26	BDDCDB

Well Depth 422 ft. **Depth Completed** 422 ft. **Date Well Completed** 1963/03/29

Well Name RICHFIELD 6

Drilling Method Cable Tool

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Well Owner's Name RICHFIELD 6

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
GLACIAL DRIFT			0	125
SILTY SAND	VARIE		125	198
REMNANT ST PETER SAND			198	202
SHAKOPEE-ONEOTA DOLO			202	208
SHAKOPEE-ONEOTA DOLO			208	331
JORDAN SANDSTONE			331	337
JORDAN SANDSTONE			337	410
SHALEY SANDSTONE			410	422

Casing Diameter **Weight(lbs/ft)**

24 in. t 208 ft

16 in. t 225 ft

Screen N **Open Hole** From 225 ft. to 422 ft.

Make Type

Static Water Level 51 ft. from Land surface Date 1963/03/29

PUMPING LEVEL (below land surface)

184 ft. after 18 hrs. pumping 2400 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☐ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)
G			

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☑ Not Installed Date Installed N

Mfr nam

Model HP 0 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

16 IN. LINER PIPE GROUTED IN CEMENT GROUT.

M.G.S. NO.249 IN LEGION PARK

WELL FORM SAID KEYS DRILLED THE WELL BUT THEY DID NOT.

WELL DEVELOPED BY SHOOTING & BAILING; 110 YDS. SANDSTONE REMOVED.

USGS Quad Minneapolis South Elevation 835

Aquifer: OPCJ Alt Id: 62-0691

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 27118

License Business Name

Name of Driller BERTHIAUME, M

Report Copy

Unique No. 00133362
County Name Hennepin

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 1031

Update Date 2016/01/05
Entry Date 1991/08/24

Township Name	Township	Range	Dir	Section	Subsection
	28	24	W	26	BBBBCC

Well Depth 1066 ft. **Depth Completed** 1066 ft. **Date Well Completed** 1977/06/28

Well Name RICHFIELD 7

Drilling Method Cable Tool

Well Owner's Name RICHFIELD 7

RICHFIELD MN 55423

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No
From ft. to ft.

Contact's Name CITY OF RICHFIELD

RICHFIELD MN 55423

Use community supply(municipal)

Casing **Drive Shoe?** ☑ Yes ☐ N

Hole Diameter

Casing Diameter			Weight(lbs/ft)
24	in. t	181 ft	171.29
20	in. t	222 ft	123.11
16	in. t	631 ft	82.77

Screen N

Open Hole From 631 ft. to 1066 ft.

Make Type

Static Water Level 173 ft. from Land surface Date 1988/06/01

PUMPING LEVEL (below land surface)
290 ft. after hrs. pumping 1900 g.p.m.

Well Head Completion
Pitless adapter mfr Model
Casing Protection ☑ 12 in. above grade
☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)
G	0	631	

Nearest Known Source of Contamination
ft. direction type
Well disinfected upon completion? ☑ Yes ☐ No

Pump ☐ Not Installed Date Installed
Mfr nam
Model HP 0 Volts

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
SAND & FILL	BROW		0	15
MUCK & PEAT	BLACK		15	25
SANDY MUCK	GRAY		25	65
CLAY, SAND, STONE	GRAY		65	110
CLAY, GRAVEL	TAN		110	150
CLAY FINE	TAN		150	160
CLAY & STONE	TAN/G		160	170
CEMENTED GRAVEL	GRAY		170	185
HARDPAN	TAN		185	215
SHAKOPEE	TAN/G		215	221
SHAKOPEE	TAN		221	280
SHAKOPEE	GRAY		280	345
JORDAN	WHITE		345	395
JORDAN	PINK		395	400
JORDAN	WHITE		400	425
ST. LAWRENCE	GRAY		425	445
ST. LAWRENCE	BLU/G		445	455
SANDSTONE	GRAY		455	475
SANDSTONE	GRAY		475	480
SANDSTONE	GREE		480	535
SHALE	GREE		535	635
SANDSTONE & SHALE	GREE		635	670
SANDY SHALE	GRAY		670	680
SHALE			680	700
SHALE & GALESVILLE	GRAY		700	705
SHALE & GALESVILLE	GRAY		705	715
SHALE	GRAY		715	735
LAMINATED SHALE & SAND	BLU/B		735	770
SHALE & SANDSTONE	BROW		770	785
SANDROCK & SHALE	WHITE		785	790
SANDROCK & SHALE	WHITE		790	830
CEMENTED STONE	DARK		830	835

SANDSTONE	GRAY	835	840
SHALE & SANDSTONE	TAN	840	874
HINCKLEY SHALE		874	885
SHALE	RED	885	900
SANDSTONE	LIGHT	900	945
SHALE	GRAY	945	950
SANDSTONE	PINK	950	960
SANDSTONE & SHALE	TAN	960	970
HINCKLEY & SANDSTONE	PINK	970	975
RED CLASTICS SHALE SAN	PINK	975	1005
FINE SHALE	RED	1005	1060
SHALE	RED	1060	1066

REMARKS, ELEVATION, SOURCE OF DATA, etc.

M.G.S. NO.1145.

USGS Quad Minneapolis South Elevation 840

Aquifer: CWMS Alt Id: 62-0691

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 27015

License Business Name

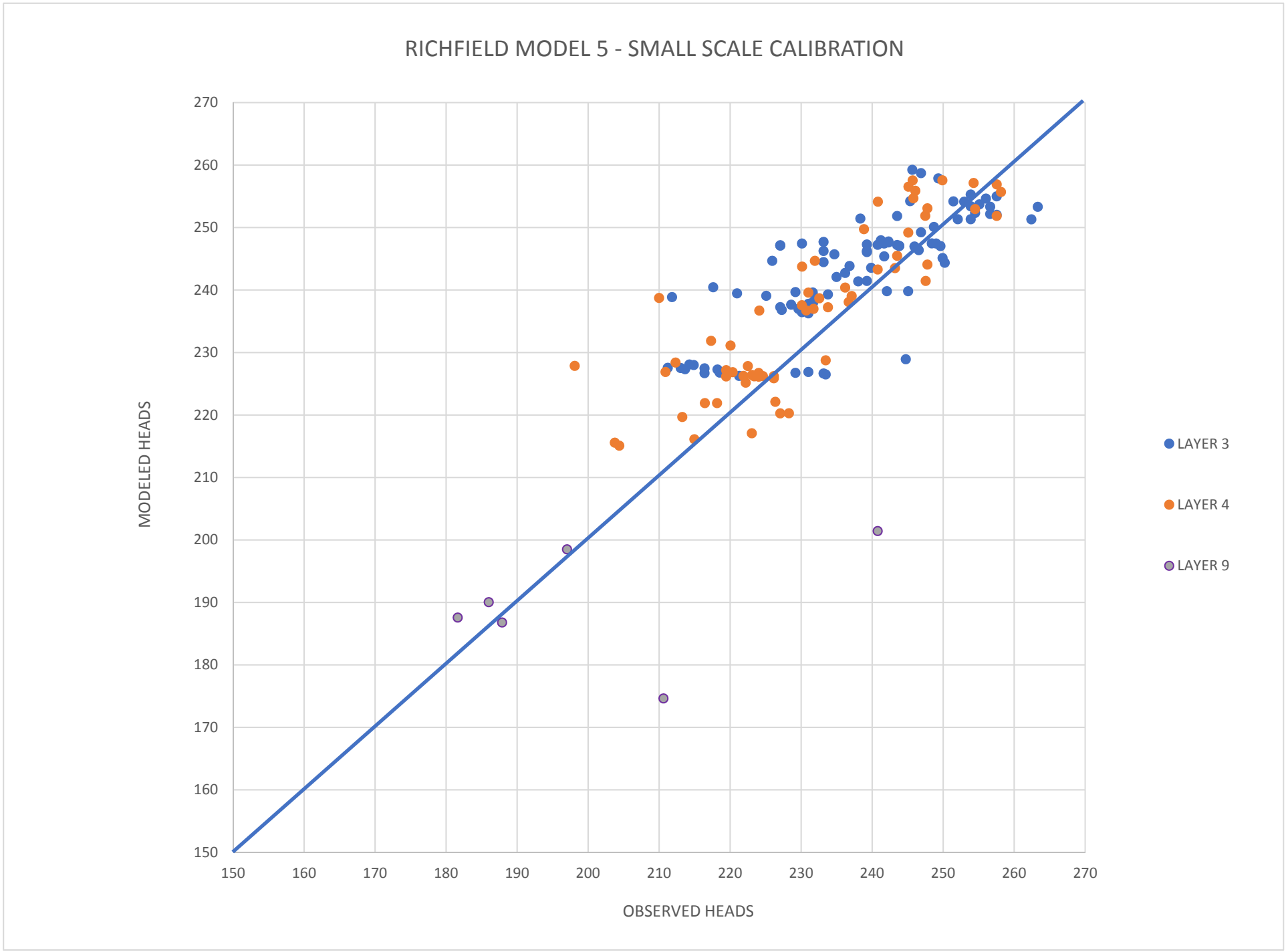
Name of Driller SIGAFOOS, G.

Report Copy

HE-01205-06 (Rev. 9/96)

APPENDIX B

MODEL CALIBRATION RESULTS


RICHFIELD MODEL 5 - SMALL SCALE CALIBRATION
MODELED HEADS
OBSERVED HEADS
150
160
170
180
190
200
210
220
230
240
250
260
270
LAYER 3
LAYER 4
LAYER 9

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
bd_w21	481095.4	4962812	316	306	1	1	1	212.974	210.042	2.933
bd_w17a	480969.9	4962835	316	305	1	1	1	212.008	210.043	1.965
cwi_223002	478663	4962836	316	259	1	1	1	222.199	225.129	-2.929
bd_w19	481100.9	4962911	315	306	1	1	1	212.122	210.036	2.086
bd_w19a	481087.2	4962933	315	306	1	1	1	211.509	210.034	1.475
bd_w22	481170	4962947	315	307	1	1	1	212.802	210.034	2.768
cwi_205312	479466	4962964	315	284	1	1	1	221.285	219.355	1.930
obwell_122	482673	4962983	315	313	1	1	1	228.459	225.492	2.968
obwell_121	482659	4962985	315	313	1	1	1	229.629	225.200	4.429
cwi_223170	475713	4963047	315	216	1	1	1	239.878	236.589	3.288
cwi_205317	479504	4963087	315	286	1	1	1	218.846	221.571	-2.725
cwi_205335	477421	4963118	315	226	1	1	1	238.963	236.332	2.631
cwi_124335	483137	4963197	315	315	1	1	1	222.199	226.378	-4.178
cwi_222997	478062	4963222	315	239	1	1	1	241.706	236.123	5.583
cwi_223031	477215	4963285	315	224	1	1	1	239.878	238.400	1.477
obwell_598	482691	4963326	315	313	1	1	1	219.191	220.967	-1.776
obwell_600	482691	4963326	315	313	1	1	1	218.690	220.967	-2.277
obwell_566	482693	4963326	315	313	1	1	1	219.313	220.986	-1.673
cwi_205358	476309	4963327	315	218	1	1	1	234.696	237.572	-2.876
obwell_599	482671	4963347	315	313	1	1	1	218.717	220.538	-1.821
obwell_604	482671	4963347	315	313	1	1	1	219.166	220.538	-1.373
cwi_205333	477233	4963361	315	224	1	1	1	244.450	239.201	5.249
obwell_601	482696	4963376	314	313	1	1	1	219.160	220.404	-1.243
cwi_205322	480012	4963407	314	297	1	1	1	213.360	211.734	1.626
obwell_602	482739	4963409	314	313	1	1	1	219.403	220.296	-0.893
obwell_564	482822	4963447	314	313	1	1	1	218.220	220.523	-2.303
obwell_603	482819	4963448	314	313	1	1	1	217.401	220.481	-3.080
obwell_563	482824	4963449	314	313	1	1	1	218.330	220.515	-2.184
cwi_205337	478777	4963481	314	262	1	1	1	233.172	234.721	-1.549
cwi_205339	478601	4963489	314	257	1	1	1	231.648	236.297	-4.649
cwi_205334	477416	4963533	314	226	1	1	1	240.182	241.203	-1.021
cwi_205324	479833	4963604	314	294	1	1	1	217.018	215.158	1.860
cwi_223168	478811	4963718	314	263	1	1	1	242.621	237.230	5.390
cwi_223343	480010	4963726	314	297	1	1	1	216.408	213.911	2.497
cwi_205355	477042	4963810	314	223	1	1	1	239.268	243.179	-3.911
cwi_206970	469554	4963815	314	200	1	1	1	266.700	244.217	22.483
cwi_222985	479818	4963825	314	294	1	1	1	216.408	219.917	-3.509
cwi_222983	480044	4963869	314	297	1	1	1	213.360	216.689	-3.329
cwi_205357	476367	4963995	313	218	1	1	1	235.306	243.731	-8.425
cwi_205330	477959	4964080	313	236	1	1	1	244.754	244.738	0.017
cwi_205353	477164	4964095	313	224	1	1	1	243.230	244.694	-1.464
cwi_205327	478716	4964164	313	260	1	1	1	243.840	242.461	1.379
cwi_205328	477557	4964243	313	228	1	1	1	243.535	245.400	-1.865
cwi_222986	479534	4964300	313	287	1	1	1	240.792	234.440	6.352
cwi_222987	479514	4964323	313	286	1	1	1	242.316	235.054	7.262
cwi_222984	479571	4964332	313	288	1	1	1	239.268	234.195	5.073
cwi_223018	477447	4964377	312	227	1	1	1	236.525	245.360	-8.835
cwi_204962	471362	4964400	312	203	1	1	1	239.268	240.525	-1.257
cwi_223344	477444	4964422	312	227	1	1	1	237.744	245.369	-7.625
cwi_223030	475164	4964439	312	214	1	1	1	235.001	243.748	-8.747
cwi_205241	476530	4964575	312	219	1	1	1	244.145	244.922	-0.777
cwi_222991	477889	4964651	312	234	1	1	1	242.926	245.601	-2.676

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_205239	476173	4964670	312	218	1	1	1	240.182	244.858	-4.676
cwi_205240	476910	4965041	311	222	1	1	1	244.450	245.959	-1.509
cwi_205238	476245	4965102	311	218	1	1	1	249.936	245.710	4.226
cwi_205230	475543	4965157	311	215	1	1	1	243.230	245.397	-2.167
cwi_204959	471983	4965243	311	205	1	1	1	236.220	241.987	-5.767
cwi_205237	476191	4965276	311	218	1	1	1	242.316	245.907	-3.591
cwi_205236	475648	4965345	311	216	1	1	1	246.888	245.803	1.085
cwi_204958	471781	4965386	310	204	1	1	1	235.610	242.676	-7.066
cwi_223000	478427	4965745	310	251	1	1	1	243.840	246.522	-2.682
cwi_205228	474445	4965765	310	211	1	1	1	237.744	246.588	-8.844
cwi_206962	469417	4965785	310	200	1	1	1	248.412	248.192	0.220
cwi_205227	474483	4965793	310	211	1	1	1	240.792	246.662	-5.870
cwi_205243	478379	4965794	310	250	1	1	1	243.230	246.538	-3.308
cwi_204956	471838	4965796	310	204	1	1	1	253.898	244.143	9.755
cwi_205234	475641	4965836	310	216	1	1	1	250.850	246.576	4.274
cwi_205242	478490	4965907	309	253	1	1	1	243.230	246.474	-3.243
cwi_205225	474866	4965921	309	212	1	1	1	243.840	246.828	-2.988
cwi_205232	477180	4965932	309	224	1	1	1	244.450	246.708	-2.258
cwi_205224	474869	4965966	309	212	1	1	1	245.364	246.921	-1.557
cwi_206958	469522	4965972	309	200	1	1	1	243.840	248.376	-4.536
cwi_222998	478288	4965994	309	247	1	1	1	244.754	246.551	-1.797
cwi_206957	469425	4966038	309	200	1	1	1	248.412	248.847	-0.435
cwi_223020	477442	4966075	309	227	1	1	1	246.278	246.734	-0.456
cwi_223001	478728	4966389	308	261	1	1	1	240.792	246.265	-5.473
cwi_205218	474780	4966415	308	212	1	1	1	241.706	247.664	-5.957
cwi_204995	475910	4966469	308	217	1	1	1	244.754	246.933	-2.179
cwi_223213	472832	4966510	308	206	1	1	1	240.487	247.162	-6.675
cwi_248816	481961	4966639	308	310	1	1	1	238.658	215.154	23.505
cwi_248817	480387	4966643	308	301	1	1	1	244.145	240.599	3.546
cwi_223015	477732	4966646	308	231	1	1	1	241.402	246.792	-5.391
cwi_204974	480103	4966652	308	298	1	1	1	242.621	242.648	-0.027
cwi_204973	479151	4966654	308	274	1	1	1	239.268	245.659	-6.391
cwi_205209	474446	4966658	308	211	1	1	1	246.888	248.208	-1.320
cwi_205208	474429	4966713	308	211	1	1	1	242.316	248.304	-5.988
cwi_222999	478423	4966739	308	251	1	1	1	245.364	246.450	-1.086
cwi_205207	474422	4966747	308	211	1	1	1	242.316	248.361	-6.045
cwi_222995	477833	4966748	308	233	1	1	1	245.059	246.786	-1.727
obwell_594	485678	4966748	308	321	1	1	1	221.854	215.220	6.633
obwell_595	485678	4966748	308	321	1	1	1	221.760	215.220	6.539
obwell_596	485678	4966748	308	321	1	1	1	221.857	215.220	6.637
obwell_597	485678	4966748	308	321	1	1	1	221.501	215.220	6.280
cwi_205216	474536	4966749	308	211	1	1	1	245.364	248.278	-2.914
cwi_222990	477924	4966775	308	235	1	1	1	245.364	246.754	-1.390
cwi_223014	477689	4966776	308	231	1	1	1	246.888	246.848	0.040
cwi_205215	474537	4966778	308	211	1	1	1	246.888	248.321	-1.433
cwi_205206	474425	4966780	308	211	1	1	1	246.278	248.409	-2.130
cwi_205214	474735	4966784	308	212	1	1	1	248.412	248.175	0.237
cwi_223013	477734	4966787	308	231	1	1	1	244.145	246.836	-2.691
obwell_576	485587	4966805	308	321	1	1	1	220.436	214.503	5.933
obwell_577	485587	4966805	308	321	1	1	1	220.841	214.503	6.338
obwell_578	485492	4966807	308	321	1	1	1	219.708	213.910	5.798
obwell_579	485492	4966807	308	321	1	1	1	220.738	213.910	6.827

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
obwell_580	485406	4966817	308	321	1	1	1	217.908	213.361	4.548
obwell_581	485406	4966817	308	321	1	1	1	217.953	213.361	4.593
cwi_222988	477995	4966820	308	237	1	1	1	245.364	246.730	-1.366
cwi_205205	474425	4966824	308	211	1	1	1	247.802	248.475	-0.673
cwi_205213	474596	4966836	308	211	1	1	1	245.364	248.361	-2.997
cwi_205217	474881	4966838	308	213	1	1	1	244.754	248.125	-3.371
cwi_205212	474737	4966843	308	212	1	1	1	248.412	248.258	0.154
cwi_223012	477693	4966854	308	231	1	1	1	246.278	246.873	-0.594
cwi_205204	474484	4966858	308	211	1	1	1	242.926	248.483	-5.557
cwi_204994	476135	4966858	308	218	1	1	1	245.364	247.007	-1.643
cwi_222994	477800	4966871	308	232	1	1	1	245.364	246.835	-1.471
cwi_222993	477831	4966874	308	233	1	1	1	245.364	246.822	-1.458
cwi_205211	474651	4966881	307	212	1	1	1	244.754	248.382	-3.628
cwi_205210	474699	4966888	307	212	1	1	1	248.412	248.353	0.059
cwi_205203	474439	4966890	307	211	1	1	1	242.316	248.565	-6.249
cwi_204997	474942	4966932	307	213	1	1	1	248.412	248.188	0.224
cwi_205202	474498	4966934	307	211	1	1	1	243.230	248.588	-5.358
cwi_205000	474436	4966952	307	211	1	1	1	245.364	248.662	-3.298
obwell_571	485749	4966962	307	321	1	1	1	220.544	214.996	5.548
obwell_572	485749	4966962	307	321	1	1	1	221.352	214.996	6.356
obwell_573	485749	4966962	307	321	1	1	1	220.501	214.996	5.505
cwi_223016	477648	4966967	307	230	1	1	1	246.583	246.927	-0.344
cwi_222989	477985	4966997	307	237	1	1	1	248.412	246.774	1.638
cwi_205201	474428	4967017	307	211	1	1	1	247.193	248.766	-1.573
cwi_204999	474550	4967038	307	211	1	1	1	240.792	248.700	-7.908
cwi_223032	476892	4967117	307	222	1	1	1	246.278	247.069	-0.790
cwi_248818	480395	4967199	307	301	1	1	1	244.145	238.938	5.206
cwi_223017	477491	4967214	307	227	1	1	1	246.583	247.103	-0.520
cwi_204998	475256	4967248	307	214	1	1	1	251.155	248.221	2.935
cwi_223027	476817	4967252	307	221	1	1	1	242.316	247.223	-4.907
cwi_223023	477017	4967259	307	223	1	1	1	245.364	247.244	-1.880
cwi_223022	477038	4967261	307	223	1	1	1	244.145	247.246	-3.101
cwi_223024	476999	4967269	307	222	1	1	1	247.802	247.256	0.547
cwi_223025	476947	4967308	307	222	1	1	1	245.974	247.303	-1.329
cwi_222996	478094	4967323	307	241	1	1	1	250.850	246.827	4.024
cwi_223021	477175	4967376	306	224	1	1	1	245.974	247.336	-1.362
cwi_223216	473166	4967377	306	207	1	1	1	244.450	249.576	-5.127
cwi_204996	475579	4967384	306	215	1	1	1	247.802	248.009	-0.207
cwi_204951	472215	4967532	306	205	1	1	1	250.546	249.761	0.785
cwi_248814	481751	4967585	306	309	1	1	1	240.182	227.664	12.518
cwi_223261	478011	4967800	305	238	1	1	1	248.717	247.189	1.528
cwi_206251	478516	4967815	305	254	1	1	1	249.326	246.660	2.666
cwi_223224	475962	4967855	305	217	1	1	1	249.022	248.445	0.576
cwi_223259	478051	4967882	304	239	1	1	1	249.022	247.228	1.794
cwi_223262	478241	4967902	304	245	1	1	1	249.022	247.044	1.977
cwi_223263	478434	4967911	304	251	1	1	1	249.631	246.823	2.808
cwi_223223	475949	4967917	304	217	1	1	1	245.974	248.549	-2.575
cwi_206263	479317	4967933	304	280	1	1	1	247.193	245.486	1.707
cwi_223285	480166	4967949	304	299	1	1	1	243.535	241.309	2.226
cwi_223287	480129	4967979	304	299	1	1	1	243.535	241.631	1.904
cwi_223284	480055	4967981	304	297	1	1	1	243.840	242.137	1.703
cwi_223286	480178	4967982	304	299	1	1	1	243.840	241.297	2.543

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_223241	477218	4968008	304	224	1	1	1	244.754	248.017	-3.263
cwi_223242	477595	4968014	304	229	1	1	1	247.193	247.772	-0.579
cwi_223240	477038	4968019	304	223	1	1	1	245.974	248.138	-2.165
cwi_223239	476916	4968058	304	222	1	1	1	242.316	248.259	-5.943
cwi_223243	477594	4968066	304	229	1	1	1	249.022	247.838	1.184
cwi_223226	475947	4968069	304	217	1	1	1	245.059	248.799	-3.740
cwi_223229	476027	4968090	304	217	1	1	1	247.498	248.806	-1.309
cwi_223257	477816	4968091	304	233	1	1	1	247.802	247.675	0.128
cwi_223228	476023	4968106	304	217	1	1	1	246.278	248.834	-2.556
cwi_223222	475945	4968113	304	217	1	1	1	247.193	248.872	-1.679
cwi_206265	480178	4968123	304	299	1	1	1	249.936	241.641	8.295
cwi_223227	476025	4968124	304	217	1	1	1	246.583	248.863	-2.279
cwi_223221	475948	4968132	303	217	1	1	1	247.193	248.903	-1.710
cwi_223256	477943	4968162	303	236	1	1	1	247.498	247.617	-0.119
cwi_223219	475798	4968167	303	216	1	1	1	249.631	249.008	0.623
cwi_223220	475948	4968178	303	217	1	1	1	248.412	248.979	-0.567
cwi_223264	478562	4968197	303	255	1	1	1	246.888	246.848	0.040
cwi_223265	478655	4968214	303	258	1	1	1	250.850	246.723	4.128
cwi_206261	479119	4968233	303	273	1	1	1	249.631	245.965	3.667
cwi_194196	487859	4968250	303	325	1	1	1	230.124	225.204	4.920
cwi_223244	477594	4968265	303	229	1	1	1	249.936	248.080	1.856
cwi_223279	478813	4968266	303	264	1	1	1	248.107	246.502	1.605
cwi_223236	476624	4968305	303	219	1	1	1	246.888	248.802	-1.914
cwi_206249	478612	4968322	303	257	1	1	1	247.498	246.866	0.631
cwi_206266	479965	4968327	303	296	1	1	1	234.086	243.321	-9.234
cwi_206268	479922	4968333	303	295	1	1	1	248.412	243.544	4.868
cwi_223277	478728	4968353	303	261	1	1	1	247.498	246.710	0.788
cwi_223245	477667	4968382	302	230	1	1	1	249.022	248.121	0.901
cwi_223268	478455	4968395	302	252	1	1	1	246.888	247.150	-0.262
cwi_223280	478827	4968405	302	264	1	1	1	249.326	246.587	2.740
cwi_223246	477665	4968407	302	230	1	1	1	249.326	248.144	1.182
cwi_223276	478749	4968417	302	261	1	1	1	247.802	246.725	1.077
cwi_184886	469055	4968427	302	199	1	1	1	256.032	258.661	-2.629
cwi_206244	477387	4968429	302	226	1	1	1	249.936	248.363	1.573
cwi_206247	477351	4968431	302	225	1	1	1	249.631	248.390	1.241
cwi_206187	474742	4968434	302	212	1	1	1	249.631	251.342	-1.710
cwi_206239	477563	4968434	302	229	1	1	1	249.631	248.245	1.386
cwi_206186	475608	4968435	302	215	1	1	1	247.498	249.638	-2.140
cwi_206245	477437	4968438	302	226	1	1	1	249.631	248.336	1.295
cwi_206237	477598	4968438	302	229	1	1	1	249.631	248.223	1.408
cwi_206238	477630	4968438	302	230	1	1	1	249.022	248.198	0.823
cwi_206246	477406	4968439	302	226	1	1	1	249.631	248.357	1.274
obwell_574	485993	4968439	302	322	1	1	1	215.268	210.498	4.771
obwell_575	485993	4968439	302	322	1	1	1	215.406	210.498	4.908
cwi_206243	477481	4968440	302	227	1	1	1	249.326	248.309	1.018
cwi_206242	477452	4968441	302	227	1	1	1	249.631	248.329	1.302
cwi_206241	477508	4968441	302	228	1	1	1	249.631	248.291	1.341
cwi_206248	477365	4968449	302	225	1	1	1	249.022	248.395	0.626
cwi_223247	477607	4968468	302	229	1	1	1	247.802	248.240	-0.438
cwi_223275	478615	4968477	302	257	1	1	1	245.364	246.982	-1.618
cwi_223248	477604	4968487	302	229	1	1	1	249.326	248.257	1.069
cwi_206259	478864	4968500	302	265	1	1	1	245.364	246.594	-1.230

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_223250	477608	4968509	301	229	1	1	1	249.631	248.272	1.359
cwi_223249	477658	4968535	301	230	1	1	1	250.850	248.255	2.596
cwi_223230	475718	4968584	301	216	1	1	1	248.412	249.771	-1.359
cwi_223235	476945	4968609	301	222	1	1	1	247.802	248.891	-1.089
cwi_223231	475714	4968610	301	216	1	1	1	248.412	249.823	-1.411
cwi_206255	480285	4968620	301	300	1	1	1	249.326	242.566	6.760
cwi_223232	476027	4968634	300	217	1	1	1	248.107	249.643	-1.536
cwi_223255	478060	4968667	300	239	1	1	1	246.888	247.960	-1.072
cwi_223273	478653	4968678	300	258	1	1	1	247.193	247.077	0.115
cwi_223274	478659	4968696	300	259	1	1	1	248.717	247.082	1.635
cwi_223252	477225	4968697	300	224	1	1	1	248.107	248.740	-0.633
cwi_248813	480403	4968699	300	301	1	1	1	252.374	242.339	10.035
cwi_223234	477014	4968737	300	223	1	1	1	249.022	248.975	0.047
cwi_223237	476519	4968740	300	219	1	1	1	244.145	249.465	-5.320
cwi_223238	476516	4968770	299	219	1	1	1	243.840	249.508	-5.668
cwi_223254	477321	4968818	299	225	1	1	1	249.326	248.761	0.565
cwi_204947	470368	4968821	299	201	1	1	1	256.032	256.099	-0.067
cwi_223283	479738	4968822	299	292	1	1	1	247.193	244.635	2.557
cwi_206182	473998	4968828	299	209	1	1	1	254.508	252.958	1.550
cwi_223253	477224	4968830	299	224	1	1	1	246.583	248.882	-2.299
cwi_223233	477142	4968851	299	224	1	1	1	247.193	249.001	-1.808
cwi_206185	475117	4968886	298	213	1	1	1	250.241	251.496	-1.255
cwi_223269	478333	4968890	298	248	1	1	1	248.107	247.760	0.347
cwi_223270	478337	4968921	298	248	1	1	1	253.898	247.783	6.115
cwi_223272	478229	4968935	298	245	1	1	1	248.717	247.968	0.749
cwi_223271	478330	4968942	298	248	1	1	1	247.802	247.814	-0.012
cwi_223282	479455	4968942	298	284	1	1	1	247.193	245.540	1.653
cwi_206253	480089	4968969	298	298	1	1	1	247.498	243.677	3.820
cwi_223918	478732	4969064	297	261	1	1	1	249.022	247.241	1.781
cwi_223920	477172	4969084	297	224	1	1	1	247.802	249.345	-1.542
cwi_206252	480404	4969111	297	301	1	1	1	246.278	243.008	3.271
cwi_206256	479147	4969207	296	274	1	1	1	248.107	246.483	1.624
cwi_206257	479143	4969232	296	274	1	1	1	249.631	246.512	3.119
cwi_218195	474002	4969261	295	209	1	1	1	245.974	254.292	-8.318
cwi_223910	479741	4969270	295	292	1	1	1	247.498	244.810	2.687
cwi_223905	479837	4969274	295	294	1	1	1	249.022	244.474	4.548
cwi_223909	479709	4969380	294	292	1	1	1	247.498	244.996	2.501
cwi_223919	478045	4969415	294	239	1	1	1	246.888	248.768	-1.880
cwi_223911	479517	4969478	293	286	1	1	1	248.412	245.704	2.708
cwi_223915	479122	4969493	293	273	1	1	1	249.326	246.798	2.528
cwi_223913	479323	4969494	293	280	1	1	1	247.193	246.285	0.908
cwi_203181	469502	4969507	292	200	1	1	1	257.556	260.248	-2.692
cwi_223916	479123	4969526	292	273	1	1	1	247.802	246.830	0.972
cwi_223852	480450	4969554	292	301	1	1	1	248.107	243.400	4.707
cwi_223853	480799	4969595	291	304	1	1	1	246.888	242.760	4.128
cwi_223912	479319	4969598	291	280	1	1	1	247.802	246.398	1.404
cwi_223917	478829	4969615	291	264	1	1	1	248.107	247.613	0.494
cwi_223908	479812	4969673	290	293	1	1	1	247.802	244.891	2.911
cwi_223907	479845	4969674	290	294	1	1	1	247.498	244.771	2.727
cwi_206317	475866	4969780	288	216	1	1	1	250.850	251.677	-0.827
cwi_251415	480409	4969855	287	301	1	1	1	249.631	243.822	5.809
cwi_248822	481180	4970000	283	307	1	1	1	247.498	242.753	4.745

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_203114	469017	4970037	281	199	1	1	1	260.604	262.210	-1.606
cwi_206316	476014	4970040	281	217	1	1	1	247.193	251.750	-4.557
cwi_206294	480099	4970080	280	298	1	1	1	250.546	244.797	5.749
cwi_206293	480102	4970082	280	298	1	1	1	249.936	244.794	5.142
cwi_223854	480741	4970123	279	303	1	1	1	245.974	243.684	2.290
cwi_206313	475714	4970130	278	216	1	1	1	251.765	252.740	-0.975
cwi_206312	475706	4970158	277	216	1	1	1	251.460	252.821	-1.361
cwi_223857	480640	4970167	277	303	1	1	1	249.326	243.929	5.397
cwi_223856	480609	4970172	277	302	1	1	1	247.498	243.989	3.509
cwi_206277	478970	4970178	277	269	1	1	1	250.241	248.120	2.121
cwi_206311	475713	4970186	277	216	1	1	1	250.850	252.854	-2.003
cwi_223855	480643	4970191	276	303	1	1	1	244.754	243.965	0.789
cwi_206315	476246	4970197	276	218	1	1	1	249.326	251.473	-2.146
cwi_206344	477601	4970257	274	229	1	1	1	249.022	250.387	-1.366
cwi_206343	477556	4970261	274	228	1	1	1	249.936	250.427	-0.491
cwi_206295	480412	4970276	274	301	1	1	1	242.316	244.490	-2.174
cwi_223851	480450	4970287	273	301	1	1	1	248.107	244.440	3.667
cwi_206299	479715	4970297	273	292	1	1	1	248.107	246.315	1.792
cwi_223860	480716	4970298	273	303	1	1	1	251.765	244.025	7.740
cwi_206341	477615	4970321	272	229	1	1	1	246.583	250.437	-3.854
cwi_206297	480406	4970349	271	301	1	1	1	242.316	244.633	-2.317
cwi_223858	480752	4970393	270	304	1	1	1	245.059	244.130	0.930
cwi_223859	480752	4970410	269	304	1	1	1	245.669	244.164	1.505
cwi_223850	480411	4970425	269	301	1	1	1	245.364	244.783	0.581
cwi_206309	475851	4970445	268	216	1	1	1	255.727	252.916	2.811
cwi_218200	472714	4970461	268	206	1	1	1	258.166	258.904	-0.738
cwi_206403	472558	4970465	268	206	1	1	1	261.214	258.653	2.561
cwi_223861	480753	4970508	266	304	1	1	1	245.974	244.363	1.611
cwi_204860	471851	4970515	266	204	1	1	1	261.518	258.552	2.966
cwi_223864	480825	4970522	266	304	1	1	1	246.278	244.259	2.019
cwi_206337	477816	4970530	266	233	1	1	1	248.412	250.527	-2.115
cwi_223866	481020	4970556	265	306	1	1	1	243.535	244.019	-0.484
cwi_226843	480751	4970575	264	304	1	1	1	245.669	244.505	1.163
cwi_223863	480818	4970577	264	304	1	1	1	245.059	244.382	0.678
cwi_206340	477603	4970582	264	229	1	1	1	248.412	250.793	-2.381
cwi_223865	480951	4970591	264	305	1	1	1	242.926	244.185	-1.259
cwi_206339	477606	4970632	262	229	1	1	1	250.546	250.857	-0.311
cwi_250779	487932	4970637	262	326	1	1	1	268.224	216.381	51.843
cwi_206338	477316	4970676	261	225	1	1	1	247.498	251.171	-3.673
cwi_206306	475704	4970732	259	216	1	1	1	253.289	253.929	-0.640
cwi_206308	475648	4970733	259	216	1	1	1	254.508	254.133	0.375
cwi_206292	479556	4970769	258	287	1	1	1	242.926	247.699	-4.773
cwi_206305	475709	4970773	258	216	1	1	1	253.289	253.982	-0.693
cwi_778035	473264	4970777	258	207	1	1	1	251.765	259.847	-8.083
cwi_206307	475648	4970778	258	216	1	1	1	254.508	254.213	0.295
cwi_206304	475756	4970779	258	216	1	1	1	253.898	253.822	0.076
cwi_206303	476058	4970800	257	217	1	1	1	252.374	252.865	-0.490
cwi_206302	479973	4970817	256	296	1	1	1	249.022	246.737	2.284
cwi_200565	472461	4971072	251	206	1	1	1	258.166	261.156	-2.991
cwi_206604	470734	4971094	251	202	1	1	1	249.936	262.330	-12.394
cwi_206607	471036	4971150	250	203	1	1	1	262.128	262.850	-0.722
cwi_206618	471248	4971186	250	203	1	1	1	259.080	262.989	-3.909

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_206612	471322	4971199	249	203	1	1	1	259.690	263.001	-3.312
cwi_206620	471272	4971201	249	203	1	1	1	259.994	263.031	-3.037
cwi_242303	471085	4971233	249	203	1	1	1	259.080	263.166	-4.086
cwi_206613	471379	4971233	249	204	1	1	1	261.518	263.107	-1.589
cwi_206611	471326	4971235	249	203	1	1	1	260.604	263.133	-2.529
cwi_206627	471983	4971242	249	205	1	1	1	260.604	262.740	-2.136
cwi_206616	471302	4971243	249	203	1	1	1	261.823	263.171	-1.348
cwi_206617	471292	4971252	248	203	1	1	1	256.032	263.207	-7.175
cwi_206610	471333	4971291	248	203	1	1	1	260.604	263.340	-2.736
cwi_114323	471152	4971340	247	203	1	1	1	259.385	263.545	-4.160
cwi_200563	473008	4971437	246	207	1	1	1	262.128	261.828	0.300
cwi_206589	470803	4971625	244	202	1	1	1	257.556	264.533	-6.977
cwi_169008	474099	4971662	243	209	1	1	1	257.556	261.024	-3.468
cwi_200580	474801	4971663	243	212	1	1	1	251.460	258.604	-7.144
cwi_206623	471955	4971797	242	205	1	1	1	263.652	265.190	-1.538
cwi_203632	470329	4972071	240	201	1	1	1	286.512	266.236	20.276
cwi_206578	470565	4972387	237	202	1	1	1	262.128	267.194	-5.066
cwi_160015	474686	4972427	237	212	1	1	1	253.594	258.859	-5.265
cwi_218191	471403	4972440	237	204	1	1	1	267.614	266.977	0.637
cwi_223768	470007	4972557	236	201	1	1	1	265.176	267.759	-2.583
cwi_203628	469956	4972570	236	201	1	1	1	263.652	267.751	-4.099
cwi_223771	469948	4972635	235	201	1	1	1	260.909	268.006	-7.097
cwi_625009	483726	4972991	234	317	1	1	1	245.273	218.510	26.763
cwi_625010	483724	4973001	234	317	1	1	1	245.273	218.270	27.002
cwi_256734	472381	4973005	234	206	1	1	1	262.128	268.738	-6.610
cwi_625013	483202	4973247	233	315	1	1	1	245.608	234.625	10.982
cwi_625014	483210	4973249	233	315	1	1	1	245.608	234.447	11.161
cwi_625012	483219	4973447	232	315	1	1	1	243.169	239.020	4.149
cwi_625011	483213	4973451	232	315	1	1	1	243.230	239.214	4.016
cwi_625003	483223	4973564	232	315	1	1	1	241.554	240.467	1.087
cwi_625004	483222	4973565	232	315	1	1	1	239.268	240.484	-1.216
cwi_200550	474015	4973764	231	209	1	1	1	263.042	263.318	-0.275
cwi_625001	483182	4973765	231	315	1	1	1	242.682	241.428	1.254
cwi_625002	483186	4973767	231	315	1	1	1	242.682	241.366	1.316
cwi_233255	471215	4973874	231	203	1	1	1	264.871	269.588	-4.716
cwi_443564	486769	4973876	230	323	1	1	1	289.255	228.645	60.610
cwi_443565	486809	4973877	230	323	1	1	1	289.255	228.685	60.570
cwi_443452	486740	4973922	230	323	1	1	1	288.036	228.700	59.336
cwi_443475	486766	4973930	230	323	1	1	1	289.560	228.737	60.823
cwi_443563	486774	4973931	230	323	1	1	1	289.865	228.746	61.119
cwi_233256	471260	4974019	230	203	1	1	1	266.090	269.608	-3.518
cwi_569696	487083	4974041	230	324	1	1	1	284.196	229.122	55.073
cwi_575339	487229	4974041	230	324	1	1	1	280.904	229.075	51.829
cwi_575340	487142	4974045	230	324	1	1	1	282.946	229.139	53.806
cwi_200548	473887	4974047	230	209	1	1	1	261.518	263.743	-2.225
cwi_223775	469893	4974061	230	201	1	1	1	263.652	270.779	-7.127
cwi_200549	473871	4974071	230	208	1	1	1	262.128	263.797	-1.669
nwis_14718	472820.2	4974457	229	206	1	1	1	264.938	267.365	-2.427
nwis_14719	472820.2	4974457	229	206	1	1	1	265.100	267.365	-2.265
cwi_203604	470085	4974589	229	201	1	1	1	268.224	270.751	-2.527
cwi_428280	487579	4974852	229	325	1	1	1	278.587	231.063	47.525
cwi_428276	487567	4974866	229	325	1	1	1	278.892	231.121	47.771

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_428278	487596	4974866	229	325	1	1	1	278.892	231.111	47.781
cwi_428279	487592	4974870	229	325	1	1	1	278.892	231.128	47.764
cwi_223848	480505	4974998	228	302	1	1	1	232.258	247.900	-15.642
cwi_114339	476375	4975215	228	218	1	1	1	251.460	258.412	-6.952
cwi_497642	470495	4975238	228	202	1	1	1	270.845	271.141	-0.296
cwi_546038	470368	4975244	228	201	1	1	1	270.358	271.262	-0.905
cwi_546046	470372	4975245	228	201	1	1	1	268.834	271.258	-2.424
cwi_497645	470338	4975246	228	201	1	1	1	269.870	271.290	-1.421
cwi_546042	470404	4975246	228	202	1	1	1	271.272	271.227	0.045
cwi_497641	470255	4975247	228	201	1	1	1	270.480	271.370	-0.891
cwi_546048	470368	4975247	228	201	1	1	1	270.662	271.261	-0.599
cwi_546044	470371	4975247	228	201	1	1	1	270.358	271.258	-0.900
cwi_546041	470399	4975247	228	202	1	1	1	270.358	271.231	-0.873
cwi_546037	470381	4975276	228	202	1	1	1	271.272	271.236	0.036
cwi_546036	470260	4975284	228	201	1	1	1	271.272	271.344	-0.072
cwi_546043	470257	4975290	228	201	1	1	1	271.272	271.343	-0.071
cwi_546047	470259	4975290	228	201	1	1	1	271.272	271.341	-0.069
cwi_546040	470269	4975292	228	201	1	1	1	271.577	271.331	0.246
cwi_497644	470259	4975293	228	201	1	1	1	271.882	271.339	0.542
cwi_546039	470267	4975295	228	201	1	1	1	271.577	271.331	0.246
nwis_15152	471926.1	4975541	227	205	1	1	1	266.761	268.215	-1.454
nwis_15153	471926.1	4975541	227	205	1	1	1	267.581	268.215	-0.634
cwi_165577	471936	4975561	227	205	1	1	1	267.614	268.139	-0.524
cwi_216038	471001	4975601	227	203	1	1	1	269.138	270.728	-1.590
cwi_216044	471002	4975601	227	203	1	1	1	268.224	270.728	-2.504
cwi_216048	471244	4975760	227	203	1	1	1	267.005	269.862	-2.857
cwi_763377	472039	4975817	227	205	1	1	1	267.919	267.364	0.555
cwi_763376	472037	4975819	227	205	1	1	1	267.919	267.366	0.553
cwi_216036	470576	4975823	227	202	1	1	1	268.224	270.898	-2.674
cwi_216047	470596	4975833	227	202	1	1	1	268.529	270.882	-2.354
cwi_216045	471084	4976010	226	203	1	1	1	268.529	269.652	-1.124
cwi_165576	471747	4976012	226	204	1	1	1	267.005	267.856	-0.851
cwi_216046	470975	4976016	226	203	1	1	1	268.529	269.910	-1.381
cwi_216039	471205	4976017	226	203	1	1	1	268.529	269.319	-0.790
cwi_216037	470978	4976020	226	203	1	1	1	268.834	269.894	-1.060
cwi_160031	472016	4976052	226	205	1	1	1	264.871	266.983	-2.112
cwi_216041	470792	4976053	226	202	1	1	1	268.529	270.324	-1.795
nwis_15442	470854.4	4976070	226	202	1	1	1	269.294	270.130	-0.836
cwi_216040	471447	4976079	226	204	1	1	1	269.138	268.562	0.576
cwi_160030	472368	4976102	226	205	1	1	1	264.871	266.053	-1.182
cwi_149711	472028	4976117	226	205	1	1	1	262.128	266.823	-4.695
nwis_15480	471950.6	4976127	226	205	1	1	1	266.670	267.050	-0.381
nwis_15479	471928.6	4976127	226	205	1	1	1	268.160	267.118	1.042
cwi_216043	470502	4976228	226	202	1	1	1	267.614	270.681	-3.067
cwi_216034	470507	4976230	226	202	1	1	1	269.443	270.675	-1.231
cwi_216033	470706	4976283	226	202	1	1	1	268.834	270.301	-1.467
cwi_552556	485194	4976358	226	320	1	1	1	264.262	231.277	32.985
cwi_216035	470279	4976376	225	201	1	1	1	271.272	270.619	0.653
cwi_614174	486798	4976600	225	323	1	1	1	280.721	237.860	42.861
cwi_165591	471694	4976644	225	204	1	1	1	268.529	267.922	0.606
cwi_216032	470574	4976770	225	202	1	1	1	271.272	269.907	1.365
cwi_223936	473742	4977009	224	208	1	1	1	261.214	262.932	-1.719

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Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_149710	470407	4977169	224	202	1	1	1	270.358	269.748	0.609
cwi_216031	470402	4977187	224	202	1	1	1	269.138	269.744	-0.606
cwi_656999	483754	4977200	224	317	1	1	1	243.535	223.773	19.762
cwi_428297	485260	4977247	224	320	1	1	1	263.042	234.515	28.528
cwi_429460	487620	4977258	224	325	1	1	1	277.368	241.856	35.512
cwi_428296	485245	4977261	224	320	1	1	1	263.042	234.481	28.562
cwi_429459	487637	4977270	224	325	1	1	1	277.368	241.935	35.433
cwi_428298	485256	4977275	224	320	1	1	1	262.433	234.612	27.821
cwi_432711	487614	4977277	224	325	1	1	1	278.892	241.926	36.966
cwi_216030	471160	4977287	224	203	1	1	1	267.310	268.544	-1.235
cwi_719430	473275	4977331	224	207	1	1	1	265.176	263.754	1.422
cwi_586372	487545	4977351	224	325	1	1	1	278.191	242.127	36.064
cwi_586373	487626	4977373	224	325	1	1	1	274.503	242.346	32.157
cwi_194870	486862	4977511	223	323	1	1	1	275.844	241.674	34.170
cwi_194871	486841	4977517	223	323	1	1	1	274.320	241.664	32.656
cwi_478998	480829	4977698	223	304	1	1	1	248.839	241.320	7.518
cwi_443532	485181	4978267	222	320	1	1	1	263.652	239.384	24.268
cwi_443530	485166	4978298	222	320	1	1	1	263.347	239.487	23.860
cwi_443531	485185	4978317	222	320	1	1	1	263.652	239.692	23.960
cwi_561692	484177	4978558	221	318	1	1	1	259.385	233.562	25.823
cwi_452982	484997	4978561	221	320	1	1	1	264.566	240.020	24.546
cwi_688419	483805	4978572	221	317	1	1	1	259.080	229.364	29.716
cwi_688421	483878	4978579	221	318	1	1	1	257.556	230.361	27.195
cwi_561690	484197	4978581	221	318	1	1	1	258.745	234.023	24.721
cwi_452981	485006	4978600	221	320	1	1	1	264.566	240.325	24.242
cwi_509582	484955	4978615	221	320	1	1	1	266.700	240.118	26.582
cwi_561689	484197	4978623	221	318	1	1	1	259.690	234.530	25.160
cwi_452983	484954	4978632	221	320	1	1	1	267.310	240.219	27.091
cwi_688420	483816	4978636	221	317	1	1	1	260.604	230.477	30.127
cwi_509591	484343	4978653	221	318	1	1	1	264.566	236.022	28.544
cwi_509590	484377	4978695	221	319	1	1	1	265.481	236.619	28.862
cwi_593616	475080	4978698	221	213	1	1	1	255.270	257.872	-2.602
cwi_594572	484333	4978750	221	318	1	1	1	266.395	236.672	29.723
cwi_428960	486809	4978817	221	323	1	1	1	266.395	246.691	19.704
cwi_455743	484784	4978935	220	319	1	1	1	265.176	241.017	24.159
cwi_452949	484753	4978937	220	319	1	1	1	264.566	240.857	23.709
cwi_452948	484766	4978949	220	319	1	1	1	270.662	241.000	29.662
cwi_455742	484801	4978970	220	319	1	1	1	264.566	241.318	23.249
cwi_474005	484158	4978992	220	318	1	1	1	260.604	237.317	23.287
cwi_455741	484780	4978993	220	319	1	1	1	265.481	241.339	24.142
cwi_205336	477615	4962941	315	229	2	1	1	233.782	227.285	6.497
cwi_118815	470356	4962978	315	201	2	1	1	233.477	238.275	-4.798
cwi_205319	479440	4963009	315	284	2	1	1	221.590	224.312	-2.722
cwi_205306	479406	4963146	315	282	2	1	1	220.980	225.640	-4.660
obwell_565	482693	4963326	315	313	2	1	1	220.259	223.064	-2.805
cwi_462940	470606	4963340	315	202	2	1	1	235.001	239.176	-4.175
cwi_205321	480004	4963473	314	297	2	1	1	210.922	222.834	-11.912
cwi_205338	478638	4963485	314	258	2	1	1	230.124	228.562	1.562
cwi_205278	479209	4963540	314	276	2	1	1	221.285	227.610	-6.325
cwi_223019	477435	4964320	313	226	2	1	1	234.086	238.552	-4.466
cwi_223036	475209	4964358	313	214	2	1	1	227.381	240.972	-13.591
cwi_223034	475192	4964381	312	214	2	1	1	231.648	241.023	-9.375

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Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_223035	475243	4964407	312	214	2	1	1	237.744	241.154	-3.410
cwi_223033	475236	4964442	312	214	2	1	1	229.210	241.251	-12.042
cwi_223029	475120	4964487	312	213	2	1	1	228.905	241.271	-12.366
cwi_204955	471232	4964516	312	203	2	1	1	234.696	240.663	-5.967
cwi_223028	475103	4964517	312	213	2	1	1	235.306	241.346	-6.040
cwi_204961	471920	4964906	311	205	2	1	1	237.134	240.081	-2.947
cwi_204960	471787	4964992	311	204	2	1	1	231.648	240.868	-9.220
cwi_205229	474238	4965612	310	210	2	1	1	245.364	244.683	0.681
cwi_206960	469362	4965930	309	199	2	1	1	249.936	247.701	2.235
cwi_206959	469386	4965986	309	200	2	1	1	251.460	247.791	3.669
cwi_204972	478843	4966903	307	264	2	1	1	234.086	240.028	-5.942
cwi_223211	470951	4967912	304	203	2	1	1	250.546	252.489	-1.943
cwi_200870	487641	4968108	304	325	2	1	1	228.600	224.805	3.795
cwi_257596	486420	4968296	303	323	2	1	1	221.894	223.559	-1.664
cwi_206270	479662	4968371	303	291	2	1	1	235.610	239.319	-3.708
cwi_206236	477253	4968572	301	225	2	1	1	245.364	244.482	0.882
cwi_404360	487492	4968753	299	325	2	1	1	230.124	223.786	6.338
cwi_195522	487441	4968867	299	325	2	1	1	225.247	223.500	1.747
cwi_257510	487430	4968871	299	325	2	1	1	230.124	223.481	6.643
cwi_242852	486752	4968950	298	323	2	1	1	227.686	222.703	4.982
cwi_204915	470428	4968953	298	202	2	1	1	249.936	257.349	-7.413
cwi_427469	487343	4968967	298	324	2	1	1	227.076	223.176	3.900
cwi_200868	487247	4969010	297	324	2	1	1	227.076	222.976	4.100
cwi_200867	487240	4969065	297	324	2	1	1	227.076	222.832	4.244
cwi_200866	487302	4969066	297	324	2	1	1	242.926	222.889	20.036
cwi_200869	486908	4969148	296	324	2	1	1	233.172	222.340	10.832
cwi_208034	470825	4969183	296	202	2	1	1	256.642	257.253	-0.612
cwi_208033	470860	4969190	296	202	2	1	1	256.032	257.219	-1.187
cwi_248865	487192	4969229	296	324	2	1	1	229.514	222.297	7.217
cwi_256972	470425	4969256	295	202	2	1	1	251.155	257.769	-6.614
cwi_271858	469095	4969317	295	199	2	1	1	252.984	259.543	-6.559
cwi_242849	486940	4969385	294	324	2	1	1	225.552	221.607	3.945
cwi_222902	469198	4969392	294	199	2	1	1	254.508	259.496	-4.988
cwi_222908	469344	4969411	294	199	2	1	1	251.765	259.288	-7.524
cwi_242850	486983	4969477	293	324	2	1	1	229.819	221.285	8.535
cwi_206397	473176	4969492	293	207	2	1	1	252.984	255.171	-2.187
cwi_223759	469278	4969597	291	199	2	1	1	245.974	259.703	-13.729
cwi_222901	469284	4969630	290	199	2	1	1	259.385	259.747	-0.363
cwi_203129	469283	4969655	290	199	2	1	1	258.775	259.790	-1.015
cwi_203128	469292	4969688	289	199	2	1	1	259.080	259.830	-0.750
cwi_222906	469318	4969785	288	199	2	1	1	260.604	259.945	0.659
cwi_249998	469158	4969846	287	199	2	1	1	251.460	260.328	-8.868
cwi_223893	472258	4969943	284	205	2	1	1	258.470	258.017	0.454
cwi_203112	469243	4970075	280	199	2	1	1	250.546	260.589	-10.043
cwi_255231	487158	4970090	280	324	2	1	1	219.151	218.661	0.490
cwi_250044	472600	4970129	278	206	2	1	1	246.583	258.079	-11.495
cwi_426381	487342	4970169	277	324	2	1	1	225.552	218.478	7.074
cwi_206404	472465	4970190	276	206	2	1	1	258.775	258.542	0.233
cwi_206278	478910	4970239	275	267	2	1	1	235.915	242.766	-6.850
cwi_206323	477678	4970270	274	230	2	1	1	247.193	245.448	1.744
cwi_223894	472041	4970277	274	205	2	1	1	261.518	259.336	2.183
cwi_200863	487195	4970301	273	324	2	1	1	210.312	217.916	-7.604

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_207249	487354	4970308	273	324	2	1	1	216.408	217.775	-1.367
cwi_200862	487397	4970321	272	325	2	1	1	230.124	217.671	12.453
cwi_206322	477674	4970333	272	230	2	1	1	247.802	245.570	2.233
cwi_204861	472140	4970403	270	205	2	1	1	260.909	259.655	1.254
cwi_255223	487066	4970455	268	324	2	1	1	219.456	217.260	2.196
cwi_257425	487143	4970472	267	324	2	1	1	209.093	217.085	-7.992
cwi_206336	477672	4970476	267	230	2	1	1	244.754	245.725	-0.971
cwi_270302	487081	4970501	266	324	2	1	1	211.836	216.993	-5.157
cwi_204862	472045	4970513	266	205	2	1	1	261.518	259.945	1.573
cwi_223899	472659	4970695	260	206	2	1	1	254.508	260.046	-5.538
cwi_223898	472660	4970706	260	206	2	1	1	257.556	260.079	-2.523
cwi_204859	472111	4970718	260	205	2	1	1	260.604	260.368	0.236
cwi_218193	471280	4970730	259	203	2	1	1	256.946	260.942	-3.996
cwi_218194	471260	4970759	258	203	2	1	1	252.984	261.047	-8.063
cwi_206402	472563	4970803	257	206	2	1	1	256.642	260.437	-3.795
cwi_206622	471354	4970996	253	203	2	1	1	260.604	261.605	-1.001
cwi_206605	470878	4971061	252	203	2	1	1	263.042	262.131	0.912
cwi_206603	470880	4971098	251	203	2	1	1	258.166	262.242	-4.076
cwi_206602	470814	4971150	250	202	2	1	1	259.080	262.438	-3.358
cwi_206601	470842	4971156	250	202	2	1	1	257.556	262.443	-4.887
cwi_206600	470831	4971206	249	202	2	1	1	259.080	262.618	-3.538
cwi_206591	470945	4971207	249	203	2	1	1	259.385	262.551	-3.167
cwi_206590	471023	4971291	248	203	2	1	1	262.128	262.770	-0.642
cwi_250021	471108	4971340	247	203	2	1	1	259.994	262.858	-2.864
cwi_200562	472858	4971533	244	206	2	1	1	259.385	261.703	-2.318
cwi_125924	480575	4971597	244	302	2	1	1	243.840	240.556	3.284
cwi_257102	469659	4971855	242	200	2	1	1	259.690	265.556	-5.867
cwi_223900	473484	4971885	241	208	2	1	1	254.203	261.815	-7.612
cwi_248884	473385	4971957	241	208	2	1	1	251.765	262.081	-10.316
cwi_200573	474574	4972110	240	211	2	1	1	253.594	259.518	-5.924
cwi_203631	470156	4972178	239	201	2	1	1	254.508	265.948	-11.440
cwi_203629	470168	4972229	239	201	2	1	1	261.214	266.038	-4.825
cwi_200581	477016	4972232	239	223	2	1	1	251.460	247.825	3.635
cwi_206570	470493	4972260	238	202	2	1	1	252.984	265.897	-12.913
cwi_200572	474748	4972323	238	212	2	1	1	248.412	259.436	-11.024
cwi_206575	470625	4972339	238	202	2	1	1	262.128	266.001	-3.873
cwi_206579	470554	4972347	238	202	2	1	1	261.214	266.068	-4.855
cwi_168724	474186	4972374	238	210	2	1	1	254.203	261.006	-6.803
cwi_200571	474703	4972375	238	212	2	1	1	252.984	259.615	-6.631
cwi_200557	473721	4972382	237	208	2	1	1	256.032	262.318	-6.286
cwi_582993	484544	4972388	237	319	2	1	1	211.531	225.967	-14.436
cwi_580533	484458	4972400	237	319	2	1	1	220.980	226.439	-5.459
cwi_223767	470177	4972410	237	201	2	1	1	262.738	266.486	-3.749
cwi_255750	470535	4972446	237	202	2	1	1	263.042	266.388	-3.346
cwi_582992	484527	4972450	237	319	2	1	1	210.922	226.058	-15.136
cwi_256991	470056	4972464	237	201	2	1	1	260.299	266.754	-6.455
cwi_203627	470225	4972473	237	201	2	1	1	259.385	266.694	-7.309
cwi_251935	470263	4972502	236	201	2	1	1	255.422	266.797	-11.374
cwi_206554	470654	4972513	236	202	2	1	1	262.738	266.608	-3.870
cwi_223849	483548	4972519	236	316	2	1	1	217.932	231.236	-13.304
cwi_206519	471357	4972592	236	203	2	1	1	268.834	266.172	2.661
cwi_203606	470011	4972638	235	201	2	1	1	263.652	267.516	-3.864

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_203622	469690	4972673	235	200	2	1	1	257.556	267.785	-10.229
cwi_441947	487935	4972809	235	326	2	1	1	210.312	215.319	-5.007
cwi_247994	469857	4972814	235	200	2	1	1	263.347	268.180	-4.833
cwi_200433	487996	4972851	235	326	2	1	1	213.360	215.490	-2.130
cwi_218190	470863	4972854	235	202	2	1	1	256.032	267.636	-11.604
cwi_203617	469865	4973064	234	200	2	1	1	254.508	268.683	-14.175
cwi_203616	469860	4973107	234	200	2	1	1	254.508	268.741	-14.233
cwi_203621	469511	4973166	233	200	2	1	1	256.946	268.874	-11.928
cwi_203619	469183	4973192	233	199	2	1	1	259.385	268.940	-9.555
cwi_137353	478038	4973238	233	239	2	1	1	244.450	246.888	-2.438
cwi_203618	469262	4973278	233	199	2	1	1	256.642	269.072	-12.431
cwi_206496	470544	4973410	232	202	2	1	1	255.118	268.831	-13.714
cwi_249851	469448	4973439	232	200	2	1	1	265.786	269.277	-3.491
cwi_223774	469442	4973455	232	200	2	1	1	263.042	269.301	-6.259
cwi_203612	469549	4973460	232	200	2	1	1	257.556	269.284	-11.728
cwi_256831	470870	4973530	232	202	2	1	1	253.289	268.752	-15.463
cwi_200552	472853	4973647	231	206	2	1	1	265.969	265.489	0.480
cwi_270233	470488	4973674	231	202	2	1	1	244.145	269.195	-25.050
cwi_206492	470658	4973730	231	202	2	1	1	257.861	269.169	-11.309
cwi_206488	470504	4973749	231	202	2	1	1	240.792	269.282	-28.490
cwi_206478	470868	4974065	230	202	2	1	1	242.011	269.473	-27.462
cwi_257407	470652	4974149	230	202	2	1	1	249.936	269.714	-19.778
cwi_206480	470798	4974150	230	202	2	1	1	256.337	269.629	-13.293
cwi_206479	470907	4974171	230	203	2	1	1	265.481	269.595	-4.114
cwi_206485	470593	4974183	230	202	2	1	1	265.176	269.779	-4.603
nwis_14965	471902.1	4975078	228	205	2	1	1	264.368	267.160	-2.792
cwi_165584	471901	4975078	228	205	2	1	1	270.967	267.161	3.806
cwi_165578	472170	4975504	227	205	2	1	1	269.748	266.440	3.308
nwis_15134	472167.1	4975509	227	205	2	1	1	255.962	266.441	-10.479
nwis_15166	471005.6	4975575	227	203	2	1	1	264.487	269.183	-4.696
cwi_216049	471002	4975595	227	203	2	1	1	264.262	269.162	-4.900
cwi_160018	470910	4975721	227	203	2	1	1	263.957	269.211	-5.254
nwis_15223	470940.5	4975730	227	203	2	1	1	266.203	269.144	-2.940
cwi_763378	472036	4975817	227	205	2	1	1	267.919	266.319	1.600
nwis_15391	470985.6	4976008	226	203	2	1	1	264.463	268.807	-4.344
cwi_114472	470976	4976019	226	203	2	1	1	263.347	268.816	-5.469
cwi_753534	470984	4976086	226	203	2	1	1	259.080	268.739	-9.659
cwi_165588	471940	4976114	226	205	2	1	1	264.262	266.160	-1.898
nwis_15478	471928.6	4976127	226	205	2	1	1	261.558	266.180	-4.622
cwi_171078	479953	4976427	225	296	2	1	1	235.001	243.679	-8.678
cwi_206441	471022	4977463	223	203	2	1	1	263.957	268.109	-4.152
cwi_559412	474803	4977620	223	212	2	1	1	258.196	260.138	-1.941
cwi_201060	474008	4977792	223	209	2	1	1	252.679	261.498	-8.819
cwi_249912	486281	4978049	222	322	2	1	1	242.926	241.004	1.922
cwi_201061	473605	4978583	221	208	2	1	1	262.128	261.273	0.855
cwi_223937	473134	4978588	221	207	2	1	1	258.775	262.282	-3.507
cwi_223901	473812	4978737	221	208	2	1	1	258.166	260.465	-2.299
cwi_452890	478202	4978832	221	244	2	1	1	250.850	247.256	3.595
cwi_201056	473814	4978899	220	208	2	1	1	254.813	260.113	-5.300
cwi_205352	478513	4963005	315	254	3	1	1	233.172	226.625	6.547
cwi_205303	479456	4963216	315	284	3	1	1	221.285	226.238	-4.953
cwi_414028	470614	4963503	314	202	3	1	1	231.739	238.136	-6.397

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_205279	479314	4963522	314	280	3	1	1	218.237	227.268	-9.031
cwi_205331	477705	4963581	314	231	3	1	1	244.754	228.906	15.848
cwi_181662	480426	4964263	313	301	3	1	1	211.226	227.530	-16.304
cwi_204940	469069	4964598	312	199	3	1	1	234.696	245.690	-10.994
cwi_204944	470220	4965471	310	201	3	1	1	239.268	246.234	-6.966
cwi_204939	469028	4965541	310	199	3	1	1	245.974	246.956	-0.982
cwi_204954	470707	4965586	310	202	3	1	1	239.268	246.057	-6.789
cwi_204953	470651	4965624	310	202	3	1	1	233.172	246.228	-13.056
cwi_206965	469263	4965720	310	199	3	1	1	227.076	247.156	-20.080
cwi_206963	469643	4965778	310	200	3	1	1	227.076	247.083	-20.007
cwi_206961	469501	4965826	310	200	3	1	1	240.792	247.224	-6.432
cwi_204938	469023	4965842	310	199	3	1	1	249.022	247.423	1.598
cwi_204937	469054	4965856	310	199	3	1	1	248.412	247.442	0.970
cwi_206966	469180	4965864	310	199	3	1	1	230.124	247.421	-17.297
cwi_206964	469653	4965906	309	200	3	1	1	239.268	247.279	-8.011
cwi_204936	469061	4966053	309	199	3	1	1	242.316	247.756	-5.440
cwi_207261	487164	4966616	308	324	3	1	1	233.477	226.478	6.999
cwi_223212	470910	4966882	307	203	3	1	1	233.172	247.685	-14.513
cwi_255944	484371	4967142	307	318	3	1	1	213.665	227.313	-13.648
cwi_205221	472853	4967198	307	206	3	1	1	243.535	247.193	-3.658
cwi_223026	476908	4967274	307	222	3	1	1	239.878	243.534	-3.656
cwi_207253	486749	4967384	306	323	3	1	1	224.333	226.197	-1.865
cwi_205219	473462	4967437	306	208	3	1	1	243.840	247.053	-3.213
cwi_247949	477599	4967468	306	229	3	1	1	235.001	242.067	-7.066
cwi_204950	472235	4967612	306	205	3	1	1	242.316	247.592	-5.276
cwi_223215	472706	4967705	305	206	3	1	1	241.706	247.432	-5.726
cwi_206262	478912	4967754	305	267	3	1	1	231.648	239.585	-7.937
cwi_223260	478015	4967828	305	238	3	1	1	238.049	241.371	-3.322
cwi_206271	479674	4967841	305	291	3	1	1	228.600	237.642	-9.042
cwi_206273	480340	4967951	304	300	3	1	1	231.038	236.251	-5.212
cwi_223258	478012	4967964	304	238	3	1	1	239.268	241.430	-2.162
cwi_223218	475454	4968083	304	215	3	1	1	249.631	247.024	2.607
cwi_206267	480022	4968326	303	297	3	1	1	227.076	237.248	-10.172
cwi_206269	479766	4968339	303	293	3	1	1	231.648	237.814	-6.166
cwi_255936	484726	4968354	303	319	3	1	1	214.274	228.057	-13.783
cwi_206188	475555	4968368	303	215	3	1	1	243.840	247.031	-3.191
cwi_255866	484836	4968452	302	319	3	1	1	214.884	227.984	-13.100
cwi_223251	477457	4968476	302	227	3	1	1	236.220	242.720	-6.500
cwi_223281	479028	4968578	301	270	3	1	1	229.210	239.657	-10.448
cwi_223869	487026	4969467	293	324	3	1	1	231.038	226.870	4.169
cwi_441919	486947	4970094	279	324	3	1	1	218.542	226.770	-8.229
cwi_255937	485734	4970162	277	321	3	1	1	213.055	227.506	-14.451
cwi_206310	475711	4970323	272	216	3	1	1	246.888	249.220	-2.332
cwi_441858	487191	4970435	269	324	3	1	1	216.408	226.678	-10.270
cwi_255771	487004	4970475	267	324	3	1	1	229.210	226.728	2.481
cwi_206606	470893	4971027	252	203	3	1	1	257.556	252.020	5.536
cwi_257414	477075	4971236	249	223	3	1	1	241.706	245.378	-3.672
cwi_206599	470806	4971268	248	202	3	1	1	254.508	252.328	2.180
cwi_139035	486733	4971556	244	323	3	1	1	216.408	227.447	-11.039
cwi_203633	470274	4971624	244	201	3	1	1	263.347	253.292	10.056
obwell_206	480409	4971731	243	301	3	1	1	242.089	239.796	2.293
syn08_0072	480409	4971731	243	301	3	1	1	245.084	239.796	5.288

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_249895	469164	4972324	238	199	3	1	1	253.898	255.266	-1.368
cwi_223769	470336	4972552	236	201	3	1	1	252.984	254.122	-1.138
cwi_223904	477274	4972580	236	225	3	1	1	246.583	246.373	0.210
cwi_505673	481123	4972629	235	306	3	1	1	233.782	239.285	-5.503
cwi_206497	470432	4972746	235	202	3	1	1	245.364	254.215	-8.851
cwi_206502	471465	4973246	233	204	3	1	1	255.118	253.697	1.421
cwi_505672	478906	4973249	233	266	3	1	1	236.830	243.840	-7.010
cwi_200551	473938	4973316	233	209	3	1	1	253.898	251.317	2.582
cwi_242300	471121	4973336	233	203	3	1	1	251.460	254.171	-2.711
cwi_233254	470650	4973550	232	202	3	1	1	257.556	254.985	2.571
cwi_206482	471088	4973561	232	203	3	1	1	256.032	254.622	1.410
cwi_505671	476259	4973764	231	218	3	1	1	248.717	250.088	-1.372
cwi_201143	475666	4975048	228	216	3	1	1	252.070	251.320	0.749
cwi_225894	475684	4975124	228	216	3	1	1	262.433	251.304	11.129
cwi_505670	475138	4975826	227	214	3	1	1	256.642	252.153	4.489
cwi_256604	472031	4976030	226	205	3	1	1	245.669	259.231	-13.562
nwis_15470	472323.2	4976125	226	205	3	1	1	246.888	258.690	-11.802
cwi_433289	484651	4976316	226	319	3	1	1	227.289	236.789	-9.500
cwi_216056	471590	4976423	225	204	3	1	1	249.326	257.862	-8.535
cwi_200654	479926	4976446	225	295	3	1	1	250.241	244.355	5.886
cwi_417110	476034	4976458	225	217	3	1	1	238.354	251.410	-13.056
cwi_233270	484852	4976723	225	319	3	1	1	229.636	236.972	-7.336
cwi_200653	479553	4976724	225	287	3	1	1	249.936	245.100	4.836
cwi_200652	479836	4976842	225	294	3	1	1	225.948	244.651	-18.703
cwi_763752	484373	4976959	224	318	3	1	1	231.038	237.768	-6.730
cwi_256198	480040	4977258	224	297	3	1	1	233.172	244.448	-11.276
cwi_255695	483669	4977290	224	317	3	1	1	225.095	239.053	-13.958
cwi_200655	475230	4977353	224	214	3	1	1	256.642	253.323	3.319
cwi_505674	483553	4977573	223	316	3	1	1	220.980	239.455	-18.475
cwi_505668	475420	4977708	223	215	3	1	1	253.898	253.384	0.515
cwi_201074	478060	4977867	223	239	3	1	1	241.249	247.937	-6.688
cwi_233508	487964	4978083	222	326	3	1	1	230.124	236.429	-6.305
cwi_509052	483480	4978355	222	316	3	1	1	217.627	240.425	-22.798
cwi_194191	485724	4978407	221	321	3	1	1	211.836	238.845	-27.009
cwi_417111	476011	4978876	220	217	3	1	1	243.535	251.824	-8.289
cwi_114303	475625	4962856	316	215	4	1	1	233.477	228.741	4.736
cwi_205315	479371	4962964	315	281	4	1	1	224.028	226.110	-2.082
cwi_205316	479305	4962995	315	279	4	1	1	219.456	226.143	-6.687
cwi_205314	479273	4963019	315	278	4	1	1	223.418	226.172	-2.754
cwi_205311	479312	4963033	315	279	4	1	1	226.162	226.194	-0.033
cwi_205318	479365	4963033	315	281	4	1	1	224.638	226.199	-1.561
cwi_205310	479302	4963068	315	279	4	1	1	221.894	226.240	-4.346
cwi_205304	479418	4963179	315	283	4	1	1	223.114	226.381	-3.267
cwi_205325	479929	4963418	314	295	4	1	1	224.028	226.706	-2.678
cwi_205276	479576	4963608	314	288	4	1	1	220.370	226.837	-6.466
syn08_0047	485599.8	4963960	313	321	4	1	1	223.065	217.064	6.001
cwi_439770	486111	4964050	313	322	4	1	1	228.295	220.266	8.029
syn08_0048	485714.4	4964125	313	321	4	1	1	214.983	216.100	-1.117
cwi_222981	480204	4964245	313	299	4	1	1	222.504	227.814	-5.310
syn08_0049	485638.3	4964285	313	321	4	1	1	204.399	215.077	-10.678
syn08_0050	485711.1	4964429	312	321	4	1	1	203.768	215.547	-11.779
cwi_205222	472359	4964592	312	205	4	1	1	227.076	220.238	6.838

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
cwi_205593	485194	4964969	311	320	4	1	1	213.269	219.667	-6.399
nwis_10440	478512.8	4965641	310	254	4	1	1	230.111	237.555	-7.444
syn08_0066	471802	4965664	310	204	4	1	1	230.147	243.726	-13.579
obwell_063	486343	4965690	310	322	4	1	1	218.164	221.886	-3.722
syn08_0001	486343	4965690	310	322	4	1	1	216.454	221.886	-5.432
cwi_204957	471756	4965763	310	204	4	1	1	247.802	244.062	3.740
nwis_10504	486284.6	4965805	310	322	4	1	1	226.381	222.095	4.286
cwi_205223	475414	4965837	310	215	4	1	1	240.792	243.261	-2.469
cwi_554199	481422	4965983	309	308	4	1	1	198.120	227.842	-29.722
cwi_204971	479333	4966766	308	280	4	1	1	230.734	236.711	-5.977
cwi_224820	486271	4966772	308	322	4	1	1	222.199	225.161	-2.962
cwi_204993	476237	4966996	307	218	4	1	1	243.230	243.492	-0.262
cwi_205220	472426	4967143	307	206	4	1	1	243.535	245.461	-1.926
cwi_200910	486109	4967290	307	322	4	1	1	226.162	225.859	0.303
cwi_248815	481631	4967563	306	309	4	1	1	217.322	231.842	-14.520
cwi_206264	479590	4967843	305	288	4	1	1	233.782	237.226	-3.444
nwis_11358	473187.8	4967975	304	207	4	1	1	247.549	241.428	6.122
cwi_524748	482501	4968014	304	312	4	1	1	220.066	231.090	-11.024
cwi_206254	480191	4968646	300	299	4	1	1	224.119	236.695	-12.575
nwis_12301	487434.1	4969845	287	325	4	1	1	210.903	226.865	-15.963
syn08_0073	471634.8	4970053	281	204	4	1	1	238.863	249.724	-10.862
cwi_244677	477990	4970186	277	237	4	1	1	236.220	240.374	-4.154
syn08_0186	478947.9	4970417	269	268	4	1	1	232.566	238.664	-6.099
syn08_0183	478082	4970589	264	240	4	1	1	231.755	236.975	-5.221
nwis_12780	478113.1	4970764	258	241	4	1	1	236.707	238.064	-1.357
cwi_206291	479476	4970800	257	285	4	1	1	237.134	239.030	-1.896
cwi_225681	486131	4971090	251	322	4	1	1	212.324	228.382	-16.058
nwis_13430	472830.8	4971772	242	206	4	1	1	245.096	249.168	-4.072
cwi_748656	470641	4972170	239	202	4	1	1	247.802	253.053	-5.250
cwi_686268	487857	4972677	235	325	4	1	1	219.456	227.158	-7.702
syn08_0074	470863.7	4973293	233	202	4	1	1	240.829	254.128	-13.300
cwi_200545	474016	4974271	230	209	4	1	1	257.556	251.844	5.712
nwis_14721	472118.1	4974336	230	205	4	1	1	245.824	254.663	-8.839
cwi_508116	474284	4974542	229	210	4	1	1	247.498	251.864	-4.367
cwi_559411	482271	4975333	228	311	4	1	1	231.038	239.570	-8.531
cwi_439751	473824	4975388	227	208	4	1	1	254.508	252.945	1.563
nwis_15441	471862.6	4976065	226	204	4	1	1	254.298	257.125	-2.826
nwis_15698	469651.3	4976569	225	200	4	1	1	249.912	257.550	-7.639
syn08_0076	469651.8	4976582	225	200	4	1	1	245.716	257.533	-11.817
nwis_16194	469874.9	4977525	223	200	4	1	1	257.556	256.891	0.665
nwis_16210	471014.5	4977550	223	203	4	1	1	246.099	255.874	-9.776
cwi_433286	479408	4978212	222	283	4	1	1	231.953	244.651	-12.699
syn08_0184	470712	4978380	221	202	4	1	1	245.134	256.518	-11.385
cwi_200185	485652	4978454	221	321	4	1	1	210.007	238.711	-28.704
cwi_224804	471570	4978715	221	204	4	1	1	258.166	255.681	2.485
cwi_253027	477060	4963485	314	223	5	1	1	235.306	227.772	7.534
obwell_211	471996	4976152	226	205	7	1	1	241.685	255.473	-13.788
nwis_15494	471972.6	4976157	226	205	7	1	1	237.478	255.496	-18.017
syn08_0250	485565	4963693	314	321	9	1	1	186.007	190.022	-4.015
nwis_11357	473187.8	4967975	304	207	9	1	1	210.617	174.611	36.006
syn08_0240	478880.8	4970731	259	266	9	1	1	181.640	187.558	-5.918
syn08_0223	483008	4976033	226	314	9	1	1	197.030	198.476	-1.445

RICHFIELD - WELLHEAD PROTECTION MODEL RUN 5 - SMALL SCALE CALIBRATION RESULTS

Name	X	Y	Row	Column	Layer	Group	Zone	Observed	Computed	Residual
syn08_0237	471036.6	4977581	223	203	9	1	1	187.900	186.779	1.121
cwi_201087	481042	4977981	222	306	9	1	1	240.792	201.411	39.381

Calculated RMSE = 11.510

Calculated Mean = 0.316

APPENDIX C

WELL VULNERABILITY ASSESSMENT WORKSHEETS

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #1 UNIQUE WELL #: 00206353

COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 27 QUARTERS: ABBC

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Jordan	
DNR Geologic Sensitivity Rating	:	Low	20
L Score	:	1	
Geologic Data From	:	Data Inferred From Nearby Wells	
Year Constructed	:	1961	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	345	5
Well Depth	:	437	
Casing grouted into borehole?		Yes	0
Cement grout between casings?		Yes	0
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1800	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<1 01/01/1974	0
Maximum tritium detected	:	5.8 04/30/2009	VULNERABLE
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	Unknown	0
Wellhead Protection Score	:		45
Wellhead Protection Vulnerability Rating	:		VULNERABLE
Vulnerability Overridden	:		

COMMENTS
Low rating is based on the stratigraphy from well 2 (206354) and the presence of basal St. Peter Sandstone.

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #2 UNIQUE WELL #: 00206354

COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 27 QUARTERS: ABCB

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Jordan	
DNR Geologic Sensitivity Rating	:	Medium	25
L Score	:	0	
Geologic Data From	:	Well Record	
Year Constructed	:	1961	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	345	5
Well Depth	:	437	
Casing grouted into borehole?		Unknown	0
Cement grout between casings?		Yes	0
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1800	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<1 01/01/1974	0
Maximum tritium detected	:	12.7 12/17/1991	VULNERABLE
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	M	0
Wellhead Protection Score	:		50
Wellhead Protection Vulnerability Rating	:		VULNERABLE
Vulnerability Overridden	:		

COMMENTS

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #3 UNIQUE WELL #: 00206361

COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 26 QUARTERS: BBBB

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Prairie Du Chien-Jordan	
DNR Geologic Sensitivity Rating	:	Low	20
L Score	:	3	
Geologic Data From	:	Well Record	
Year Constructed	:	1963	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	226	5
Well Depth	:	425	
Casing grouted into borehole?		Yes	0
Cement grout between casings?		Yes	0
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1800	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<.4 08/13/1990	0
Maximum tritium detected	:	Unknown	0
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	Unknown	0
Wellhead Protection Score	:		45
Wellhead Protection Vulnerability Rating	:		VULNERABLE
Vulnerability Overridden	:		Jim Walsh

COMMENTS
VULNERABLE BASED ON TRITIUM RESULT FROM WELL #2.

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #4 UNIQUE WELL #: 00206276

COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 26 QUARTERS: BCBA

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Prairie Du Chien-Jordan	
DNR Geologic Sensitivity Rating	:	High	VULNERABLE
L Score	:	0	
Geologic Data From	:	Well Record	
Year Constructed	:	1962	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	208	5
Well Depth	:	405	
Casing grouted into borehole?		Yes	0
Cement grout between casings?		Yes	0
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1200	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<1 01/01/1974	0
Maximum tritium detected	:	Unknown	0
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	Unknown	0
Wellhead Protection Score	:		25
Wellhead Protection Vulnerability Rating	:		VULNERABLE
Vulnerability Overridden	:		

COMMENTS

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #5 UNIQUE WELL #: 00206280

COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 26 QUARTERS: BCDB

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Prairie Du Chien-Jordan	
DNR Geologic Sensitivity Rating	:	High	VULNERABLE
L Score	:	0	
Geologic Data From	:	Data Inferred From Nearby Wells	
Year Constructed	:	1963	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	225	5
Well Depth	:	408	
Casing grouted into borehole?		Yes	0
Cement grout between casings?		Yes	0
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1800	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<.4 08/13/1990	0
Maximum tritium detected	:	Unknown	0
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	Unknown	0
Wellhead Protection Score	:		25
Wellhead Protection Vulnerability Rating	:		VULNERABLE
Vulnerability Overridden	:		

COMMENTS

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #6 UNIQUE WELL #: 00206279

COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 26 QUARTERS: BDDC

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Prairie Du Chien-Jordan	
DNR Geologic Sensitivity Rating	:	High	VULNERABLE
L Score	:	0	
Geologic Data From	:	Data Inferred From Nearby Wells	
Year Constructed	:	1963	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	335	5
Well Depth	:	415	
Casing grouted into borehole?		Unknown	0
Cement grout between casings?		Unknown	5
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1800	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<.4 08/13/1990	0
Maximum tritium detected	:	Unknown	0
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	Unknown	0
Wellhead Protection Score	:		30
Wellhead Protection Vulnerability Rating	:		VULNERABLE
Vulnerability Overridden	:		

COMMENTS

625 Robert St. N. St. Paul MN 55155
P.O. Box 64975 St. Paul MN 55164 - 0975

MINNESOTA DEPARTMENT OF HEALTH
SECTION OF DRINKING WATER PROTECTION
SWP Vulnerability Rating

PWSID: 1270045 TIER: 2
SYSTEM NAME: Richfield WHP RANK:
WELL NAME: Well #7 UNIQUE WELL #: 00133362

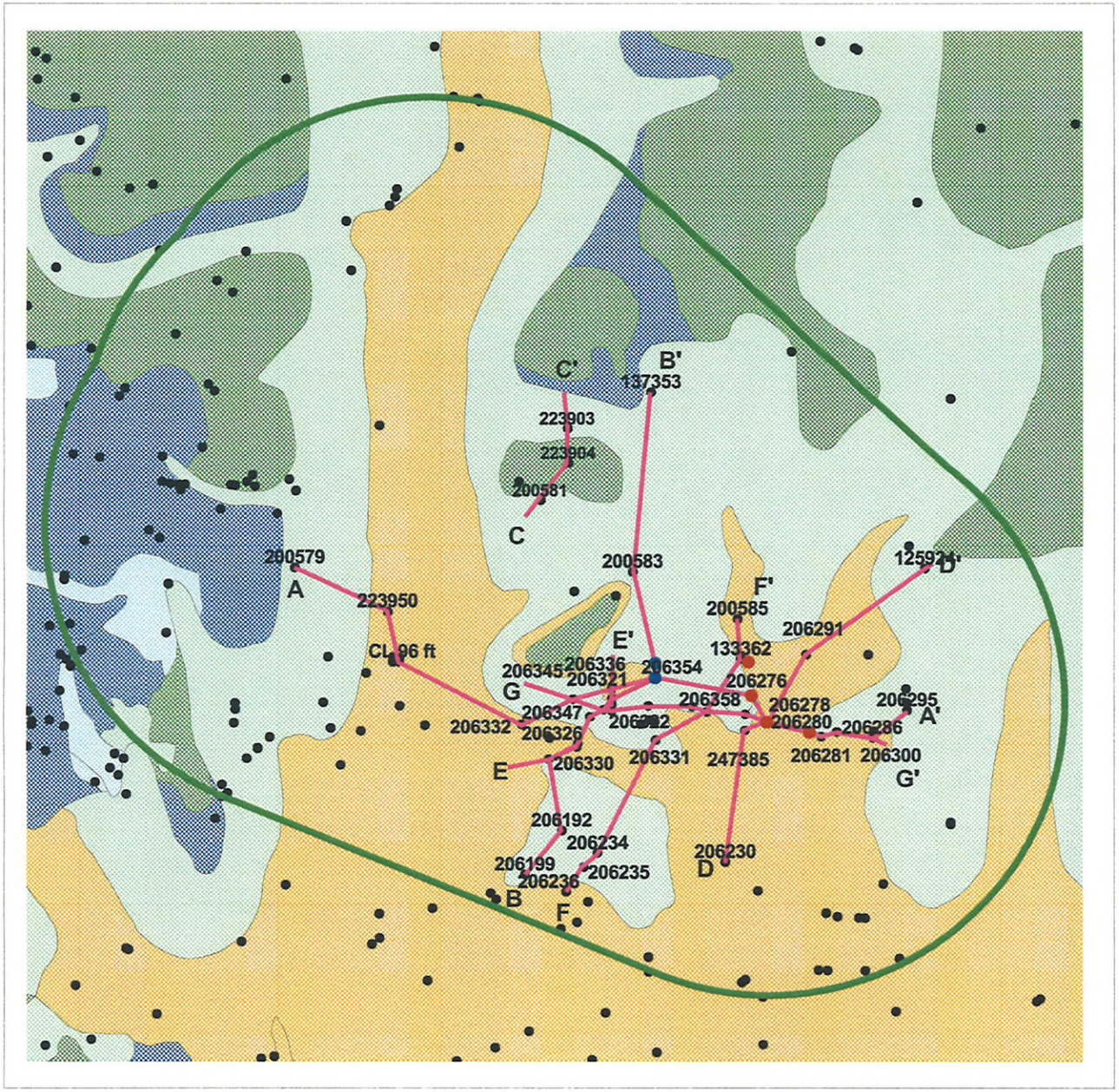
COUNTY: Hennepin TOWNSHIP NUMBER: 28 RANGE: 24 W SECTION: 26 QUARTERS: BBBB

CRITERIA		DESCRIPTION	POINTS
Aquifer Name(s)	:	Wonewoc-Mt.Simon	
DNR Geologic Sensitivity Rating	:	Very low	15
L Score	:	5	
Geologic Data From	:	Well Record	
Year Constructed	:	1977	
Construction Method	:	Cable Tool/Bored	0
Casing Depth	:	631	0
Well Depth	:	1066	
Casing grouted into borehole?		Yes	0
Cement grout between casings?		Yes	0
All casings extend to land surface?		Yes	0
Gravel - packed casings?		No	0
Wood or masonry casing?		No	0
Holes or cracks in casing?		Unknown	0
Isolation distance violations?			0
Pumping Rate	:	1200	20
Pathogen Detected?			0
Surface Water Characteristics?			0
Maximum nitrate detected	:	<.4 05/01/1979	0
Maximum tritium detected	:	Unknown	0
Non-THMS VOCs detected?			0
Pesticides detected?			0
Carbon 14 age	:	Unknown	0
Wellhead Protection Score	:		35
Wellhead Protection Vulnerability Rating	:		NOT VULNERABLE
Vulnerability Overridden	:		

COMMENTS

APPENDIX D

GEOLOGIC CROSS-SECTIONS



View 19: Cross-Section Locations

Richfield Prairie du Chien/Jordan Wells

- OPDC/Jordan
- Jordan
- Proposed WHPA

MGS Sensitivity Map

- HM
- L
- LM
- M
- VL

Figure 19
CROSS_SECTIONS LOCATIONS
(City of Richfield)

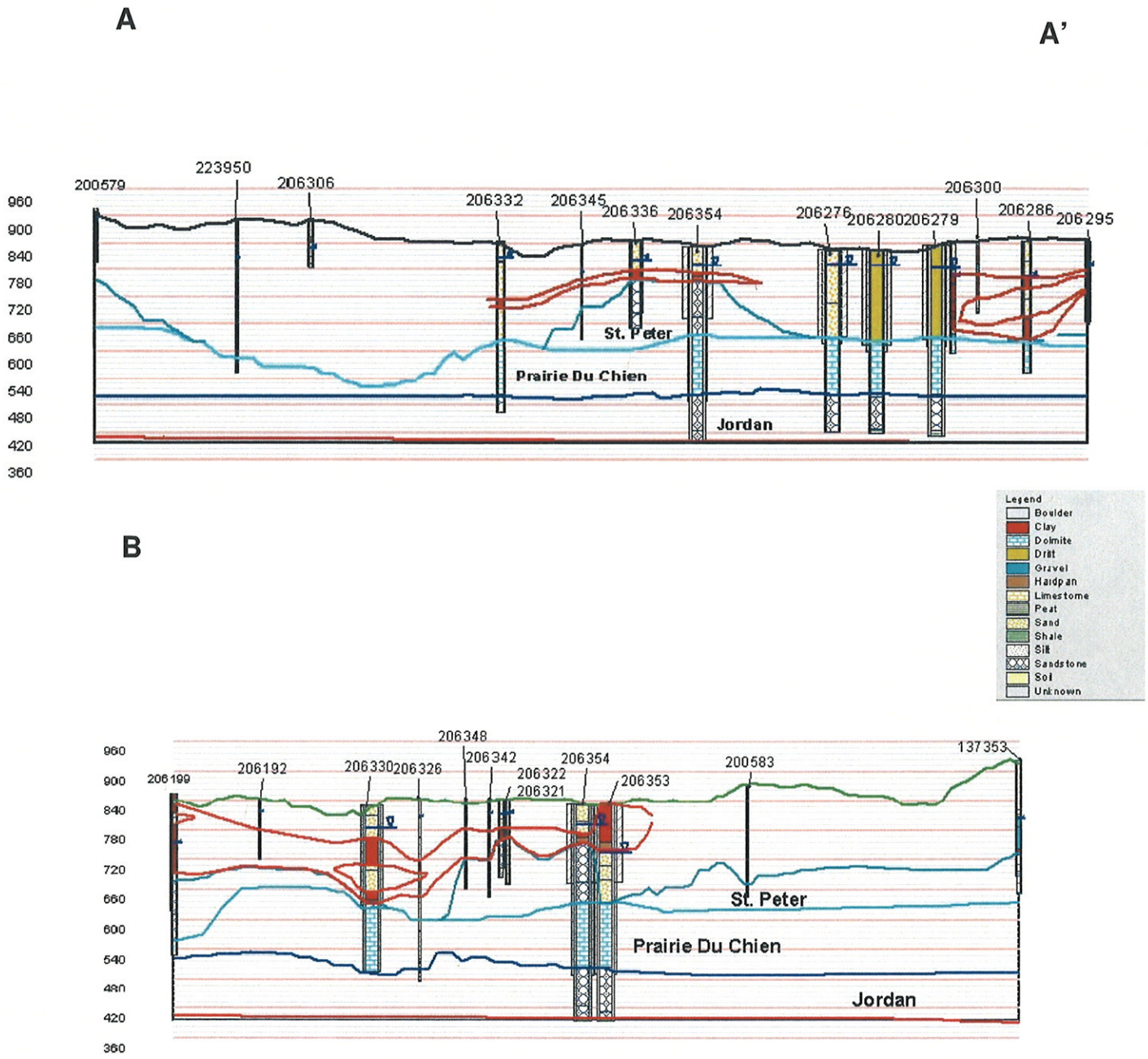


Figure 20a
CROSS-SECTIONS A-A' AND B-B'
(City of Richfield)

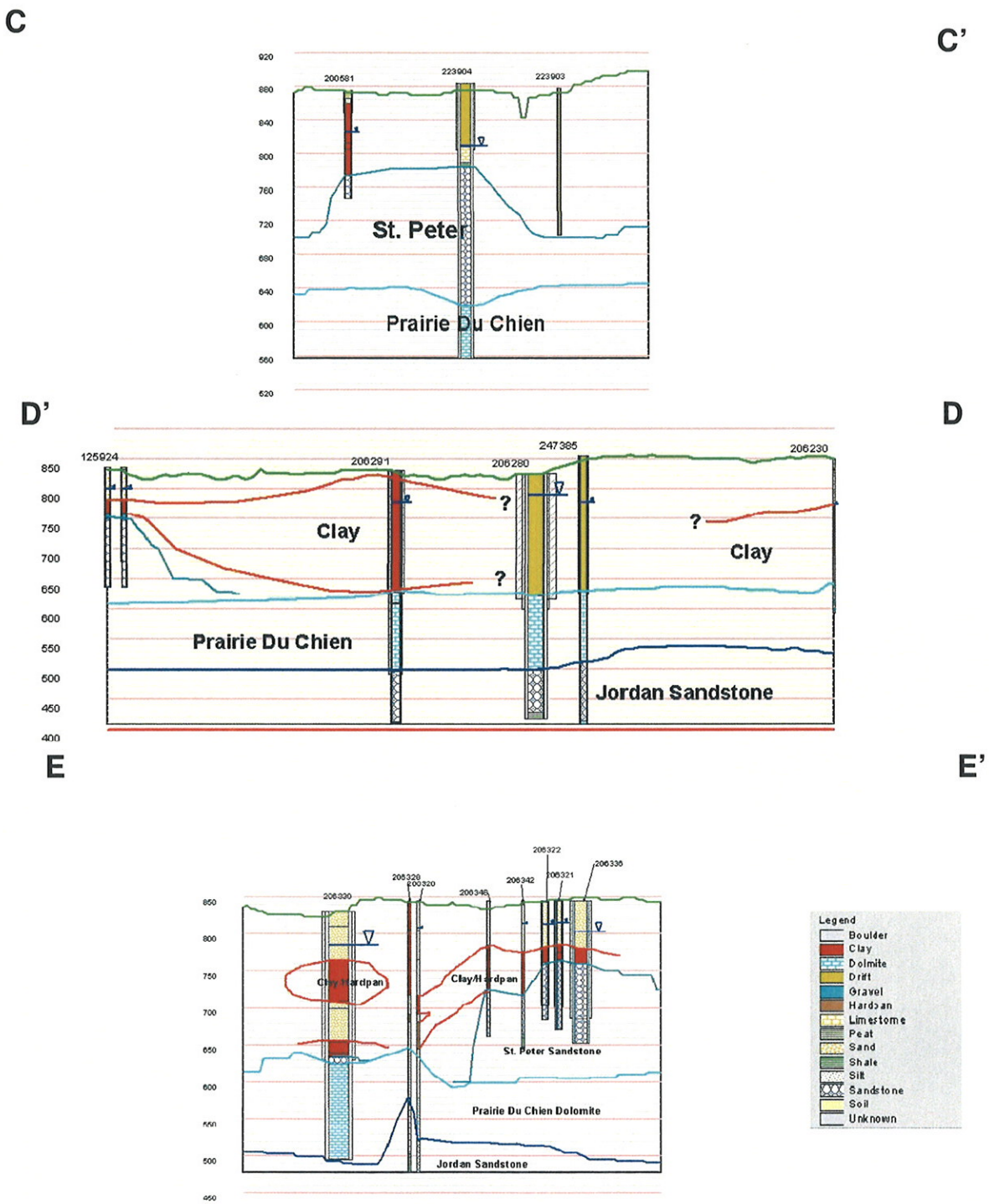


Figure 20b
CROSS-SECTIONS C-C', D-D', AND E-E''
(City of Richfield)

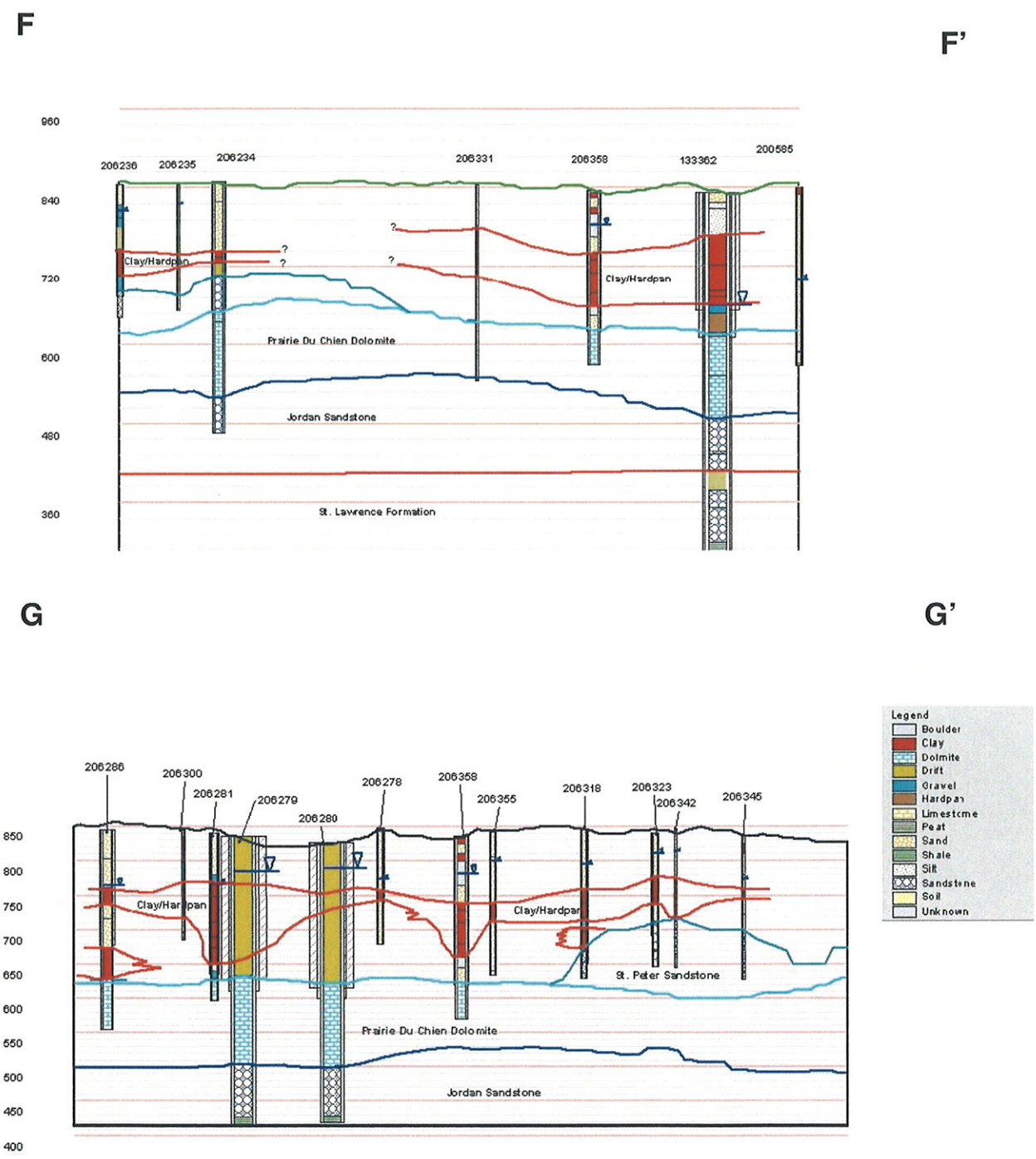


Figure 20c
CROSS-SECTIONS F-F' AND G-G''
(City of Richfield)

APPENDIX E

ASSESSMENT OF DATA ELEMENTS

Assessment of the Data Elements

This table presents the assessment of these data elements relative to the present and future implications of planning items that are specified in Minnesota Rules, part 4720.5210.

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

Data Element	Present and Future Implications				Data Source
	Use of the Well s	Delineation Criteria	Quality and Quantity of Well Water	Land and Groundwater Use in DWSMA	
Permitted withdrawals	L	L	L	L	DNR
Protected levels/flows	L	L	L	L	DNR
Water use conflicts	L	L	L	L	DNR
Groundwater Quantity					
Permitted withdrawals	H	H	H	H	DNR, Richfield
Groundwater use conflicts	L	L	L	L	DNR
Water levels	H	H	H	H	CWI, MDH, Richfield

Data Element	Present and Future Implications				Data Source
	Use of the Well s	Delineation Criteria	Quality and Quantity of Well Water	Land and Groundwater Use in DWSMA	
Surface Water Quality					
Stream and lake water quality management classification					
Monitoring data summary	L	L	M	M	SWCD
Groundwater Quality					
Monitoring data	H	H	H	H	MDH
Isotopic data	H	H	H	H	MDH
Tracer studies	H	H	H	H	Not Available
Contamination site data	M	M	M	M	MPCA
Property audit data from contamination sites					
MPCA and MDA spills/release reports	M	M	M	L	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 the WHP plan

Acronyms used in this report are listed on page ii, after the "Glossary of Terms."