

Hydrogeologic Study Report and Alternate Well Location Evaluation Final

City of Airway Heights
Airway Heights, Washington

Prepared for:

*Brice-AECOM JV1
3800 Centerpoint Drive, Suite 400
Anchorage, Alaska 99503*

Prepared by:

*NewFields Government Services, LLC
608 Mabry Hood Road, Suite 209
Knoxville, Tennessee 37932*



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EXECUTIVE SUMMARY

This report presents the results of a hydrogeologic study and alternate well location evaluation completed by NewFields Government Services, LLC (NewFields) for Brice Environmental Services Corporation (Brice) and AECOM Technical Services Inc. (AECOM) Joint Venture (JV) 1 (Brice-AECOM JV). The primary objective of the hydrogeologic study is to identify a potential alternate source of drinking water for the City of Airway Heights (Airway Heights) that will be evaluated as an alternative in an engineering evaluation/cost analysis (EE/CA). Brice-AECOM JV has been contracted by the U.S. Army Corps of Engineers (USACE) Seattle District to complete an EE/CA for a non-time critical removal action (NTCRA) for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water at the City of Airway Heights on behalf of the Fairchild Air Force Base (FAFB), Washington. The project is being performed under Contract Number W912DW-18-D-1014, Task Order W912DW18F2100 and in accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

In 2017, as a part of site inspections (SIs) completed at FAFB (AMEC Foster Wheeler Environment and Infrastructure, Inc. [AMEC] 2019), PFOS and PFOA were detected in groundwater at concentrations above the U.S. Environmental Protection Agency's (EPA's) lifetime health advisories (HA) of 70 parts per trillion (ppt) for PFOS and PFOA in drinking water (individual or combined). PFOS and PFOA were subsequently detected at concentrations above the HA in water samples collected from Airway Heights water supply wells 1 and 4 (a wellfield referred to as Wells 1/4) and supply well 9. Airway Heights stopped utilizing the wells, and immediate temporary measures were taken to provide residents with drinking water. Airway Heights is located about six miles to the west of the City of Spokane, Washington, and is adjacent to FAFB to the southwest and Spokane International Airport to the southeast.

The hydrogeologic study and alternate well Location evaluation included the following tasks:

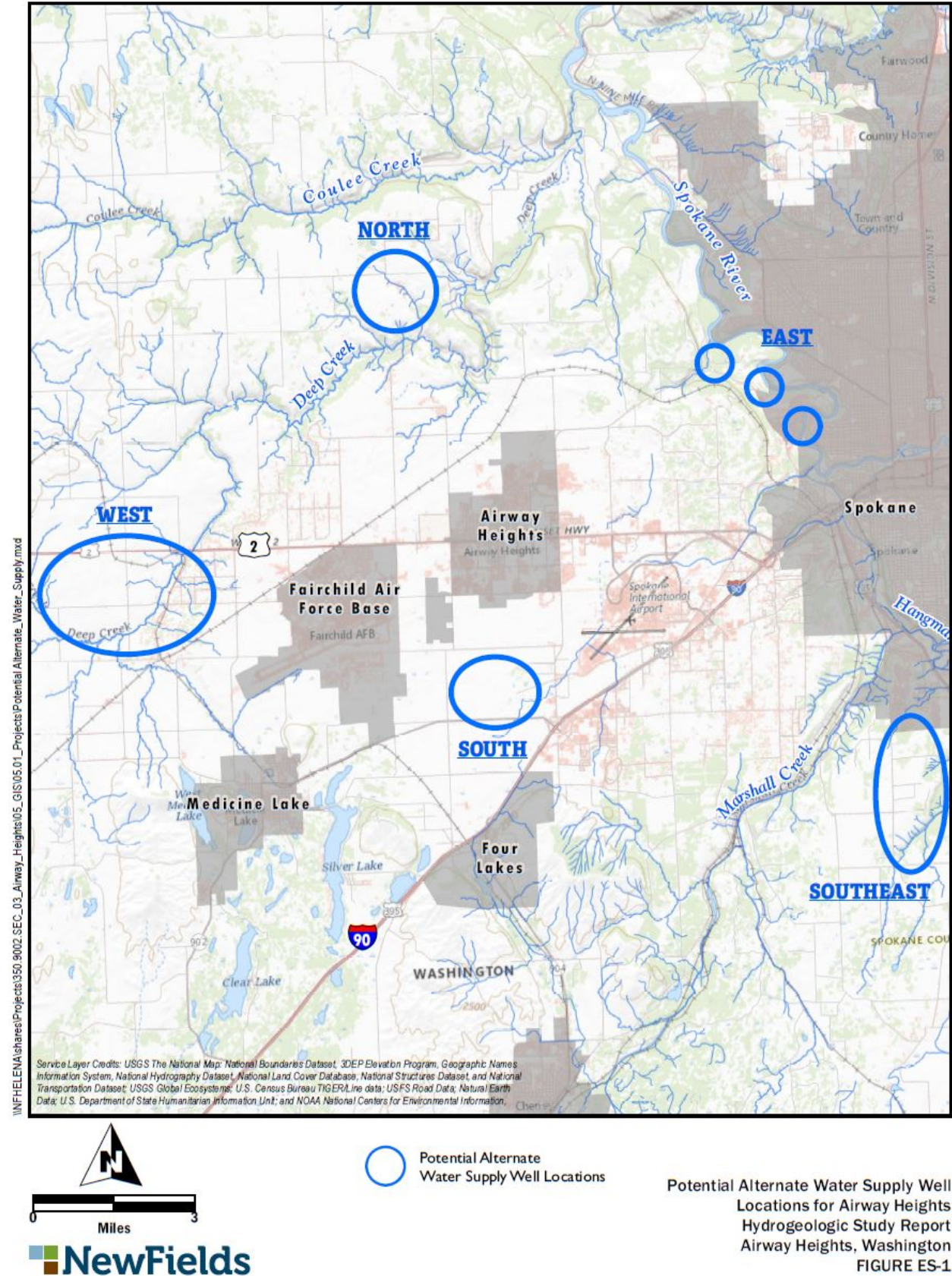
- Review available information and evaluate aquifer conditions within a 7-mile radius of Airway Heights (Study Area);
- Evaluate the feasibility of alternate water supply locations and identify one or more locations (1-square mile area) for a detailed evaluation (First Level Screening);
- Document existing water rights in the area of influence of the potential alternate well(s) areas;
- Evaluate if the potential alternate well(s) areas will impact or impair senior water rights;
- Evaluate if the potential alternate well(s) areas will impact or impair established instream flows and closures as identified by the State of Washington by establishing parameters and setbacks;
- Conduct groundwater modeling for the potential alternate well area(s) for existing and future groundwater withdrawal rates for Airway Heights; and
- Evaluate if the potential alternate well(s) locations will meet state and county laws including the Growth Management Act/State Building Code.

First Level Screening of Alternate Well Location

Potential alternate water supply well locations for Airway Heights were evaluated within a 7-mile radius of the City. Based on a review of the geology, hydrogeology, and water quality of the area, five general locations were identified for an initial screening. These general locations are shown on **Figure ES-1**. The five potential alternate well locations were evaluated further based on an initial assessment of water availability, pumping impacts, water quality, water rights, and other considerations such as infrastructure. Two of the five locations, East and West, were retained for a more detailed evaluation.

The East Area in the SVRP aquifer was considered to be the best option for a new water supply well location. Well yields in the SVRP aquifer are expected to be high and with good water quality. Reduced Spokane River flows, known as depletion in water rights applications, would occur, but this could be offset by using existing Airway Heights water rights. In addition, the existing infrastructure for the intertie could potentially be used to route water to Airway Heights.

Of the four potential locations in the basalt aquifers of the West Plains, the West Area was considered the best option. The area is upgradient of potential PFOS and PFOA sources, and far enough away from other water supply wells that impacts to the wells may not be significant. It is likely that some depletion of Deep Creek flows would occur, but additional analysis is necessary to assess the potential impact to surface water. Existing Airway Heights water rights could not be used to mitigate surface water depletion and the purchase of existing water rights would be necessary.



Numerical Groundwater Flow Model

A numerical groundwater flow model was constructed to evaluate potential water supply well locations in the Study Area retained from the first level screening. The primary purpose of the model was to quantify potential pumping impacts, including aquifer drawdown and stream depletion, associated with potential well locations for Airway Heights that were retained from the initial screening process.

The model code chosen for the West Plains Model is MODFLOW NWT. The model domain covers the West Plains area, and a portion of the SVRP where groundwater discharges from the West Plains (**Figure ES-1**). Model boundary conditions include General Head Package cells, River Package cells, Well Package cells, and Analytical Element wells. The model is divided into five layers, as summarized in **Table ES-1**.

Table ES-1. Numerical Model Layers

Layer	Geologic Unit	
	West Plains	SVRP
1	Unconsolidated	SVRP*
2	Wanapum	
3	Upper Latah	
4	Grande Ronde	
5	Lower Latah	

* SVRP is 1 ft thick in Layers 1-3, bulk of unit is in Layers 4 and 5

Elevations for the West Plains portion of Layers 1 through 5 were developed from GIS coverages provided by Spokane County. GIS coverages included top elevations and unit thicknesses for the unconsolidated material, Wannapum, Upper Latah, Grande Ronde, and Lower Latah. Layer elevations for the SVRP portion of the model were developed from model layer thicknesses assigned to the USGS model of the SVRP. Hydraulic conductivity values were assigned using hydrogeologic zones based on specific capacity data from wells, and adjusted during calibration.

A total of five model calibration goals were established, and the model was calibrated using single-event water level measurements from wells and estimated fluxes developed for a groundwater budget. Head target residual statistics, a plot of the observed versus simulated groundwater elevations at the target points, and simulated fluxes for components of the groundwater budget indicate that the model calibration goals have been met and the model is capable of providing reasonable results for simulations of potential alternate well locations.

Detailed Alternate Well Location Evaluation

The calibrated West Plains model was used to simulate potential new water supply wells for Airway Heights at the two locations retained after the First Level Screening. While these simulations provide a more detailed evaluation of the alternate well locations, they are not intended to be the final answer to how the wells could impact groundwater and surface water rights. Predictive simulations were completed for potential wells in the SVRP and in the West Plains to the west of Airway Heights. The simulated pumping rate for both simulations was 1,014 gallons per minute (gpm), which is based on the current

water use by Airway Heights, with consideration of water lost to recharge, at the time PFOS and PFOA were detected in drinking water.

Model results show that the potential East alternate supply well in the SVRP results in minimal drawdown due to the high transmissivity of the SVRP aquifer. Simulated drawdown at the well is small (8.5 ft) and the 0.1-foot drawdown contour extends out to a distance of about 3,000 ft from the simulated pumping well. The maximum drawdown in any of the nearby wells was 0.8 ft, which will not likely be considered an adverse effect. Pumping at the East supply well location for this simulation however would result in depletion of the Spokane River.

The West Plains model was also used to demonstrate that the potential East alternate supply well in the SVRP is downgradient of the Airway Heights wells, meaning a transfer of the Airway Heights existing water rights could be completed. An evaluation of the infrastructure needed is beyond the scope of this evaluation, but it is possible some existing infrastructure could be used, such as the intertie with the City of Spokane that Airway Heights currently uses to obtain water.

The potential West alternate supply well was simulated as a wellfield and has a much larger zone of influence than the potential East alternate supply well in the SVRP. The 5-foot drawdown contour for the West alternate supply well extends south to the edge of the model domain, west to the town of Reardon, and east to the upper reach of Deep creek. In addition, the drawdown extends to the southeast almost to FAFB. Because of the large zone of influence from pumping the potential wells, there are many wells that are predicted to experience drawdown. The greatest predicted drawdown in any of the nearby wells is 7.9 ft, which would need further evaluation to determine if drawdown is an adverse effect. Pumping at the potential West alternate supply well location for this simulation would result in depletion of Deep Creek and Coulee Creek.

Because the potential West alternate supply wells are upgradient of the Airway Heights wells, the City's existing water rights cannot be transferred to these new wells. Instead, an existing water right or several rights, would need to be purchased to offset the predicted impacts from pumping. The simulated West alternate supply wells are located along U.S. Highway 2, which would facilitate routing the water to Airway Heights. However, pipes would need to be installed along with pumps to transmit the water from the wellfield to the City.

Numerical Model Limitations

Numerical models are simplifications of complex systems. In all modeling exercises, some input parameters are not well quantified due to insufficient data or for other reasons, which leads to uncertainty in model predictions. The primary objective of the modeling exercise described in this document was to develop a numerical tool to help evaluate pumping impacts from potential water supply wells. The actual well locations will be refined if developing an alternate water source is selected as a remedial alternative. The true nature of pumping impacts could vary somewhat from these predictions, but the model predictions are useful for evaluating the magnitude and spatial nature of the influence of a new well.

Although the numerical model has undergone a quantitative calibration, its ability to accurately predict groundwater elevations at specific locations varies from place to place. The overall groundwater

movement and groundwater-surface water interaction is reasonable and falls within ranges of estimated groundwater budget components. However, specific matches to measured water levels at some locations is off by tens of feet. The discrepancy between simulated and measured water levels may be due to a variety of reasons including but not necessarily limited to:

- The measured water levels may not be representative of steady-state conditions and instead may be the result of short-term transient conditions such as recharge or pumping;
- The simplified representation of the geologic units, such as representing the Grande Ronde with a single layer, may reasonably replicate heads and flow in the unit overall but not be able to replicate differences between the variable layers that make up each unit; and
- Uniform hydraulic conductivity values are used over large areas of the model, when in fact there are likely spatial variations.

Despite the limitations of the model and uncertainty regarding accuracy at specific locations, the model is considered a reliable tool for evaluating pumping impacts associated with potential East and West water supply wells. The simulations presented evaluate the difference between potential water supply well pumping and non-pumping conditions and as such provide a reasonable general prediction of the magnitude of the change caused by the simulated pumping.

Conclusions

The hydrogeologic study and alternate well location evaluation concluded the following:

- The majority of groundwater within the Study Area occurs in an isolated portion of the CRBG, which flows eastward into the SVRP.
- Although the SVRP represents a small portion of the Study Area, flow through the SVRP accounts for 84% of the total flow in and 97% of the total flow out of the groundwater system.
- Instream flows specified for the Spokane River and SWSL for Deep Creek means that a new water right within the Study Area could only be obtained if stream depletion is mitigated by using the City's existing portfolio or purchasing other existing water rights.
- Based on a first level screening of potential water supply well locations, the East Area in the SVRP aquifer was considered to be the best option for a new water supply well location, and of the four potential locations in the basalt aquifers of the West Plains, the West Area was considered the best option.
- For the potential East Area well in the SVRP:
 - Pumping in the well is predicted to have a limited spatial zone of influence, and drawdown in nearby wells is small and would not likely be an adverse effect.
 - Pumping would result in depletion in the Spokane River.
 - It is likely that the existing rights could be transferred to the new well because the potential well location is downgradient from the existing Airway Heights water rights.
- For the potential West Area well(s) in the basalt aquifers of the West Plains:

- Pumping is predicted to have a large spatial zone of influence, which may affect many existing wells. However, drawdown does not appear to be significant and may not be considered an adverse effect.
- The pumping would result in depletion in Deep Creek and Coulee Creek.
- Because the potential well location is upgradient from the existing Airway Heights water rights, these rights could not be transferred to the new well location. Instead, other existing water rights would need to be purchased. Analyses would need to be conducted to verify that the purchased rights would offset potential pumping impacts from the new well in place and time.
- The East Area in the SVRP provides the best option for alternate supply well(s) in terms of well yields at the full replacement rate and water rights.
- In the West Area in the basalt aquifers, developing alternate supply well(s) that would provide the full replacement rate is uncertain and would require purchasing existing water rights and an analysis to prove those rights would offset pumping impacts. Well yield is also uncertain for this location.

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ACRONYMS AND ABBREVIATIONS

AECOM	AECOM Technical Services Inc.
Airway Heights	City of Airway Heights
BF	baseflow (groundwater discharge to surface water)
Brice	Brice Environmental Services Corporation
cfs	cubic feet per second
CRBG	Columbia River Basalt Group
DEM	USGS digital elevation model
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
FAFB	Fairchild Air Force Base
ft MSL	feet above mean sea level
ft ²	square feet
ft ³ /d	cubic feet per day
GAC	granular activated carbon
GE	groundwater extraction
GHB	General Head Boundary
GIS	Geographical Information System
gpm	gallons per minute
GWin	groundwater flow in (underflow in)
GWout	groundwater flow out (underflow out)
HA	Health Advisory
INF	infiltrating recharge from precipitation
JV	Joint Venture
K	hydraulic conductivity
mya	million years in age
NewFields	NewFields Government Services, LLC
NOAA	National Oceanic & Atmospheric Administration
NTCRA	Non-Time Critical Removal Action
PFAS	per- and polyfluoroalkyl substances
PFOS/PFOA	Perfluorooctanesulfonic Acid/Perfluorooctanoic Acid
ppt	parts per trillion
Q	water flow
ROE	Report of Examination
SVRP	Spokane Rathdrum Prairie Aquifer
SWS	surface water seepage (Spokane River and creeks)

SWSL	Surface Water Source Limitations on streams
T	transmissivity
USACE	United States Army Corps of Engineers
USGS	United State Geological Survey
WRIA	State of Washington Water Resource Inventory Area

1.0 INTRODUCTION

This report presents the results of a hydrogeologic study and alternate well location evaluation completed by NewFields Government Services, LLC (NewFields) for Brice Environmental Services Corporation (Brice) and AECOM Technical Services Inc. (AECOM) Joint Venture (JV) 1 (Brice-AECOM JV). The primary objective of the hydrogeologic study is to identify a potential alternate source of drinking water for the City of Airway Heights (Airway Heights) that will be evaluated as an alternative in an engineering evaluation/cost analysis (EE/CA). Brice-AECOM JV has been contracted by the United States Army Corps of Engineers (USACE) Seattle District to complete an EE/CA for a non-time critical removal action (NTCRA) for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water at the City of Airway Heights on behalf of the Fairchild Air Force Base (FAFB), Washington. The project is being performed under Contract Number W912DW-18-D-1014, Task Order W912DW18F2100 and in accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

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1.1 SCOPE OF WORK

The hydrogeologic study and alternate well location evaluation included the following tasks:

- Review available information and evaluate aquifer conditions within a 7-mile radius of Airway Heights (Study Area);
- Evaluate the feasibility of alternate water supply locations and identify one or more locations (1-square mile area) for a detailed evaluation (First Level Screening);
- Document existing water rights in the area of influence of the potential alternate well(s) areas;
- Evaluate if the potential alternate well(s) areas will impact or impair senior water rights;
- Evaluate if the potential alternate well(s) areas will impact or impair established instream flows and closures as identified by the State of Washington by establishing parameters and setbacks;
- Conduct groundwater modeling for the potential alternate well area(s) for existing and future groundwater withdrawal rates for Airway Heights; and
- Evaluate if the potential alternate well(s) locations will meet state and county laws including the Growth Management Act/State Building Code.

On 30 January 2019, a scoping meeting was held with stakeholders (USACE, U.S. Air Force [USAF], Airway Heights, Washington Department of Ecology [Ecology], EPA, and the First Level Screening results for the

hydrogeologic study were discussed. Based on a review of the geology, hydrogeology, and water quality of the area, five general locations were identified. Two of the five locations, potential East Area in the SVRP and potential West Area in the basalt aquifers of the West Plains, were recommended for a more detailed evaluation (bullets 3 through 7 above).

An evaluation of the PFOS/PFOA data for spatial and vertical variations and extent was not part of this hydrogeologic study. The hydrologic study focused on assessing groundwater resources away from areas with PFOS/PFOA detections, excluding the area of the West Plains that includes FAFB, Airway Heights, and the Spokane International Airport.

In addition, the replacement water volume used for the potential well location screening and groundwater model simulations is based on the current water use by Airway Heights, with consideration of water infiltrated for later use, at the time PFOS and PFOA were detected in drinking water.

2.0 SITE SETTING

The location of Airway Heights, and the 7-mile radius Study Area surrounding the City, which is the focus of this hydrogeologic study, are illustrated on **Figure 2-1**. Airway Heights is located about six miles to the west of the City of Spokane, Washington, and is adjacent to FAFB to the southwest and Spokane International Airport to the southeast. The City's corporate boundaries cover roughly 5.5 square miles of land, with the City center lying at an elevation of approximately 2,390 feet above mean sea level (ft MSL). The population of Airway Heights was slightly over 8,300 in 2015 and is projected to increase to over 10,000 by 2035 (Century West, 2017a).

The majority of the Study Area is referred to as the "West Plains", which is an elevated plateau west of the City of Spokane. The West Plains' boundaries are not well defined, but it is generally the area west of the Spokane River, south of Deep Creek, north of Interstate 90, and east of Lincoln County. A study in 2013 (Spokane County, 2013a), expanded the area slightly to the north and south. A small portion of the Study Area to the east-northeast includes the Spokane River and underlying portions of the Spokane Rathdrum Prairie Aquifer (SVRP), and Hangman Creek.

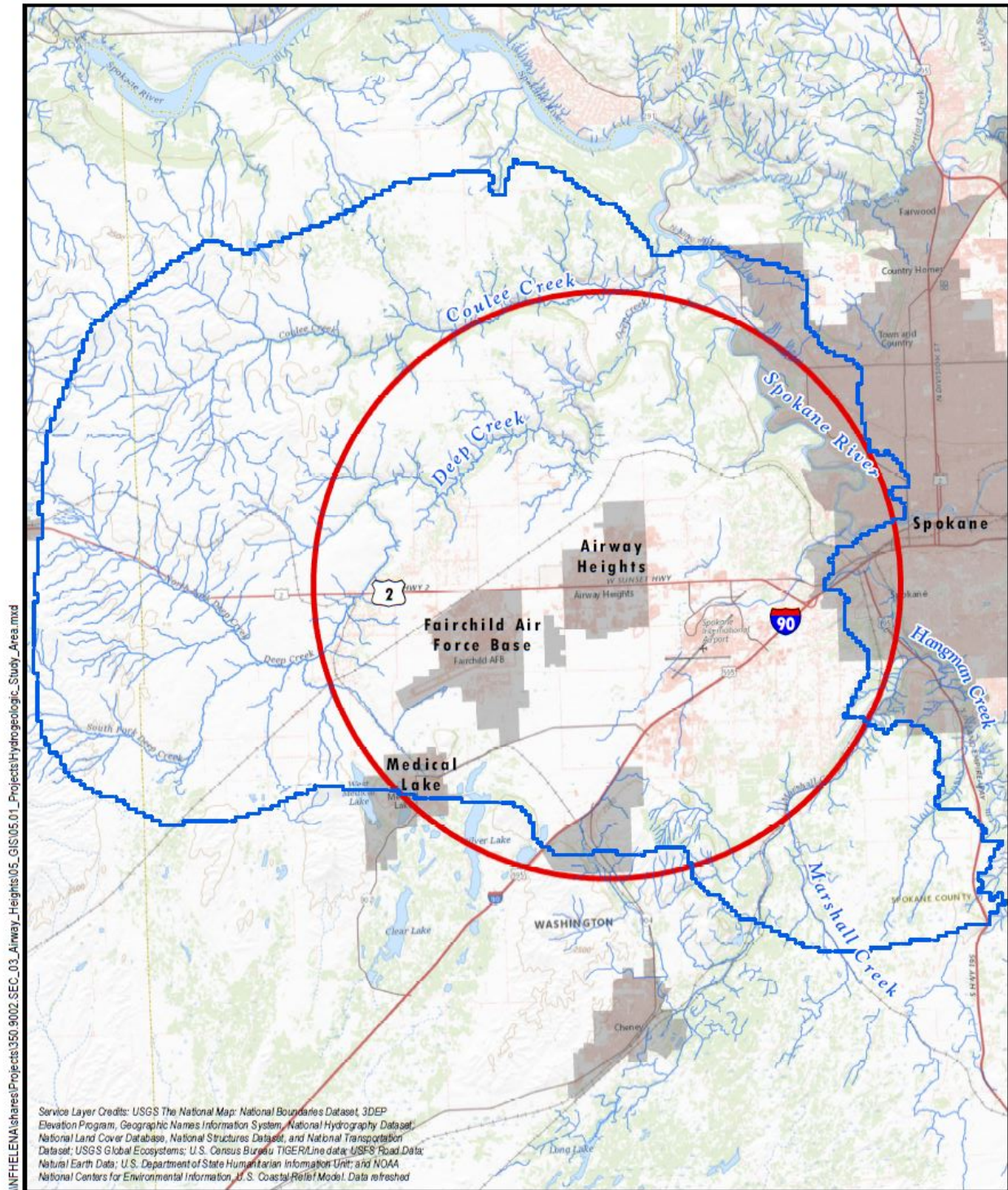
The State of Washington is divided into Water Resource Inventory Areas (WRIAs). Half of the Study Area falls within WRIA 54 (Lower Spokane), portions to the south and southeast fall within WRIA 34 (Palouse) and WRIA 56 (Hangman), and a small portion to the east is in WRIA 57 (Middle Spokane).

2.1 CLIMATE

Climate is important from a hydrogeologic perspective because the amount of precipitation that falls over the course of a year and whether it falls as snow or rain is a critical factor in recharge to groundwater. Precipitation is the primary recharge component for the majority of the Study Area as discussed in **Section 2.5**.

The Köppen climate classification in the Study Area is warm summer continental (Peel et al, 2007). The average temperature in the Study Area is 48.1 degrees Fahrenheit (°F), with an average maximum of 99 °F and an average minimum of -6 °F, based on National Oceanic & Atmospheric Administration (NOAA) data from 1881 to 2017.

Average annual precipitation at the Spokane Airport is 16.3 inches since 1881, and 16.6 inches for the last 40 years (1978-2017). Precipitation varies in the Study Area from 15.7 to 17.8 inches per year as shown on **Figure 2-2**. November is the wettest month, July is the driest, and about half of the annual precipitation falls as snow (Tetra Tech, 2009).



- Study Area (14 mile diameter)
- Numerical Model Domain

Hydrogeologic Study Area
Hydrogeologic Study Report
Airway Heights, Washington
FIGURE 2-1



Bar chart showing the variance from average annual precipitation for Spokane, WA, from 1978 to 2017. The y-axis represents the variance in inches, ranging from -6 to 10. The x-axis represents the years. The chart shows significant variability, with a major deficit in 1985 and a major surplus in 1996.

Year	Variance from Average Annual Precip. (inches)
1978	2.5
1979	-2.2
1980	0.3
1981	-1.5
1982	0.5
1983	6.0
1984	1.3
1985	-5.5
1986	-0.2
1987	1.0
1988	-0.1
1989	-1.8
1990	3.0
1991	-2.1
1992	-2.0
1993	-3.0
1994	-2.8
1995	5.0
1996	8.5
1997	0.7
1998	1.1
1999	-1.7
2000	-1.8
2001	-2.9
2002	-2.8
2003	-2.1
2004	-1.4
2005	0.6
2006	4.5
2007	-2.6
2008	-0.1
2009	0.0
2010	2.4
2011	-0.1
2012	4.7
2013	-5.5
2014	-1.5
2015	-2.5
2016	1.6
2017	5.7

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2.2 GEOLOGY

Geology in the Study Area consists of Precambrian basement rock, overlain in most places by Tertiary basalt flows of the Columbia River Basalt Group (CRBG), with Pleistocene and Quaternary deposits being the youngest geologic units in the area. A representative stratigraphic column of the Study Area geology is shown on **Figure 2-4**, and a geologic map of the Study Area is presented on **Figure 2-5**.

Geologic Time				Simplified geologic unit	
Phanerozoic Eon (544 mya to present)	Cenozoic Era (65 mya to present)	Quaternary Period (1.8 mya to present)	Holocene Epoch (8,000 ya to present)	Recent non-glacial sediment	
			Pleistocene Epoch (1.8 mya to 8,000 ya)	Glacial deposits and catastrophic flood deposits	
		Tertiary Period (65 to 1.8 mya)	Pliocene Epoch (5.3 to 1.8 mya)	–	
			Miocene Epoch (23.8 to 5.3 mya)	Basalt and older sediments	
			Oligocene Epoch (33.7 to 23.8 mya)	–	
			Eocene Epoch (55.5 to 33.7 mya)	Intrusive igneous rocks	
			Paleocene Epoch (65 to 55.5 mya)		
	Mesozoic Era (248 to 65 mya)	Cretaceous Period (145 to 65 mya)		–	
		Jurassic Period (213 to 145 mya)			
		Triassic Period (248 to 213 mya)			
	Paleozoic Era (544 to 248 mya)	Permian Period (286 to 248 mya)			–
		Carboniferous Period (360 to 286 mya)			
		Devonian Period (410 to 360 mya)			
		Silurian Period (440 to 410 mya)			
		Ordovician Period (505 to 440 mya)			
		Cambrian Period (544 to 505 mya)		Sedimentary rocks	
Precambrian Time (4,500 to 544 mya)	Proterozoic (2,500 to 544 mya)		Metamorphic rocks		
	Archean (3,800 to 2,500 mya)		–		
	Hadean (4,500 to 3,800 mya)				

Figure 2-4. Representative Stratigraphic Column (from Kahle and Bartolino, 2007)

The spatial distribution and composition of these geologic units have been documented in numerous studies that represent a steady progression in the understanding of geology in the Study Area. The geologic description of the Study Area is derived from these studies, and the cited documents are considered key references for this study but the list is not intended to be inclusive of all studies completed to date.

Geologic quadrangle maps that include the Study Area have been developed by Griggs (1966), Joseph (1990), and Stoffel et. al (1991). A number of CRBG studies have been completed, mostly by the United States Geological Survey (USGS), including Luzier and Burt (1974), Drost and Whiteman (1986), Bauer and Hansen (2000), Kahle et. al (2009), Kahle et. al (2011), Kahle et. al (2013), Ely et. al (2014), and Vacarro et. al (2015).

Several studies have been completed specific to the West Plains area, including Deobald and Buchanan (1995), Golder (2009), McCollum and Hamilton (2011), GeoEngineers (2011), Spokane County (2013a and 2013b), and GSI et. al (2015). The last two of these studies represent the best and most current description of the Study Area geology and hydrogeology (see **Section 2.3**), and much of the data included in these analyses has been provided by Spokane County.

Studies in adjacent WRIAs that fall within the Study Area include NLW (2011 and 2012) for WRIA 56 (Hangman). Additional references are cited below where appropriate.

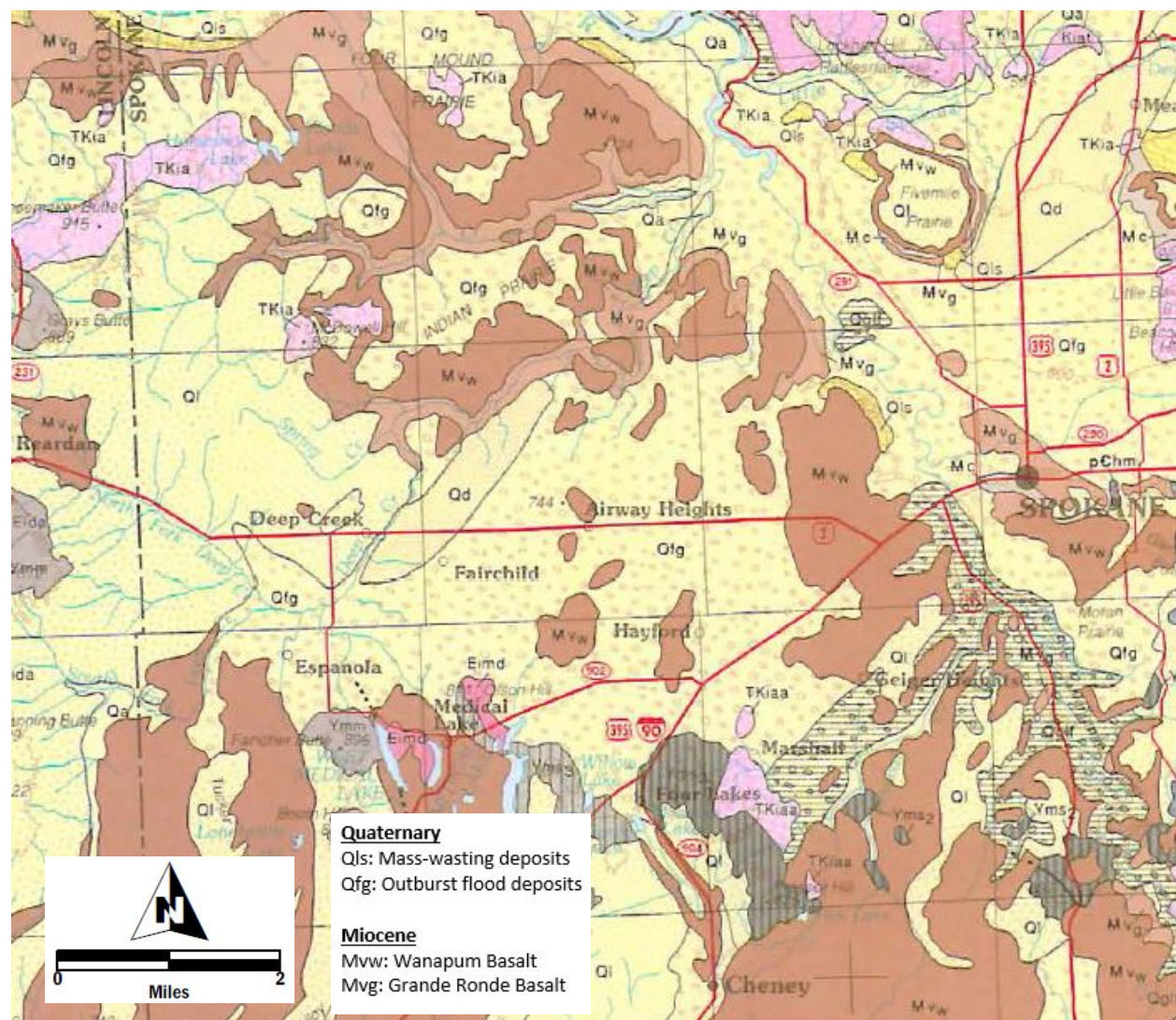


Figure 2-5. Geologic Map of Study Area (from Stoffel et. al, 1991)

2.2.1 Precambrian Basement Rock

Basement rock in the Study Area consists primarily of Precambrian Belt Supergroup metasedimentary rocks of greater than 570 million years (mya) in age. These rocks are comprised of fine-grained sediments that were originally deposited in a north-south trending marine basin during the Precambrian, and consist of low grade-metamorphosed argillite, siltite, and quartzite that grade locally into more highly metamorphosed schist and gneiss. Granitic plutons intruded into the metasedimentary rocks in places during the Mesozoic (245-65 mya) and Tertiary (65-1.5 mya).

The surface of the basement rock outcrops at a few places in the Study Area, but is primarily below the ground surface. Subsurface highs in the basement rock have been identified (**Figure 2-6**). These subsurface highs effect the hydrogeology by isolating the part of the CRBG in the Study Area from the rest of the regional system, and by creating separate groundwater sub-basins (see **Section 2.3**). These bedrock highs are manifested as steptoes, defined as an isolated hill or mountain surrounded by CRBG lava.

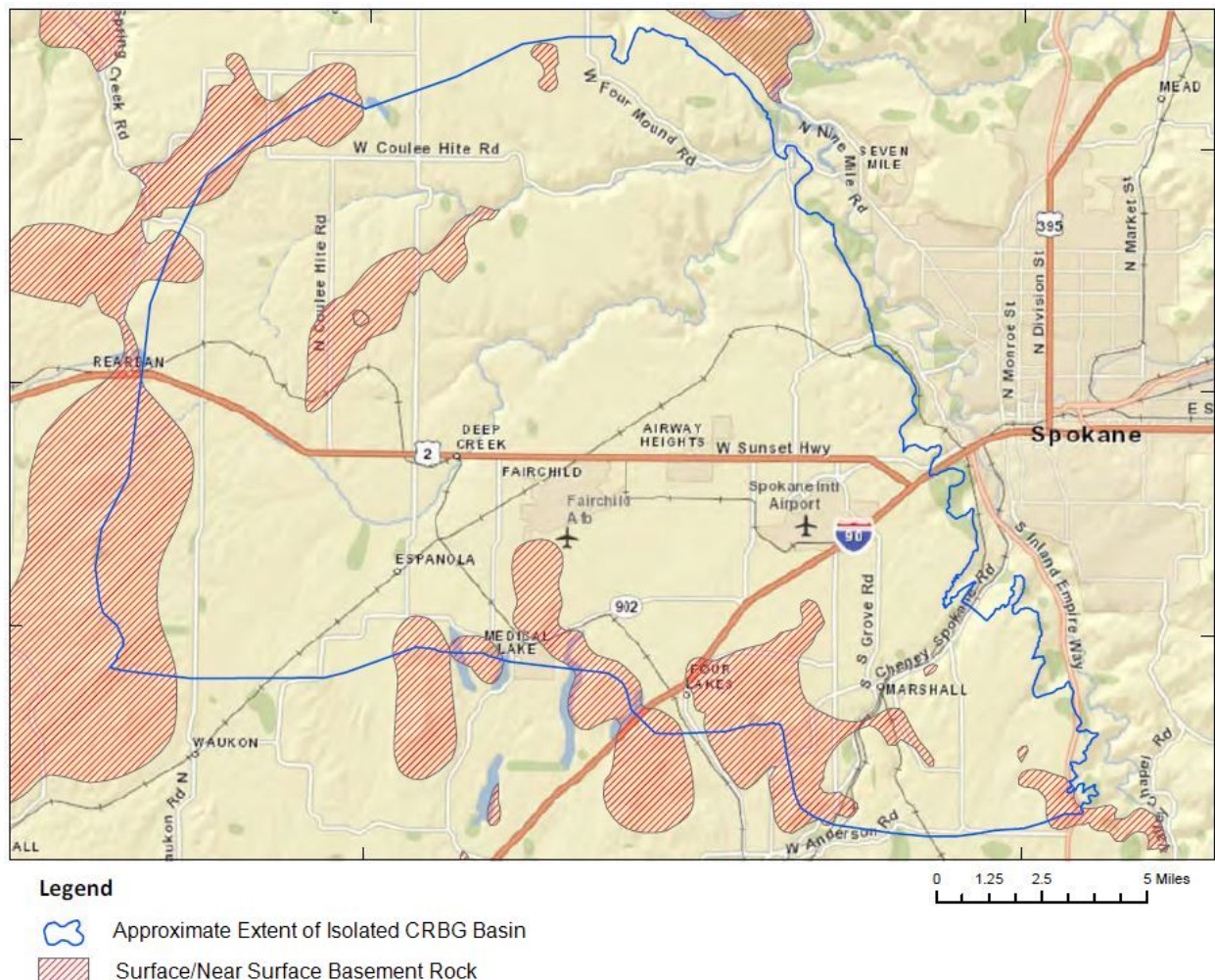


Figure 2-6. Surface or Near Surface Basement Rock (from Spokane County, 2013a)

2.2.2 Tertiary Deposits

Tertiary CRBG lava deposits overlie the basement rock in most of the Study Area, which were deposited during the Miocene (23-5 mya) and consist of a series of basalt flows that came from fissures and vents in eastern Washington, west-central Idaho, and northeastern Oregon. The basalt flows form the CRBG covering large parts of Washington, Oregon, and Idaho.

The Study Area lies on the northeastern margin of the CRBG, and includes the Grande Ronde Basalt and the Wanapum Basalt (**Figure 2-7**). The Grande Ronde Basalt is the thickest and most continuous formation in the Study Area, while the Wanapum Basalt has been significantly eroded at the ground surface and is dissected in many places by paleochannels (see **Section 2.2.3**).

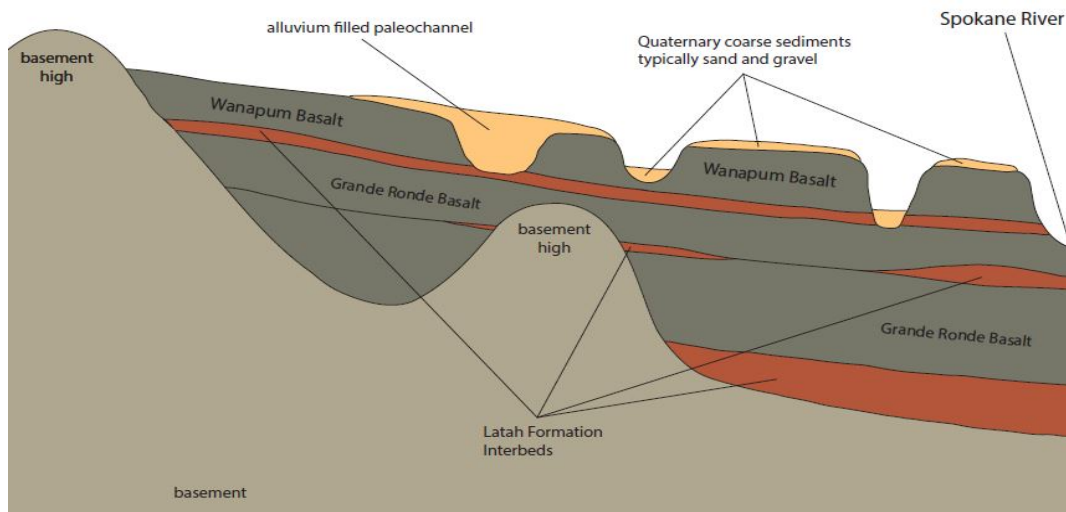


Figure 2-7. Idealized West to East Cross-Section Across Study Area (from GSI et. al, 2015)

The nature of the basalt flows varies from bottom to top as illustrated on **Figure 2-8**. The flows are characterized by dense and less permeable interiors interspersed with more permeable interflow zones.

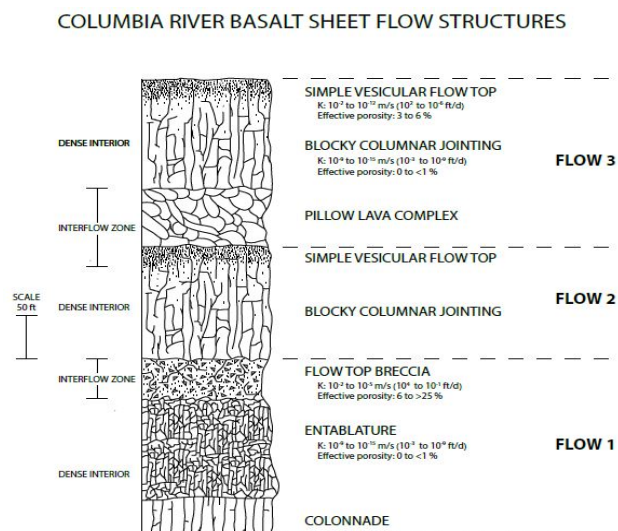


Figure 2-8. Columbia River Basalt Sheet Flow Structures (from GSI et. al, 2015)

Interspersed between the basalt flows is the Latah Formation. This unit is predominantly clayey in nature, and consists of sands, silts, and clays that were deposited in between lava flows when the basalt dammed drainages and created lakes and swamps that covered large areas of lowlands.

2.2.3 Quaternary Geology

Quaternary deposits or alluvium in the Study Area include Pleistocene to Holocene-aged alluvium, Pleistocene Missoula flood deposits, and Pleistocene loess. These Quaternary sediments can be grouped into coarse-grained deposits (Missoula flood deposits and Holocene alluvial deposits) and fine-grained deposits (predominantly loess).

At the eastern margin of the Study Area, a series of catastrophic floods from Glacial Lake Missoula to the east resulted in significant erosion and the ultimate deposit of a thick sequence of coarse-grained material that stretches eastward into Idaho. These units consist of sand with gravels and boulders, and reworked till and outwash. These catastrophic flood deposits make up the Spokane Valley-Rathdrum Prairie (SVRP) aquifer, the extent of which is shown on **Figure 2-9** (in **Section 2.3**).

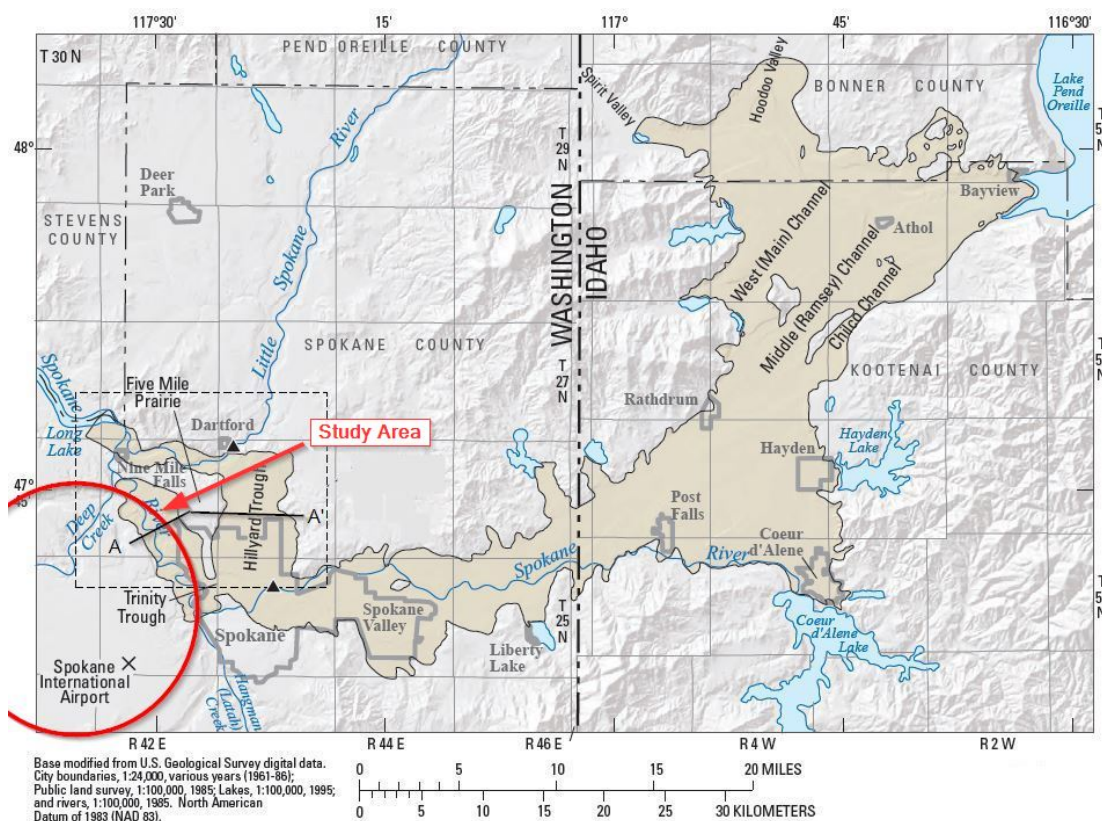


Figure 2-9. Spatial Extent of the SVRP Aquifer (from Kahle and Bartolino, 2007)

A geologic cross section at the edge of the Study Area (A to A' on **Figure 2-9**) is presented on **Figure 2-10**. The depth to bedrock in the Trinity Trough portion of the SVRP that falls within the Study Area is not known for certain but is believed to be up to 500 feet below the Spokane River.

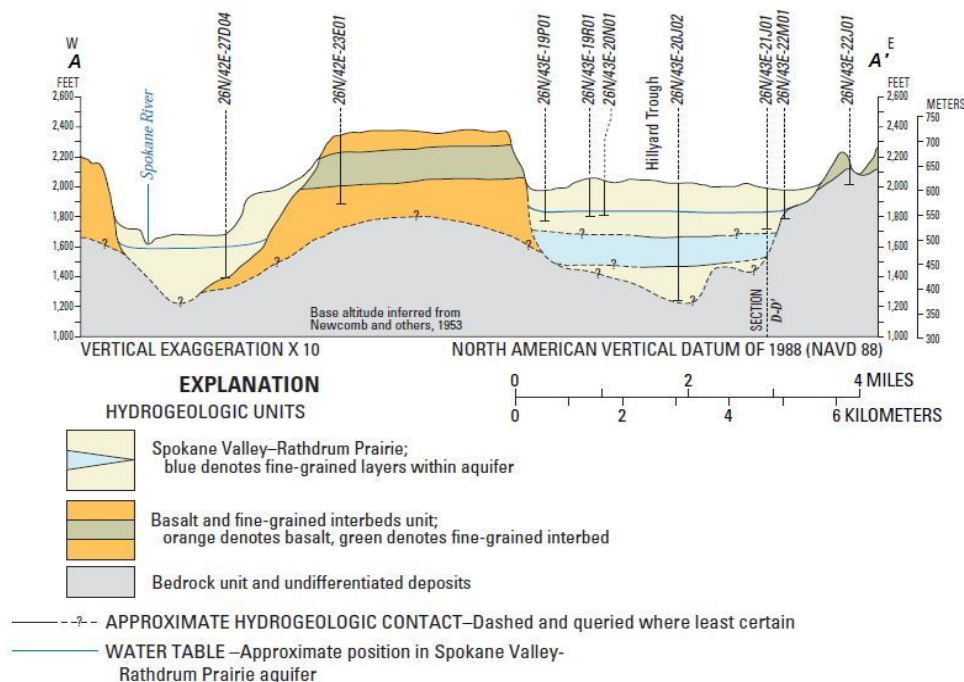


Figure 2-10. Generalized Section of the Western Portion of the SVRP Aquifer (from Hsieh et. al, 2007)

Elsewhere in the Study Area, coarse-grained Quaternary deposits can be found along streams and coulees, and as infill to older paleochannels cut into underlying rock. The approximate location of three of these paleochannels is shown on **Figure 2-11**. Fine-grained deposits consisting of silt, silty sand, and fine sandy loess, occur around hills and valleys but is mostly absent in coulees and drainages.

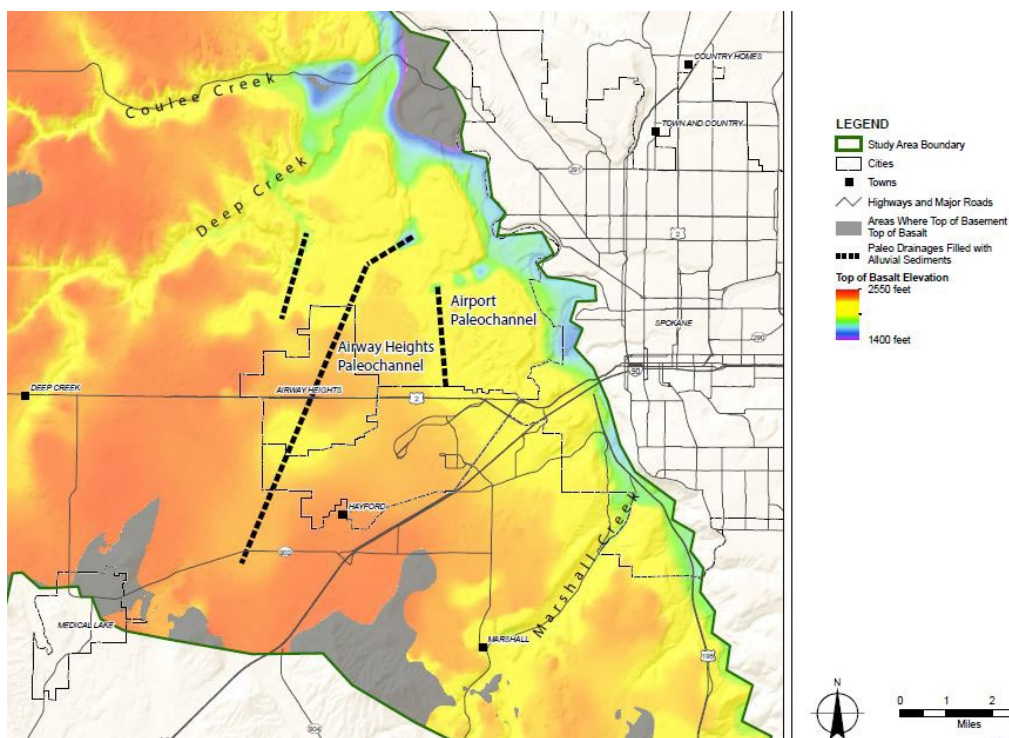


Figure 2-11. Top of Basalt Map and Approximate Location of Paleochannels (from GSI et. al, 2015)

2.2.4 Geologic Structure

Geologic structure in the Study Area is predominantly characterized by a series of northwest-southeast trending faults, as shown on **Figure 2-12**. This figure was developed by GSI et. al (2015) based on work presented by McCollum and Pritchard (2012).

The key faults shown include the Latah Fault, which follows the valley of Hangman Creek and the Spokane River, the St. Joe and Minnie Creek faults to the southeast of Airway Heights, and the Clear Lake and Jump Off Joe faults that lie to the west of Airway Heights and FAFB. Other recent work suggests there is a fault bounding the eastern side of FAFB (AECOM, 2012), however this fault is not shown on geologic maps of that portion of the Study Area.

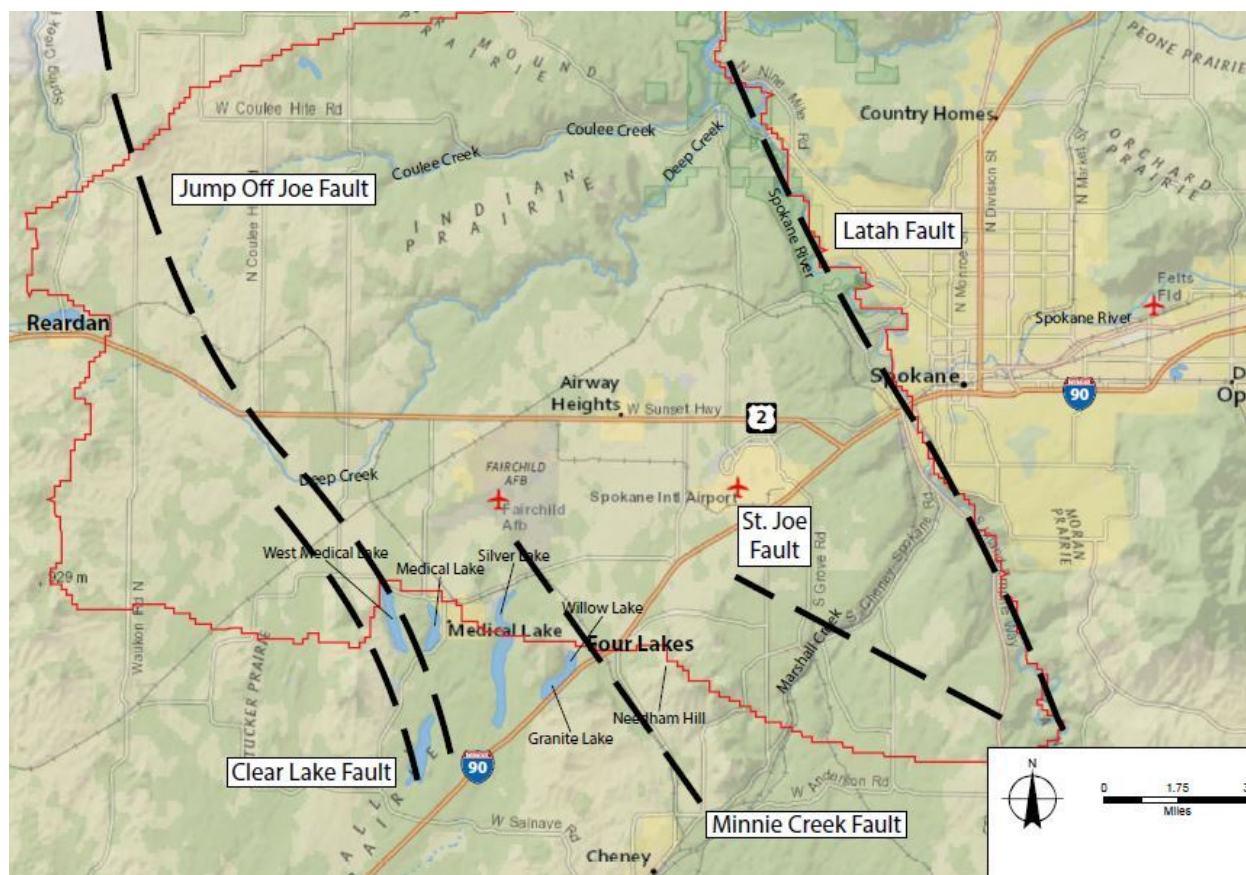


Figure 2-12. Approximate Location of Faults in the Study Area (from McCollum and Pritchard, 2012)

2.3 HYDROGEOLOGY

Aquifers in the Study Area consist of alluvial sediment, the CRBG, basement bedrock, and the eastern margin in the alluvium of the SVRP aquifer (**Figure 2-13**). The southwest portion of the Study Area that is noted as “insufficient data” in **Figure 2-13** appears to be a mix of CRBG, basement rock, and a likely continuation of the sand and gravel paleochannel shown at Airway Heights.

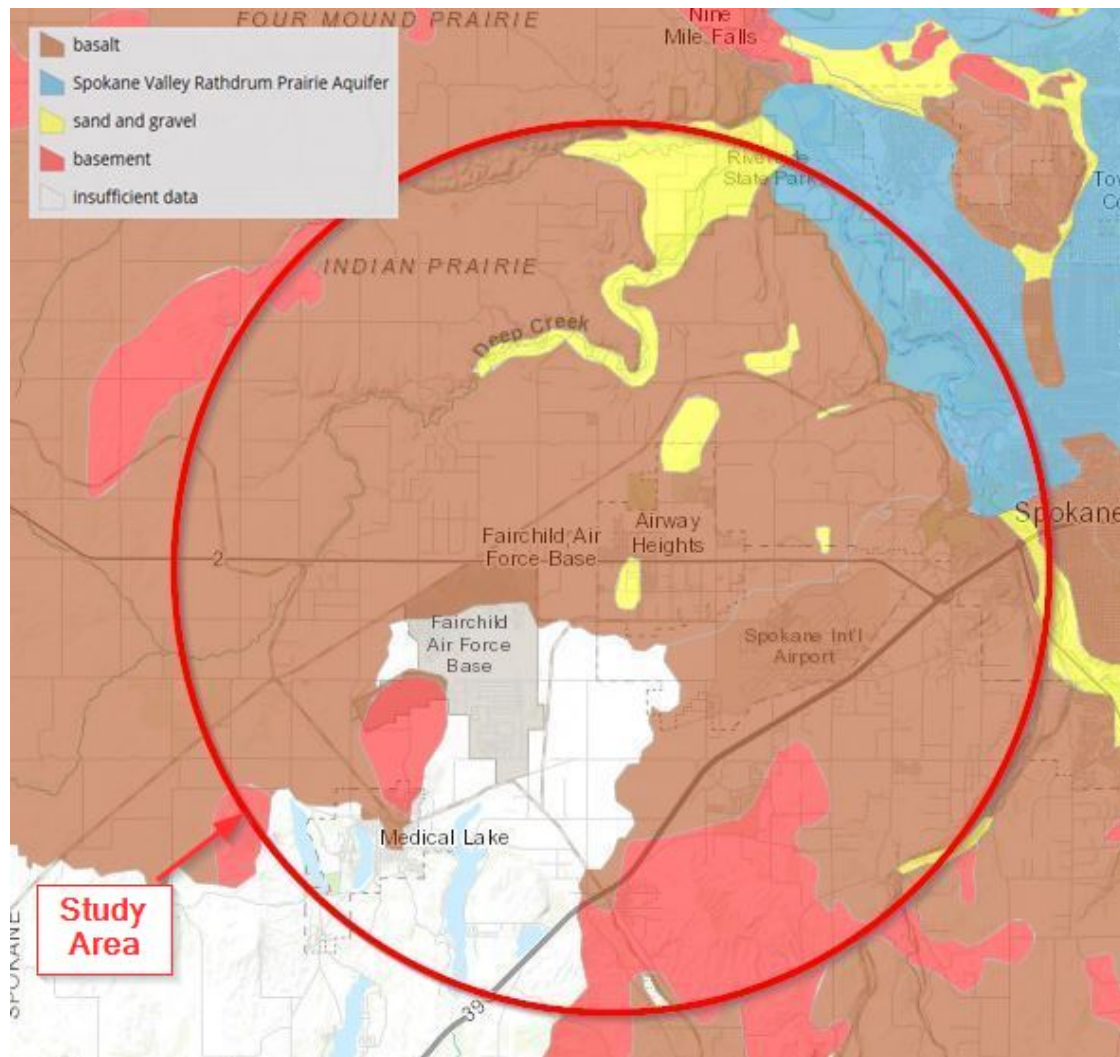


Figure 2-13. Aquifers Within the Hydrogeologic Study Area (from Spokane County website)

The most thorough documents to date describing aquifers in the Study Area are Spokane County (2013a) and GSI et. al (2015) for the West Plains, and Kahle and Bartolino (2007) and Hsieh et. al (2007) for the SVRP aquifer. The descriptions below are derived primarily from these four documents. Additional documentation for WRIA 56 (Hangman) is provided by NLW (2011 and 2012).

2.3.1 Basement Bedrock Hydrogeology

The basement bedrock unit is present at ground surface along the western and southern margins of the Study Area (**Figure 2-6**), and lies beneath the alluvial, basalt, and SVRP aquifers everywhere else. The fine-grained metasediments and crystalline rocks that comprise the basement bedrock unit have a low primary porosity. Groundwater is available in this aquifer where secondary porosity occurs such as fracturing or the faults shown on **Figure 2-12**.

For sufficient water to be available in the basement bedrock, joints and fractures not only need to be able to channel recharge into the aquifer, but also be continuous and interconnected to facilitate movement of groundwater. Wells drilled into basement bedrock aquifer typically produce low yields.

2.3.2 West Plains Alluvial Aquifer

The West Plains Alluvial Aquifer in the Study Area consists of a series of discontinuous, unconsolidated sediment deposits lying on top of basalt. These sediment deposits include paleochannels, which have been incised into the basalt and subsequently filled in with sediment, deposits along current drainages, and unconsolidated deposits that overlay the basalt but are not incised like the paleochannels (**Figure 2-7**). The lateral extent of the alluvial aquifer is controlled by basalt and basement outcrops.

The location of the West Plains Alluvial Aquifer in the Study Area is shown on **Figure 2-13**. However, the location and full extent of paleochannels in the area is still uncertain, and some additional suspected paleochannels are shown on **Figure 2-11**. Characterization of the paleochannels is ongoing with two recent studies (GeoEngineers, 2020 and Pritchard, 2020) providing evidence that the paleochannels may be more interconnected than previously thought. These studies however were not available at the time the modeling work was completed for this Hydrogeologic Study.

Alluvial aquifer thickness appears to range from a few feet to several tens of feet. Depth to water in the alluvial aquifer varies from near surface on floodplains near streams to several feet or tens of feet distally from streams. In the paleochannels, the depth to water can be several tens of feet or more.

Water from the alluvial aquifer discharges to streams and ponds located in coulees and locally to the underlying basalt. The presence of paleochannels and modern drainage channels where the alluvial aquifer occurs serves to alter groundwater flow between basalt units that the alluvium is incised through. The nature of the change in flow is not well understood but likely routes water along the alluvial channels preferentially before continuing on the downgradient side of where the alluvium interrupts the basalt.

Hydraulic conductivity of the alluvial aquifer can range from hundreds to thousands of feet per day (feet/day) where the material is coarse to 3 to 5 orders of magnitude lower where fine-grained alluvial sediments are present. Coarse alluvium can be highly transmissive and produce high well yields on a short term basis, but the limited spatial extent of the material limits the long term sustainability of those yields.

2.3.3 CRBG Aquifer System

The CRBG aquifer system in the Study Area consists of three parts: the Wanapum Basalt and the upper and lower Grande Ronde Basalt. Groundwater in the CRBG aquifer system occurs primarily in interflow zones and interbedded Latah Formation sediments, where present (**Figure 2-8**). Interflow groundwater is present in joints, vesicles, fractures, brecciated basalt flow tops and bottoms and in sediment interbeds. Hydraulic conductivity of the interflow zones average 0.1 feet/day and can be as high as 1,000 feet/day, while the hydraulic conductivity of the dense interiors is 6 to 9 orders of magnitude less than the flow tops and bottoms (USDOE, 1988).

The discrepancy in hydraulic conductivity of the flow tops and bottoms from that of the dense interior, and the planar nature of the basalt flows results in groundwater flow in the CRBG aquifer system that travels down dip, or from west to east towards the Spokane River. Generalized potentiometric maps of the Wanapum and Grande Ronde aquifers are shown on **Figure 2-14** and **Figure 2-15**, respectively.

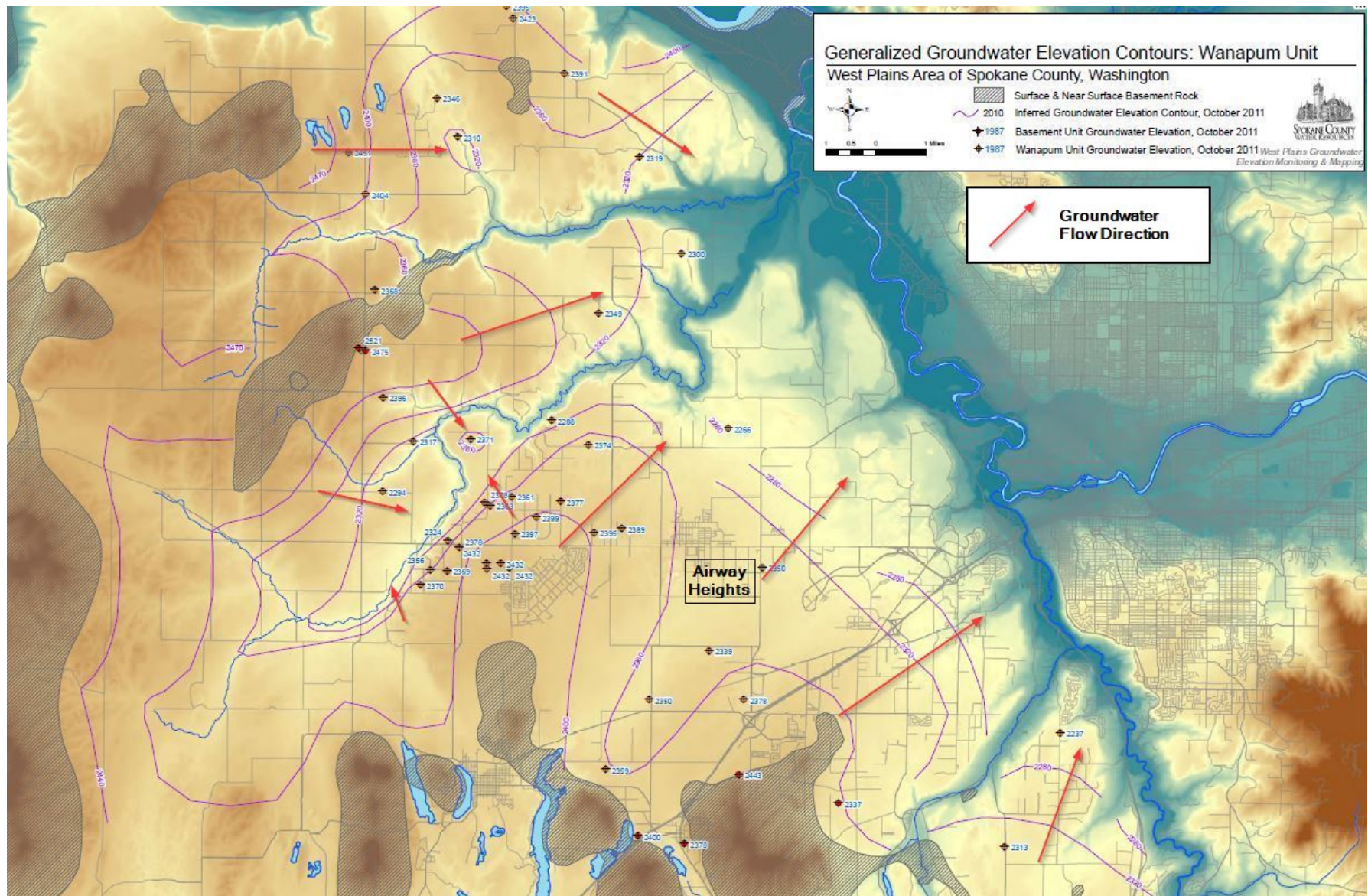


Figure 2-14. Groundwater Contours-Wanapum Basalt (from Spokane County, 2013b)

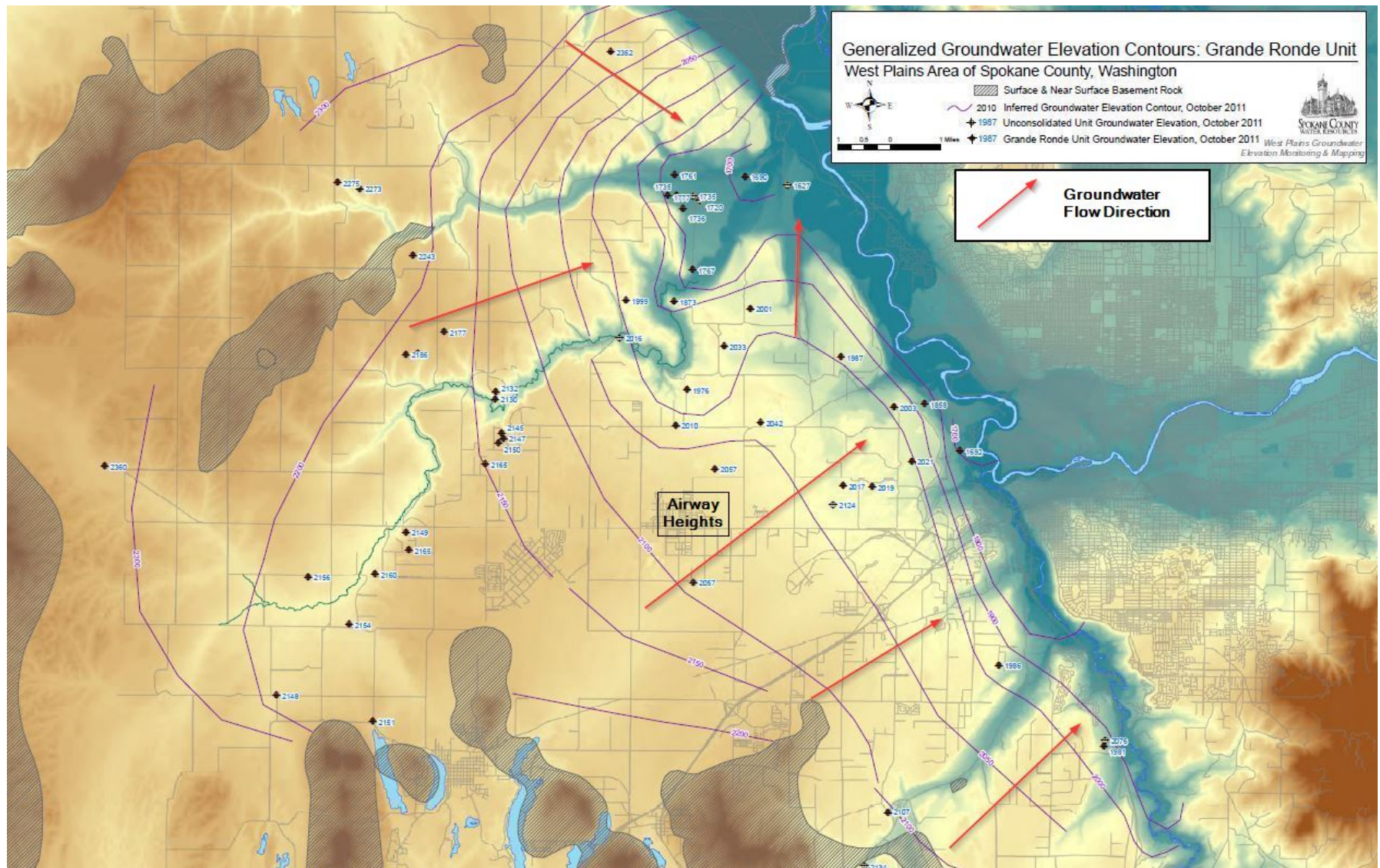


Figure 2-15. Groundwater Contours-Grande Ronde Basalt (from Spokane County, 2013b)

Note that **Figure 2-14** and **Figure 2-15** are generalized groundwater elevation contours. Adjacent wells in the CRBG can have similar or very different groundwater elevations depending on whether they are screened across similar intervals. Wells used to generate the two groundwater elevation maps were chosen to represent similar units within the CRBG.

The primary source of recharge for the CRBG in the Study Area is from precipitation. A critical influence on groundwater flow and occurrence in the CRBG is the presence of basement bedrock highs. Basement Bedrock at or near ground surface to the west and south in the Study Area (**Figure 2-6**) has the effect of creating a groundwater divide that isolates this portion of the CRBG aquifer from the much larger portion of the CRBG that extends into Idaho and Oregon. Groundwater flow in the larger part of the CRBG is generally to the south-southwest, while in the Study Area groundwater flow is to the northeast. As a result, the CRBG in the Study Area does not receive any groundwater inflow from the rest of the CRBG.

In addition, the basement bedrock highs appear to have the effect of compartmentalizing flow in the CRBG in the Study Area. Inferred bedrock ridges in the Study Area are shown on **Figure 2-16**. Portions of these bedrock ridges have been identified from drilling records and geophysical studies, or have been inferred from differences in well hydrographs and water level responses to pumping.

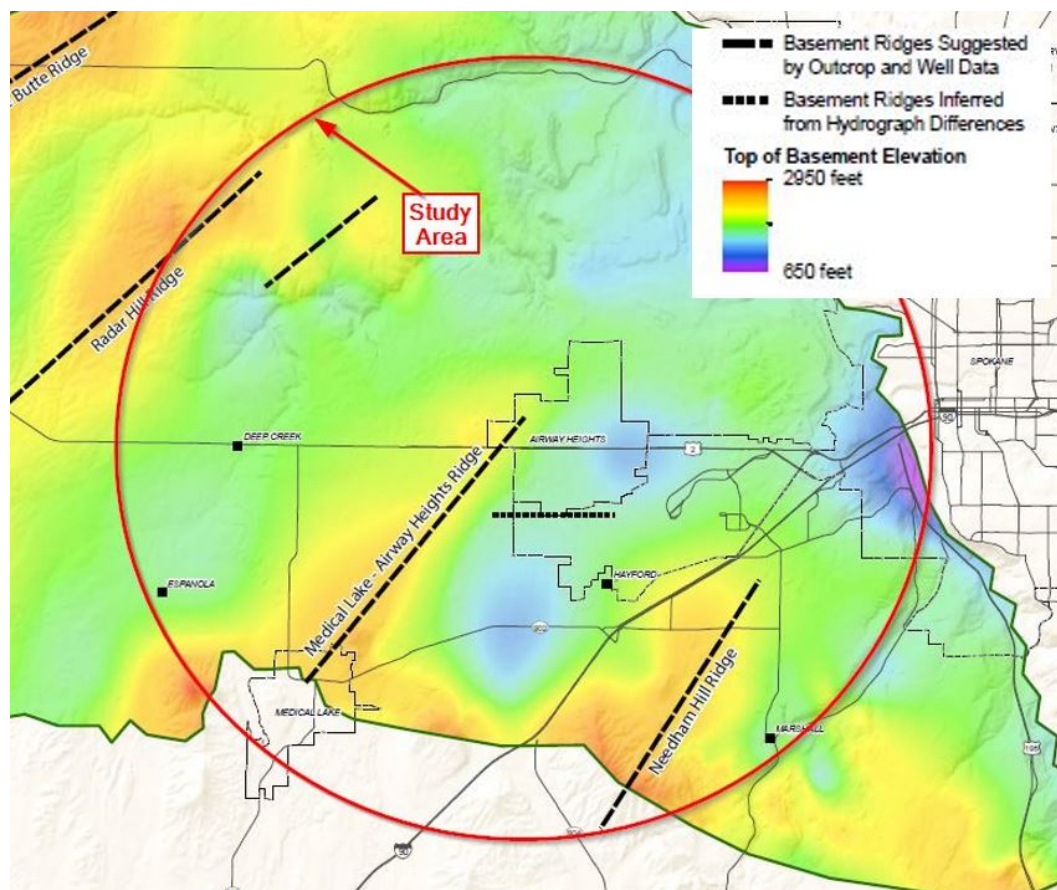


Figure 2-16. Compartmentalized Basalt Sub-Basins (from GSI et al., 2015)

Groundwater levels in the CRBG aquifer system have declined over recent years in some places within the Study Area. Select well locations and hydrographs for the Airway Heights area are shown on **Figures 2-17**

and 2-18, for the area west of FAFB on **Figures 2-19 and 2-20**, and for the area north of Airway Heights on **Figures 2-21 and 2-22**.

Hydrographs for the Four Lakes and Parkwest wells (**Figure 2-18**) show a significant decline of about 200 feet, coincident with Parkwest pumping. The water level declines illustrate the limited nature of recharge for the CRBG in the Study Area. Parkwest is one of Airway Heights wells, and reduction of pumping of the well has resulted in a moderate recovery.

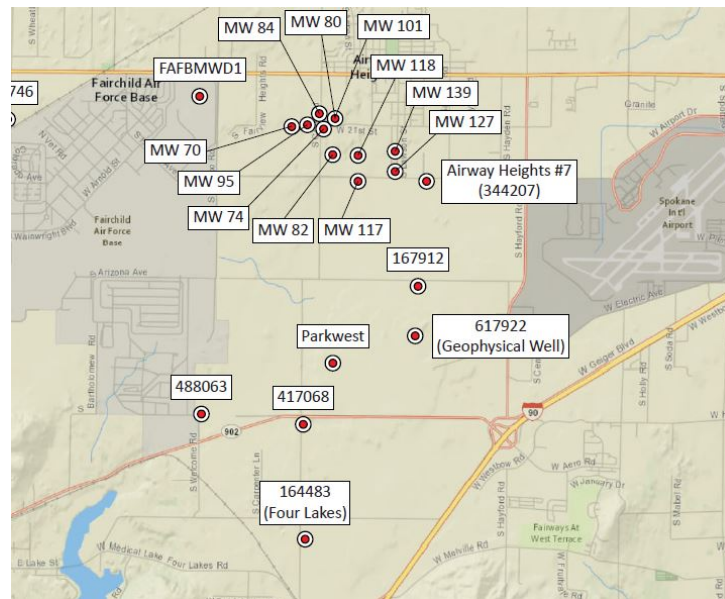


Figure 2-17. Select Wells in the Airway Heights Area (from GSI et al., 2015)

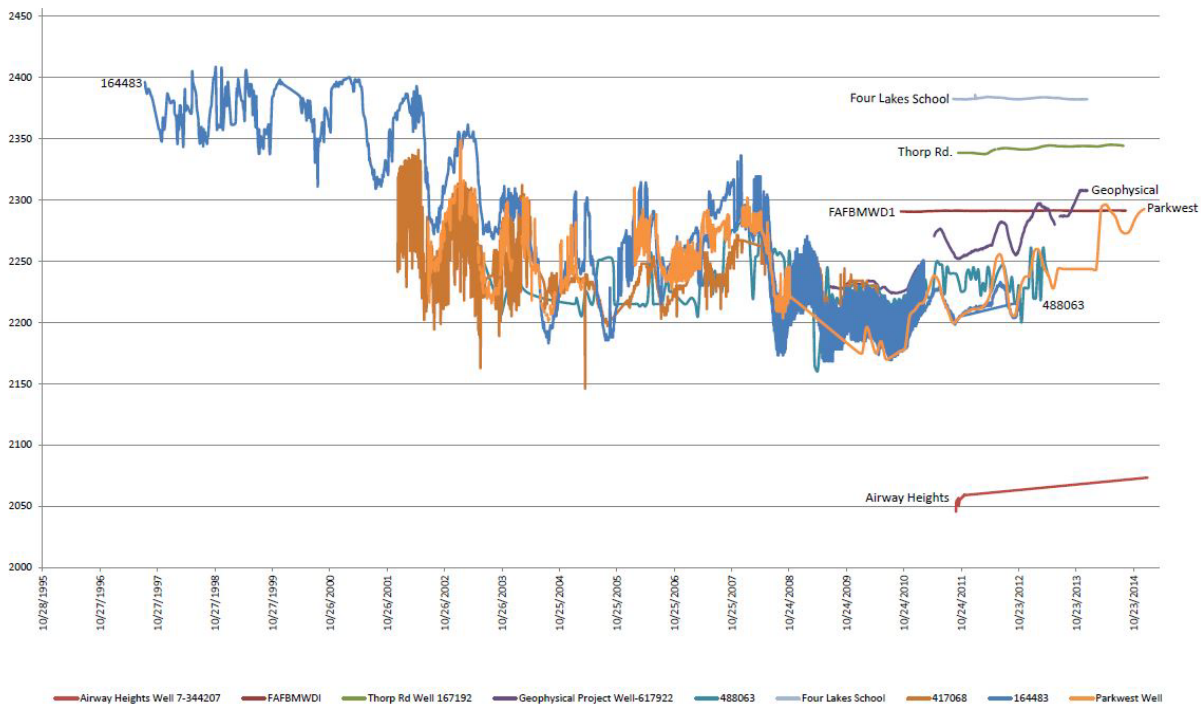


Figure 2-18. Hydrographs for Select Wells in the Airway Heights Area (from GSI et al., 2015)

Wells west of FAFB (**Figure 2-20**) show fairly stable water levels with seasonal fluctuations of about five feet for the period 1991 to 2013. All of these wells are screened in the Wannapum Basalt.

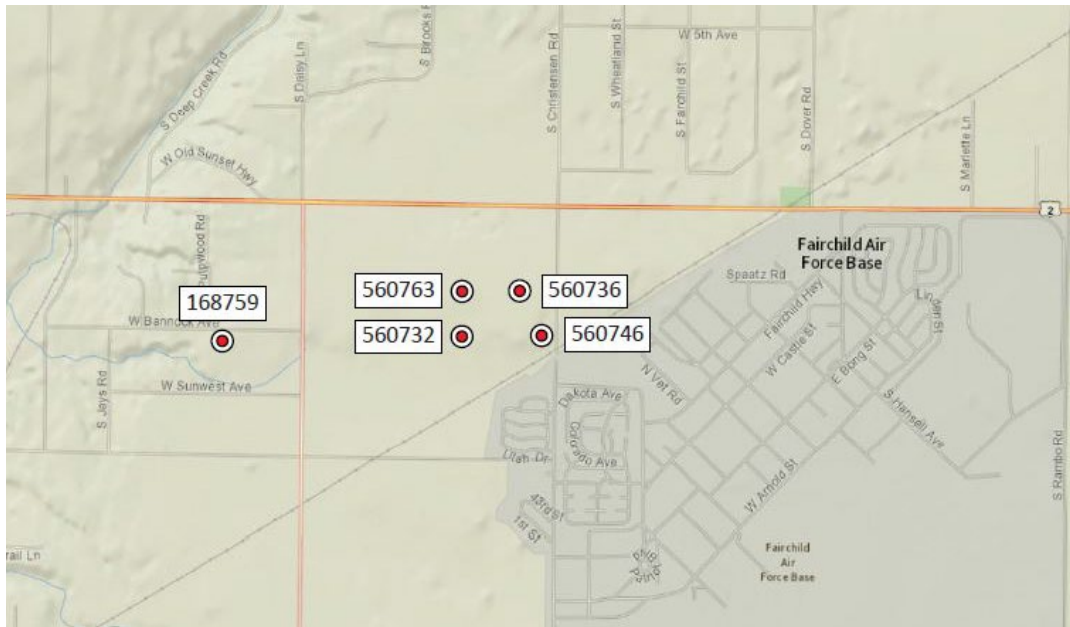


Figure 2-19. Select Wells West of FAFB (from GSI et al., 2015)

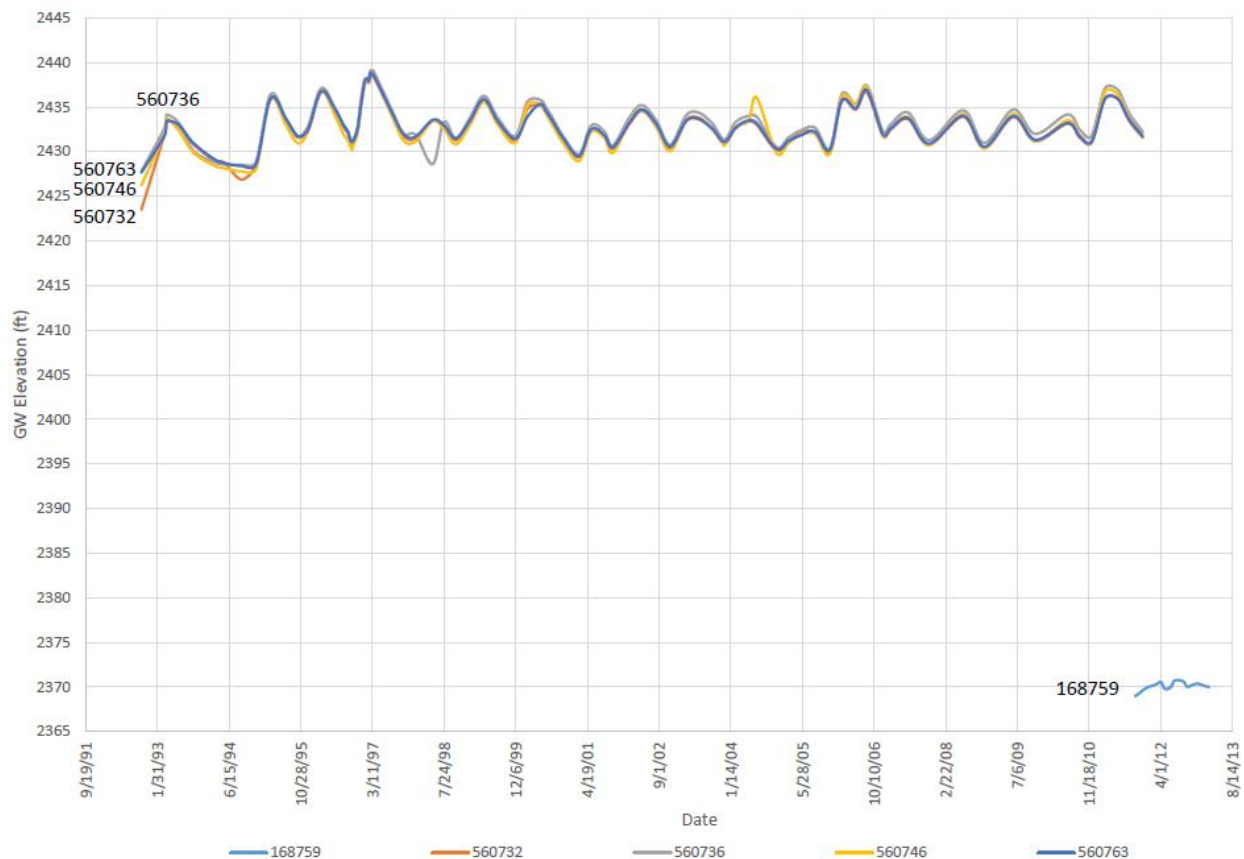


Figure 2-20. Hydrographs for Select Wells West of FAFB (from GSI et al., 2015)

Hydrographs for wells north and northeast of Airway Heights (**Figure 2-22**) exhibit generally stable water levels for the period 2011 to 2014. Well 472535 is screened in a paleochannel north of the airport, and the hydrograph shows a slight decline in water levels. The other wells are all screened in the Grande Ronde basalt. Well PCA 411175 is east of the West Plains plateau and fluctuations are considered to be the result of interaction with the Spokane River.

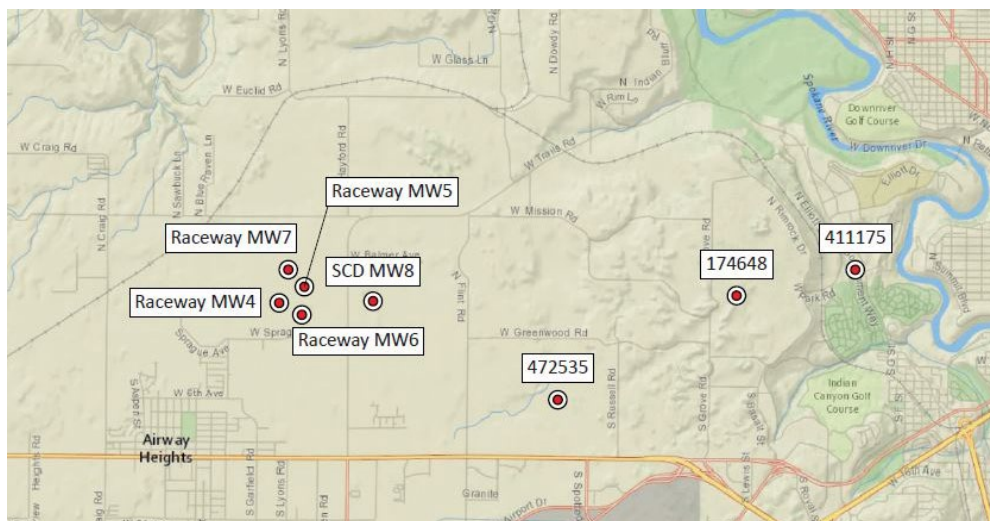


Figure 2-21. Select Wells North of Airway Heights (from GSI et al., 2015)

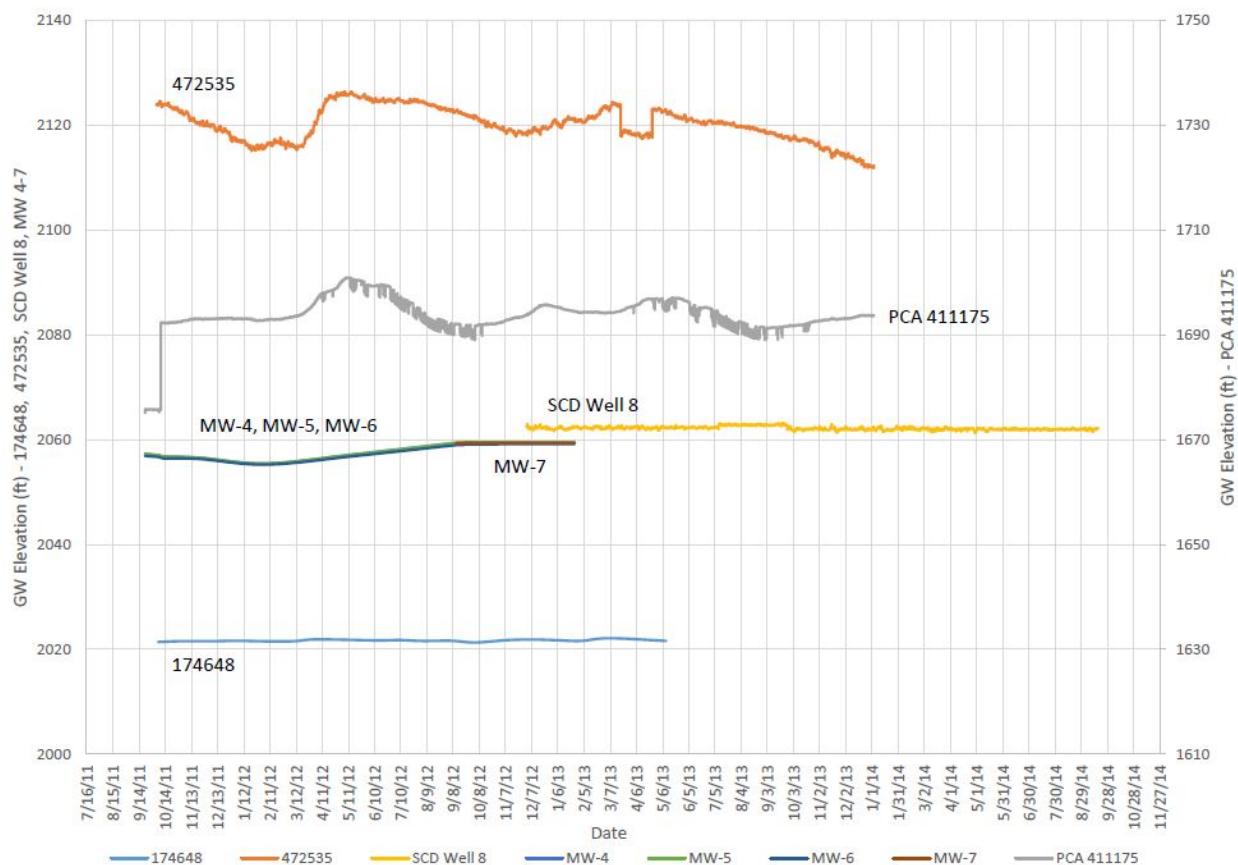


Figure 2-22. Hydrographs for Select Wells North of Airway Heights (from GSI et al., 2015)

Age dating of groundwater in the CRBG aquifer system, completed over the past several years (NLW, 2014; GWMA, 2009), has shown recharge to deeper units in the West Plains to be very slow, ranging from thousands to several tens of thousands of years.

Ages of water in the West Plains and Hangman Creek area from NLW (2014) are shown on **Figure 2-23**. Ages of deep groundwater range from 3,310 to over 15,000 years, except near Deep Creek where the age is much younger (350 years) indicating quicker recharge to the deep aquifer in this area. Results from intermediate depths are only shown for one well, and the age at that location (8,220 years) appears to be older than the deeper unit. The age of groundwater in shallow wells generally range from 1,800 to about 5,000 years, with the exception of near Deep Creek where the age is only 105 years.

The old age of many of these groundwater samples, particularly the deeper ones, illustrates the hydrologic isolation of this portion of the CRBG. Recharge takes a very long time to reach some of the deeper aquifers, and as a result the water availability and sustainability in many areas appears to be questionable, and the slow rate of recharge indicates that the basalts are vulnerable to depletion. The word depletion in this report is a commonly used term for water rights applications and refers to reduced stream flows or available water in an aquifer.

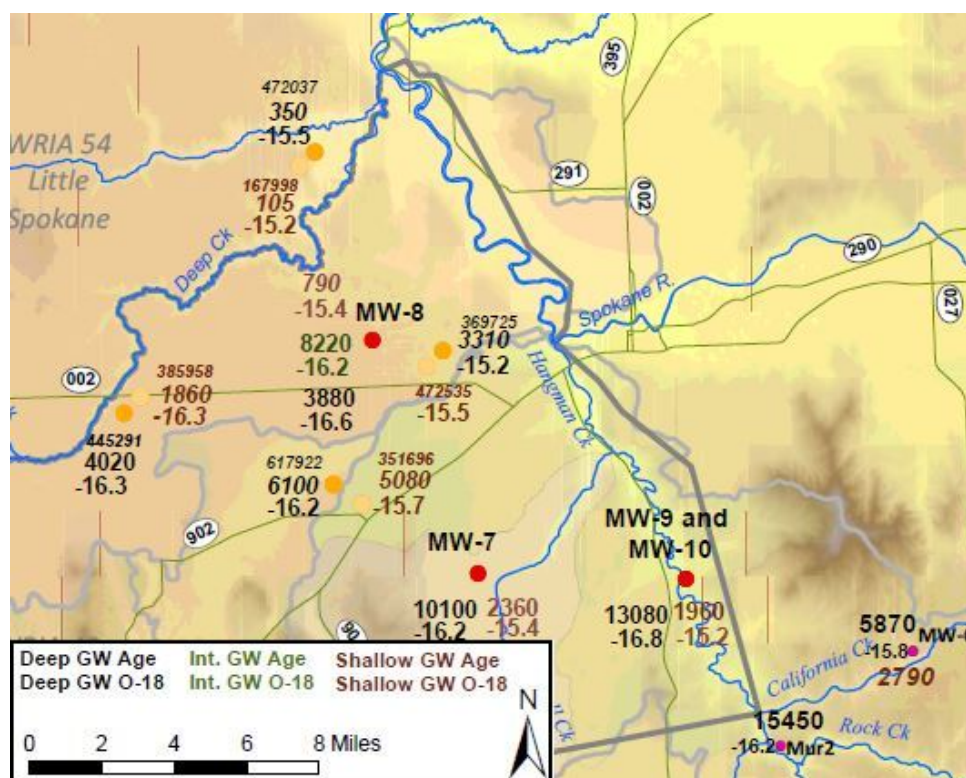


Figure 2-23. Groundwater Age Dating Results (from NLW, 2014)

2.3.4 SVRP Aquifer

On the eastern margin of the Study Area is a portion of the SVRP aquifer that extends eastward into Idaho and covers about 370 square miles (**Figure 2-9** and **Figure 2-24**). This aquifer is comprised largely of

outburst flood gravels, cobbles, and boulders and is the sole source of drinking water for over half a million people.

Groundwater flow in the SVRP aquifer is generally from east to west as shown on **Figure 2-24**. Flow in the Washington State part of the aquifer generally follows the Spokane River with groundwater entering and being recharged by the river over different stretches. At the City of Spokane, groundwater flow splits with one split heading northward into the Hillyard Trough and following the Little Spokane River before rejoining the Spokane River. The other groundwater split at Spokane follows the Spokane River and heads northwest through the Trinity Trough.

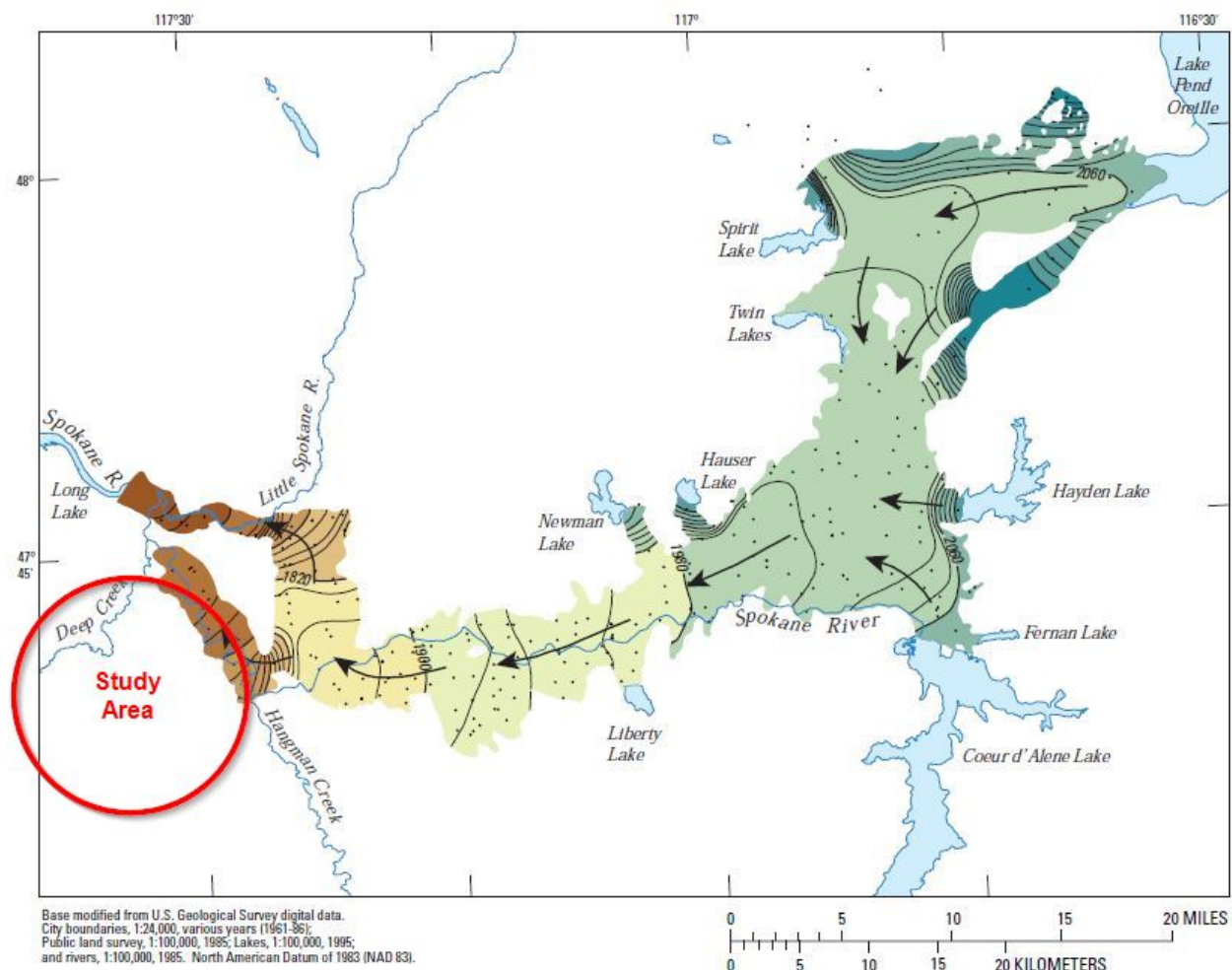


Figure 2-24. SVRP Groundwater Elevations (from Hsieh et. al, 2007)

A large amount of water moves through the SVRP as shown by the overall water budget on **Figure 2-25**. As of 2007, the total inflow to the aquifer was estimated to be 1,471 cubic feet per second (cfs). Inflows are mostly from the Spokane River (718 cfs), tributary lakes and basins (399 cfs), and areal recharge (233 cfs). The aquifer primarily discharges to the Spokane and Little Spokane rivers (861 and 232 cfs, respectively), and is pumped for public water supply (205 cfs). Tributary basins in the Study Area are shown on **Figure 2-26**.

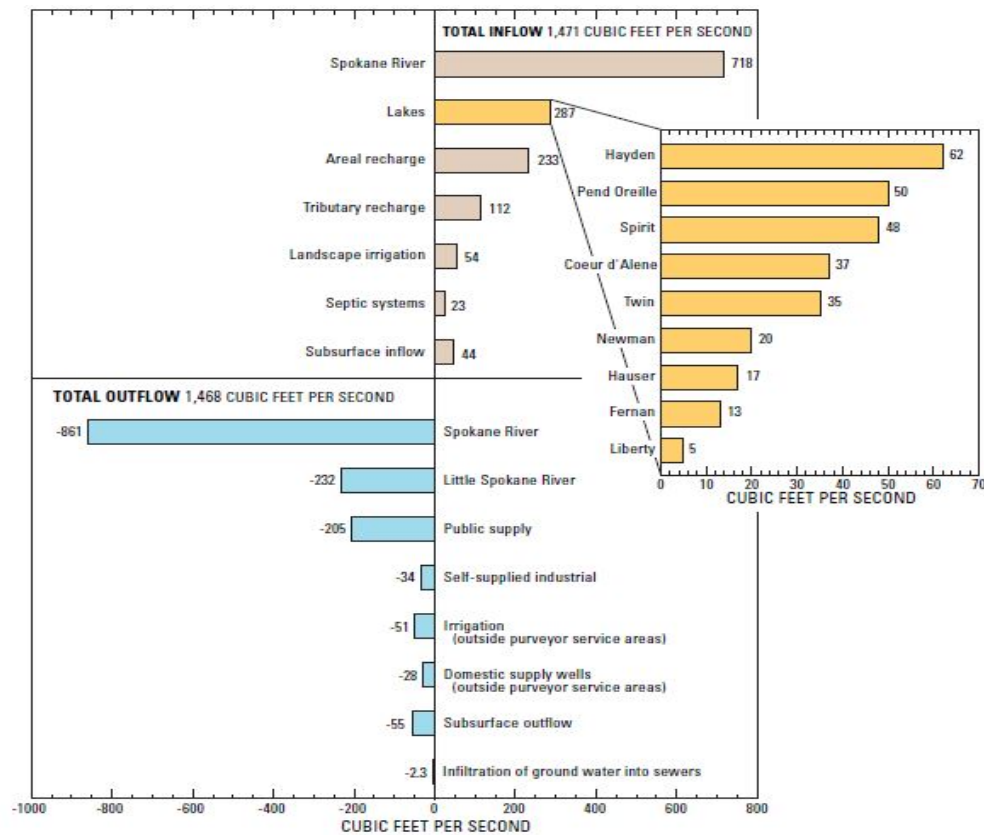


Figure 2-25. SVRP Water Budget (from Hsieh et. al, 2007)

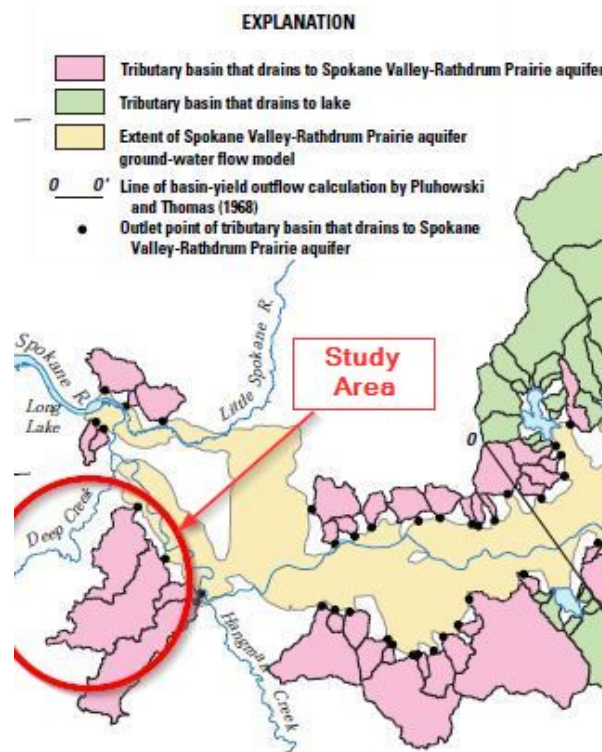


Figure 2-26. SVRP Tributary Basins (from Hsieh et. al, 2007)

The coarse-grained nature of the SVRP aquifer facilitates multiple high-yield wells. Water purveyor wells that lie in the SVRP aquifer are shown on **Figure 2-27**, but there are many more high-yield wells including agricultural wells. Two water purveyor wells fall inside the Study Area, one of which is for FAFB.

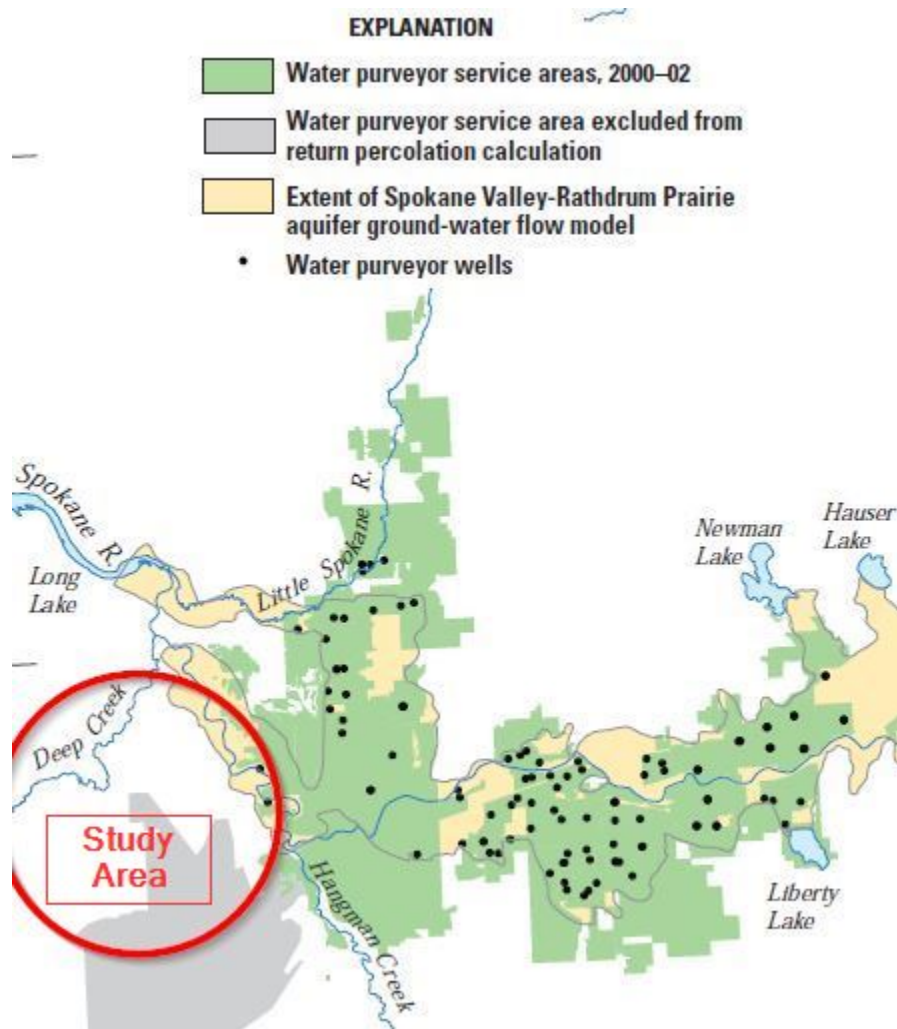


Figure 2-27. SVRP Water Purveyor Wells (from Hsieh et. al, 2007)

2.4 SURFACE WATER

Key surface water bodies in the Study Area are shown on **Figure 2-1**. The Spokane River to the northeast is the dominant drainage in the Study Area. Several tributary creeks flow toward the Spokane River, including Deep Creek (joined by Coulee Creek) and Hangman Creek (joined by Marshall Creek). Of these four creeks, only Hangman Creek provides perennial surface water flow to the Spokane River.

Information on surface water conditions in the Study Area are documented in the WRIA 54 Watershed Plan and Implementation Plan (Tetra Tech, 2009 and 2010), and the WRIA 56 Watershed Plan (SCCD, 2005). Additional studies related to surface water in the Study Area include Fernandez (2009) and Kahle and Bartolino (2007) for the Spokane River, Kahle et. al (2013) for the Little Spokane River (including portions of the Spokane River), GeoEngineers (2011) for Deep Creek, and Spokane County (2013a) for groundwater-surface water interaction in the West Plains.

2.4.1 Spokane River

The Spokane River has several gaining and losing reaches as it flows from Idaho through the Study Area. A map of the gaining and losing reaches from Kahle et. al (2005) is shown on **Figure 2-28**. The reach within the Study Area is primarily gaining. A short losing reach lies downstream above the Little Spokane River confluence.

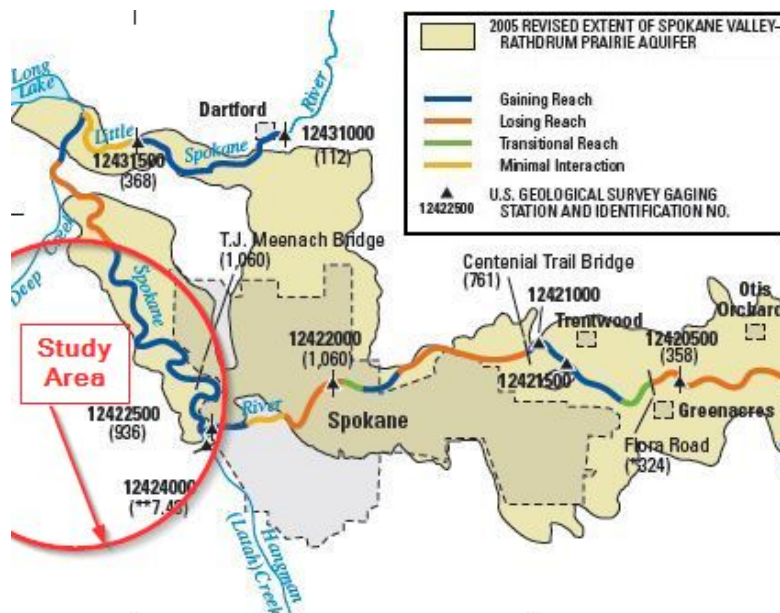


Figure 2-28. Spokane River Gaining and Losing Reaches (from Kahle et. al, 2005)

Data from USGS gages on the Spokane River at Spokane (USGS gage #12422500) and Below Nine Mile Dam (USGS gage #12426000) were reviewed for this study. These gages are shown on **Figure 2-29**.

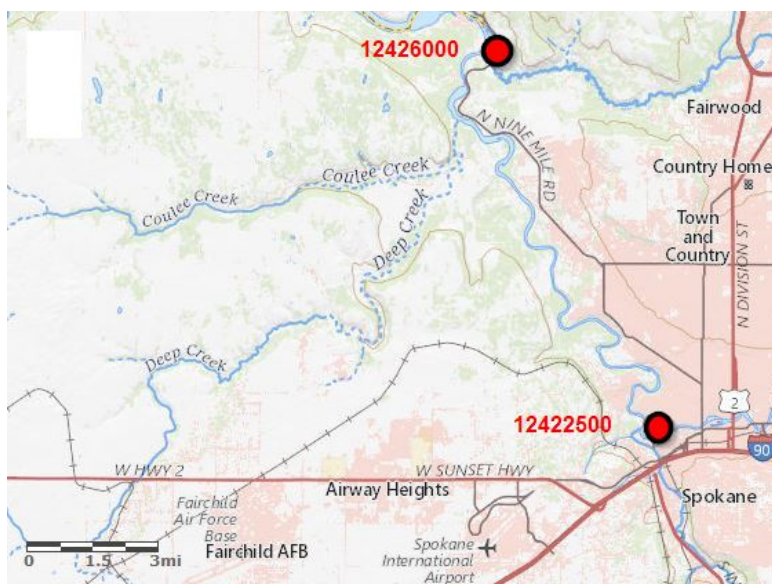


Figure 2-29. USGS Gages on the Spokane River Reviewed for this Study

The USGS gage at Spokane has the longest period of record of data of any gage in Washington State, with flow data from 1891 to present. This gage site is upstream of the Study Area, and is a key location marking the instream flow rights discussed in **Section 3.5** (850 cfs for June 16-September 30).

A plot of daily mean, minimum, and maximum flows for the entire dataset of the Spokane gage is shown on **Figure 2-30**. Mean flows typically peak in May at just under 20,000 cfs and are lowest during July-September. The lowest minimum flows typically occur in August. Maximum flows are highest in the winter and spring months.

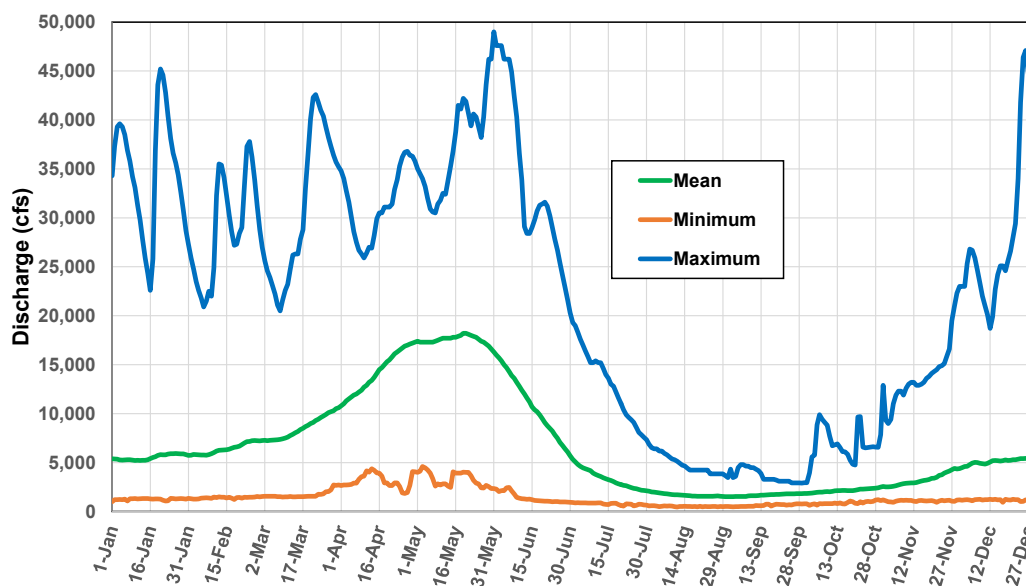


Figure 2-30. Daily Flows for Gage 12422500 (1891-2018)

Yearly minimum flows at the Spokane gage for the period 1980 to 2018 are shown on **Figure 2-31**. The instream flow right of 850 cfs established in 2015 is also plotted.

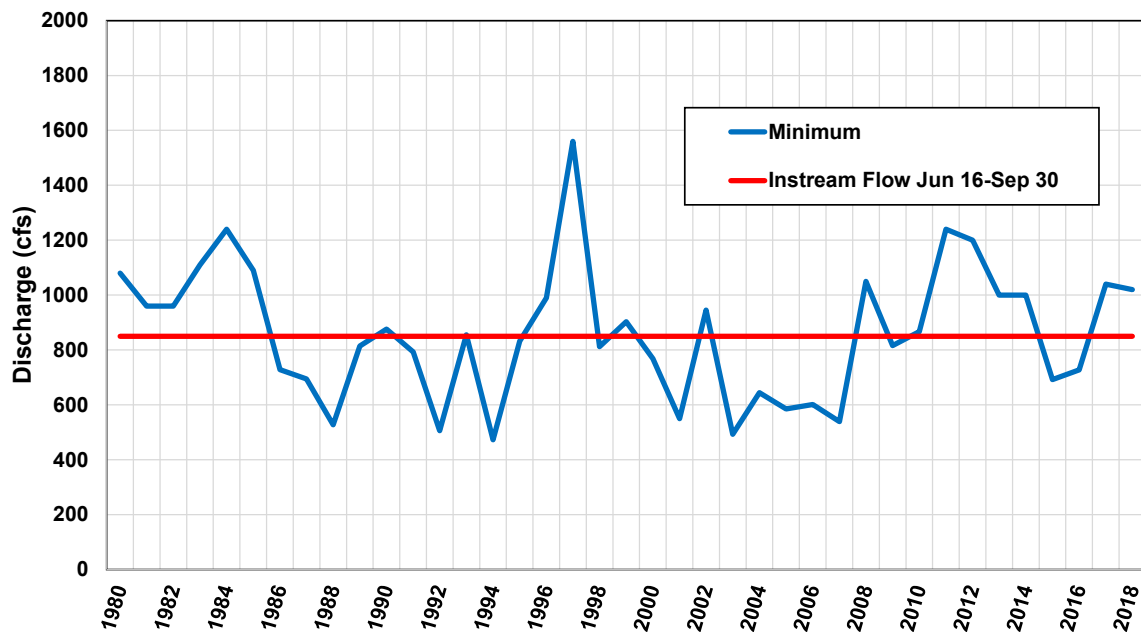


Figure 2-31. Yearly Minimum Flows for Gage 12422500 (1980-2018)

For the past 39 years, yearly minimum flows for about half of the years (19 of the 39 years) are below the instream flow right established in 2015. As a result, potential impacts to the river above this gage, such as pumping from groundwater connected to the river, are being studied by Ecology.

The Spokane River in the Study Area lies downstream of the gage at Spokane where instream flow regulations have been established (see **Section 3.5.1**). Along this reach of the river, tributary flows join in, including Hangman Creek, Deep Creek (seasonally), and the Little Spokane River just below the Study Area.

Further downstream is the USGS gage below Nine Mile Dam (**Figure 2-29**). A plot of daily mean, minimum, and maximum flows for the entire dataset is shown on **Figure 2-32**. The dataset from this gage is much smaller than from the Spokane gage, but it does show tributary flow contributions from the Little Spokane River, and to a lesser extent from Hangman Creek and Deep Creek. Flows below the dam on the river are higher than at Spokane (**Figure 2-30**), in particular the minimum and mean flows.

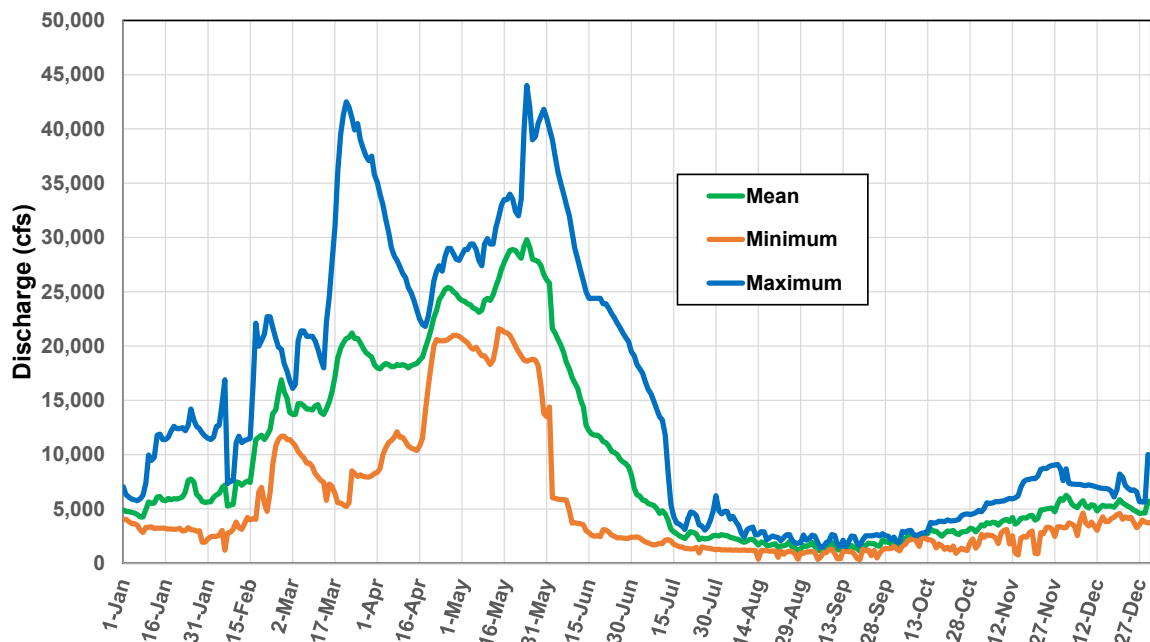


Figure 2-32. Daily Flows for Gage 12426000 (1948-1950, 2016-2018)

2.4.2 Hangman Creek and Marshall Creek

Hangman Creek flows perennially into the Spokane River and a USGS gage near the confluence provides flow data for a reasonably long period (1948-2017). The Hangman Creek basin drains 689 square miles.

A plot of daily mean, minimum, and maximum flows for the entire dataset is shown on **Figure 2-33**. Flow patterns are similar to the Spokane River with peaks of mean flow of about 1,000 cfs occurring in the spring, albeit slightly earlier, in March.

Flows in Hangman Creek decline significantly during the summer, and an expanded plot of the summer months is shown on **Figure 2-34**. Minimum flows range from less than 1 cfs to about 43 cfs, with the average low flow being about 5 cfs (SCCD, 2005).

Flow in Marshall Creek was measured at 0.6 to 1.7 cfs in the summer of 2001 and 2002 (SCCD, 2005). During that same time, SCCD noted that flow in Hangman Creek increased by 2 to 6.5 cfs below the confluence with Marshall Creek.

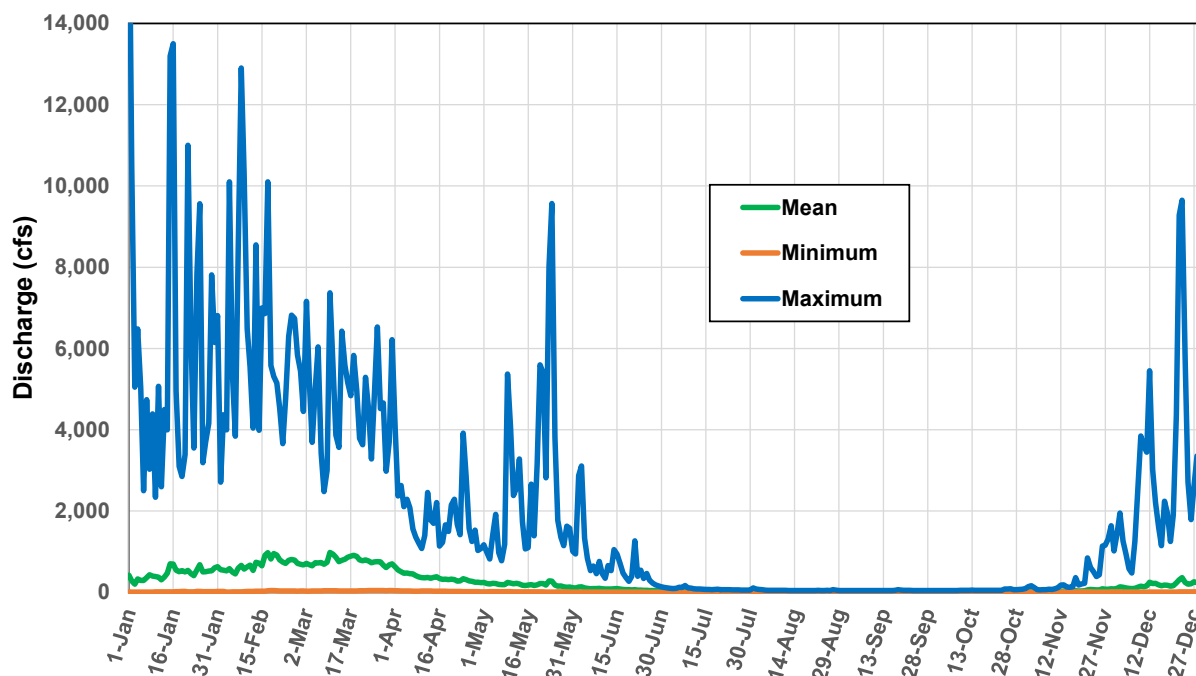


Figure 2-33. Daily Flows for Gage 12424000-Hangman (1948-2017)

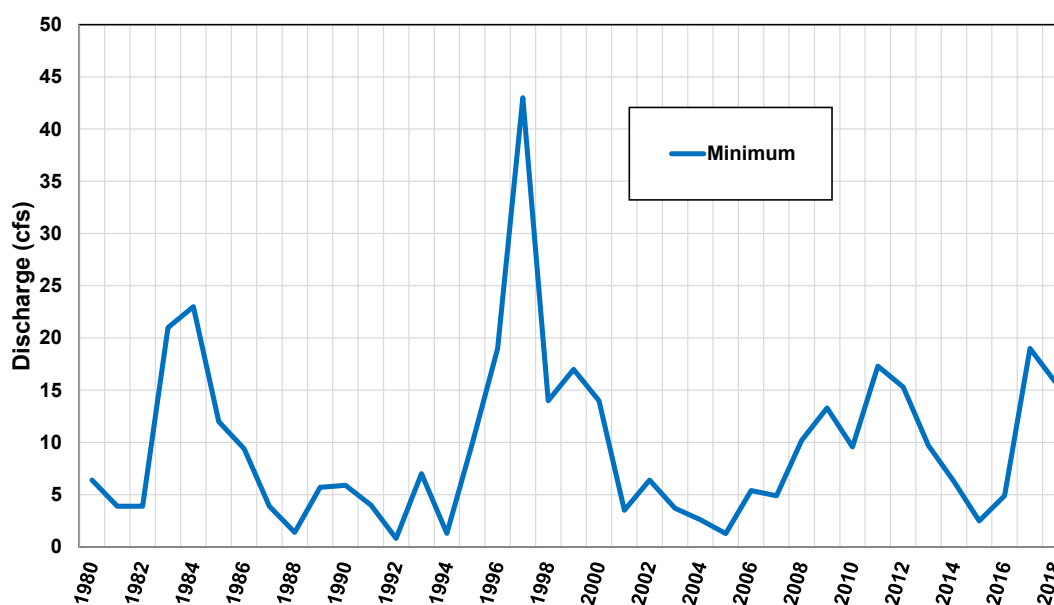


Figure 2-34. Yearly Minimum Flows for Gage 12424000 (1980-2018)

2.4.3 Deep Creek and Coulee Creek

Deep Creek and Coulee Creek begin in the steptoes near Reardon, starting 3 miles apart and converging about 0.75 miles from the Spokane River. The creeks originate in rolling hills and descend into narrow and steep-walled valleys. The last 4 miles of creek bed lie on top of a thick sequence of sand and gravel.

Most of the year Deep Creek does not discharge into the Spokane River and in some years there is no discharge (Spokane County, 2013a).

Streamflow measurements for both creeks are limited. Measurement locations and flow measurement data from measurements in 2010 (GeoEngineers, 2011) and in 2012 (Spokane County, 2013a) are summarized in **Table 2-1**, with the locations shown on **Figure 2-35**. The data collected in May-July of 2010 and in September and October 2012 show that both creeks gain water in their upper reaches, then lose water before going completely dry.

Table 2-1. Deep Creek and Coulee Creek Stream Flow (from Spokane County, 2013a)

Date	Deep Creek 2	Deep Creek 8	Deep Creek 13	Coulee Creek 1	Coulee Creek 2
Water Quality Study					
5/23/10	1.9	3.8	1.4	0	1.8
6/6/10	4.7	8.9	3.7	2.6	3.1
6/22/10	4.5	6.2	1.8	1.6	2.4
7/12/10	0.5	2.7	0.9	0.2	0.5
7/25/10	0.3	1.5	0.6	0.1	0.3
Deep & Coulee Creek Seepage Run					
9/24/12	0.23	2.15	0.38	-	-
10/1/12	-	0	-	0	0.1

stream flow values in CFS

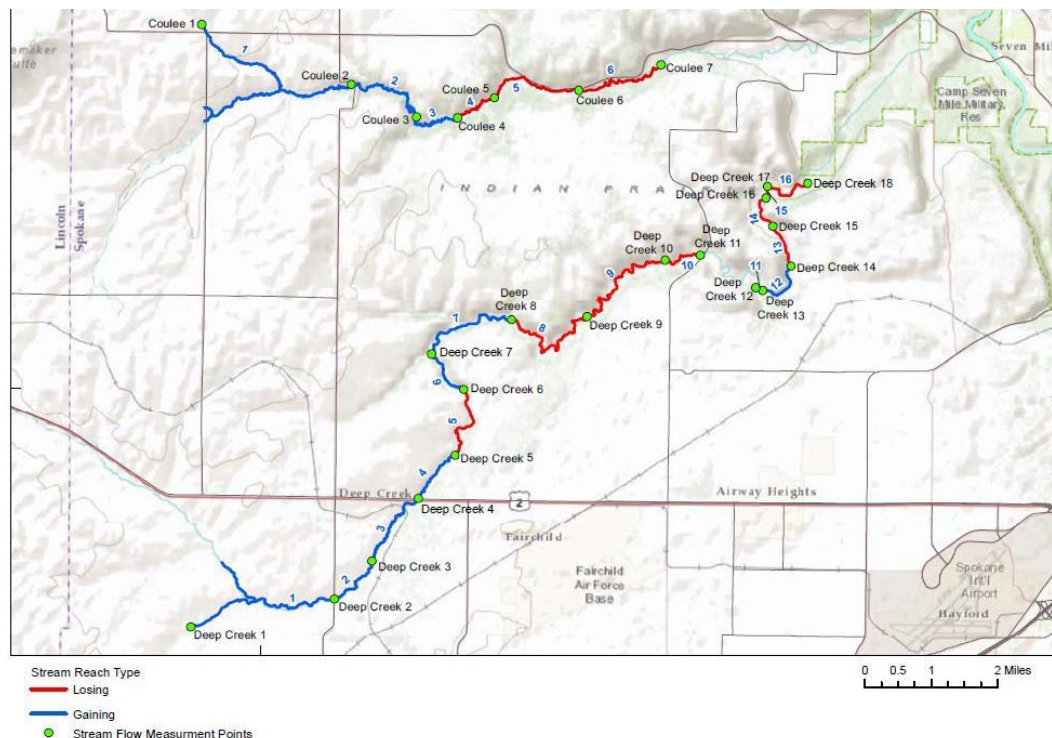


Figure 2-35. Deep Creek and Coulee Creek Flow Measurement Sites (from Spokane County, 2013a)

2.5 GROUNDWATER BUDGET

The steady-state groundwater budget presented in **Table 2-2** was developed as part of the conceptual framework that bounds the design of the numerical groundwater model (see **Section 5.0**). This groundwater budget includes estimated annual average inflows and outflows for various components, along with a range (minimum and maximum) bounding the estimated values. An illustration of the groundwater budget components is provided on **Figure C-2 (Appendix C)**.

Table 2-2. Model Domain Groundwater Budget Components

Component	Flow (ft ³ /d)		
	Min	Max	Est
Inflow			
Underflow In (SVRP)	11,652,273	75,511,364	37,800,000
Underflow In (Hangman)	450,000	5,040,000	2,400,000
Upper Deep Creek	129,600	768,960	399,168
Lower Deep Creek	51,840	319,680	145,152
Coulee Creek	25,920	267,840	139,968
Infiltration: Total	2,524,261	10,097,042	5,048,521
Infiltration: West Plains	2,322,370	9,289,479	4,644,739
Infiltration: SVRP	201,891	807,564	403,782
Total In	14,626,533	90,648,406	45,248,521
Outflow			
Underflow Out (SVRP)			
Underflow Out (to Hangman)	475,000	9,500,000	2,375,000
Spokane River	29,708,640	146,942,117	111,388,320
Upper Deep Creek	129,600	768,960	399,168
Lower Deep Creek	51,840	319,680	145,152
Coulee Creek	25,920	267,840	139,968
Groundwater Extraction	139,871	326,367	233,119
Total Out	30,530,871	158,124,964	114,680,727

The steady-state groundwater budget can be expressed by the following equation, based on significant sources of groundwater recharge and groundwater discharge in the Study Area:

$$GWin + SWS + INF = GWout + BF + ET + GE$$

where:

GWin = groundwater underflow from upgradient of the Domain

SWS = surface water (Spokane River and Creeks) seepage

INF = infiltrating recharge from precipitation

GWout = groundwater underflow leaving the Site

BF = groundwater discharge to surface water (baseflow)

ET = evapotranspiration

GE = groundwater extraction

A domain, or area, is necessary to quantify the groundwater budget. The domain established for this water balance is the domain of the numerical model (see **Section 5**), which facilitates the use of estimated water balance components as model calibration targets. **Table 2-2** presents ranges of estimated flow rates for

each component of the groundwater budget. Each component of the budget was developed as an independent estimate with associated margins of error; thus, the surface water seepage component was adjusted to make the equation shown above balance. The following subsections describe how the estimates were developed.

2.5.1 Inflows

Groundwater Underflow In

Groundwater underflow into the domain occurs in the SVRP where groundwater enters the domain through the Trinity trough and Hangman Creek valley.

Underflow into the domain through the Trinity trough was estimated using the area of the boundary, and the simulated gradients and hydraulic conductivity and from the USGS SVRP Model (Hsieh et. al, 2007):

$$\text{Groundwater Underflow In} = 450,000 \text{ ft}^2 * 0.028 * 3,000 \text{ ft/d} = 37,800,000 \text{ ft}^3/\text{d}$$

The groundwater gradient in this area is steep, which introduces a fair degree of uncertainty in the estimated flow. Minimum and maximum flow estimates were calculated by varying both gradient and hydraulic conductivity (K), resulting in 11,652,273 ft³/d for the minimum (31% of estimated) and 75,511,364 ft³/d for the maximum (200% of estimated).

Groundwater underflow in from Hangman Creek valley is much less substantial, and there is more uncertainty in the estimated flow. Using the domain area and an estimated gradient and hydraulic conductivity value, the flow is calculated as follows:

$$\text{Groundwater Underflow In} = 600,000 \text{ ft}^2 * 0.020 * 200 \text{ ft/d} = 2,400,000 \text{ ft}^3/\text{d}$$

Minimum and maximum estimates of flow were estimated by varying hydraulic conductivity and gradient within reasonable ranges. The minimum and maximum estimates for underflow in from the Hangman Creek valley are 450,000 ft³/d for the minimum (19% of estimated) and 5,040,000 ft³/d for the maximum (210% of estimated).

Seepage from Creeks

Seepage from Deep Creek and its tributary Coulee Creek into the groundwater system occurs where surface water flow is decreasing and discharge to the creeks occurs where surface water flow is increasing. Deep Creek does not flow into the Spokane River under steady-state conditions, though it does occur seasonally. Therefore, it was assumed that seepage from these creeks to the groundwater system is equal to the discharge entering the creeks from the groundwater system. Groundwater discharge into the creeks is discussed in **Section 2.5.2**.

Infiltration

Infiltration from precipitation to groundwater is defined as soil infiltration minus the portion of water lost to evapotranspiration from unsaturated soil. Total infiltration in the domain is the sum of the infiltration from the West Plains area and the SVRP.

Infiltration to groundwater in the West Plains area of the domain was provided by Spokane County in a GIS coverage that related spatial precipitation (**Figure 2-2**) to land use to estimate infiltration. The infiltration values vary spatially, but using an average infiltration rate of 2.7 in/yr, infiltration for the West Plains is estimated to be 4,644,739 ft³/d. The minimum rate is assumed to be 2,322,370 ft³/d (50% of the estimated), and the maximum rate is assumed to be 9,289,479 ft³/d (200% of the estimated).

Estimated infiltration in the SVRP area is based on the USGS model for the SVRP, which specifies an average rate of 4.2 in/yr or 403,872 ft³/d. The minimum rate is assumed to be 201,891 ft³/d (50% of the estimated), and the maximum rate is assumed to be 807,564 ft³/d (200% of the estimated).

2.5.2 Outflows

Groundwater Underflow Out

Groundwater underflow out of the domain occurs along the southeast edge of the West Plains where groundwater discharges from the basalts into Hangman Creek valley. Using the domain area and an estimated gradient and hydraulic conductivity value, the flux is calculated as follows:

$$\text{Groundwater Underflow Out} = 2,375,000 \text{ ft}^2 * 0.010 * 100 \text{ ft/d} = 2,375,000 \text{ ft}^3/\text{d}$$

Minimum and maximum estimates of flow were estimated by varying hydraulic conductivity and gradient within reasonable ranges. The minimum and maximum estimates for outflow to the Hangman Creek valley are 475,000 ft³/d for the minimum (25% of estimated) and 9,500,000 ft³/d for the maximum (200% of estimated).

Discharge to the Spokane River

Groundwater discharge to the Spokane River in the domain was estimated using gage data from the USGS. Data used were for gage 12422500 (1891-2018) located at the upstream edge of the domain, gage 12426000 (2017-2018) located below 9 Mile Dam at the downstream edge of the domain, and gage 12424000 (1948-2018) on Hangman Creek, a tributary to the Spokane River. Discharge to the river is calculated by subtracting the flow from the upstream Spokane River gage and the Hangman Creek gage from the flow at the downstream gage.

The estimated discharge to the Spokane River is 111,388,320 ft³/d, calculated by using the median flow for the three gages:

$$\text{Discharge to the Spokane River} = 8,282 \text{ cfs} - 6,759 \text{ cfs} - 233 \text{ cfs} = 1,289 \text{ cfs} = 111,388,320 \text{ ft}^3/\text{d}$$

Maximum flow was calculated using the average flow of all the gage data, which results in a flow of 146,942,117 ft³/d. The minimum flow was calculated using the average flow for 2018 at the gages, which gives a flow of 29,708,640 ft³/d for the maximum (200% of estimated).

Discharge to Deep Creek and Coulee Creek

Groundwater discharge to Deep Creek and Coulee Creek was calculated using measured flows in a 2010 field survey. The measured flows are shown in **Table 2-1**, with the locations illustrated on **Figure 2-35**. Deep Creek was separated into the upper portion of the creek before it goes dry and the lower portion of the creek. Measuring points used to calculate discharge are DC8 (Upper Deep Creek), DC13 (Lower Deep Creek), and CC2 (Coulee Creek).

Estimated groundwater discharge to the creeks was calculated using an average of the five flow measurements in 2010. Maximum and minimum discharge to the creeks was determined using the highest and lowest of the five flow measurements. A summary of the minimum, maximum, and average measured flows for Deep Creek and Coulee Creek are summarized in **Table 2-3**.

Table 2-3. Deep Creek and Coulee Creek Measured Flow Summary

Creek Reach	Minimum Flow		Maximum Flow		Average Flow	
	cfs	ft ³ /d	cfs	ft ³ /d	cfs	ft ³ /d
Deep Creek-Upper	1.5	129,600	8.9	768,960	4.6	399,168
Deep Creek-Lower	0.6	51,840	3.7	319,680	1.68	145,152
Coulee Creek	0.3	25,920	3.1	267,840	1.62	139,968

Groundwater Extraction

Groundwater removed by pumping was calculated using estimated pumping rates for water supply wells located within the domain and noted as Group A wells on the Washington Department of Health (DOH) website. The listed capacity for each of the 15 wells (see **Table A-5** in **Appendix A**) was used to calculate the total estimated rate of 233,119 ft³/d. The minimum was assumed to be 60% of the estimated rate or 139,871 ft³/d. The maximum rate was assumed to be 140% of the estimated rate or 326,367 ft³/d.

Groundwater pumping also occurs at domestic wells and irrigation wells in the domain. Domestic well pumping is assumed to be minimal and was not included in the calculations. Irrigation well pumping is seasonal and was also not included.

3.0 CITY OF AIRWAY HEIGHTS WATER SUPPLY WELLS AND WATER RIGHTS

A description of water supply wells and other water sources for Airway Heights is provided below, along with a summary of associated water rights, and water rights considerations for evaluating alternative water supply well locations.

3.1 AIRWAY HEIGHTS WATER SUPPLY WELLS

The City's current water supply infrastructure includes:

- Eight City-owned water supply wells (Century West, 2017a);
- Two interties to the City of Spokane water system for supplemental water; and
- An aquifer recharge facility that uses reclaimed water to recharge the paleochannel beneath the City (Century West, 2017a; Esvelt, 2004).

Airway Heights well locations are shown on **Figure 3-1**, and a summary of the wells is in **Table 3-1**. For well identification (ID), Ecology (2012) indicated that well IDs would be changed to correspond to the DOH Source Codes, but documents since that time have not adopted that approach, so for this study, the terminology shown in **Table 3-1** is used.

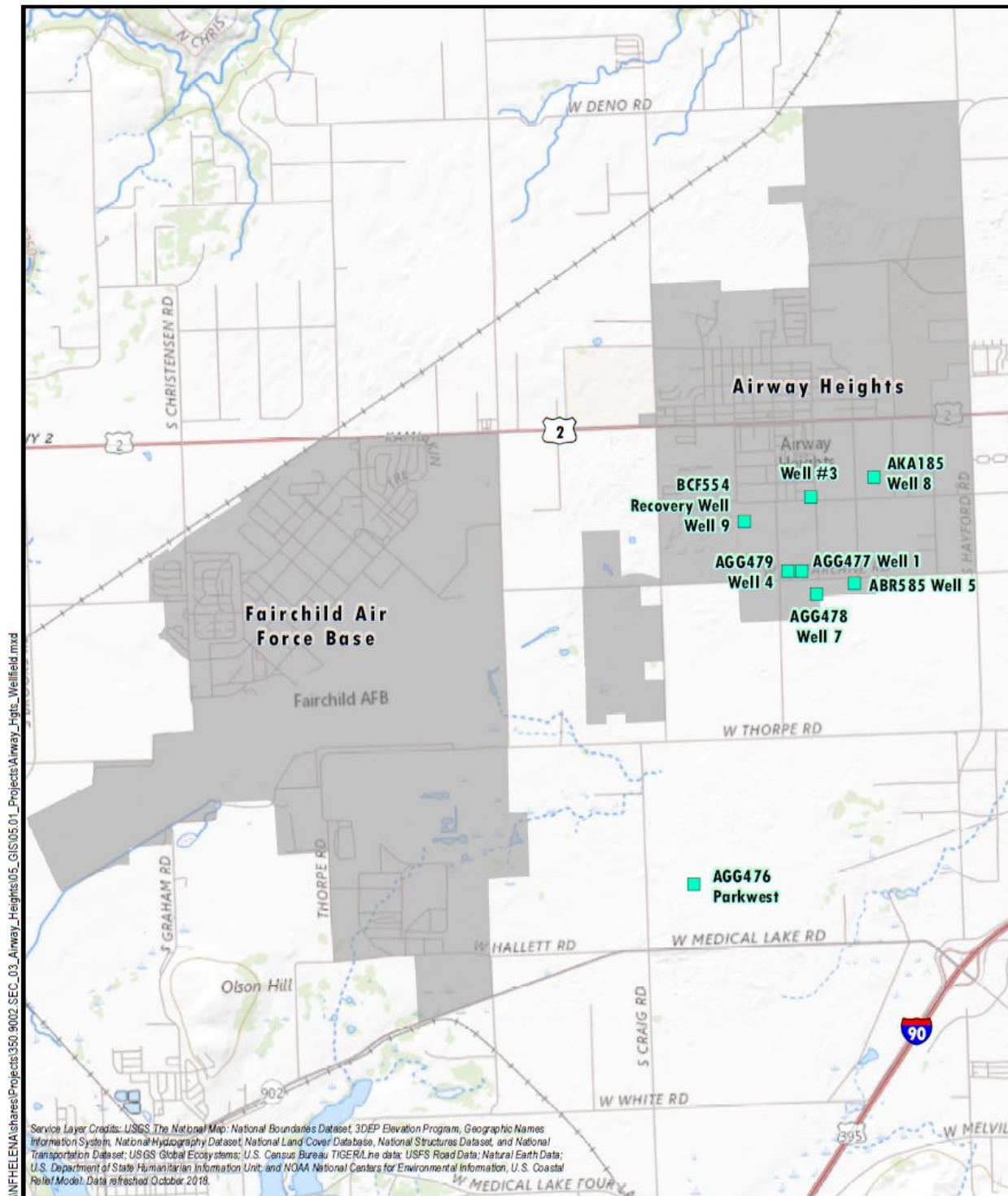
Table 3-1. City of Airway Heights Water Supply Wells

Well No. ¹	Source Number ²	Alternative Name	Well Tag	Status	Well Details							Hydrogeologic Unit
					Install Date	Total Depth (ft)	Casing Depth (ft)	Screen Length (ft)	SWL (ft)	Capacity (gpm)		
										Design	Sustained	
Existing Supply Wells												
1	S01	S08 wellfield	AGG477	Off - WQ	<1961	192	175	30	113	448	160	Paleochannel
4	S04		AGG479	Off - WQ	1967	200	181	20	113		190	Paleochannel
3	S03	-	-----	Non-Potable Use	1943?	130	80	NA	34	NA	60	?
5	S05	-	ABR585	Off - Dry	1970	204	63	NA	57	NA	65	Basalt
7	S07	-	AGG478	Off - Emergency Backup	1994	440	380	60	340	120	85	Basalt
8	S10	-	AKA185	Off - WQ	2005	830	478	NA	310	300	45	Basalt
9	S11	Recovery Well	BCF554	Off - WQ	2012	255	200	50	130.5	3,000	1,000	Paleochannel
10	S09	Parkwest	AGG475	Off - Emergency Backup	1979	301	152	NA	50	1,400	NA	Basalt
Spokane Interties												
NA		Intertie #1	-	Active	-	-	-	-	-	?	1,500	-
NA		Intertie #2	-	Active	-	-	-	-	-	?	500	-
Decommissioned (or to be decommissioned) Supply Wells												
2	S02	-	AGG476	Replaced by Well 8, to be decommissioned	1983	170	170	NA	NM	NA	NA	NA
6	S06	-	-----	Decommissioned	1981	466	224	NA	264	NA	NA	Basalt

¹ Well numbers have been revised over time to match the Dept. of Health Source Numbers

² Washington State Dept. of Health (DOH)

SWL: Static water level (depth)



NewFields

Wellfield Locations

City of Airway Heights Wellfield
Hydrogeologic Study Report
Airway Heights, Washington
FIGURE 3-1

A summary of the current status of the wells is as follows:

- Well 1 and Well 4 (S01 and S04): Wells 1 and 4 are screened in paleochannel material. The wells had a combined yield of 350 gallons per minute (gpm) before routine pumping stopped in May 2017 following detection of PFOS/PFOA. A granular activated carbon (GAC) treatment system is installed;
- Well 3 (S03): Well 3 was removed from potable use in 2012 due to elevated nitrate concentrations (Esvelt, 2014; Ecology 2012). It is currently only used for non-potable water uses, such as filling water trucks;
- Well 5 (S05): Well 5 ran dry in 2012 (Ecology, 2012) and presumably has not been used since;
- Well 7 (S07): Well 7 has historically had limited production (Ecology, 2012), ran dry in 2001 (Century West, 2017a), and presumably has not been used since;
- Well 8 (S10): Well 8 was installed in 2005 as a replacement for Well 2 and then deepened in 2006. Well 8 experienced declining yields, then a reduced operational pumping rate of 45 gpm, and is no longer in service (AMEC, 2018);
- Well 9 (S11): Well 9 is also known as the “Recovery Well” because water withdrawn (recovered) includes recharged reclaimed water. Well 9 has experienced declining yield from 3,000 gpm during initial testing in 2012 to about 1,000 gpm in 2017. Pumping stopped in May 2017 following detection of PFOS/PFOA. It is unknown if seasonal pumping still occurs;
- Well 10/Parkwest Well (S09): Well 10, also known as the Parkwest Well, was originally owned and operated by Parkwest Properties, Inc for continuous industrial use. In around 2001, the City purchased the property hosting the well and acquired the well and associated water right (Permit G3-29249P) for continuous industrial use. The well is capable of producing up to 1,400 gpm, but drawdown interference with other wells in the area led to a 2011 agreement between Ecology and the City (Agreed Order Docket No. 8703) to only use the well for emergency purposes. In 2012, a portion of the right changed to municipal use (Certificate G3-29249(A)) while the rest of the right remained industrial purpose of use (Superseding-Permit G3-29249(B));
- Well 2 (S02): Well 2 is inactive, has not been used since 1985 (Century West, 2017a), and was replaced in 2008 by Well 8; and
- Well 6 (S06): Well 6 was installed in 1981 but has “long since been decommissioned” (Ecology, 2012).

3.2 AIRWAY HEIGHTS WATER RIGHTS

In 2012, Airway Heights consolidated its water rights portfolio in a batch of Ecology-approved change applications to six water rights (five municipal, one industrial). The City’s water right portfolio is summarized in **Table 3-2**. Total authorized withdrawal under the six consolidated water rights is 2,315 gpm and 2,328 acre-feet/year (municipal: 1,676 gpm and 1780.5 acre-feet/year; industrial: 639 gpm and 547.5 acre-feet/year).

Points of withdrawal authorized by the 2012 Report of Examination (ROE) included the seven active City wells at the time (Wells 1, 3, 4, 5, 7, 8, and 10) and up to seven additional wells with predetermined Quarter Quarter Section locations, for a total of 14 authorized points of withdrawal. Later in 2012, after the ROE, the City installed Well 9, the Recovery Well. The 2012 ROEs indicate a development schedule of Complete Project by July 1, 2013 and Put Water to Full Use by July 1, 2022. To our knowledge, the additional six wells have not been installed.

Table 3-2. City of Airway Heights Water Rights Summary

Purpose of Use	Record No.	Permit No.	Certificate No.	Record Type	Priority Date	Priority Date of Last Change	Additive		Non-Additive	Authorized Points of Withdrawal ^{1,2}	Season of Use
							Qi (gpm)	Qa (AFY)	Qi (gpm)		
Municipal	CG3-*09535C@2	----	6321-A	Change-ROE	6/21/1968	1/25/2012	350	224	0	14 wells	1/1-12/31
	CG3-23465C@2	----	G3-23465C	Change-ROE	6/27/1974	1/25/2012	65	2	0	14 wells	1/1-12/31
	CG3-26657C@2	----	G3-26657C	Change-ROE	9/4/1980	1/25/2012	500	800	0	14 wells	1/1-12/31
	CG3-27427C@2	----	G3-27427C	Change-ROE	12/21/1982	1/25/2012	0	102	65	14 wells	1/1-12/31
	CG3-29249(A)@1	G3-29249	G3-29249(A)	Change-ROE	8/4/1992	1/25/2012	761	652.5	0	14 wells	1/1-12/31
Industrial	G3-29249(B)	G3-29249(B)	-	Superseding Permit	8/4/1992	1/25/2012	639	547.5	0	14 wells	1/1-12/31
Totals		Municipal Use Authority					1,676.00	1,780.50	65		
		Industrial Use Authority					639	547.5	-----		
		Total Withdrawal Authority					2,315.00	2,393.00	-----		

Qi = instantaneous withdrawal authorization

Qa = annual withdrawal authorization

¹ 14 wells authorized by the 2012 Change-ROEs; 8 existing, 6 proposed

² Development Schedule of the 2012 Change-ROEs include Complete Project By 7/1/2013 and Put Water to Use By 7/1/2012.

Municipal Water Law Overview

In Washington, municipal water rights do not adhere to the “use it or lose it” principle of most other types of water rights. Municipal water law allows municipal water suppliers to retain rights they are not currently using, allowing municipalities flexibility to plan for future growth.

Ecology’s Municipal Water Law webpage¹ provides an overview of the history and current status of Municipal Water Law; below is a relevant excerpt:

“Like many areas of water law, municipal water law is shaped by court rulings.

Historically, we granted utilities and municipal suppliers water rights based on system capacity (their “pumps and pipes”) rather than beneficial use. A Washington State Supreme Court case in 1998, Ecology v. Theodoratus, threw into question whether these rights were valid because they

¹ <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Municipal-Water-Law>

were not based on beneficial use like most other water rights. In response to this uncertainty, the Legislature passed the [Municipal Water Law](#) in 2003 to clearly define municipal water suppliers and help clarify the status of their rights.

Two subsequent state Supreme Court cases, one in [2010](#)² and another in [2015](#)³, upheld the constitutionality of the Municipal Water Law. A central issue in the cases was that the Municipal Water Law allows us to recognize municipal rights based on system capacity. The court affirmed this but stipulated that municipal suppliers must show reasonable diligence, or potential, to grow into their full water right.

Under current law, rights under “pumps and pipes” certificates are considered to be in good standing and remain as such. However, if a municipal supplier applies to change their right, we must conduct an analysis to determine how much of the right has been beneficially used or is likely to be beneficially used in the future. This is called a tentative determination of extent and validity, which could have two outcomes:

- If we find that the right has been used in full or is likely to be needed fully in the future, then we will certificate the entire water right; or
- If we determine that part of the right has not been fully used and the water supplier has not shown reasonable diligence to use it fully in the future, we may reduce the water right accordingly.”

3.3 WATER QUALITY ISSUES

Groundwater in the area of the Airway Heights wells has been impacted by nitrates (Well 3), and PFOS and PFOA were detected in water supply wells 1/ 4 and 9 at concentrations above EPA’s HA of 70 ppt for PFOS and PFOA in drinking water (individual or combined). This hydrologic study focused on assessing groundwater resources away from areas with PFOS and PFOA detections, which for the purposes of this study excludes the area of the West Plains that includes FAFB, Airway Heights, and the Spokane International Airport.

3.4 AIRWAY HEIGHTS WATER DEMAND AND REPLACEMENT VOLUME

Water production for Airway Heights was reported in the Comprehensive Water Plan (Century West, 2017a) and the annual production for years 2011-2016 are listed in **Table 3-3**. Water production for the City increased from an average of 921 gpm in 2011 to over 1,000 gpm in 2016. These rates are average rates and peak demand rates would be higher but were not reported in the Water Plan.

² Lummi Indian Nation v. State of Washington
https://fortress.wa.gov/ecy/wrdocs/WaterRights/wrwebpdf/10282010_lummi.pdf

³ Cornelius v. Dep’t of Ecology
<https://fortress.wa.gov/ecy/wrdocs/WaterRights/wrwebpdf/88317-3%20Opinion.pdf>

Table 3-3. City of Airway Heights Water Production 2011-2016

Year	Water Production	
	(gals)	(gpm)
2011	484,320,380	921
2012	495,417,400	943
2013	483,272,850	919
2014	496,237,900	944
2015	537,942,000	1,023
2016	532,730,810	1,014

The replacement volume used for the potential well location screening and groundwater model simulations is 532,752,742 gallons/year, or about 1,014 gpm (USAF, 2019). This volume is based on the 2016 water use by Airway Heights, with consideration of water infiltrated for later use, at the time PFOS and PFOA were detected in drinking water.

3.5 WATER RIGHTS CONSIDERATIONS

Groundwater and surface water in WRIA 54 and WRIA 56 is currently considered to be over appropriated. As a result, Ecology has placed administrative restrictions on surface water and groundwater within the West Plains portion of the Study Area and has adopted instream flow rights for the SVRP portion of the Study Area.

The restrictions and instream flow rights essentially means that no new consumptive water rights can be expected within the Study Area without mitigation. Therefore, the only way Airway Heights can obtain a water right for a new water supply well will be to either use their existing water rights, or purchase and transfer of another existing water right in the area of the new well.

3.5.1 Streamflow Restrictions

Ecology has placed administrative restrictions, known as Surface Water Source Limitations (SWSL), on streams in the Study Area (Ecology, 2017b). These restrictions limit most water sources in the area, and groundwater is also subject to SWSL restrictions. In addition, instream flow rights for surface water bodies in and near the Study Area have been adopted by Ecology for the Spokane and Little Spokane rivers. A summary of restrictions for the major surface water bodies in the Study Area is as follows:

- **Spokane River:** Minimum instream flows were adopted January 2015 (Chapter 173-557 WAC) for two monitoring locations. Instream flows for the USGS gage at Spokane (USGS gage #12422500), just upstream of the Study Area, are set at 1,700 cfs for October 1 – March 31, 6,500 cfs for April 1 – June 15, and 850 cfs for June 16 –September 30 of. Further upstream at the gage at Greenacres (USGS gage #12420500) the instream flow is established at 500 cfs for June 16 – September 30. The Greenacres gage has not been active since September 2011;
- **Little Spokane River:** The Little Spokane River flows into the Spokane River downstream of the Study Area. Minimum instream flows were set for the Little Spokane River in 1976 (Chapter 173-555 WAC) at 4 control stations, with established flows varying for the 1st and 15th of each month.

The base flow established at the confluence with the Spokane River is 375 cfs for July to September, and at 400 cfs for November, December, and January;

- **Deep Creek:** Deep Creek is closed to new appropriations by SWSL, and the stream is not available for new uses; and
- **Hangman Creek:** Minimum instream flows for Hangman Creek were developed by the WRIA 56 Planning Unit at 50 cfs for the reach below the confluence with Marshall Creek and 26 cfs above the confluence with Marshall Creek (SCCD, 2005). Recommendations for managing groundwater will be developed by the Planning Unit before requesting Ecology to begin rulemaking (Ecology, 2017a).

3.5.2 Use of Airway Heights Existing Water Rights for Mitigation

The potential option of using existing Airway Heights water rights to mitigate new use by a new water supply well was discussed with Ecology in a meeting on March 12, 2020. Ecology indicated the existing Airway Heights water rights could be used as mitigation for a new water supply well given the following conditions:

- The new well would have to be proven to be downgradient of the existing wells currently authorized by the City's water rights; and
- The process would consist of Airway Heights relinquishing adequate portions of their existing rights and noting that conditional relinquishment in an application for a new water right for the replacement well(s).

3.5.3 Water Rights Purchase for Mitigation

For locations that are not downgradient of the existing Airway Heights water supply wells, other existing water rights would need to be purchased to provide mitigation of new uses. The purchased water rights would need to cover the location and timing of the predicted impacts of the new uses.

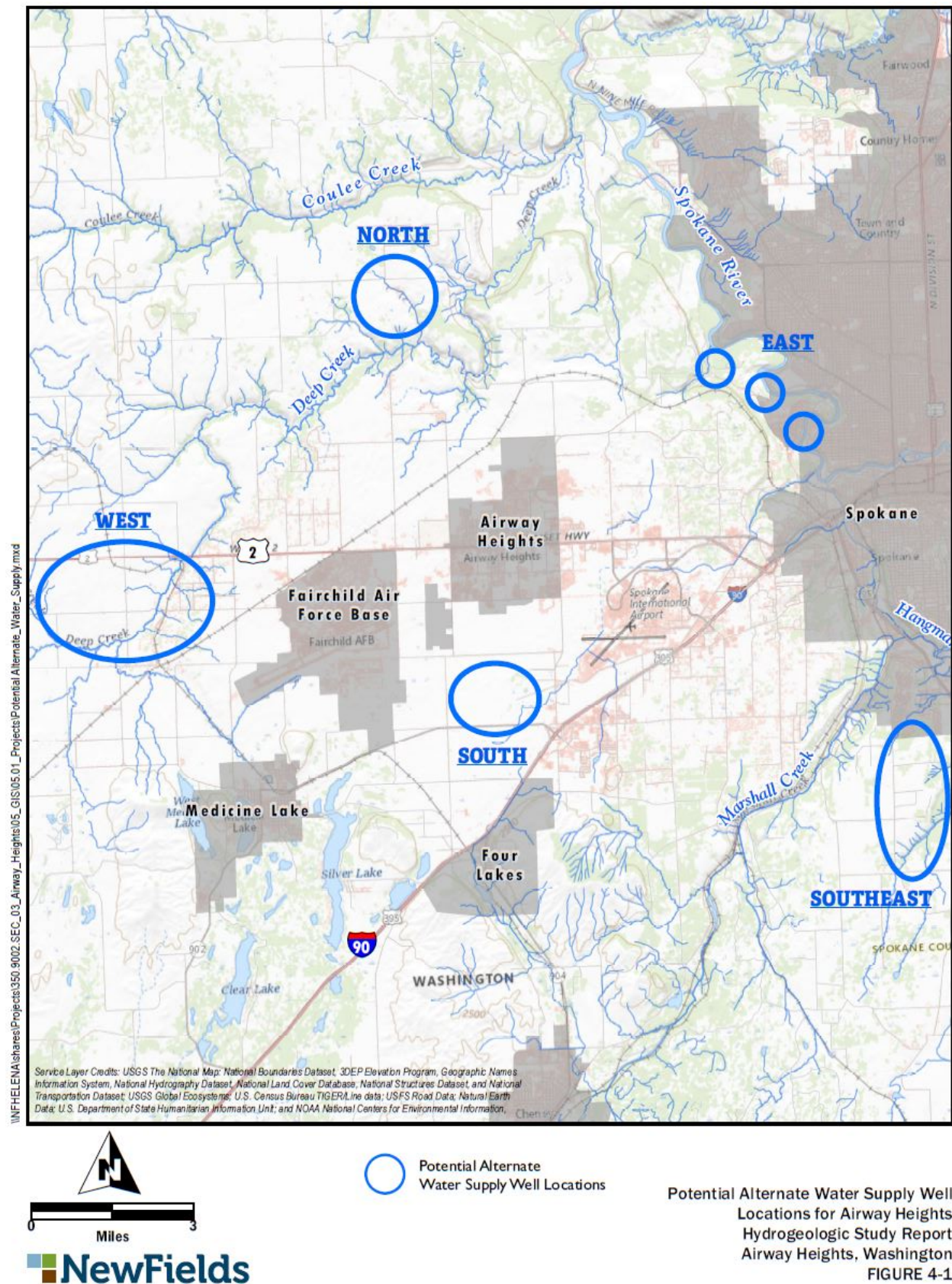
Ecology noted in the March 12, 2020 meeting that the attributes of a purchased and transferred water right could potentially be revised so the authorized period of use covers the proposed period of use of the new uses. For example, an irrigation water right that only has a 5 to 6 month period of use could be modified to a 12-month period of use. However, in order for Ecology to grant the change, an analysis would be required demonstrating the change in period of use will not cause greater impacts than the original water right(s).

4.0 FIRST LEVEL SCREENING OF ALTERNATE WELL LOCATION

Potential alternate water supply well locations for Airway Heights were evaluated within a 7-mile radius of the City. Based on a review of the geology, hydrogeology, and water quality of the area summarized in **Sections 2.0** and **3.0**, five locations were identified for an initial screening. These general areas are shown on **Figure 4-1**, and defined as follows:

- East: This location is in the SVRP Aquifer, downgradient of Airway Heights;
- North: This is in the Deep Creek/Coulee Creek area, downgradient of Airway Heights. Wells would likely be screened in the Grande Ronde basalt;
- West: This is upgradient of Airway Heights and FAFB, in the upper part of the Deep Creek drainage. Wells would likely be screened in the Grande Ronde;
- South: This is within the influence of the City's existing wells and also near wells for Four Lakes and Medical Lake. Wells would likely be screened in the Grande Ronde or alluvium; and
- Southeast: Wells in this area would likely be screened in the Grande Ronde or alluvium of Hangman Creek.

These potential alternate well locations are evaluated below based on an initial assessment of water availability, pumping impacts, water quality, water rights, and other considerations such as infrastructure.



4.1 EAST

Potential well locations to the east of Airway Heights would fall within the western margin of the coarse-grained and highly transmissive SVRP aquifer. A previous evaluation of alternative water supply options for the City identified this area as the location with the best potential for success from a water supply perspective (Century West, 2017b), and three previously identified potential well locations are shown on **Figure 4-1**. Water supply wells for FAFB are located in this area (URS, 2004) and there is piping infrastructure in place as part of the intertie agreement with the City of Spokane, which could potentially be used to route water to Airway Heights.

4.1.1 Water Availability

The SVRP is a highly transmissive aquifer, and it is highly likely that a well or pair of wells would be capable of producing the 1,014 gpm replacement rate. Other supply wells in the general vicinity of the East Area include FAFB wells, and the Washington Department of Health (DOH) website lists well capacities for the FAFB wells ranging from 850 to 1,400 gpm.

4.1.2 Pumping Impacts

Due to the highly transmissive nature of the SVRP aquifer, groundwater drawdown due to pumping from a new well in the East Area is expected to be minimal. The drawdown therefore would not result in an adverse impact to other wells in the area of a new well. Pumping from a new well in the SVRP aquifer however would likely result in stream depletion of the Spokane River.

4.1.3 Water Quality

Water quality in the East Area is expected to be good. A 2018 report on the drinking water for the City of Spokane (City of Spokane, 2018) noted that the water used by the City of Spokane had detections of arsenic and nitrate but no organic compounds. The city of Spokane draws water from different parts of the SVRP, and the report did not specify the location of the detections.

The closest wells to the potential SVRP well for Airway are the FAFB supply wells and a well in Riverside State Park. Water quality sampling and analysis data from the DOH website for these wells indicate that there have been no exceedances of drinking water standards in the past two years for coliform, inorganic chemicals, and organic compounds with one exception. The exception was a presence of total coliform and e. coli on 2/26/20 at the FAFB distribution system, a subsequent sample has not been reported on the website.

4.1.4 Water Rights

As previously noted, Ecology will not grant a new uninterruptible water right for a new municipal supply well in this area due to the instream flow rights for the Spokane River (see **Section 3.5.1**). However, this area is downgradient of the Airway Heights wells so transferring existing Airway Heights water rights to a new municipal supply well in the SVRP appears to be likely.

4.1.5 Other Considerations

Transmission of the water from a well in this location to Airway Heights would require the installation of pipes from the well to the City. It is possible that the existing intertie piping that routes water from Spokane to Airway Heights could be used, which would reduce costs significantly, but that potential needs to be explored further.

4.2 NORTH

Potential well locations to the area north of Airway Heights (**Figure 4-1**) would fall within the drainage of Deep Creek and possibly Coulee Creek further north. This area has potential for supply wells in the deeper Grande Ronde basalt.

4.2.1 Water Availability

Existing wells in the West Plains exhibit a wide range of yields ranging from 3.5 to 1,000 gpm, with an average of 51 gpm based on well logs. High-yield wells (greater than 300 gpm) are rare and are typically located in paleochannels. Water supply wells listed on the DOH website in the general vicinity of the North Area range from 48 to 190 gpm. Multiple wells would likely be necessary in the North Area to achieve the full replacement rate of 1,014 gpm.

4.2.2 Pumping Impacts

Drawdown due to pumping the new wells in this area could be significant in the vicinity of the wells. Other wells in close proximity to the new wells could experience an adverse impact. The new wells would also likely cause stream depletion in Deep Creek and Coulee Creek, which could be significant depending on the proximity of the new wells to the creeks.

4.2.3 Water Quality

Water quality in the North Area is expected to be good. Other supply wells in the area include those operated by Indian Village Estates, Clear Lake Water Users Association, and the Spokane Hutterian Brethren. Water sampling and analysis data from the DOH website for these systems indicate that there have been no exceedances of drinking water standards in the past two years for coliform, inorganic chemicals, and organic compounds with one exception. The exception was a presence of coliform in 2019 at the Clear Lake Water Users Association distribution system, but subsequent sampling indicated no exceedance.

4.2.4 Water Rights

As previously noted, Ecology will not grant a new water right for a well in this area due to the SWSL restrictions on Deep Creek (see **Section 3.5.1**). In addition, this area is not downgradient of the Airway Heights wells so a transfer of the Airway Heights existing water rights is not feasible.

In order to offset the anticipated depletion of Deep Creek, another existing water right or multiple water rights would need to be purchased. The purchased water rights would need to offset the depletion in time and place for the purchased water rights to be transferred to any new wells.

4.2.5 Other Considerations

Infrastructure necessary to route water from new wells in this area to Airway Heights could be expensive. Piping would need to be installed, and would have to cross Deep Creek, which would make the infrastructure installation more difficult.

4.3 WEST

Potential well locations to the west of Airway Heights (**Figure 4-1**) would fall to the south of, but within, the Deep Creek drainage. This area has potential for supply wells in the deeper Grande Ronde basalt.

4.3.1 Water Availability

Existing supply wells in the West Plains exhibit a wide range of yields from 3.5 to 1,000 gpm, with an average of 51 gpm based on well logs. High-yield wells (greater than 300 gpm) are rare and are typically located in paleochannels. Water supply wells listed on the DOH website in the general vicinity of the West Area range from 26 to 270 gpm. The two highest yielding wells are Town of Reardon Well 8 (270 gpm) and City of Medical Lake Well 2 (200 gpm). Multiple wells would likely be necessary in the West Area to achieve the full replacement rate of 1,014 gpm.

4.3.2 Pumping Impacts

Drawdown due to pumping the new wells in this area could be significant in the vicinity of the wells. Other wells in close proximity to the new wells could experience an adverse impact. The new wells would also cause stream depletion in Deep Creek and possibly Coulee Creek, which could be significant depending on the proximity of the new wells to the creeks.

4.3.3 Water Quality

Water quality in the West Area is expected to be good. Other supply wells in the area include those operated by Reardon and Deep Creek Ranchettes. Water quality sampling and analysis data from the DOH website for these systems indicate that there have been no exceedances in the past two years for coliform, inorganic chemicals, and organic compounds with one exception. The exception was an exceedance in 2019 for coliform at the Town of Reardon distribution system, but subsequent sampling indicated no exceedance.

4.3.4 Water Rights

As previously noted, Ecology will not grant a new water right for a well in this area due to the SWSL restrictions on Deep Creek (see **Section 3.5.1**). In addition, this area is not downgradient of the Airway Heights wells so a transfer of the Airway Heights existing water rights is not feasible.

In order to offset the anticipated depletion of Deep Creek, another existing water right or multiple water rights would need to be purchased. The purchased water rights would need to offset the depletion in time and place for the purchased water rights to be transferred to any new wells.

4.3.5 Other Considerations

Infrastructure necessary to route water from new wells in this area to Airway Heights could be expensive. Required infrastructure for this location has not been evaluated in great detail, but would include piping and possibly booster pumps to deliver the water to the City.

4.4 SOUTH

Potential well locations to the south of Airway Heights (**Figure 4-1**) would fall between Airway Heights and the City of Medical Lake, Four Lakes, and Cheney. This area has potential for supply wells in the deeper Grande Ronde basalt and in paleochannels.

4.4.1 Water Availability

Existing supply wells in the West Plains exhibit a wide range of yields from 3.5 to 1,000 gpm, with an average of 51 gpm based on well logs. High-yield wells (greater than 300 gpm) are rare and are typically located in paleochannels. Water supply wells listed on the DOH website in the general vicinity of the South Area range from 25 to 35 gpm, although wells for the City of Medical Lake have yields of about 200 gpm, and the Airway Heights Parkwest well has yields closer to 1,000 gpm. Multiple wells would likely be necessary in the South Area to achieve the full replacement rate of 1,014 gpm.

4.4.2 Pumping Impacts

Drawdown due to pumping the new wells in this area could be significant in the vicinity of the wells. Other wells in close proximity to the new wells could experience an adverse impact. A previous evaluation of impacts from the Parkwest well revealed adverse impacts to wells in Medical Lake and Four Lakes, which led to Ecology stipulating that the Parkwest well could only be used for emergency purposes. New wells in this area would likely have impacts to nearby wells similar to that of the Parkwest well.

4.4.3 Water Quality

Water quality in the South Area is expected to be good. Other supply wells in the area include those operated by Medical Lake, Cheney, and Four Lakes. Water sampling and analysis data from the DOH website for these systems indicate that there have been no exceedances in the past two years for coliform, inorganic chemicals, and organic compounds with two exceptions. The first exception was an exceedance in 2019 for coliform at the Town of Medical Lake distribution system, but subsequent sampling indicated no exceedance. The second exception was for iron at one of the Four Lakes wells where iron was detected at 0.887 mg/L, which is above the standard of 0.3 mg/L.

4.4.4 Water Rights

New wells in this area would not be downgradient of the Airway Heights wells so a transfer of the Airway Heights existing water rights is not feasible. Another existing water right or multiple water rights would need to be purchased. In addition, adverse impacts would be expected for existing wells in the area so the purchased water rights would need to offset the depletion in time and place for the purchased water rights to be transferred to any new wells.

4.4.5 Other Considerations

Infrastructure costs are expected to be less than for the other areas under consideration because of the shorter distance to route water to the City.

4.5 SOUTHEAST

Potential well locations to the southeast of Airway Heights (**Figure 4-1**) would fall near the edge of the West Plains and above the Hangman Creek valley. This area has potential for supply wells in the deeper Grande Ronde basalt.

4.5.1 Water Availability

Existing supply wells in the West Plains exhibit a wide range of yields from 3.5 to 1,000 gpm, with an average of 51 gpm based on well logs. High-yield wells (greater than 300 gpm) are rare and are typically located in paleochannels. There are no water supply wells listed on the DOH website in the general vicinity of the Southeast Area. Multiple wells would likely be necessary in the Southeast Area to achieve the full replacement rate of 1,014 gpm.

4.5.2 Pumping Impacts

Drawdown due to pumping the new wells in this area could be significant in the vicinity of the wells. Other wells in close proximity to the new wells could experience an adverse impact. In addition, new wells in this area would likely cause depletion in Marshall Creek and Hangman Creek.

4.5.3 Water Quality

No data have been found for other wells in the area so the potential water quality is unknown.

4.5.4 Water Rights

New wells in this area may result in depletion to Marshall Creek and Hangman Creek. As previously noted, Ecology will not grant a new water right for a well in this area due to the SWSL restrictions on Hangman Creek (see **Section 3.5.1**). In addition, this area is not downgradient of the Airway Heights wells so a transfer of the Airway Heights existing water rights is not feasible.

In order to offset the anticipated depletion of Hangman Creek another existing water right or multiple water rights would need to be purchased. The purchased water rights would need to offset the depletion in time and place for the purchased water rights to be transferred to any new wells.

4.5.5 Other Considerations

Infrastructure necessary to route water from new wells in this area to Airway Heights could be expensive. Required infrastructure for this location has not been evaluated in great detail, but would include piping and possibly booster pumps to deliver the water to the City.

4.6 PREFERRED ALTERNATE WELL LOCATIONS

A summary of the initial screening of potential well locations is provided in **Table 4-1**. Two of the five locations, East and West, were retained for a more detailed evaluation presented in **Section 6.0**.

The East Area is considered to be the best option for a new water supply well location. Well yields in the SVRP aquifer are expected to be high and good water quality is anticipated. Depletion of Spokane River flows would occur, but this could be offset by using existing Airway Heights water rights. In addition, the existing infrastructure for the intertie could potentially be used to route water to Airway Heights.

Of the four potential locations in the basalt aquifers of the West Plains, the West Area was considered the best option. The area is upgradient of places of known PFAS impact, and it is far enough away from other water supply wells that impacts to the wells may not be significant. It is likely that some depletion of Deep Creek flows would occur, but additional analysis is necessary to assess the potential impact to surface water. Existing Airway Heights water rights could not be used to mitigate surface water depletion and the purchase of existing water rights would be necessary.

The South Area is removed from further consideration primarily due to the proximity of water supply wells for the cities of Cheney and Medical Lake. As discussed in **Section 3.0**, the Parkwest well to the south of Airway Heights has been shown to interfere with these other supply wells, and any new wells to the south of the City would likely have a similar impact.

The Southeast Area is also removed from consideration. This location is the furthest away from Airway Heights and would therefore likely have the highest infrastructure costs. Pumping in this area may also cause depletion in Hangman Creek. Like the West Area, this location is not near other water supply wells so well impact may be minimal, but the area provides no advantage over the West Area.

The North Area is expected to have well yields similar to the other locations in the basalt aquifers. However, impacts to Deep Creek and Coulee Creek are expected to be significant. While those surface water impacts could be mitigated with the purchase of existing water rights, coordinating purchased water rights with the amount and timing of depletions could be difficult.

Table 4-1. Initial Well Location Screening Summary

Rank	Area	Aquifer	Physical Water Availability	Pumping Impacts	Water Quality	Legal Water Availability	Water Rights Options	Other Considerations	Retain?
1	East	SVRP	FAFB and other wells in area suggest high yields are probable.	Drawdown in adjacent wells likely not significant, and impairment unlikely. Would impact Spokane River flows.	Probable high quality water. PFOS/PFOA not expected.	Spokane River and SVRP instream flow rule water right established 2015 (Chapter 173-557 WAC). New unmitigated water rights in SVRP will be interruptible to instream flow rule; so a <u>new unmitigated water right</u> will not work for City. City could pursue a <u>new mitigated water right</u> or an <u>existing senior SVRP right</u> .	Option A: Purchase existing senior SVRP water right(s). Option B: Donate existing City rights to instream flow in Spokane River for new (possibly reduced) mitigated water right in SVRP. Option C: Consolidate City's water rights with City of Spokane and use their existing SVRP water rights and supply infrastructure. Option D: Short term solution: temporarily lease an existing senior SVRP water right with supply via City of Spokane intertie. Use this option until PFOS/PFOA treatment system in place or cleaned-up and can return to City's existing system. Option E: Change points of withdrawal of existing COAH water rights to new wells.	Land purchase for new wells may be difficult. Spokane Intertie infrastructure present	Yes
2	West	Basalt, Alluvium, or Paleochannel	60-80 gpm (Basalt) and 100+gpm (paleochannel) possible. May be adequate.	Fewer wells so drawdown in adjacent wells may not be significant with proper placement. May reduce upper Deep Creek flows.	Probable high quality water. Upgradient of COAH and PFOS/PFOA unlikely.	Groundwater generally not available for new water rights (over-appropriation, Deep Creek SWSL)	Option A: Purchase existing senior water right(s). Option B: Use reclaimed water from City's WWTP to recharge aquifer.	No existing infrastructure but closer to COAH	Yes
3	North	Basalt or Alluvium	Similar yields to West expected, uncertain if paleochannel could be found. May be adequate.	Drawdown in adjacent wells could be significant. May reduce Deep Creek flows.	Likely high quality water. Presence of PFOS/PFOA uncertain/not expected.	Groundwater generally not available for new water rights (over-appropriation, Deep Creek SWSL)	Option A: Purchase existing senior water right(s). Option B: Use reclaimed water from City's WWTP to recharge aquifer.	No existing infrastructure	No
4	Southeast	Basalt or Alluvium	Similar yields to West expected. May be adequate.	Drawdown in adjacent wells could be significant. May reduce Hangman Creek flows.	Probable high quality water. PFOS/PFOA uncertain/not expected.	Groundwater generally not available for new water rights (over-appropriation, Hangman Creek SWSL)	Option A: Purchase existing senior water right(s).	Considerable distance to get water to City	No
5	South	Basalt or Alluvium	Similar yields to West. May be adequate.	Park West well suggests pumping impacts could impact wells as far south as Four Lakes and Medical Lake	Likely high quality water. Presence of PFOS/PFOA uncertain/not expected.	Groundwater generally not available for new water rights (over-appropriation, known impacts to nearby wells)	Option A: Purchase existing senior water right(s). Option B: Use reclaimed water from City's WWTP to recharge aquifer.	No existing infrastructure	No

SVRP: Spokane Valley Rathdrum Prairie Aquifer
 FAFB: Fairchild Air Force Base

COAH: City of Airway Heights
 WWTP: Waste Water Treatment Plant

SWSL: Surface Water Source Limitations (Ecology)

5.0 GROUNDWATER FLOW MODEL

This section describes the numerical groundwater flow model that was used to evaluate potential water supply well locations in the Study Area. The numerical model, referred to as the West Plains Model, is based on the physical setting described in **Section 2.0** of this report.

The primary purpose of the model was to quantify potential pumping impacts, including aquifer drawdown and stream depletion, associated with potential well locations for Airway Heights that were retained from the initial screening process (see **Section 4.0**). The numerical model therefore focuses on changes between non-pumping and pumping conditions that would ultimately be used in applications for water rights.

Model code, domain and grid, boundary conditions and properties, and calibration are detailed below. Additional details are provided in **Appendix A** (Model Boundary Conditions), **Appendix B** (Model Properties), and **Appendix C** (Model Calibration).

5.1 CODE SELECTION

The model code chosen for the West Plains Model is MODFLOW NWT (Niswonger et. al, 2011). MODFLOW NWT was selected because it is effective at simulating conditions where model cells become unsaturated, which is the case in many places of the West Plains, particularly in the upper geologic units. The graphical-user-interface Groundwater Vistas® (ESI, 2011, Version 7.24, Build 50) was used for model pre- and post-processing.

5.2 MODEL CONSTRUCTION

Model construction details are provided below.

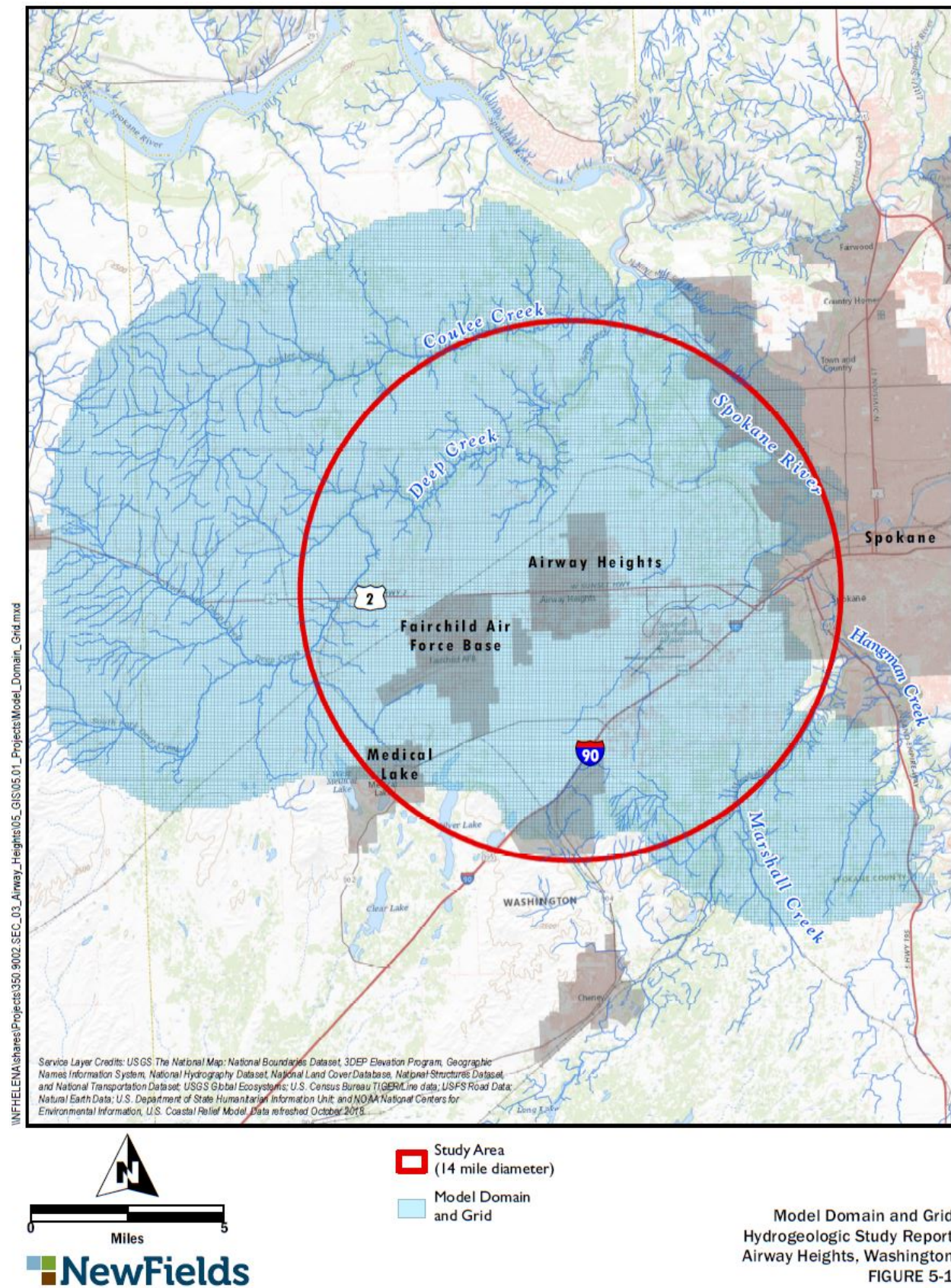
5.2.1 Model Domain and Grid

The model domain covers the West Plains area (see **Section 2.0**), and a portion of the SVRP (Trinity Trough) where groundwater discharges from the West Plains (**Figure 5-1**). The model is divided into five layers, as summarized in **Table 5-1**.

Table 5-1. Numerical Model Layers

Layer	Geologic Unit	
	West Plains	SVRP
1	Unconsolidated	SVRP*
2	Wanapum	
3	Upper Latah	
4	Grande Ronde	
5	Lower Latah	

* SVRP is 1 ft thick in Layers 1-3, bulk of unit is in Layers 4 and 5



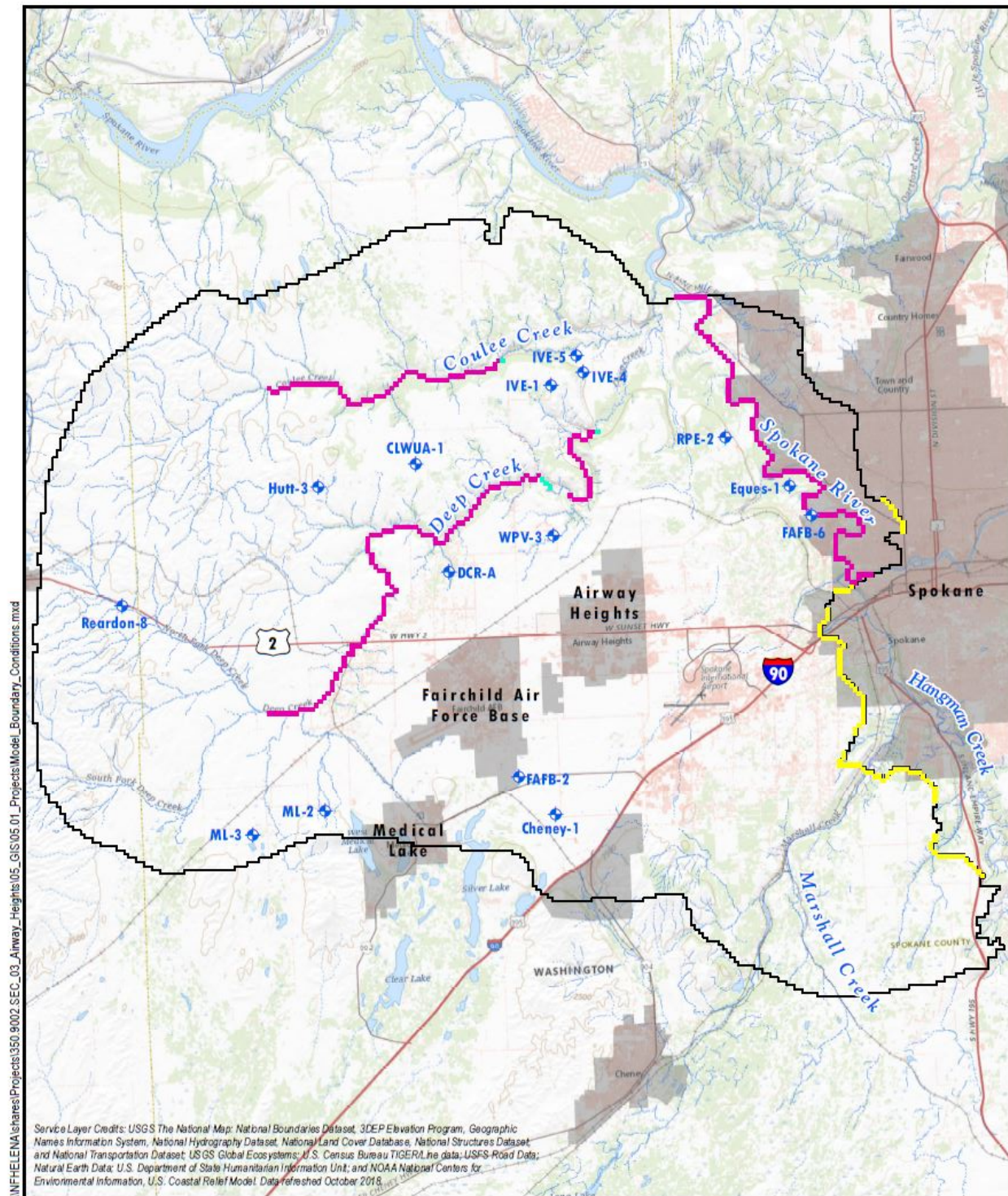
Model layer elevations are illustrated on **Figure B-1** through **Figure B-6** in **Appendix B**. Ground surface was interpolated using a USGS digital elevation model (DEM). Elevations for the West Plains portion of Layers 1 through 5 were developed from GIS coverages provided by Spokane County. GIS coverages included top elevations and unit thicknesses for the unconsolidated material, Wannapum, Upper Latah, Grande Ronde, and Lower Latah (see **Table 5-1** for corresponding layers in the model). These coverages were developed over several years using information from well logs and analyses conducted as part of previous investigations (Spokane County, 2013a; Spokane County, 2013b; GSI et. al, 2015).

The GIS coverages were developed for each unit by interpolating between known points. This interpolation resulted in areas of the model where elevations and thicknesses were inconsistent between the various units. This inconsistency was addressed in a spreadsheet, where elevations and thicknesses were imported and information adjusted manually, where necessary, so that every cell had at least a minimum thickness of 1 ft.

Layer elevations for the SVRP portion of the model were developed from model layer thicknesses assigned to the USGS model of the SVRP (Hsieh et. al, 2007) and the ground surface DEM. The top of the SVRP is lower in elevation than the unconsolidated and Wannapum units of the West Plains, so model layers 1 through 3 in the SVRP portion of the model were assigned a nominal thickness of 1 ft. The bulk of the thickness of the SVRP was assigned to Layers 4 and 5.

5.2.2 Model Boundary Conditions

Model boundary conditions include General Head Package cells, River Package cells, Well Package cells, and Analytical Element wells (**Figure 5-2**). Boundary condition specifications are summarized below, with additional details included in **Appendix A**.



Model Boundary Conditions
Hydrogeologic Study Report
Airway Heights, Washington
FIGURE 5-2

General Head Boundary Package Cells

General Head Boundary (GHB) cells are specified in the model in three locations (**Figure 5-2**). GHB cells along the eastern edge of the SVRP represent groundwater underflow into the model domain from the east. A small section of GHB cells along the southern extent of the SVRP in the model also represents groundwater underflow into the model domain from the Hangman Creek valley. GHB cells along the southeastern portion of the West Plains represents groundwater outflow from the West Plains units into the Hangman Creek valley.

A GHB is a head-dependent boundary where the flow in or out of the model is equal to the difference between the head in the model cell and the head at a distance from the model boundary times the estimated conductance of the GHB. The conductance is estimated by the following equation:

$$\text{Conductance} = WTK/L$$

Where: W = Width of cell
 T = Saturated thickness of cell
 K = Hydraulic conductivity
 L = Distance to the assigned head value

Heads (groundwater elevation) for the GHB cells in the West Plains portion of the model were assigned based on the potentiometric surface contours shown on **Figures 2-14** and **2-15**. Heads for the GHB cells in the SVRP portion of the model were assigned based on groundwater elevation contours shown on **Figure 2-24** and evaluation of simulated heads in the SVRP from the USGS model.

GHB conductance, which controls the rate at which water enters the model, varies based on K values assigned in accordance with the geologic units. As noted above, conductance is calculated from parameters based on cell geometry and an estimate of hydraulic conductivity.

Each of the three GHB cell areas were assigned a unique reach number to facilitate evaluation of model fluxes. GHB cell parameters used in the model are included in **Table A-1** in **Appendix A**.

River Package Cells

The River Package was used to simulate water flow into and out of surface water bodies within the model domain. Surface water represented in the model with River Package cells are shown on **Figure 5-2** and include:

- Spokane River;
- Deep Creek; and
- Coulee Creek.

The Spokane River is simulated with River Package cells along its entire length in the model domain. Deep Creek and Coulee Creek are represented with River Package cells from the headwaters of the two creeks

to points where the creeks go dry (based on data from Spokane County (2013a) and shown on **Figure 2-35**). Deep Creek has two sections where the creek is represented with River Package cells. River Package cells were assigned unique reach numbers for the three simulated streams to facilitate determining fluxes into or out of the surface water bodies.

The River Package is a head-dependent boundary condition that allows water to move into and out of the model cell based on the difference between the groundwater elevation and surface water stage. A conductance assigned to the river cell controls the flow rate. The conductance is estimated by the following equation:

$$\text{Conductance} = KLW/D$$

Where:

<i>K</i>	=	<i>Hydraulic conductivity</i>
<i>L</i>	=	<i>Length of cell</i>
<i>W</i>	=	<i>Width of cell</i>
<i>D</i>	=	<i>Riverbed Thickness</i>

Surface water elevation (stage) values for the Spokane River were assigned based on stage elevations specified in the USGS SVRP model (Hsieh et. al, 2007). The USGS model was used to specify stage at the furthest upgradient and downgradient river cell. A uniform gradient between the two was then applied to specify stage for all of the Spokane River cells.

Stage values for Deep Creek and Coulee Creek were assigned based on measured elevations from seepage runs conducted by Spokane County (Spokane County, 2013a). Creek elevations were reported for measuring points along the creeks (**Figure 2-36**). Stage values for river cells in between the measuring points were specified using a uniform gradient between points.

Conductance terms for river cells are commonly one of the least known model parameters. Stream length and width can be reasonably approximated, but streambed thickness and hydraulic conductivity are not often measured and must be estimated based on certain assumptions. Conductance terms are typically varied during calibration to match measured gains or losses. Conductance terms based on a reasonable range of values for site conditions were first assigned to the river cells. Conductance was then varied during calibration until simulated gains and losses in the surface water bodies reasonable matched measured values. A summary of River Package cell parameters used in the model is included in **Table A-2** and **Table A-3** in **Appendix A**.

Well Package Cells and Analytical Element Wells

Three types of wells are represented in the West Plains model. These include stream injection wells, pumping wells, and target water level wells. The pumping and injection wells are described below. Target water level wells are summarized in **Section 5.3.1**.

MODFLOW Well Package cells were used to specify five injection wells along Deep Creek and Coulee Creek (**Figure 5-2**). The wells are located at the ends of stretches of the creeks represented with river cells, and represent the loss of water from the creeks to groundwater where the creeks stop flowing. Injection rates for the Well Package cells were assigned in an iterative approach where injection rates were specified

based the simulated gain in creek flows along a given stretch, then the model was rerun and the injection rates were updated until creek flow and injection rates were similar. A summary of the injection well specifications is included in **Table A-4** in **Appendix A**.

MODFLOW's Well Package was also used to represent 15 public supply wells in the model domain. These wells represent the significant supply wells in the model domain, and specified rates are based on well capacities noted on the DOH website. Pumping from irrigation wells may also be significant in the model area, but pumping from these wells is seasonal and the model is run in steady-state so irrigation wells have not been included at this time. A summary of the pumping well specifications is included in **Table A-5** in **Appendix A**.

5.2.3 Model Properties

Model properties specified in the model include hydraulic conductivity and recharge.

Hydraulic Conductivity

Hydraulic conductivity (K) values were assigned using hydrogeologic zones. Hydrogeologic zones are areas where hydraulic parameters are spatially constant, and were assigned in the model using aquifer parameter data from wells in the Study Area.

Spokane County provided specific capacity data (yield divided by drawdown) from well logs for 142 wells in the West Plains area. Specific capacity was then converted to hydraulic conductivity and transmissivity (**Table 5-2**). Specific capacity provides a way of estimating hydraulic conductivity, although the resulting estimate is only as good as the flow rate and drawdown measurements recorded on the well log by the driller, so the values presented in **Table 5-2** are not considered absolute.

Table 5-2. Summary of Available Aquifer Parameter Data

Geologic Unit	Parameter	Number of Points	Minimum	Maximum	Average	Median
Unconsolidated	K (ft/d)	6	1.83	182	52	22
	T (ft ² /d)	6	18.35	909	392	216
Basalt	K (ft/d)	124	0.09	471	46	14
	T (ft ² /d)	124	4.18	15396	785	269
Bedrock	K (ft/d)	12	0.01	44	7	0.8
	T (ft ² /d)	12	1.30	464	118	44

Initial zones for the unconsolidated unit (Layer 1) and for the basalt units (Layer 2 and Layer 4) were assigned based on the ranges in **Table 5-2**. Specific capacity data was not available for the Upper Latah (Layer 3) and Lower Latah (Layer 5), so these units were assigned K values representative of a mixture of sand, silt, and clay that is predominantly clay. The SVRP was assigned a K value of 3,000 ft/d, which is the value used in the USGS SVRP model.

Vertical hydraulic conductivity of unconsolidated deposits is generally less than the horizontal hydraulic conductivity, especially for highly stratified unit such as the basalts in the Study Area. Initial values for vertical hydraulic conductivity were assigned using a ratio of 100:1 between horizontal and vertical hydraulic conductivity.

A total of 8 hydrogeologic zones were used in the model to represent the various geologic units in the Study Area. Initial values were adjusted during calibration to optimize the match between predicted and observed groundwater elevations. The final calibrated hydraulic conductivity values are summarized in **Table 5-3** and shown on **Figure B-7** through **Figure B-11 (Appendix B)**.

Table 5-3. Model Hydraulic Conductivity Zones

Hydraulic Conductivity Zone	Hydraulic Conductivity Value (ft/d)			Comment
	Kx	Ky	Kz	
1	0.1	0.1	5.00E-05	Layer 3 (Upper Latah)
2	0.1	0.1	0.1	Layer 5 (Lower Latah)
3	10	10	1	
4	10	10	0.01	Layer 1 (Unconsolidated)
5	70	70	0.7	Layer 2 (Wannapum)
6	60	60	6	
7	100	100	0.1	Layer 4, Layer 5 (Grande Ronde)
8	200	200	0.15	Layer 4 (Grand Ronde)
9	120	120	0.12	Layer 1, Layer 2 Paleochannels
10	3000	3000	30	SVRP

Recharge

Water entering the groundwater system as infiltration of precipitation is simulated using the Recharge Package. Recharge rates were specified using a recharge GIS coverage provided by Spokane County that combines precipitation data (see **Figure 2-2**) with land use to arrive at infiltration rates across the model domain.

5.3 MODEL CALIBRATION

Model calibration is the process of comparing model predicted conditions such as groundwater elevations in wells and boundary fluxes to measured or estimated values. Model parameters and boundary conditions are adjusted during calibration until the comparison of simulated to observed data are within established calibration goals. Adjustments are typically made preferentially to parameters with uncertainty in the actual values such as hydraulic conductivity and stream conductance.

Calibration goals are summarized below, along with data used as targets for the calibration. Results of the calibration are then summarized, with additional detail provided in **Appendix C**.

5.3.1 Calibration Goals

The model was calibrated to demonstrate that it is capable of simulating field-measured groundwater elevations and changes in streamflow. For this modeling effort, the model was calibrated to steady-state conditions. The calibration process required first establishing a set of calibration targets and goals. Model inputs were then adjusted iteratively within appropriate ranges based on measured data to achieve a reasonable match between observed and simulated target values. The quality of the match was judged using both quantitative and qualitative methods.

Data used as calibration targets (see **Section 5.3.2**) include single-event water level measurements from wells and estimated fluxes developed for the groundwater budget (see **Section 2.5**).

Calibration goals include the following:

1. *The residual standard deviation divided by the head range of calibration targets. Adequately calibrated is <10%, well calibrated is <5%;*
2. *The residual mean divided by the head range of the calibrated targets. Adequately calibrated is <5%, well calibrated is <1%;*
3. *Residual mean in areas of interest (Layer 4 and Groups 1, 4, and 5) is less than 10 feet;*
4. *No bias, that is, no clustering of positive and negative residuals unless residuals are small; and*
5. *Model predicted fluxes for groundwater budget components are within the estimated ranges.*

In addition, a comparison of simulated groundwater elevation contours to those derived from measured data (**Figure 2-15**) was used as a qualitative measure of calibration.

5.3.2 Calibration Targets

Calibration targets used for the West Plains Model include measured groundwater elevations at wells, and estimated fluxes for groundwater budget components.

Groundwater Elevations

Groundwater elevation (head) targets were selected by compiling data from wells within the Study Area from several sources. The primary groundwater elevation sources were the synoptic measuring events in the fall and spring of 1994, and the fall event in 2011 and subsequent spring event in 2012. The measuring events in 2011/2012 included more wells than the event in 1994. Synoptic events are when water levels are measured in wells at roughly the same time, and are preferred for model calibration because it reduces well to well temporal variations due to factors such as recharge or pumping.

After review of the available groundwater elevation data, the synoptic event in the spring of 2012 was chosen for the calibration targets. The majority of the groundwater elevations in this dataset were measured in April. Because the model is currently run in steady-state the goal was to have it represent annual average conditions, and the spring dataset is presumed to be most representative of those average conditions. April water level measurements are likely made before significant recharge or seasonal pumping (e.g., irrigation) occurs.

A total of 46 wells were used for model calibration. The locations of these targets are shown on **Figure C-1 (Appendix C)**. The spring 2012 dataset includes a total of 108 wells, but the points used for calibration were reduced to address clustering (i.e. multiple points in a small area that could bias spatial statistics), eliminate points where water levels appeared anomalous when compared to nearby wells, and eliminate wells that exhibited significant groundwater level fluctuations over the measured events.

Wells used in the calibration were separated into groups based on spatial location, as illustrated on **Figure C-1 (Appendix C)**. Grouping groundwater elevation targets helps to facilitate the evaluation of the model calibration on a spatial basis such that calibration in specific areas of interest can be prioritized.

In addition, weights were assigned to the target water levels. This is a statistical way to reduce the importance of some targets on the overall calibration. There are a number of reasons for reducing the weight of a given target. There may be a degree of uncertainty associated with the accuracy of the measuring point elevation, which introduces potential error in the calculated elevation. In other cases the target well may be a pumping well, or near a pumping well and if the measurement is taken too soon after pumping it could be unrepresentative of steady-state conditions. Lastly, some wells are in locations of greater interest or importance to the model goals than others.

As a result of the uncertainties regarding the measured groundwater elevations, weights were applied to the targets. Weighting was prioritized to focus on the Grande Ronde (Layer 4 and Layer 5) in well groups 1, 4, and 5 (areas of potential well locations and Airway Heights). Weight values assigned to each target are included in **Table C-1 (Appendix C)** and the weighting scheme used in the West Plains Model is as follows:

<u>Well</u>	<u>Weight</u>
Layer 4/Layer 5, Groups 1, 4, & 5	1
Layer 2, Groups 1, 4, & 5	0.8
Groups 2 & 3	0.5
Wells with >5 ft change in water levels	0.5
Wells with >10 ft change in water levels	0.1

Groundwater budget

Groundwater budget components described and presented in **Section 2.5** were also used as calibration targets. The estimated groundwater flux for each component consists of a range between the minimum and maximum value with a best estimate within that range.

5.3.3 Calibration Results

Model calibration results are presented below and in **Appendix C**. Results presented include head target residual statistics (calibration goals 1, 2, and 3), an observed versus simulated plot (calibration goal 4), and a summary of simulated fluxes for each groundwater budget component (calibration goal 5).

A summary of the head target residual statistics is presented in **Table 5-4**, and simulated heads and residuals at each target point are provided in **Table C-1 (Appendix C)**. The summary statistics indicate that calibration goals 1, 2, and 3 have been met (highlighted values). The residual standard deviation divided by the head range (calibration goal 1) is 4.9% indicating the model is well calibrated. The residual mean divided by the head range (calibration goal 2) is 0.6%, also indicating the model is well calibrated. Residual mean values for well groups 1, 4, 5 and for Layer 4 are all below the target of 10 feet at 7.0, -6.4, -8.2, and 5.3 feet, respectively (calibration goal 3).

Table 5-4. Calibration Head Target Residual Statistics

Residual Mean	4.9
Absolute Residual Mean	32.9
Residual Std. Deviation	38.9
Sum of Squares	70579.4
RMS Error	39.2
Min. Residual	-94.6
Max. Residual	81.2
Number of Observations	46.0
Range in Observations	797.1
Scaled Residual Std. Deviation	0.0
Scaled Absolute Residual Mean	0.0
Scaled RMS Error	0.0
Scaled Residual Mean	0.0
Res Std Dev/Head Range (<10%):	4.9%
Res Mean/Head Range (<5%):	0.6%

Grp	Pts	
1	12	7.0
2	7	21.8
3	10	10.7
4	12	-6.4
5	5	-8.2

Layer	Pts	
2	16	15.5
4	23	5.3
5	7	-20.3

A plot of the observed versus simulated groundwater elevations at the target points is presented on **Figure 5-3**. A perfect match between observed and simulated values would fall along the red line shown on the figure. Points above the line have higher simulated than observed heads and points below the line have lower simulated than observed heads.

The plot indicates that there are no significant clusters of points that are all above or below the optimal line, except perhaps for points at the highest elevations. The conclusion that can be drawn from **Figure 5-3** is that there appears to be no spatial bias for the majority of the model (calibration goal 4), but higher elevation points (western portion of the model domain) appear to show a slight bias toward underestimating groundwater elevations.

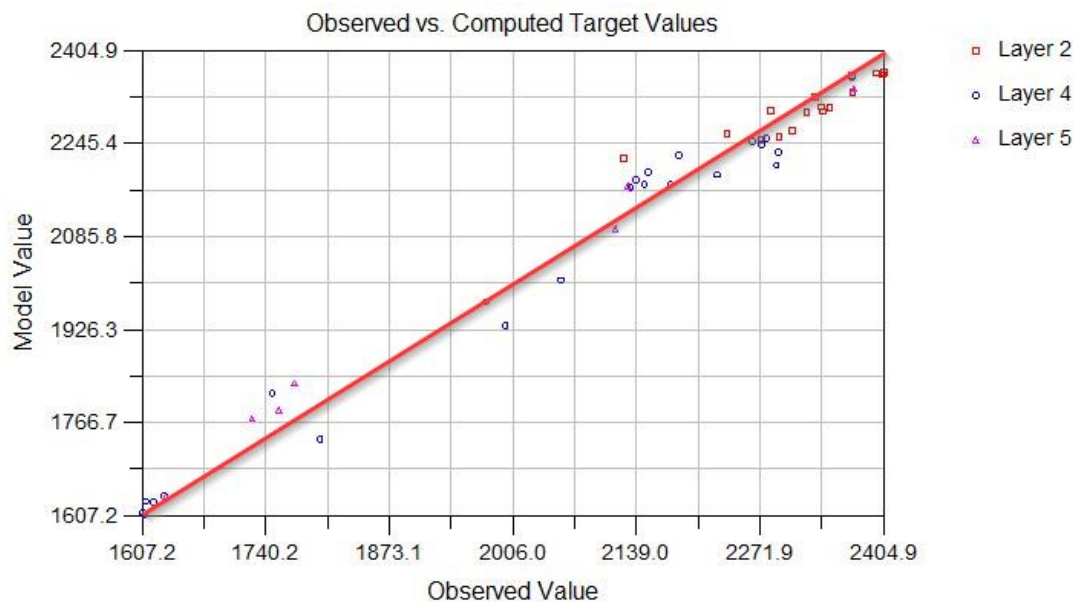
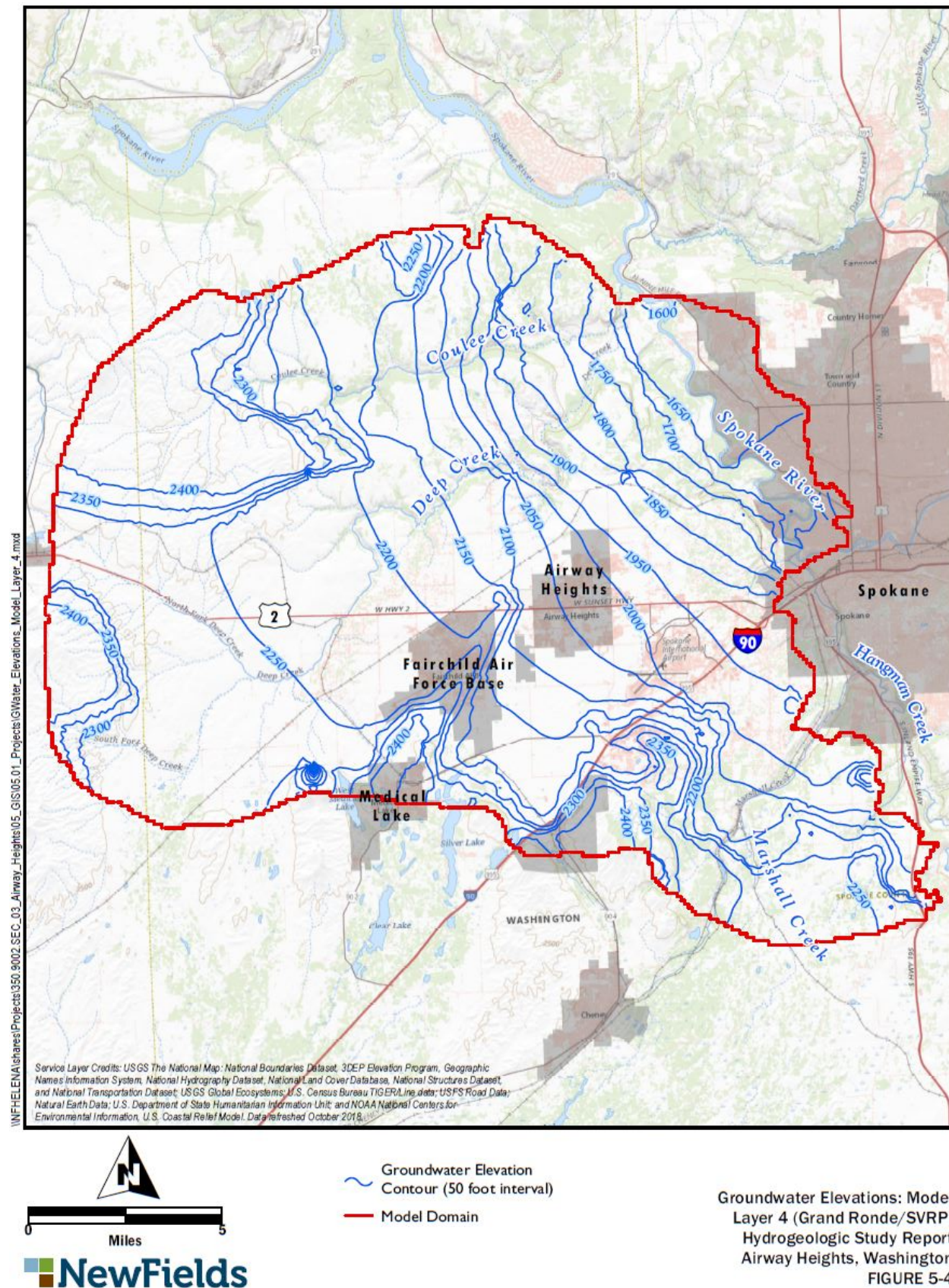


Figure 5-3. Observed versus Simulated Heads at Calibration Targets

Simulated groundwater elevations for model Layer 4 (Grande Ronde) are shown on **Figure 5-4**. In general, the simulated groundwater elevations compare favorably to the contoured elevations from measured values shown on **Figure 2-15**. There are some localized discrepancies, for example the observed contours show a bending or convergence of groundwater flow at the mouth of Deep Creek whereas the model only shows a minor bending of the contours. This comparison was used as a qualitative measure of calibration.



The range of fluxes calculated for the groundwater budget, described in **Section 2.5**, was used to evaluate model simulated fluxes for each of the components. A summary of the calculated and simulated fluxes is provided in **Table C-2 (Appendix C)** and shown graphically on **Figure C-3 (Appendix C)**.

The simulated fluxes fall within the calculated ranges for all components in the groundwater budget with the exception of the fluxes for Coulee Creek, where the simulated flux is below the minimum calculated value. Minimum flow for Coulee Creek was calculated using a low measured flow rate (0.3%), and there can be significant error in measurement for flows that low. In addition, Coulee Creek is a minor component of the overall budget (0.12% of the overall outflow).

The greatest amount of water in the groundwater budget is flow into the domain from the SVRP and discharge to the Spokane River (**Figure C-3 in Appendix C**). Model simulated flows for the underflow in from the SVRP is within the calculated range but near the maximum. Discharge to the Spokane River is closer to the estimated value.

6.0 DETAILED ALTERNATE WELL LOCATION EVALUATION

The calibrated West Plains model was used to simulate potential new water supply wells for Airway Heights. The predictive simulations are intended to present a detailed evaluation of potential impacts from the installation of a new water supply well(s) and is the next step after the First Level Screening of alternate well locations presented in **Section 4.0**.

The alternate well locations simulated and discussed below are the two locations retained in that First Level Screening. While these simulations provide a more detailed evaluation of the alternate well locations, they are not intended to be the final answer to how the wells could impact groundwater and surface water rights. In the event that either of the two alternate well locations are pursued further, additional work will be necessary to prepare an analysis to accompany water rights application material and to itemize costs for well installation and infrastructure updates. In particular, the simulated well location(s) are approximate and will need to be refined based on land access and water rights considerations and, depending upon the outcome of the EE/CA, the pumping rate simulated may need to be revised.

6.1 MODEL SIMULATIONS

Predictive simulations were completed for potential wells in the SVRP and in the West Plains to the west of Airway Heights. The simulated pumping rate for both simulations was 1,014 gpm.

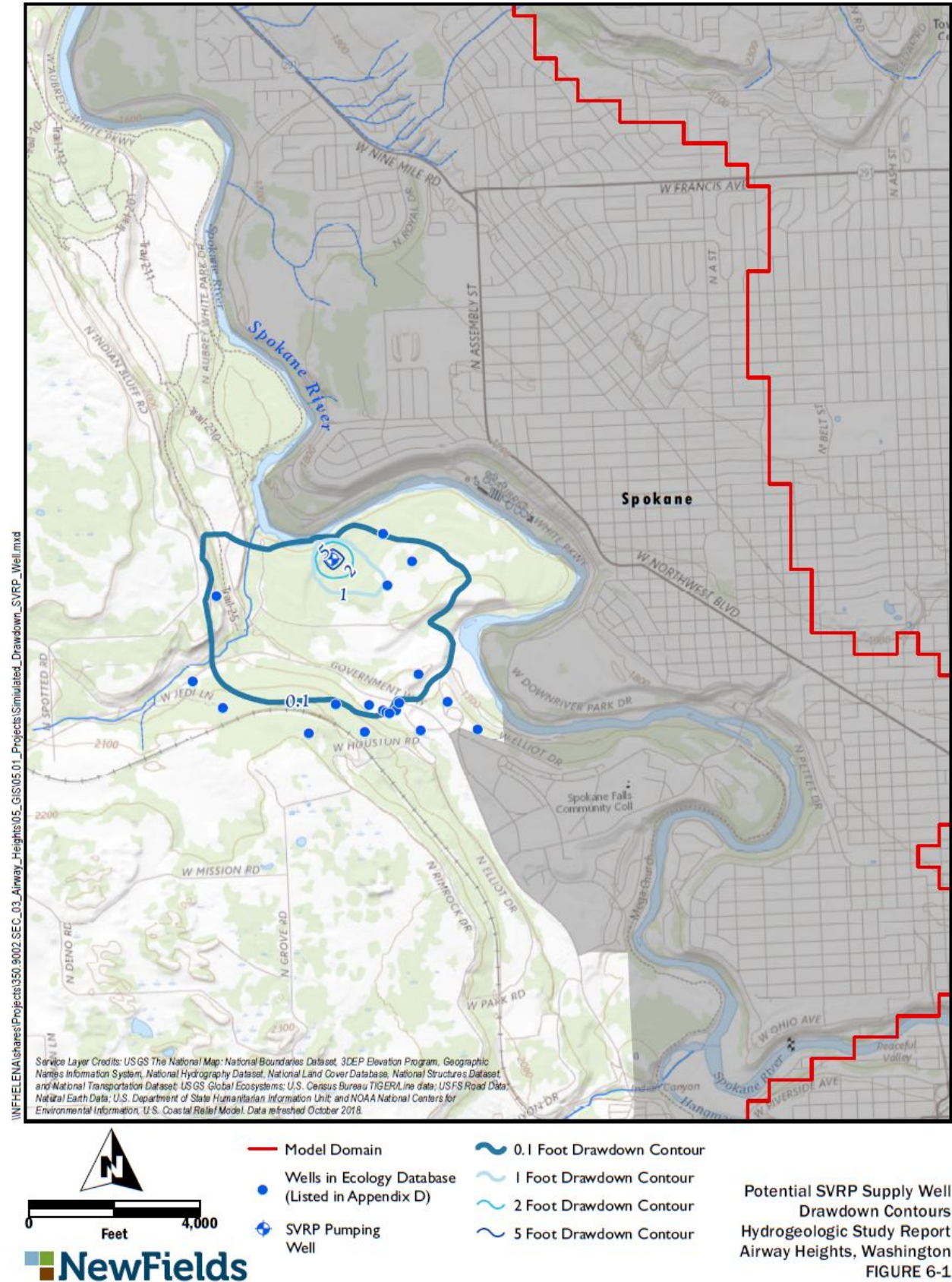
For the potential well in the SVRP, a location to the north of the FAFB wellfield was chosen (**Figure 6-1**). This specific location was chosen because it falls within one of the areas previously identified for potential well locations in the SVRP (**Figure 4-1**), and it is downgradient of the existing Airway Heights wells, which will be crucial for addressing water rights aspects of the alternate well location.

Alternate well locations in the area west of Airway Heights were chosen based on proximity to U.S. Highway 2 (**Figure 6-1**), but as noted above, the actual locations of these wells would need to be refined at a later date if this alternate well location is pursued. For this simulation it was assumed that three wells would be necessary to provide the total well yield needed for replacement because wells in the West Plains typically have lower yields and a single well would not likely provide the 1,014 gpm needed.

6.2 SIMULATION 1: POTENTIAL WELL IN THE SVRP

6.2.1 Potential Impact Evaluation

Model results show that the potential alternate well in the SVRP results in minimal drawdown due to the high transmissivity of the SVRP aquifer (**Figure 6-1**). Simulated drawdown at the well is small (8.5 ft) and the 0.1-foot drawdown contour extends out to a distance of about 3,000 ft from the simulated pumping well.



Predicted impacts to nearby wells are summarized in **Table D-1 (Appendix D)**. The maximum drawdown in any of the nearby wells was 0.8 ft, which will not likely be considered to be an adverse effect. For this simulation it was assumed that all nearby wells identified in the Ecology database are in the same layer as the pumping well to provide a conservative scenario.

Pumping at the supply well location for this simulation however would result in depletion of the Spokane River. Because the river is the only point of discharge for groundwater in this area, the depletion in the river will be equal to the amount pumped and will be consistent throughout the year because the pumping will be year round.

6.2.2 Water Rights Feasibility

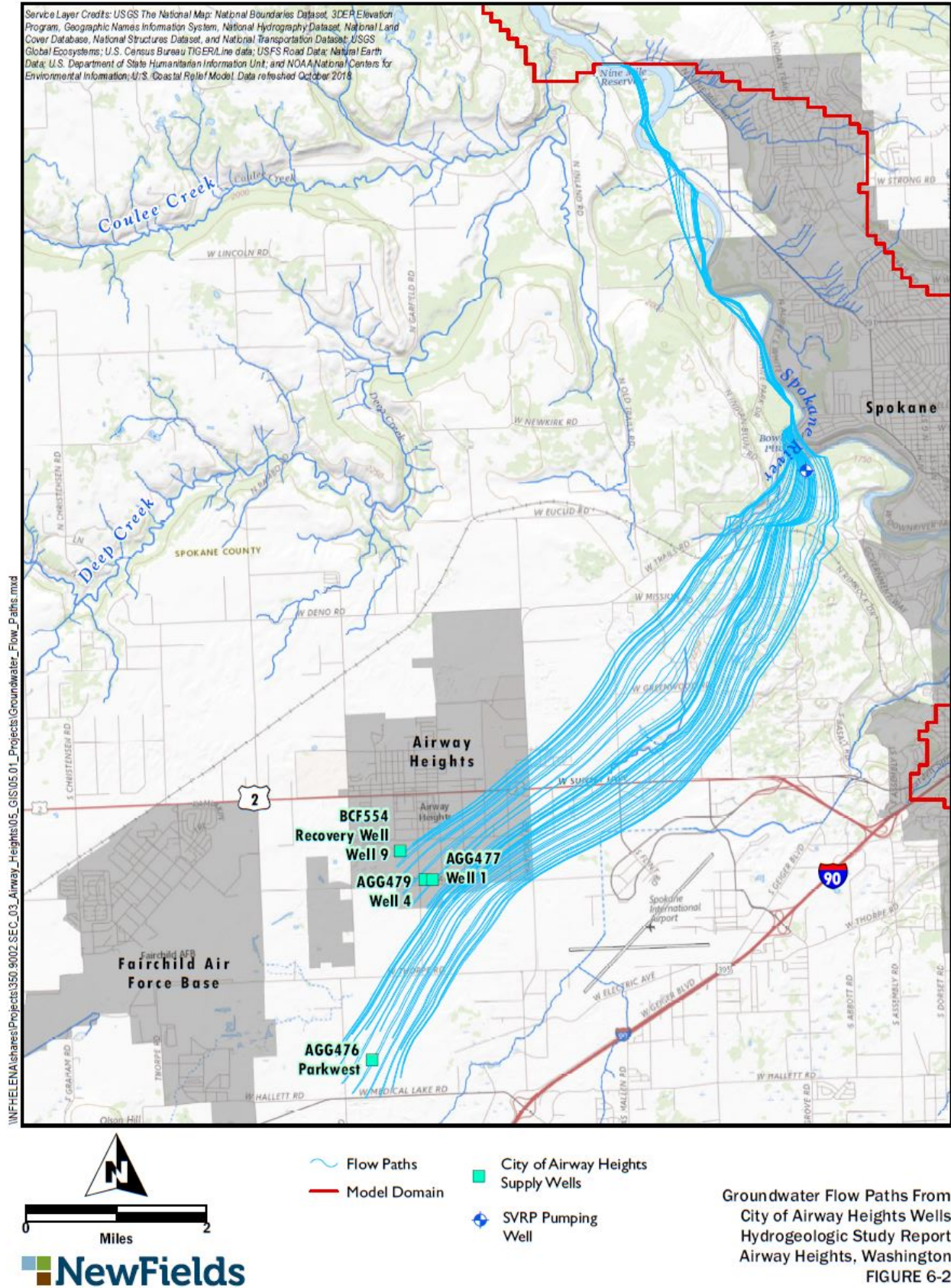
As previously noted, Ecology will not grant a new water right for a well in this area due to the instream flow rights for the Spokane River (see **Section 3.5.1**). However, if the alternate well location is downgradient of the Airway Heights wells, then a transfer of the Airway Heights existing water rights could be completed. The transfer process would consist of Airway Heights relinquishing existing water rights and noting that relinquishment in an application for a new water right for the replacement well(s).

The West Plains model was used to evaluate if the alternate well location in the SVRP is downgradient of the existing Airway Heights wells. Particle tracking was used with particles placed around the existing Airway Heights wells and allowed to move forward in time (i.e., in the direction of groundwater flow). **Figure 6-2** shows particle tracking results, which indicate that the simulated alternate well location is downgradient of the existing Airway Heights wells.

6.2.3 Access and Other Considerations

For a well to draw water from the SVRP it would need to be located below the bluffs of the West Plains basalt and west of the Spokane River. Water would be pumped up from that location to transmission lines, which would then route the water to Airway Heights, similar to what FAFB does with their water supply further upstream.

Infrastructure would need to be built to pump water from the newly installed well up to the West Plains. From there, additional infrastructure such as pipes and pumps would need to be installed to transmit water to Airway Heights. An evaluation of the infrastructure needed is beyond the scope of this evaluation, but it is possible some existing infrastructure could be used, such as the intertie with the City of Spokane that Airway Heights currently uses to obtain water.



6.3 SIMULATION 2: POTENTIAL WELLFIELD WEST OF AIRWAY HEIGHTS

6.3.1 Potential Impact Evaluation

The simulated wellfield to the west of Airway Heights has a much larger zone of influence than the potential alternate well in the SVRP (**Figure 6-3**). The 5-foot drawdown contour extends south to the edge of the model domain, west to the town of Reardon, and east to the upper reach of Deep creek. In addition, the drawdown extends to the southeast almost to FAFB.

Predicted impacts to nearby wells are summarized in **Table D-2 (Appendix D)**. Because of the large zone of influence from pumping the potential wells, there are many wells that are predicted to experience drawdown. The greatest predicted drawdown in any of the nearby wells is 7.9 ft, which would need further evaluation to determine if it is an adverse effect. For this simulation, it was assumed that all nearby wells identified in the Ecology database are in the same layer as the pumping well to provide a conservative scenario.

Note that although the model is calibrated, the Grande Ronde in the area of the simulated wells is assigned a uniform hydraulic conductivity. The aquifer material in this area most likely varies spatially and if the hydraulic conductivity were lower in the vicinity of the wells, then drawdown would be greater around the well but not extend as far. If supply wells at this location are to be considered further, additional evaluation of aquifer properties in the area of these pumping wells will be needed to better quantify potential drawdown effects.

Pumping at the supply well location for this simulation would result in depletion of Deep Creek and Coulee Creek. Estimates of the depletion to the creeks from this simulation is 180 gpm for Deep Creek and 0.4 gpm for Coulee Creek.

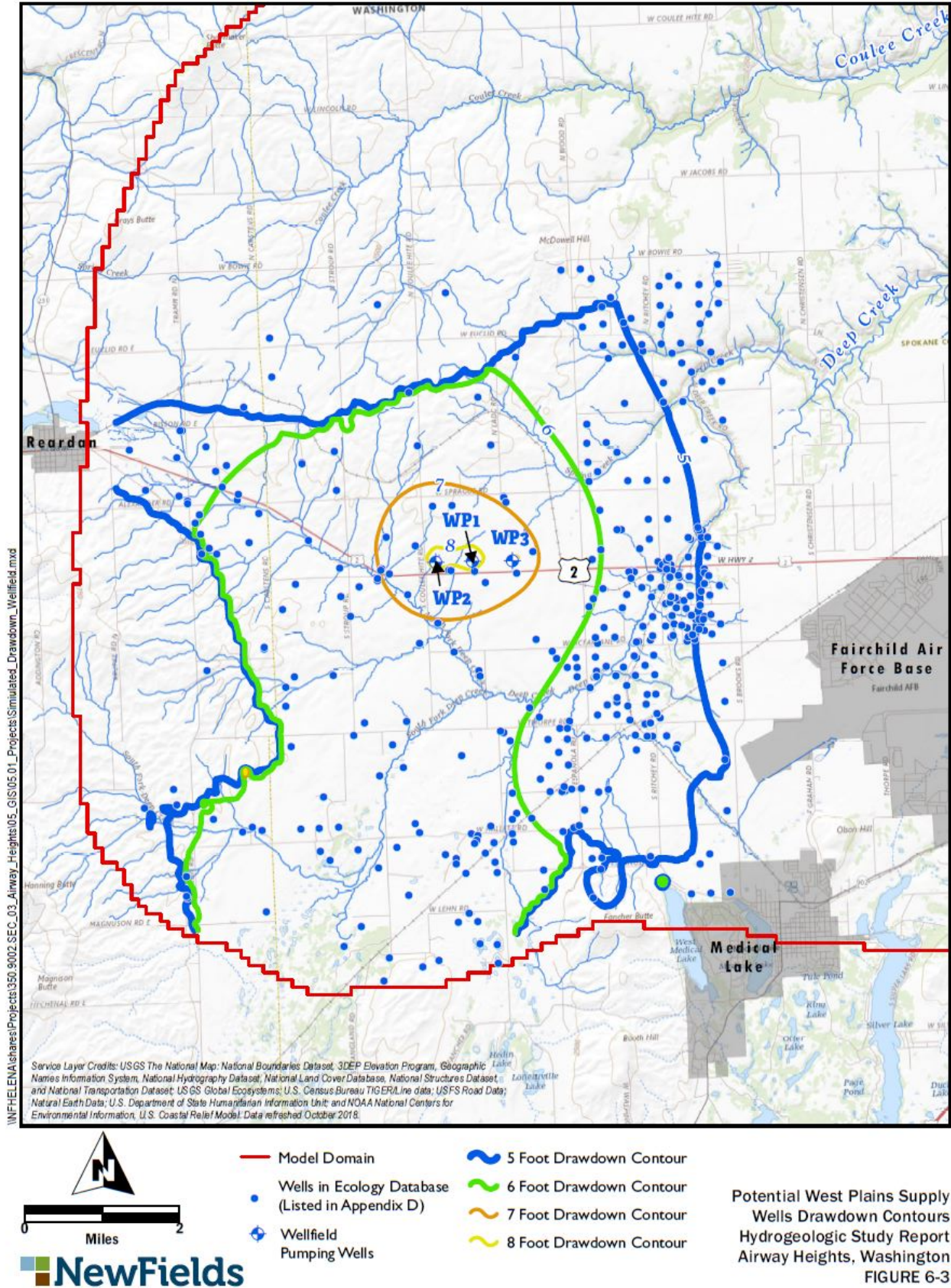
6.3.2 Water Rights Feasibility

Because the simulated wells are upgradient of the Airway Heights wells, the City's existing water rights cannot be used for these new wells. Instead, an existing water right or several rights, would need to be purchased to offset the predicted impacts from pumping.

The supply wells would presumably be pumped year round, but the most likely water right purchased would be an irrigation right, which would be seasonal. It would need to be demonstrated that a seasonal right or rights are adequate to mitigate the impacts from pumping the supply wells. A transient analysis would likely be necessary using the model to simulate seasonal pumping and mitigation.

Infiltration of reclaimed water from the City could be considered, perhaps along Deep Creek to mitigate some of the pumping impacts. The volume of water needed from a purchased right would be less if reclaimed water infiltration were to be used.

An investigation of water rights that might be available for purchase was not conducted for this evaluation.



6.3.3 Access and Other Considerations

The simulated wells are located along U.S. Highway 2, which would facilitate routing the water to Airway Heights. However, pipes would need to be installed along with pumps to transmit the water from the wellfield to the City.

In addition, land purchase may be necessary, or right-of-way agreements completed to install and access the potential wells. An evaluation of the infrastructure and access needed is beyond the scope of this evaluation.

7.0 NUMERICAL MODEL LIMITATIONS

Numerical models are simplifications of complex systems. In all modeling exercises, some input parameters are not well quantified due to insufficient data or for other reasons, which leads to uncertainty in model predictions. The primary objective of the modeling exercise described in this document was to develop a numerical tool to help evaluate pumping impacts from potential water supply wells. The actual well locations will be refined if an alternate water source is pursued further. The true nature of pumping impacts could vary somewhat from these predictions, but the model predictions are useful for evaluating the magnitude and spatial nature of the influence of a new well.

Although the numerical model has undergone a quantitative calibration, its ability to accurately predict groundwater elevations at specific locations varies from place to place. The overall groundwater movement and groundwater-surface water interaction is reasonable and falls within ranges of estimated groundwater budget components. However, specific matches to measured water levels at some locations is off by tens of feet. The discrepancy between simulated and measured water levels may be due to a variety of reasons including but not necessarily limited to:

- The measured water levels may not be representative of steady-state conditions and instead may be the result of short-term transient conditions such as recharge or pumping;
- The simplified representation of the geologic units, such as representing the Grande Ronde with a single layer, may reasonably replicate heads and flow in the unit overall but not be able to replicate differences between the variable layers that make up each unit; and
- Uniform hydraulic conductivity values are used over large areas of the model, when in fact there are likely spatial variations.

Despite the limitations of the model and uncertainty regarding accuracy at specific locations, the model is considered a reliable tool for evaluating pumping impacts from potential water supply wells. The simulations presented evaluate the difference between potential water supply well pumping and non-pumping conditions and as such provide a reasonable general prediction of the magnitude of the change caused by the simulated pumping.

8.0 CONCLUSIONS

The hydrogeologic study and alternate well location evaluation concluded the following:

- The majority of groundwater within the Study Area occurs in an isolated portion of the CRBG, which flows eastward into the SVRP.
- Although the SVRP represents a small portion of the Study Area, flow through the SVRP accounts for 84% of the total flow in and 97% of the total flow out of the groundwater system.
- Instream flows specified for the Spokane River and SWSL for Deep Creek means that a new water right within the Study Area is not likely unless the new right is fully mitigated.
- Based on a first level screening of potential water supply well locations, the East Area in the SVRP aquifer was considered to be the best option for a new water supply well location, and of the four potential locations in the basalt aquifers of the West Plains, the West Area was considered the best option.
- For the potential East Area well in the SVRP:
 - Pumping in the well is predicted to have a limited spatial zone of influence, and drawdown in nearby wells is small and would not likely be an adverse effect.
 - Pumping would result in depletion in the Spokane River.
 - It is likely that the existing rights could be transferred to the new well because the potential well location is downgradient from the existing Airway Heights water rights.
- For the potential West Area well(s) in the basalt aquifers of the West Plains:
 - Pumping is predicted to have a large spatial zone of influence that may affect many existing wells. Drawdown however does not appear to be significant and may not be considered an adverse effect.
 - The pumping would result in depletion in Deep Creek and Coulee Creek.
 - Because the potential well location is upgradient from the existing Airway Heights water rights, these rights could not be transferred to the new well location. Instead, other existing water rights would need to be purchased. Analyses would need to be conducted to verify that the purchased rights would offset potential pumping impacts from the new well in place and time.
- The East Area in the SVRP provides the best option for an alternate supply well(s) in terms of well yields at the full replacement rate and water rights.
- In the West Area in the basalt aquifers, developing alternate supply well(s) that would provide the full replacement rate is uncertain and would entail purchasing existing water rights and an analysis to prove those rights would offset pumping impacts. Well yield is also uncertain for this location.

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APPENDIX A
GROUNDWATER FLOW MODEL BOUNDARY CONDITIONS

Table A-1
General Head Package Boundaries

Model Row	Model Column	Model Layer	Reach	Head	Cell Width	Saturated Thickness	GHB Distance	Hydraulic Conductivity	Layer Bottom
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SVRP Upgradient

88	224	4	1	1850	500	100	1	1.00E+03	1825.2
88	224	5	1	1850	500	100	1	1.00E+03	1785.2
89	225	4	1	1850	500	100	1	1.00E+03	1827.6
89	225	5	1	1850	500	100	1	1.00E+03	1787.6
90	226	4	1	1850	500	100	1	1.00E+03	1708.3
90	226	5	1	1850	500	100	1	1.00E+03	1588.3
91	227	4	1	1850	500	100	1	1.00E+03	1711
91	227	5	1	1850	500	100	1	1.00E+03	1591
92	227	4	1	1850	500	100	1	1.00E+03	1716.5
92	227	5	1	1850	500	100	1	1.00E+03	1596.5
93	228	4	1	1850	500	100	1	1.00E+03	1721.7
93	228	5	1	1850	500	100	1	1.00E+03	1601.7
94	229	4	1	1850	500	100	1	1.00E+03	1725
94	229	5	1	1850	500	100	1	1.00E+03	1605
95	229	4	1	1850	500	100	1	1.00E+03	1729.6
95	229	5	1	1850	500	100	1	1.00E+03	1609.6
96	229	4	1	1870	500	100	1	1.00E+03	1857.3
96	229	5	1	1850	500	100	1	1.00E+03	1817.3

SVRP From Hangman Creek Valley

110	216	4	2	1750	500	50	1	4.00E-01	1692.3
110	216	5	2	1750	500	50	1	4.00E-01	1652.3
111	212	4	2	1820	500	50	1	4.00E-01	1817.4
111	212	5	2	1780	500	50	1	4.00E-01	1777.4
111	213	4	2	1820	500	50	1	4.00E-01	1813
111	213	5	2	1780	500	50	1	4.00E-01	1773
111	214	4	2	1780	500	50	1	4.00E-01	1728.8
111	214	5	2	1780	500	50	1	4.00E-01	1688.8
111	215	4	2	1780	500	50	1	4.00E-01	1728.8
111	215	5	2	1780	500	50	1	4.00E-01	1688.8

West Plains Discharge to Hangman Creek Valley

116	210	4	3	1900	500	50	1	1.00E+02	1865
116	210	5	3	1900	500	50	1	1.00E+02	1779
117	210	4	3	1901.1	500	50	1	1.00E+02	1876
117	210	5	3	1901.1	500	50	1	1.00E+02	1796
118	210	4	3	1902.1	500	50	1	1.00E+02	1872
118	210	5	3	1902.1	500	50	1	1.00E+02	1831
119	209	4	3	1903.2	500	50	1	1.00E+02	1875
119	209	5	3	1903.2	500	50	1	1.00E+02	1836
120	208	4	3	1904.3	500	50	1	1.00E+02	1870
120	208	5	3	1904.3	500	50	1	1.00E+02	1833
121	208	4	3	1905.3	500	50	1	1.00E+02	1867
121	208	5	3	1905.3	500	50	1	1.00E+02	1826
122	208	4	3	1906.4	500	50	1	1.00E+02	1887

Table A-1
General Head Package Boundaries

Model Row	Model Column	Model Layer	Reach	Head	Cell Width	Saturated Thickness	GHB Distance	Hydraulic Conductivity	Layer Bottom
122	208	5	3	1906.4	500	50	1	1.00E+02	1839
123	209	4	3	1907.4	500	50	1	1.00E+02	1871
123	209	5	3	1907.4	500	50	1	1.00E+02	1856
123	210	4	3	1908.5	500	50	1	1.00E+02	1897
123	210	5	3	1908.5	500	50	1	1.00E+02	1834
123	211	4	3	1909.6	500	50	1	1.00E+02	1886
123	211	5	3	1909.6	500	50	1	1.00E+02	1856
123	212	4	3	1910.6	500	50	1	1.00E+02	1873
123	212	5	3	1910.6	500	50	1	1.00E+02	1848
124	213	4	3	1911.7	500	50	1	1.00E+02	1880
124	213	5	3	1911.7	500	50	1	1.00E+02	1820
125	214	4	3	1912.8	500	50	1	1.00E+02	1899
125	214	5	3	1912.8	500	50	1	1.00E+02	1806
126	213	4	3	1913.8	500	50	1	1.00E+02	1875
126	213	5	3	1913.8	500	50	1	1.00E+02	1818
127	213	4	3	1914.9	500	50	1	1.00E+02	1899
127	213	5	3	1914.9	500	50	1	1.00E+02	1811
128	213	4	3	1916	500	50	1	1.00E+02	1896
128	213	5	3	1916	500	50	1	1.00E+02	1805
129	213	5	3	1917	500	50	1	1.00E+02	1802
130	213	4	3	1918.1	500	50	1	1.00E+02	1890
130	213	5	3	1918.1	500	50	1	1.00E+02	1800
131	213	4	3	1919.1	500	50	1	1.00E+02	1913
131	213	5	3	1919.1	500	50	1	1.00E+02	1800
132	213	4	3	1920.2	500	50	1	1.00E+02	1877
132	213	5	3	1920.2	500	50	1	1.00E+02	1826
133	214	4	3	1921.3	500	50	1	1.00E+02	1848
133	214	5	3	1921.3	500	50	1	1.00E+02	1796
134	215	4	3	1922.3	500	50	1	1.00E+02	1858
134	215	5	3	1922.3	500	50	1	1.00E+02	1804
135	216	4	3	1923.4	500	50	1	1.00E+02	1873
135	216	5	3	1923.4	500	50	1	1.00E+02	1816
136	217	4	3	1924.5	500	50	1	1.00E+02	1887
136	217	5	3	1924.5	500	50	1	1.00E+02	1825
137	218	4	3	1925.5	500	50	1	1.00E+02	1887
137	218	5	3	1925.5	500	50	1	1.00E+02	1821
138	219	4	3	1926.6	500	50	1	1.00E+02	1882
138	219	5	3	1926.6	500	50	1	1.00E+02	1820
139	219	4	3	1927.7	500	50	1	1.00E+02	1887
139	219	5	3	1927.7	500	50	1	1.00E+02	1830
140	219	4	3	1928.7	500	50	1	1.00E+02	1887
140	219	5	3	1928.7	500	50	1	1.00E+02	1832
141	219	4	3	1929.8	500	50	1	1.00E+02	1885
141	219	5	3	1929.8	500	50	1	1.00E+02	1832
142	219	4	3	1930.9	500	50	1	1.00E+02	1893
142	219	5	3	1930.9	500	50	1	1.00E+02	1843

Table A-1
General Head Package Boundaries

Model Row	Model Column	Model Layer	Reach	Head	Cell Width	Saturated Thickness	GHB Distance	Hydraulic Conductivity	Layer Bottom
143	219	4	3	1931.9	500	50	1	1.00E+02	1901
143	219	5	3	1931.9	500	50	1	1.00E+02	1859
144	219	4	3	1933	500	50	1	1.00E+02	1904
144	219	5	3	1933	500	50	1	1.00E+02	1876
145	218	4	3	1934	500	50	1	1.00E+02	1913
145	218	5	3	1934	500	50	1	1.00E+02	1912
146	217	4	3	1935.1	500	50	1	1.00E+02	1908
146	217	5	3	1935.1	500	50	1	1.00E+02	1907
147	217	4	3	1936.2	500	50	1	1.00E+02	1924
147	217	5	3	1936.2	500	50	1	1.00E+02	1923
152	214	5	3	1941.5	500	50	1	1.00E+02	1931
153	214	4	3	1942.6	500	50	1	1.00E+02	1933
153	214	5	3	1942.6	500	50	1	1.00E+02	1895
154	213	4	3	1943.6	500	50	1	1.00E+02	1924
154	213	5	3	1943.6	500	50	1	1.00E+02	1887
155	213	4	3	1944.7	500	50	1	1.00E+02	1911
155	213	5	3	1944.7	500	50	1	1.00E+02	1832
155	214	4	3	1945.7	500	50	1	1.00E+02	1887
155	214	5	3	1945.7	500	50	1	1.00E+02	1814
155	215	4	3	1946.8	500	50	1	1.00E+02	1892
155	215	5	3	1946.8	500	50	1	1.00E+02	1792
155	216	4	3	1947.9	500	50	1	1.00E+02	1903
155	216	5	3	1947.9	500	50	1	1.00E+02	1766
155	217	5	3	1948.9	500	50	1	1.00E+02	1740
155	218	4	3	1950	500	50	1	1.00E+02	1936
155	218	5	3	1950	500	50	1	1.00E+02	1714
156	219	4	3	1951.1	500	50	1	1.00E+02	1845
156	219	5	3	1951.1	500	50	1	1.00E+02	1665
156	227	4	3	1952.1	500	50	1	1.00E+02	1856
156	227	5	3	1952.1	500	50	1	1.00E+02	1735
156	228	4	3	1953.2	500	50	1	1.00E+02	1854
156	228	5	3	1953.2	500	50	1	1.00E+02	1747
156	229	4	3	1954.3	500	50	1	1.00E+02	1853
156	229	5	3	1954.3	500	50	1	1.00E+02	1753
156	230	4	3	1955.3	500	50	1	1.00E+02	1869
156	230	5	3	1955.3	500	50	1	1.00E+02	1772
157	220	4	3	1956.4	500	50	1	1.00E+02	1770
157	220	5	3	1956.4	500	50	1	1.00E+02	1637
157	221	4	3	1957.4	500	50	1	1.00E+02	1756
157	221	5	3	1957.4	500	50	1	1.00E+02	1633
157	226	4	3	1958.5	500	50	1	1.00E+02	1854
157	226	5	3	1958.5	500	50	1	1.00E+02	1724
157	231	4	3	1959.6	500	50	1	1.00E+02	1833
157	231	5	3	1959.6	500	50	1	1.00E+02	1806
157	232	4	3	1960.6	500	50	1	1.00E+02	1834
157	232	5	3	1960.6	500	50	1	1.00E+02	1807

Table A-1
General Head Package Boundaries

Model Row	Model Column	Model Layer	Reach	Head	Cell Width	Saturated Thickness	GHB Distance	Hydraulic Conductivity	Layer Bottom
157	233	4	3	1961.7	500	50	1	1.00E+02	1833
157	233	5	3	1961.7	500	50	1	1.00E+02	1806
158	222	4	3	1962.8	500	50	1	1.00E+02	1793
158	222	5	3	1962.8	500	50	1	1.00E+02	1632
158	223	4	3	1963.8	500	50	1	1.00E+02	1854
158	223	5	3	1963.8	500	50	1	1.00E+02	1641
158	225	4	3	1964.9	500	50	1	1.00E+02	1925
158	225	5	3	1964.9	500	50	1	1.00E+02	1680
158	234	4	3	1966	500	50	1	1.00E+02	1827
158	234	5	3	1966	500	50	1	1.00E+02	1804
159	224	4	3	1967	500	50	1	1.00E+02	1910
159	224	5	3	1967	500	50	1	1.00E+02	1669
159	235	4	3	1968.1	500	50	1	1.00E+02	1839
159	235	5	3	1968.1	500	50	1	1.00E+02	1820
160	236	4	3	1969.1	500	50	1	1.00E+02	1850
160	236	5	3	1969.1	500	50	1	1.00E+02	1836
161	237	4	3	1970.2	500	50	1	1.00E+02	1863
161	237	5	3	1970.2	500	50	1	1.00E+02	1858
162	237	4	3	1971.3	500	50	1	1.00E+02	1886
162	237	5	3	1971.3	500	50	1	1.00E+02	1881
163	237	4	3	1972.3	500	50	1	1.00E+02	1899
163	237	5	3	1972.3	500	50	1	1.00E+02	1893
164	237	4	3	1973.4	500	50	1	1.00E+02	1962
164	237	5	3	1973.4	500	50	1	1.00E+02	1958
173	237	5	3	1983	500	50	1	1.00E+02	1973
174	237	5	3	1984	500	50	1	1.00E+02	1971
175	236	5	3	1985.1	500	50	1	1.00E+02	1972
176	236	5	3	1986.2	500	50	1	1.00E+02	1981
177	237	4	3	1987.2	500	50	1	1.00E+02	1979
177	237	5	3	1987.2	500	50	1	1.00E+02	1978
178	238	5	3	1988.3	500	50	1	1.00E+02	1982
178	239	5	3	1989.4	500	50	1	1.00E+02	1976
178	240	5	3	1990.4	500	50	1	1.00E+02	1976
178	241	5	3	1991.5	500	50	1	1.00E+02	1977
178	242	5	3	1992.6	500	50	1	1.00E+02	1974
178	243	5	3	1993.6	500	50	1	1.00E+02	1967
178	244	5	3	1994.7	500	50	1	1.00E+02	1957
179	245	5	3	1995.7	500	50	1	1.00E+02	1952
180	246	5	3	1996.8	500	50	1	1.00E+02	1936
181	247	5	3	1997.9	500	50	1	1.00E+02	1909
182	248	5	3	1998.9	500	50	1	1.00E+02	1872
183	249	5	3	2000	500	50	1	1.00E+02	1821

Table A-2
River Package Cells: Spokane River

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
107	221	4	1	1710	1690	500	30	1	1.00E+03	1657.1
107	220	4	1	1708.11	1688.11	500	30	1	1.00E+03	1655.7
107	219	4	1	1707.17	1687.17	500	30	1	1.00E+03	1655.7
107	218	4	1	1706.22	1686.22	500	30	1	1.00E+03	1659.3
108	218	4	1	1705.28	1685.28	500	30	1	1.00E+03	1662.1
109	217	4	1	1704.33	1684.33	500	30	1	1.00E+03	1652.1
109	216	4	1	1703.39	1683.39	500	30	1	1.00E+03	1649.4
108	215	4	1	1702.44	1682.44	500	30	1	1.00E+03	1649.3
107	215	4	1	1701.5	1681.5	500	30	1	1.00E+03	1646.2
106	215	4	1	1700.55	1680.55	500	30	1	1.00E+03	1644.3
105	216	4	1	1699.61	1679.61	500	30	1	1.00E+03	1642.7
104	215	4	1	1698.66	1678.66	500	30	1	1.00E+03	1641.3
103	214	4	1	1697.72	1677.72	500	30	1	1.00E+03	1638.7
103	213	4	1	1696.77	1676.77	500	30	1	1.00E+03	1636
103	212	4	1	1695.83	1675.83	500	30	1	1.00E+03	1521.7
102	212	4	1	1694.88	1674.88	500	30	1	1.00E+03	1537.5
101	212	4	1	1693.94	1673.94	500	30	1	1.00E+03	1520.9
100	212	4	1	1692.99	1672.99	500	30	1	1.00E+03	1511.6
99	212	4	1	1692.05	1672.05	500	30	1	1.00E+03	1511.2
98	212	4	1	1691.1	1671.1	500	30	1	1.00E+03	1516.5
97	212	4	1	1690.16	1670.16	500	30	1	1.00E+03	1415.6
96	213	4	1	1689.21	1669.21	500	30	1	1.00E+03	1388.9
96	214	4	1	1688.27	1668.27	500	30	1	1.00E+03	1387.1
97	215	4	1	1687.32	1667.32	500	30	1	1.00E+03	1405.1
97	216	4	1	1686.38	1666.38	500	30	1	1.00E+03	1423.1
97	217	4	1	1685.43	1665.43	500	30	1	1.00E+03	1424.6
97	218	4	1	1684.49	1664.49	500	30	1	1.00E+03	1384.4
96	219	4	1	1683.54	1663.54	500	30	1	1.00E+03	1391.9
95	219	4	1	1682.6	1662.6	500	30	1	1.00E+03	1509.8
94	218	4	1	1681.65	1661.65	500	30	1	1.00E+03	1506.7
93	218	4	1	1680.71	1660.71	500	30	1	1.00E+03	1499
92	217	4	1	1679.76	1659.76	500	30	1	1.00E+03	1496.7
92	216	4	1	1678.82	1658.82	500	30	1	1.00E+03	1377.4
92	215	4	1	1677.87	1657.87	500	30	1	1.00E+03	1371.9
91	214	4	1	1676.93	1656.93	500	30	1	1.00E+03	1384.5
91	213	4	1	1675.98	1655.98	500	30	1	1.00E+03	1373.5
92	212	4	1	1675.04	1655.04	500	30	1	1.00E+03	1422.8
92	211	4	1	1674.09	1654.09	500	30	1	1.00E+03	1402.6
92	210	4	1	1673.15	1653.15	500	30	1	1.00E+03	1383.7
92	209	4	1	1672.2	1652.2	500	30	1	1.00E+03	1368.5
92	208	4	1	1671.26	1651.26	500	30	1	1.00E+03	1366.2
92	207	4	1	1670.31	1650.31	500	30	1	1.00E+03	1366.3
92	206	4	1	1669.37	1649.37	500	30	1	1.00E+03	1366.1
91	205	4	1	1668.43	1648.43	500	30	1	1.00E+03	1365.4
90	204	4	1	1667.48	1647.48	500	30	1	1.00E+03	1367.2
89	204	4	1	1666.54	1646.54	500	30	1	1.00E+03	1363.2
88	204	4	1	1665.59	1645.59	500	30	1	1.00E+03	1397.1
87	204	4	1	1664.65	1644.65	500	30	1	1.00E+03	1362.6
87	205	4	1	1663.7	1643.7	500	30	1	1.00E+03	1361.7
87	206	4	1	1662.76	1642.76	500	30	1	1.00E+03	1359.5
87	207	4	1	1661.81	1641.81	500	30	1	1.00E+03	1382.9
86	208	4	1	1660.87	1640.87	500	30	1	1.00E+03	1358.7

Table A-2
River Package Cells: Spokane River

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
85	209	4	1	1659.92	1639.92	500	30	1	1.00E+03	1389.9
84	208	4	1	1658.98	1638.98	500	30	1	1.00E+03	1356.7
83	207	4	1	1658.03	1638.03	500	30	1	1.00E+03	1362.3
83	206	4	1	1657.09	1637.09	500	30	1	1.00E+03	1361.1
82	205	4	1	1656.14	1636.14	500	30	1	1.00E+03	1352.2
81	204	4	1	1655.2	1635.2	500	30	1	1.00E+03	1374.8
81	203	4	1	1654.25	1634.25	500	30	1	1.00E+03	1374.6
81	202	4	1	1653.31	1633.31	500	30	1	1.00E+03	1437.1
81	201	4	1	1652.36	1632.36	500	30	1	1.00E+03	1402.3
81	200	4	1	1651.42	1631.42	500	30	1	1.00E+03	1348.7
81	199	4	1	1650.47	1630.47	500	30	1	1.00E+03	1359
82	198	4	1	1649.53	1629.53	500	30	1	1.00E+03	1348.7
82	197	4	1	1648.58	1628.58	500	30	1	1.00E+03	1488.1
82	196	4	1	1647.64	1627.64	500	30	1	1.00E+03	1514.9
82	195	4	1	1646.69	1626.69	500	30	1	1.00E+03	1511.8
82	194	4	1	1645.75	1625.75	500	30	1	1.00E+03	1588.9
81	194	4	1	1644.8	1624.8	500	30	1	1.00E+03	1608
80	194	4	1	1643.86	1623.86	500	30	1	1.00E+03	1515.6
79	195	4	1	1642.91	1622.91	500	30	1	1.00E+03	1452.8
78	196	4	1	1641.97	1621.97	500	30	1	1.00E+03	1332.9
77	196	4	1	1641.02	1621.02	500	30	1	1.00E+03	1331.5
76	195	4	1	1640.08	1620.08	500	30	1	1.00E+03	1328.2
75	194	4	1	1639.13	1619.13	500	30	1	1.00E+03	1359.7
74	193	4	1	1638.19	1618.19	500	30	1	1.00E+03	1327.6
73	192	4	1	1637.24	1617.24	500	30	1	1.00E+03	1319.5
72	192	4	1	1636.3	1616.3	500	30	1	1.00E+03	1338.3
71	192	4	1	1635.35	1615.35	500	30	1	1.00E+03	1379.4
70	191	4	1	1634.41	1614.41	500	30	1	1.00E+03	1337.5
69	191	4	1	1633.46	1613.46	500	30	1	1.00E+03	1311.9
68	191	4	1	1632.52	1612.52	500	30	1	1.00E+03	1323.6
67	192	4	1	1631.57	1611.57	500	30	1	1.00E+03	1319.3
66	192	4	1	1630.63	1610.63	500	30	1	1.00E+03	1310.3
65	192	4	1	1629.69	1609.69	500	30	1	1.00E+03	1310.4
64	192	4	1	1628.74	1608.74	500	30	1	1.00E+03	1310
63	191	4	1	1627.8	1607.8	500	30	1	1.00E+03	1307.3
63	190	4	1	1626.85	1606.85	500	30	1	1.00E+03	1322.6
63	189	4	1	1625.91	1605.91	500	30	1	1.00E+03	1324.4
63	188	4	1	1624.96	1604.96	500	30	1	1.00E+03	1327.1
64	187	4	1	1624.02	1604.02	500	30	1	1.00E+03	1452.3
64	186	4	1	1623.07	1603.07	500	30	1	1.00E+03	1463.3
63	185	4	1	1622.13	1602.13	500	30	1	1.00E+03	1421.2
62	185	4	1	1621.18	1601.18	500	30	1	1.00E+03	1461
61	185	4	1	1620.24	1600.24	500	30	1	1.00E+03	1463.7
60	185	4	1	1619.29	1599.29	500	30	1	1.00E+03	1454.1
59	185	4	1	1618.35	1598.35	500	30	1	1.00E+03	1299
58	185	4	1	1617.4	1597.4	500	30	1	1.00E+03	1309.8
57	186	4	1	1616.46	1596.46	500	30	1	1.00E+03	1298
56	186	4	1	1615.51	1595.51	500	30	1	1.00E+03	1297.8
55	186	4	1	1614.57	1594.57	500	30	1	1.00E+03	1417.9
54	186	4	1	1613.62	1593.62	500	30	1	1.00E+03	1417.5
53	185	4	2	1612.68	1592.68	500	30	1	1.00E+03	1417.7
52	184	4	2	1611.73	1591.73	500	30	1	1.00E+03	1417.2

Table A-2
River Package Cells: Spokane River

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
51	183	4	2	1610.79	1590.79	500	30	1	1.00E+03	1417.6
50	182	4	2	1609.84	1589.84	500	30	1	1.00E+03	1417.4
49	181	4	2	1608.9	1588.9	500	30	1	1.00E+03	1417.4
48	180	4	2	1607.95	1587.95	500	30	1	1.00E+03	1420.2
47	180	4	2	1607.01	1587.01	500	30	1	1.00E+03	1441
47	179	4	2	1606.06	1586.06	500	30	1	1.00E+03	1417.5
46	178	4	2	1605.12	1585.12	500	30	1	1.00E+03	1417
45	177	4	2	1604.17	1584.17	500	30	1	1.00E+03	1544.2
44	177	4	2	1603.23	1583.23	500	30	1	1.00E+03	1540.9
43	178	4	2	1602.28	1582.28	500	30	1	1.00E+03	1416.7
42	179	4	2	1601.34	1581.34	500	30	1	1.00E+03	1417
41	180	4	2	1600.39	1580.39	500	30	1	1.00E+03	1536.7
40	180	4	2	1599.45	1579.45	500	30	1	1.00E+03	1536.7
39	180	4	2	1598.5	1578.5	500	30	1	1.00E+03	1539.1
38	180	4	2	1597.56	1577.56	500	30	1	1.00E+03	1538.1
37	179	4	2	1596.61	1576.61	500	30	1	1.00E+03	1537.2
37	178	4	2	1595.67	1575.67	500	30	1	1.00E+03	1541.9
37	177	4	2	1594.72	1574.72	500	30	1	1.00E+03	1542.2
37	176	4	2	1593.78	1573.78	500	30	1	1.00E+03	1536.8
37	175	4	2	1592.83	1572.83	500	30	1	1.00E+03	1536.2
37	174	4	2	1591.89	1571.89	500	30	1	1.00E+03	1536.1
37	173	4	2	1590.94	1570.94	500	30	1	1.00E+03	1536.2
37	172	4	2	1590	1570	500	30	1	1.00E+03	1548.9

Table A-3
River Package Cells: Coulee Creek and Deep Creek

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
Coulee Creek										
60	69	1	4	2330	2329	1	3	1	1.00E+00	2328
61	70	1	4	2316	2315	1	3	1	1.00E+00	2302
61	71	1	4	2308	2307	1	3	1	1.00E+00	2266
60	72	4	4	2301	2300	1	3	1	1.00E+00	2199
60	73	1	4	2294	2293	1	3	1	1.00E+00	2251
60	74	1	4	2287	2286	1	3	1	1.00E+00	2279
59	75	2	4	2280	2279	1	3	1	1.00E+00	2270
59	76	2	4	2272	2271	1	3	1	1.00E+00	2265
59	77	1	4	2265	2264	1	3	1	1.00E+00	2265
59	78	4	4	2258	2257	1	3	1	1.00E+00	2164
59	79	4	4	2252	2251	1	3	1	1.00E+00	2187
59	80	1	4	2247	2246	1	3	1	1.00E+00	2247
59	81	1	4	2241	2240	1	3	1	1.00E+00	2241
59	82	4	4	2236	2235	1	3	1	1.00E+00	2159
59	83	4	4	2230	2229	1	3	1	1.00E+00	2153
59	84	1	4	2225	2224	1	3	1	1.00E+00	2224
59	85	4	4	2219	2218	1	3	1	1.00E+00	2125
59	86	4	4	2213	2212	1	3	1	1.00E+00	2145
60	87	4	4	2208	2207	1	3	1	1.00E+00	2120
61	87	1	4	2202	2201	1	3	1	1.00E+00	2202
62	88	1	4	2197	2196	1	3	1	1.00E+00	2193
63	89	4	4	2191	2190	1	3	1	1.00E+00	2137
64	89	1	4	2184	2183	1	3	1	1.00E+00	2182
64	90	4	4	2176	2175	1	3	1	1.00E+00	2139
64	91	4	4	2169	2168	1	3	1	1.00E+00	2132
64	92	4	4	2162	2161	1	3	1	1.00E+00	2112
63	93	4	4	2155	2154	1	3	1	1.00E+00	2132
63	94	1	4	2147	2146	1	3	1	1.00E+00	2146
63	95	4	4	2140	2139	1	3	1	1.00E+00	2118
62	96	4	4	2135	2134	1	3	1	1.00E+00	2115
62	97	1	4	2131	2130	1	3	1	1.00E+00	2089
62	98	1	4	2126	2125	1	3	1	1.00E+00	2120
61	99	3	4	2122	2121	1	3	1	1.00E+00	2122
60	100	4	4	2117	2116	1	3	1	1.00E+00	2013
59	101	5	4	2112	2111	1	3	1	1.00E+00	2009
58	102	2	4	2108	2107	1	3	1	1.00E+00	2108
57	103	4	4	2103	2102	1	3	1	1.00E+00	2021
56	104	4	4	2098	2097	1	3	1	1.00E+00	2046
56	105	4	4	2094	2093	1	3	1	1.00E+00	2021
56	106	4	4	2089	2088	1	3	1	1.00E+00	2039
57	107	2	4	2085	2084	1	3	1	1.00E+00	2085
57	108	4	4	2080	2079	1	3	1	1.00E+00	2013
58	109	1	4	2075	2074	1	3	1	1.00E+00	2057
58	110	1	4	2071	2070	1	3	1	1.00E+00	2064
58	111	1	4	2066	2065	1	3	1	1.00E+00	2065
58	112	4	4	2061	2060	1	3	1	1.00E+00	1981
58	113	4	4	2057	2056	1	3	1	1.00E+00	1992
58	114	4	4	2052	2051	1	3	1	1.00E+00	1993
57	115	4	4	2047	2046	1	3	1	1.00E+00	2007
57	116	4	4	2041	2040	1	3	1	1.00E+00	1960
57	117	4	4	2036	2035	1	3	1	1.00E+00	1962
57	118	4	4	2030	2029	1	3	1	1.00E+00	1967
56	119	1	4	2025	2024	1	3	1	1.00E+00	1986
56	120	1	4	2019	2018	1	3	1	1.00E+00	1990
56	121	1	4	2014	2013	1	3	1	1.00E+00	2005

Table A-3
River Package Cells: Coulee Creek and Deep Creek

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
56	122	2	4	2008	2007	1	3	1	1.00E+00	2008
56	123	4	4	2003	2002	1	3	1	1.00E+00	1887
55	124	4	4	1997	1996	1	3	1	1.00E+00	1893
55	125	4	4	1992	1991	1	3	1	1.00E+00	1887
55	126	4	4	1986	1985	1	3	1	1.00E+00	1787
54	126	1	4	1981	1980	1	3	1	1.00E+00	1978
53	127	1	4	1975	1974	1	3	1	1.00E+00	1964

Upper Deep Creek

142	69	2	31	2322	2321	500	3	1	5.00E-02	2264
142	70	2	31	2322	2321	500	3	1	5.00E-02	2267
142	71	2	31	2321	2320	500	3	1	5.00E-02	2264
142	72	2	31	2321	2320	500	3	1	5.00E-02	2271
142	73	2	31	2321	2320	500	3	1	5.00E-02	2274
142	74	2	31	2320	2319	500	3	1	5.00E-02	2273
142	75	2	31	2320	2319	500	3	1	5.00E-02	2273
142	76	2	31	2319	2318	500	3	1	5.00E-02	2276
141	77	1	31	2319	2318	500	3	1	5.00E-02	2319
141	78	1	31	2319	2318	500	3	1	5.00E-02	2313
141	79	1	31	2318	2317	500	3	1	5.00E-02	2299
141	80	1	31	2318	2317	500	3	1	5.00E-02	2289
140	81	1	31	2315	2314	500	3	1	5.00E-02	2282
139	82	1	31	2312	2311	500	3	1	5.00E-02	2289
138	83	1	31	2309	2308	500	3	1	5.00E-02	2303
137	84	1	31	2306	2305	500	3	1	5.00E-02	2304
136	85	1	31	2303	2302	500	3	1	5.00E-02	2302
135	85	2	31	2300	2299	500	3	1	5.00E-02	2246
134	85	2	31	2297	2296	500	3	1	5.00E-02	2257
133	86	2	31	2293	2292	500	3	1	5.00E-02	2266
132	86	2	31	2289	2288	500	3	1	5.00E-02	2268
131	87	2	31	2285	2284	500	3	1	5.00E-02	2265
130	88	1	31	2280	2279	500	3	1	5.00E-02	2256
129	88	1	31	2276	2275	500	3	1	5.00E-02	2260
128	88	2	31	2272	2271	500	3	1	5.00E-02	2267
127	89	2	31	2268	2267	500	3	1	5.00E-02	2256
127	90	1	31	2264	2263	500	3	1	5.00E-02	2263
126	90	2	31	2260	2259	500	3	1	5.00E-02	2250
125	90	2	31	2255	2254	500	3	1	5.00E-02	2248
125	91	1	31	2251	2250	500	3	1	5.00E-02	2251
125	92	2	31	2247	2246	500	3	1	5.00E-02	2235
124	93	4	31	2243	2242	500	3	1	5.00E-02	2109
123	93	2	31	2240	2239	500	3	1	5.00E-02	2220
122	94	2	31	2236	2235	500	3	1	5.00E-02	2219
121	94	1	31	2233	2232	500	3	1	5.00E-02	2197
120	95	1	31	2230	2229	500	3	1	5.00E-02	2210
119	96	1	31	2226	2225	500	3	1	5.00E-02	2203
118	97	2	31	2223	2222	500	3	1	5.00E-02	2180
117	98	2	31	2219	2218	500	3	1	5.00E-02	2182
116	98	4	31	2216	2215	500	3	1	5.00E-02	2097
115	98	4	31	2215	2214	500	3	1	5.00E-02	2105
114	98	4	31	2213	2212	500	3	1	5.00E-02	2079
113	98	4	31	2212	2211	500	3	1	5.00E-02	2067
112	99	4	31	2211	2210	500	3	1	5.00E-02	2096
112	100	1	31	2209	2208	500	3	1	5.00E-02	2158
111	101	1	31	2208	2207	500	3	1	5.00E-02	2208
110	100	1	31	2206	2205	500	3	1	5.00E-02	2204
109	99	4	31	2205	2204	500	3	1	5.00E-02	2050

Table A-3
River Package Cells: Coulee Creek and Deep Creek

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
108	99	4	31	2204	2203	500	3	1	5.00E-02	2003
107	99	2	31	2202	2201	500	3	1	5.00E-02	2202
106	98	3	31	2201	2200	500	3	1	5.00E-02	2201
106	97	4	31	2198	2197	500	3	1	5.00E-02	2019
105	96	4	31	2194	2193	500	3	1	5.00E-02	2022
104	95	1	31	2191	2190	500	3	1	5.00E-02	2161
103	95	3	31	2187	2186	500	3	1	5.00E-02	2185
102	95	4	31	2184	2183	500	3	1	5.00E-02	2033
101	94	3	31	2180	2179	500	3	1	5.00E-02	2180
100	94	4	31	2179	2178	500	3	1	5.00E-02	2012
99	94	4	31	2177	2176	500	3	1	5.00E-02	2003
98	94	1	31	2176	2175	500	3	1	5.00E-02	2160
97	95	1	31	2174	2173	500	3	1	5.00E-02	2164
97	96	1	31	2173	2172	500	3	1	5.00E-02	2129
97	97	1	31	2171	2170	500	3	1	5.00E-02	2125
96	98	1	31	2170	2169	500	3	1	5.00E-02	2165
96	99	1	31	2168	2167	500	3	1	5.00E-02	2163
96	100	4	31	2167	2166	500	3	1	5.00E-02	2015
95	101	1	31	2165	2164	500	3	1	5.00E-02	2164
95	102	1	31	2164	2163	500	3	1	5.00E-02	2162
95	103	1	31	2162	2161	500	3	1	5.00E-02	2162
95	104	2	31	2161	2160	500	3	1	5.00E-02	2161
95	105	4	31	2159	2158	500	3	1	5.00E-02	2025
95	106	4	31	2158	2157	500	3	1	5.00E-02	2019
96	107	1	31	2154	2153	500	3	1	5.00E-02	2118
97	108	1	31	2150	2149	500	3	1	5.00E-02	2143
97	109	1	31	2146	2145	500	3	1	5.00E-02	2143
97	110	4	31	2141	2140	500	3	1	5.00E-02	1999
98	111	3	31	2137	2136	500	3	1	5.00E-02	2137
99	111	4	31	2133	2132	500	3	1	5.00E-02	1996
99	112	1	31	2129	2128	500	3	1	5.00E-02	2124
99	113	1	31	2125	2124	500	3	1	5.00E-02	2086
98	114	1	31	2121	2120	500	3	1	5.00E-02	2091
97	114	4	31	2117	2116	500	3	1	5.00E-02	2007
96	115	4	31	2112	2111	500	3	1	5.00E-02	2018
95	116	4	31	2108	2107	500	3	1	5.00E-02	2037
94	117	4	31	2104	2103	500	3	1	5.00E-02	2024
94	118	1	31	2100	2099	500	3	1	5.00E-02	2093
93	119	4	31	2097	2096	500	3	1	5.00E-02	2033
92	120	4	31	2094	2093	500	3	1	5.00E-02	2030
91	120	4	31	2091	2090	500	3	1	5.00E-02	2029
90	121	4	31	2089	2088	500	3	1	5.00E-02	2027
89	122	4	31	2086	2085	500	3	1	5.00E-02	2022
88	122	1	31	2083	2082	500	3	1	5.00E-02	2083
87	123	1	31	2080	2079	500	3	1	5.00E-02	2018
86	124	1	31	2077	2076	500	3	1	5.00E-02	2045
85	125	4	31	2074	2073	500	3	1	5.00E-02	1970
85	126	4	31	2071	2070	500	3	1	5.00E-02	1978
85	127	1	31	2069	2068	500	3	1	5.00E-02	2040
84	128	5	31	2066	2065	500	3	1	5.00E-02	1975
84	129	4	31	2063	2062	500	3	1	5.00E-02	2021
84	130	1	31	2060	2059	500	3	1	5.00E-02	2015
84	131	2	31	2058	2057	500	3	1	5.00E-02	2028
84	132	1	31	2056	2055	500	3	1	5.00E-02	2010
83	133	1	31	2054	2053	500	3	1	5.00E-02	2015
82	134	1	31	2053	2052	500	3	1	5.00E-02	1998
83	135	1	31	2051	2050	500	3	1	5.00E-02	2011

Table A-3
River Package Cells: Coulee Creek and Deep Creek

Model Row	Model Column	Model Layer	Reach	Head	River Bottom	Cell Length	Cell Width	Bed Thickness	Hydraulic Conductivity	Layer Bottom
83	136	1	31	2049	2048	500	3	1	5.00E-02	2010
82	137	1	31	2047	2046	500	3	1	5.00E-02	1974

Lower Deep Creek

87	145	4	32	1982	1981	500	3	1	1.00E-01	1874
88	146	4	32	1979	1978	500	3	1	1.00E-01	1850
88	147	4	32	1972	1971	500	3	1	1.00E-01	1850
88	148	4	32	1969	1968	500	3	1	1.00E-01	1955
88	149	4	32	1966	1965	500	3	1	1.00E-01	1813
87	150	1	32	1962	1961	500	3	1	1.00E-01	1909
86	150	1	32	1959	1958	500	3	1	1.00E-01	1931
85	150	1	32	1955	1954	500	3	1	1.00E-01	1925
84	150	1	32	1952	1951	500	3	1	1.00E-01	1924
83	150	1	32	1947	1946	500	3	1	1.00E-01	1927
82	149	4	32	1942	1941	500	3	1	1.00E-01	1706
81	149	4	32	1937	1936	500	3	1	1.00E-01	1715
80	148	4	32	1931	1930	500	3	1	1.00E-01	1725
79	148	1	32	1926	1925	500	3	1	1.00E-01	1899
78	147	1	32	1921	1920	500	3	1	1.00E-01	1870
77	146	1	32	1916	1915	500	3	1	1.00E-01	1879
76	145	1	32	1914	1913	500	3	1	1.00E-01	1859
75	145	1	32	1912	1911	500	3	1	1.00E-01	1856
74	145	1	32	1910	1909	500	3	1	1.00E-01	1867
73	145	1	32	1903	1902	500	3	1	1.00E-01	1857
72	146	3	32	1895	1894	500	3	1	1.00E-01	1895
72	147	1	32	1892	1891	500	3	1	1.00E-01	1885
73	148	1	32	1889	1888	500	3	1	1.00E-01	1875
73	149	1	32	1887	1886	500	3	1	1.00E-01	1881
72	150	4	32	1884	1883	500	3	1	1.00E-01	1708
71	150	1	32	1881	1880	500	3	1	1.00E-01	1881
71	151	1	32	1878	1877	500	3	1	1.00E-01	1876

Table A-4 Well Package Cells: Deep Creek and Coulee Creek Injection Points

Model Row	Model Column	Model Layer	Reach	Rate (cfd)	Layer Bottom	Comment
83	138	2	31	160000	1983	Upper Deep Creek
84	139	2	31	160000	2015	Upper Deep Creek
85	140	2	31	160000	2022	Upper Deep Creek
71	152	2	32	110000	1891	Lower Deep Creek
53	128	2	40	3670	1995	Coulee Creek

Table A-5 Analytical Wells: Water Supply Wells

Name	DOH ID	Conn.	Dist Capacity (gals)	Avg gpm (Capac/wells)	Well Number/Name	Model ID	Coordinates		Layer		Pumping Rate		
							X	Y	Top	Bottom	cfd	gpm	gpd
Indian Village Estates Water Association	12028	34	35,400	8	1	IVE-1	2435002	282775	2	2	1540	8	11,520
					4	IVE-4	2438962	284383	4	5	1540	8	11,520
					5	IVE-5	2438186	286510	4	5	1540	8	11,520
Town of Reardon	71550		393,000	273	8	Reardon-8	2380769	254931	4	5	51975	270	388,800
Deep Creek Ranchettes	39003	49	38,000	26	A	DCR-A	2422030	259234	4	5	5005	26	37,440
West Prairie Village	10614	130	70,000	49	3	WPV-3	2435247	263792	4	5	9433	49	70,564
Ridgeview Park Estates	04828	11	50,000	35	2	RPE-2	2456905	276162	4	5	6738	35	50,404
WSDP Riverside SP Equestrian	SP727	5	?	----	1	Eques-1	2465065	270042	4	5	1925	10	14,400
Fairchild AFB	24350	1336	2,166,049	251	2	FAFB-2	2430829	233368	4	5	9625	50	72,000
					6	FAFB-6	2467712	266353	4	5	48125	250	360,000
Clear Lake Water Users Assn.	13525	72	60,000	42	1	CLWUA-1	2417957	272795	4	5	8085	42	60,480
Spokane Hutterian Brethren	18375	20	?	20	3	Hutt-3	2405603	269912	4	5	3850	20	28,800
City of Medical Lake	53400	2067	4,000,000	556	3 New City-Lehn Rd	ML-3	2397270	226068	4	5	38500	200	288,000
					2 (Old City)	ML-2	2406431	229086	4	5	38500	200	288,000
Cheney Public Schools	00545	9	50,000	35	1	Cheney-1	2435508	228636	4	5	6738	35	50,404

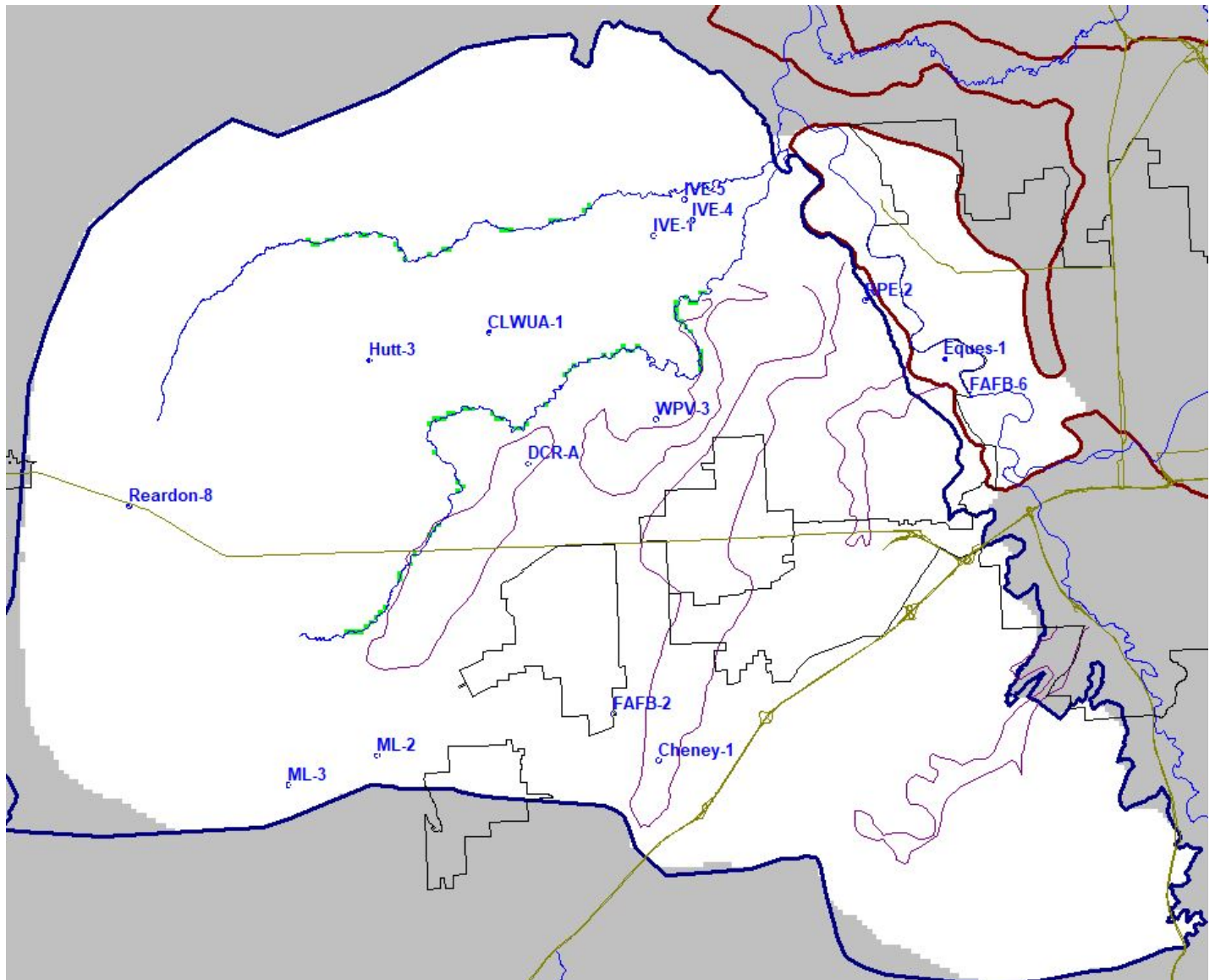


Figure A-1 Analytical Wells: Water Supply Wells

APPENDIX B
GROUNDWATER FLOW MODEL PROPERTIES

Model Layer Elevations

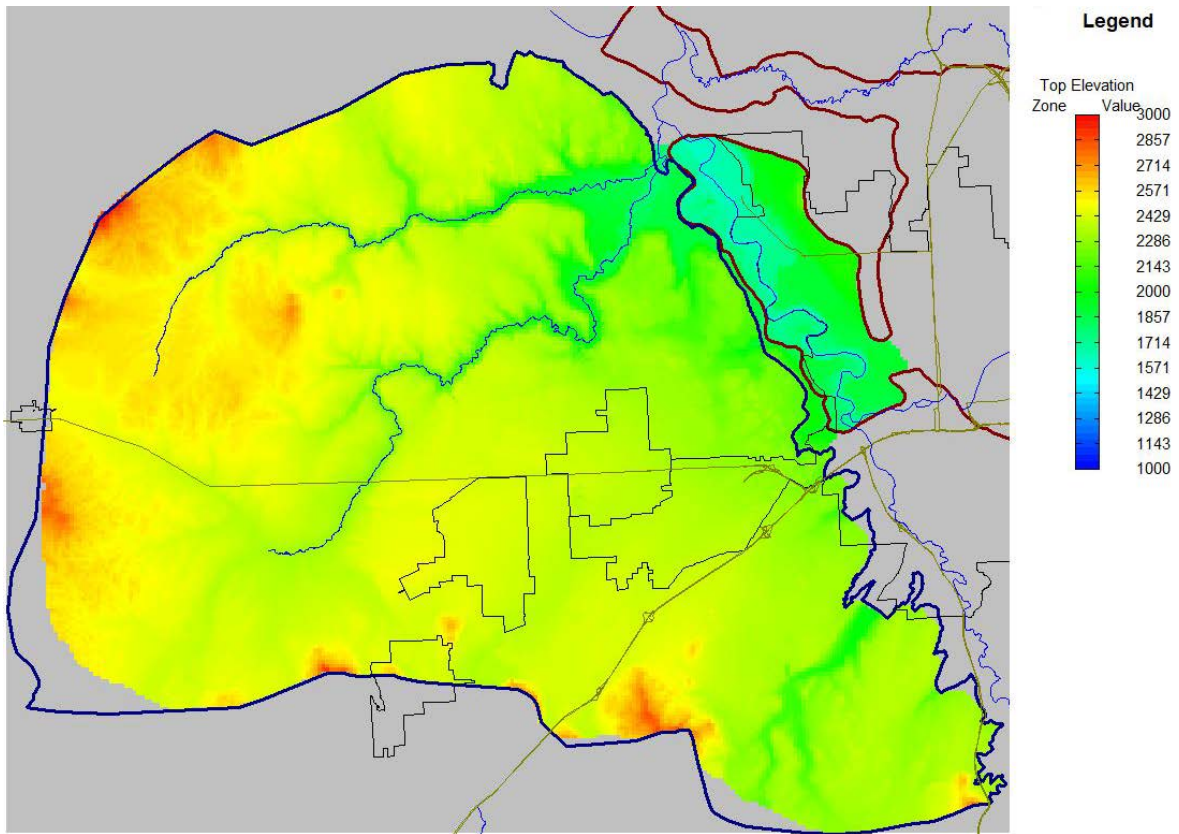


Figure B-1 Elevation: Top of Layer 1

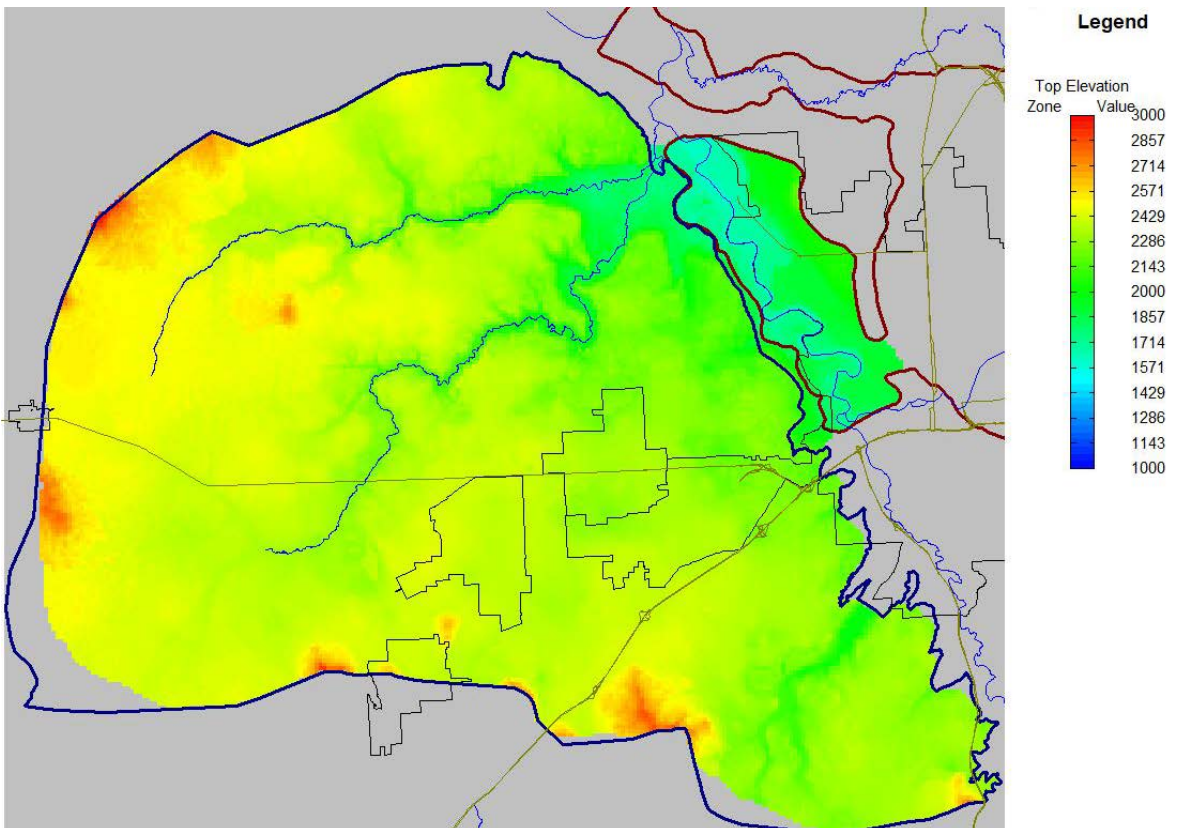


Figure B-2 Elevation: Top of Layer 2

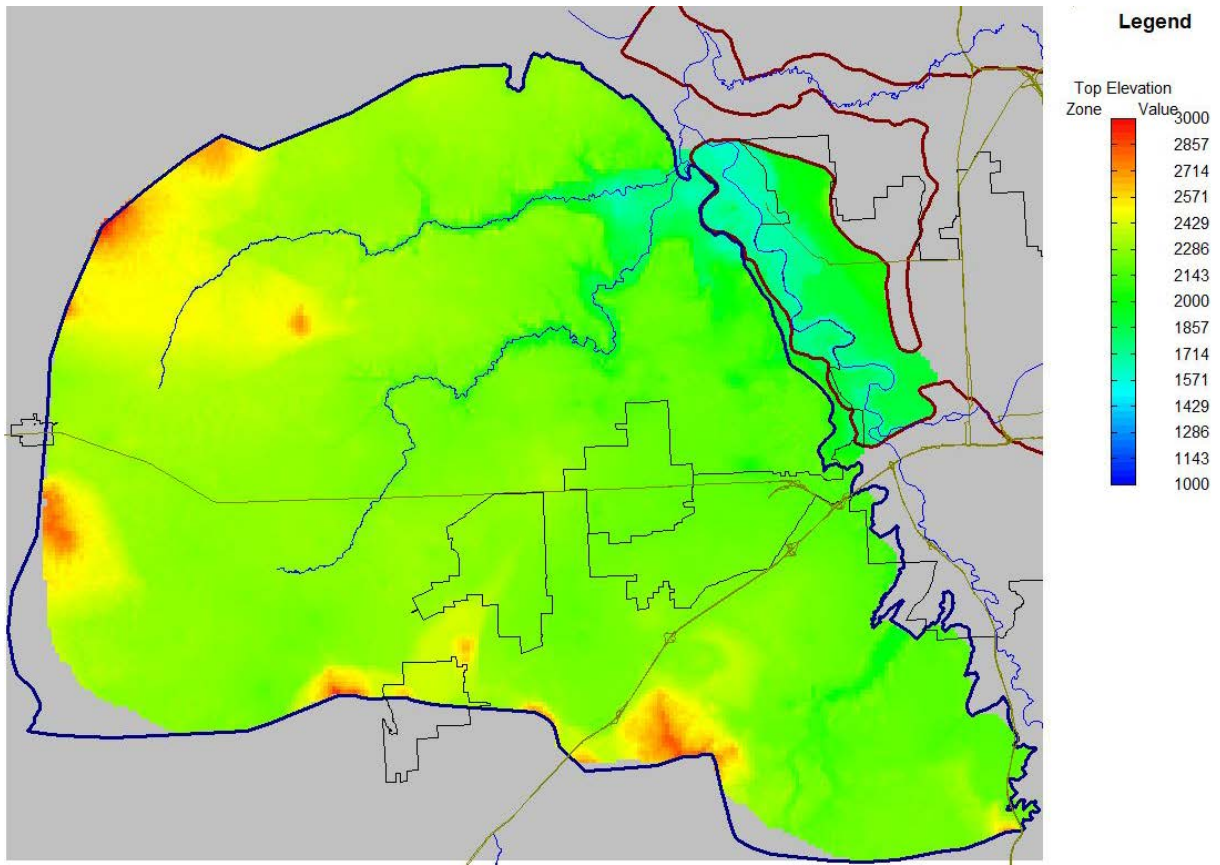


Figure B-3 Elevation: Top of Layer 3

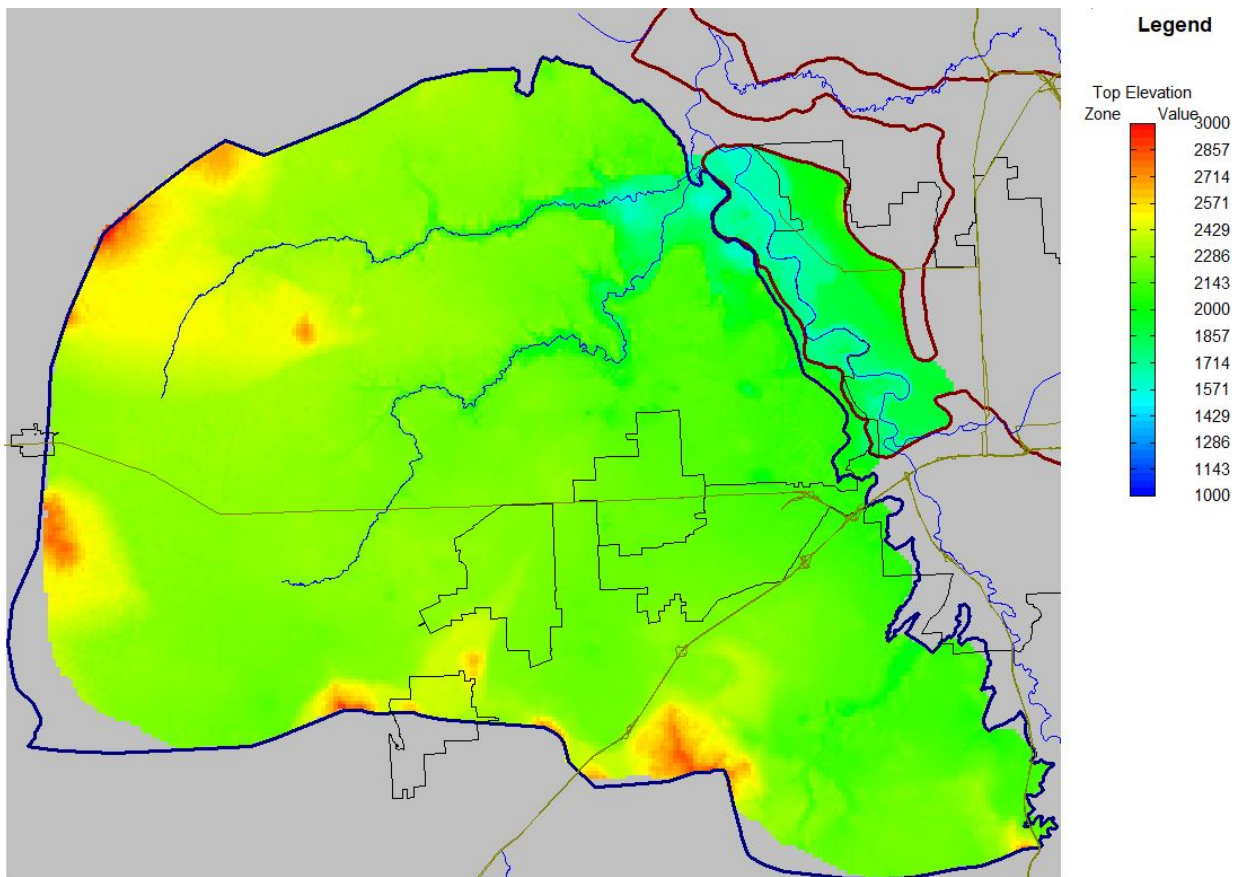


Figure B-4 Elevation: Top of Layer 4

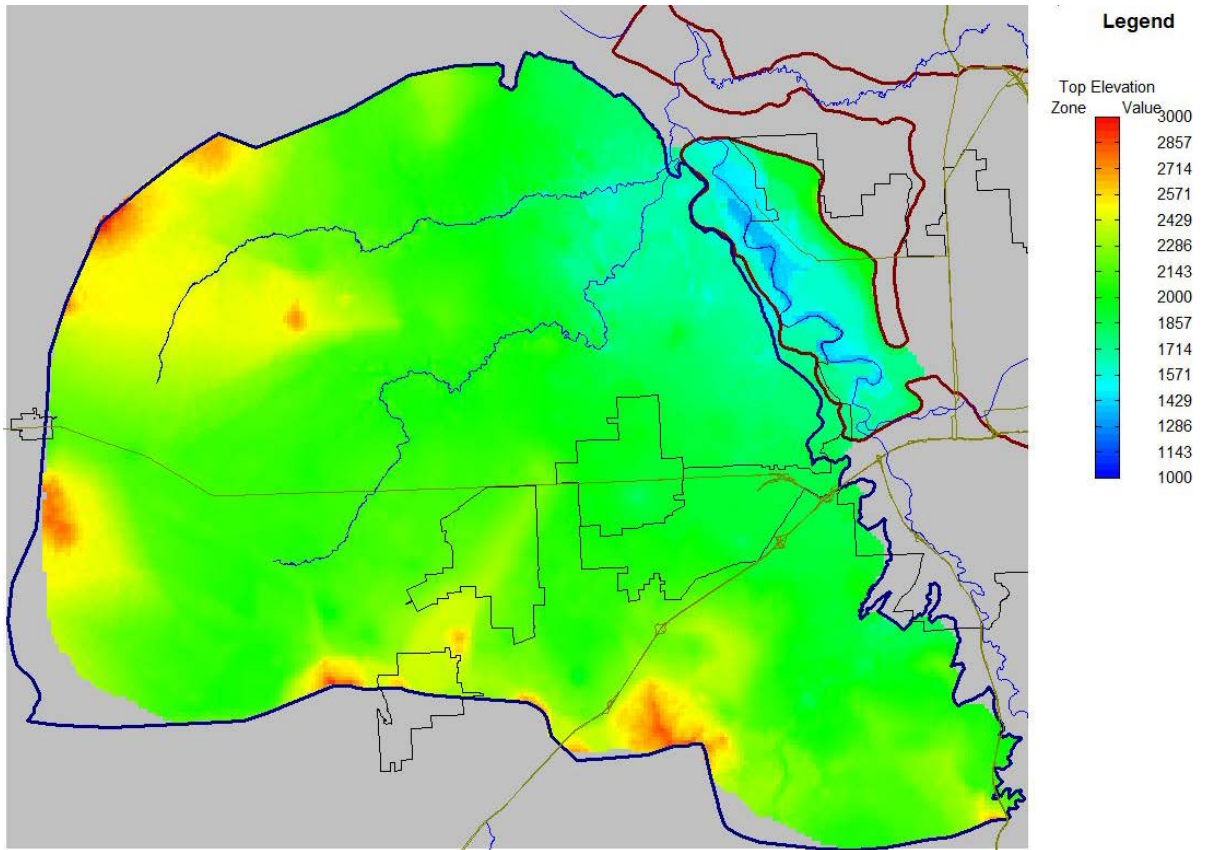


Figure B-5 Elevation: Top of Layer 5

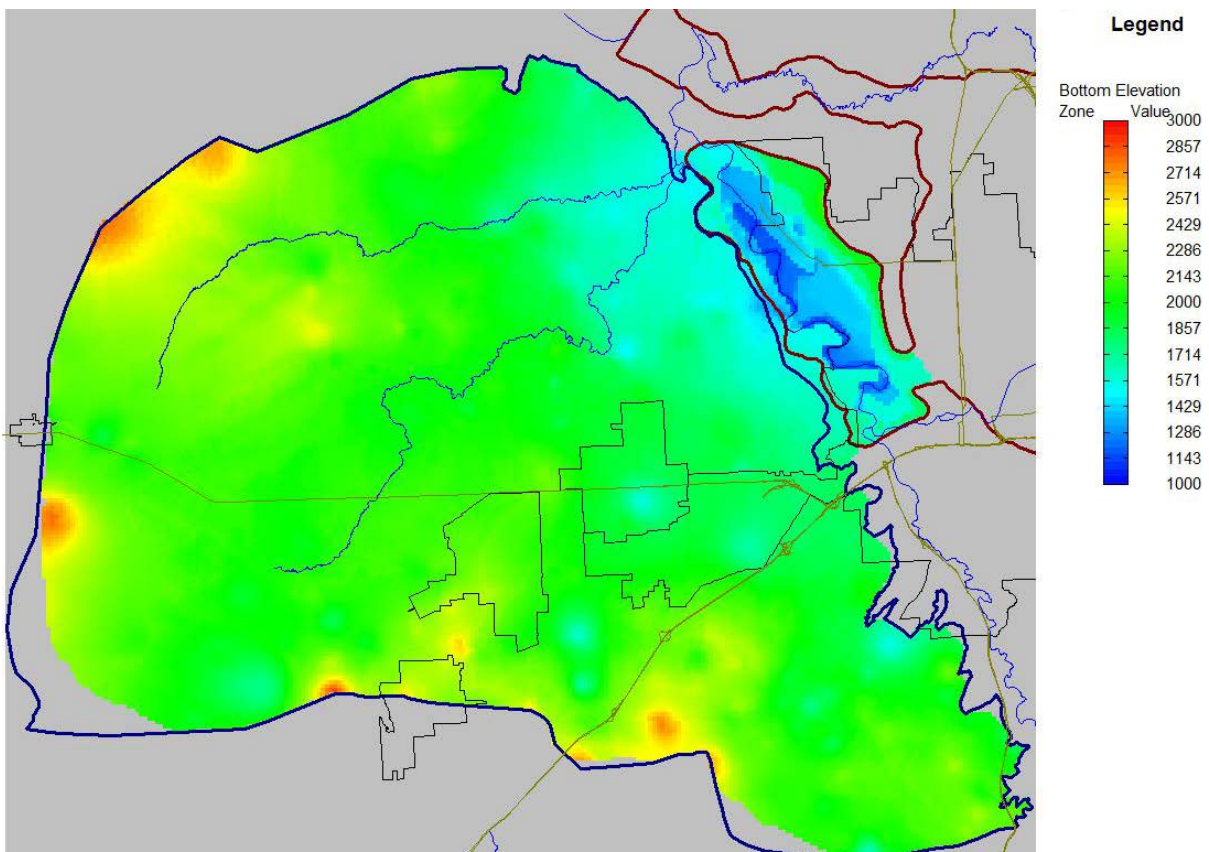


Figure B-6 Elevation: Bottom of Layer 5

Model Hydraulic Conductivity

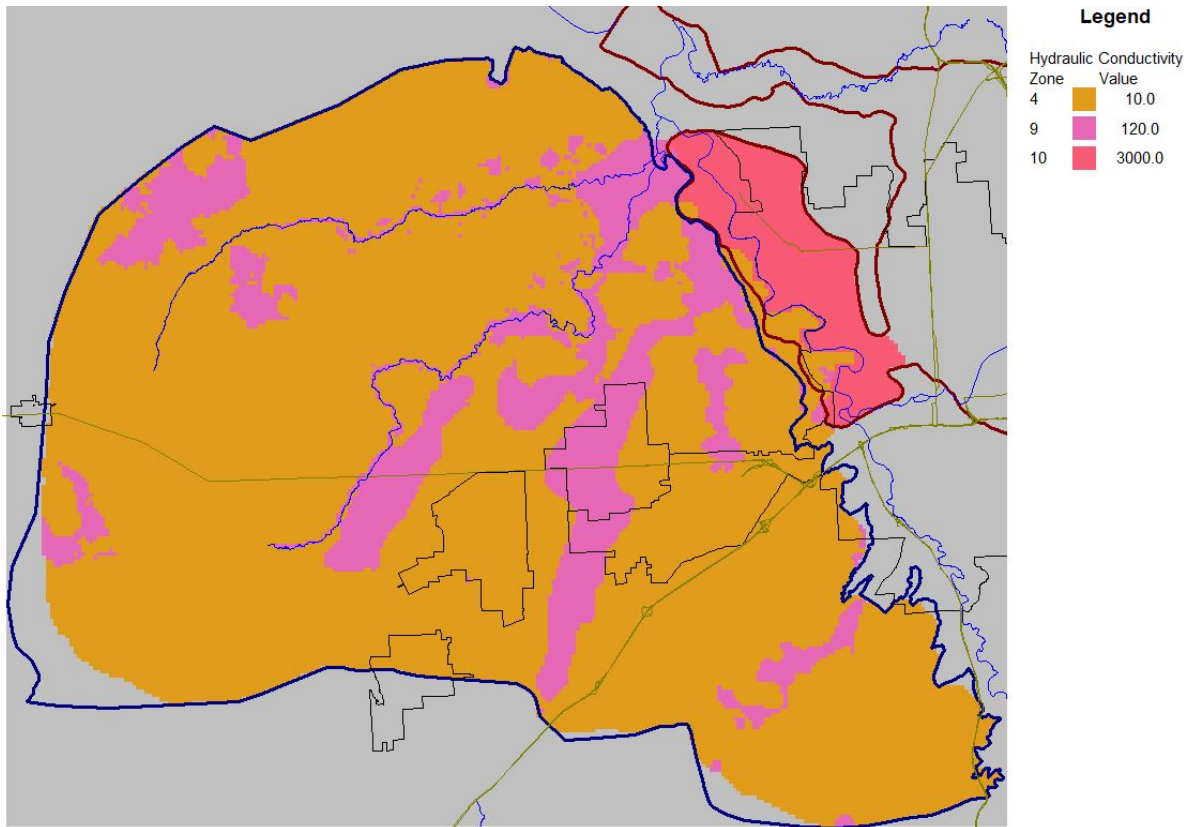


Figure B-7 Hydraulic Conductivity Zones: Layer 1

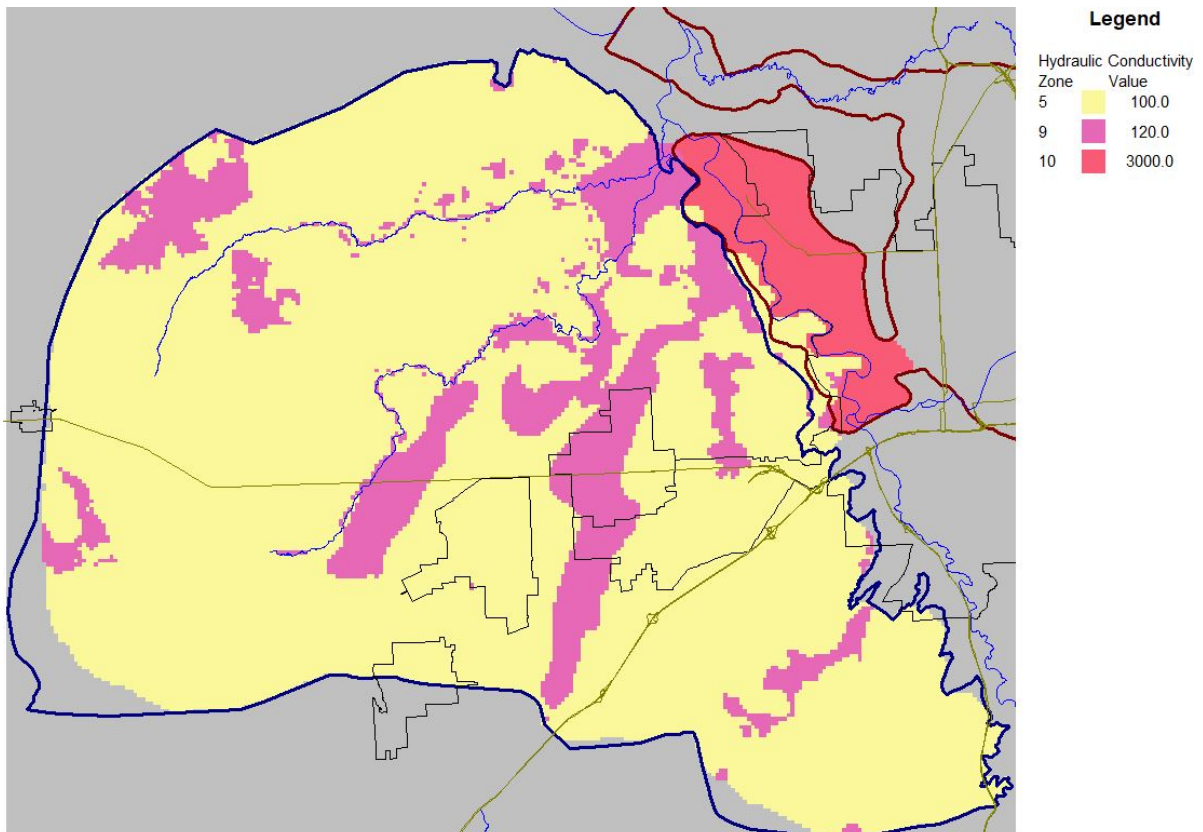


Figure B-8 Hydraulic Conductivity Zones: Layer 2

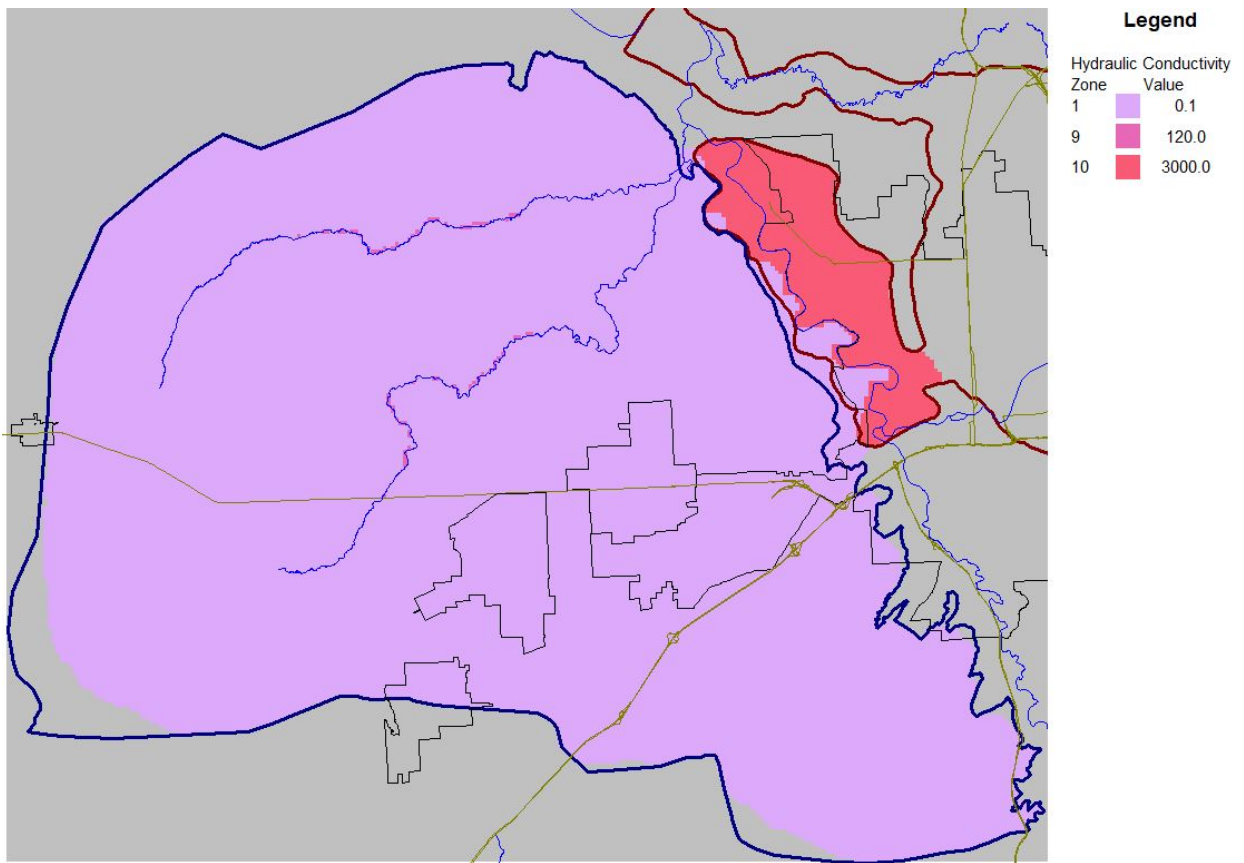


Figure B-9 Hydraulic Conductivity Zones: Layer 3

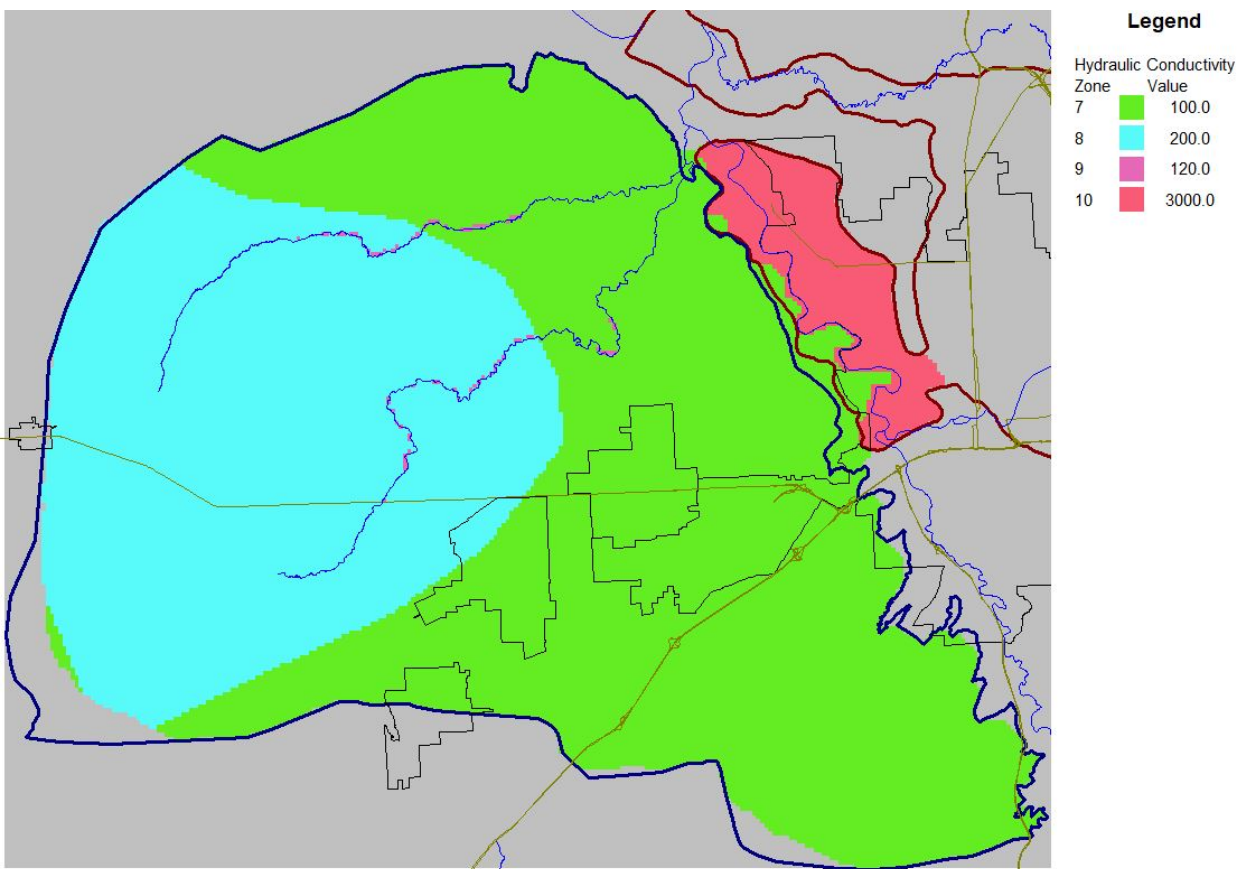


Figure B-10 Hydraulic Conductivity Zones: Layer 4

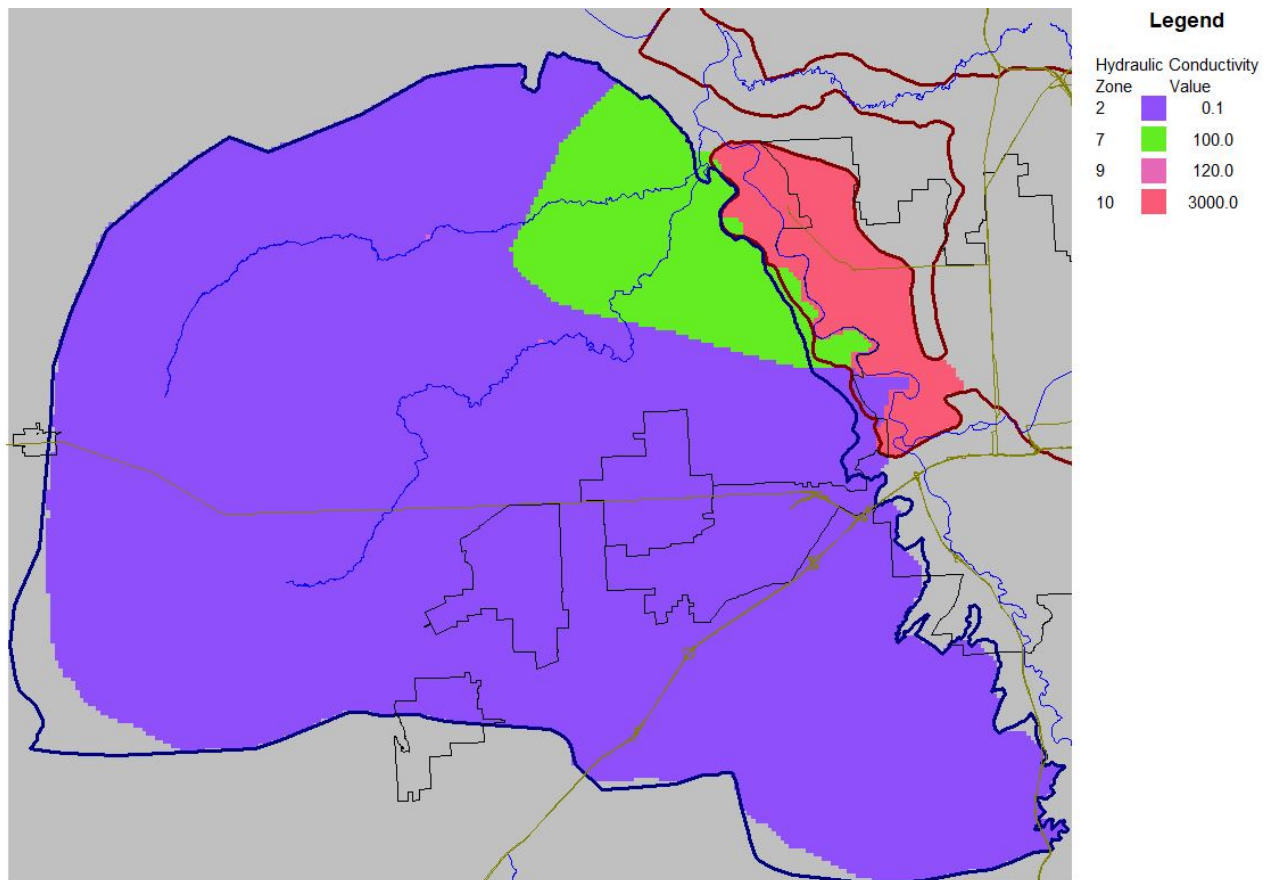


Figure B-11 Hydraulic Conductivity Zones: Layer 5

Model Recharge

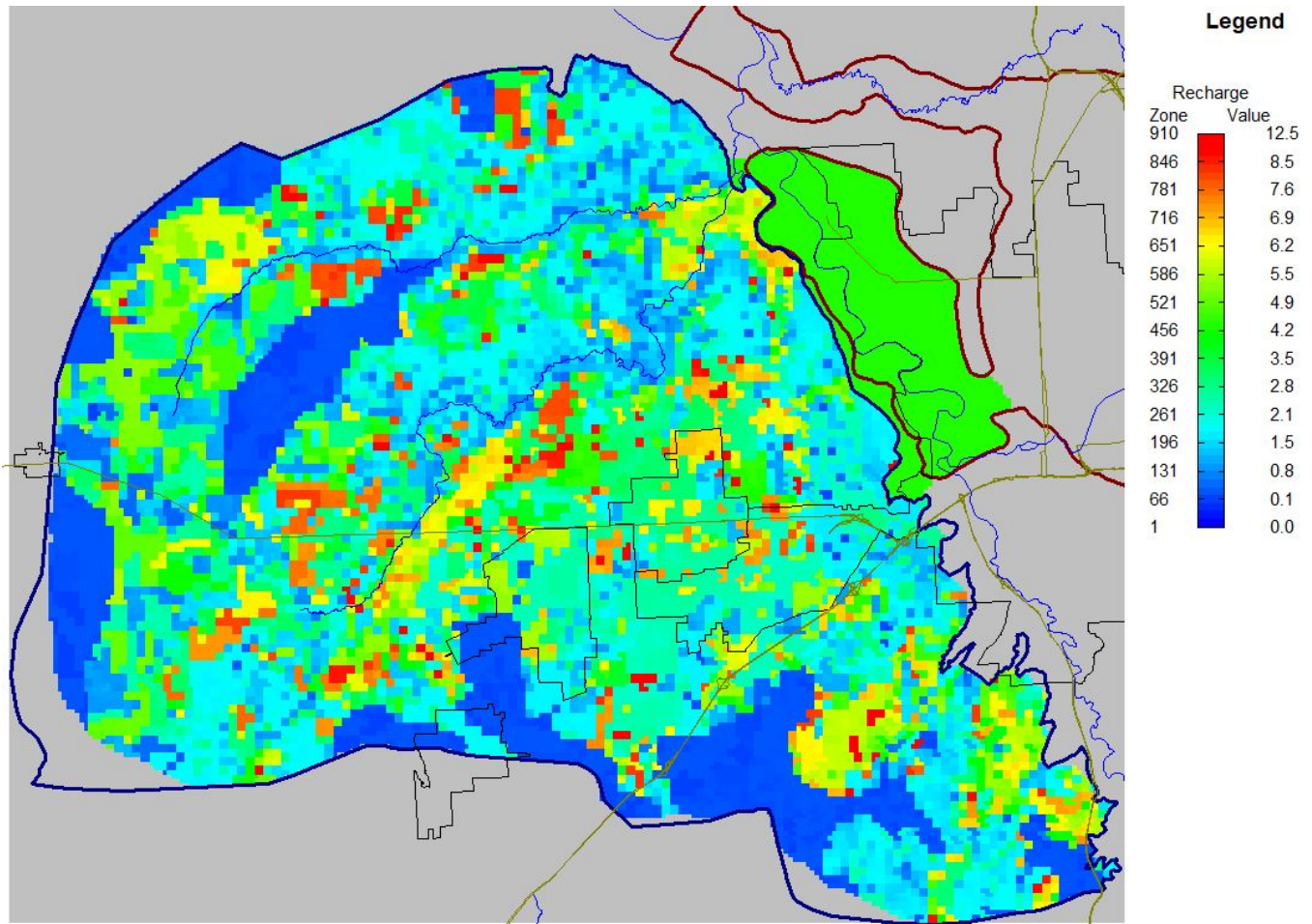


Figure B-12 Model Recharge Zones

APPENDIX C
GROUNDWATER FLOW MODEL CALIBRATION

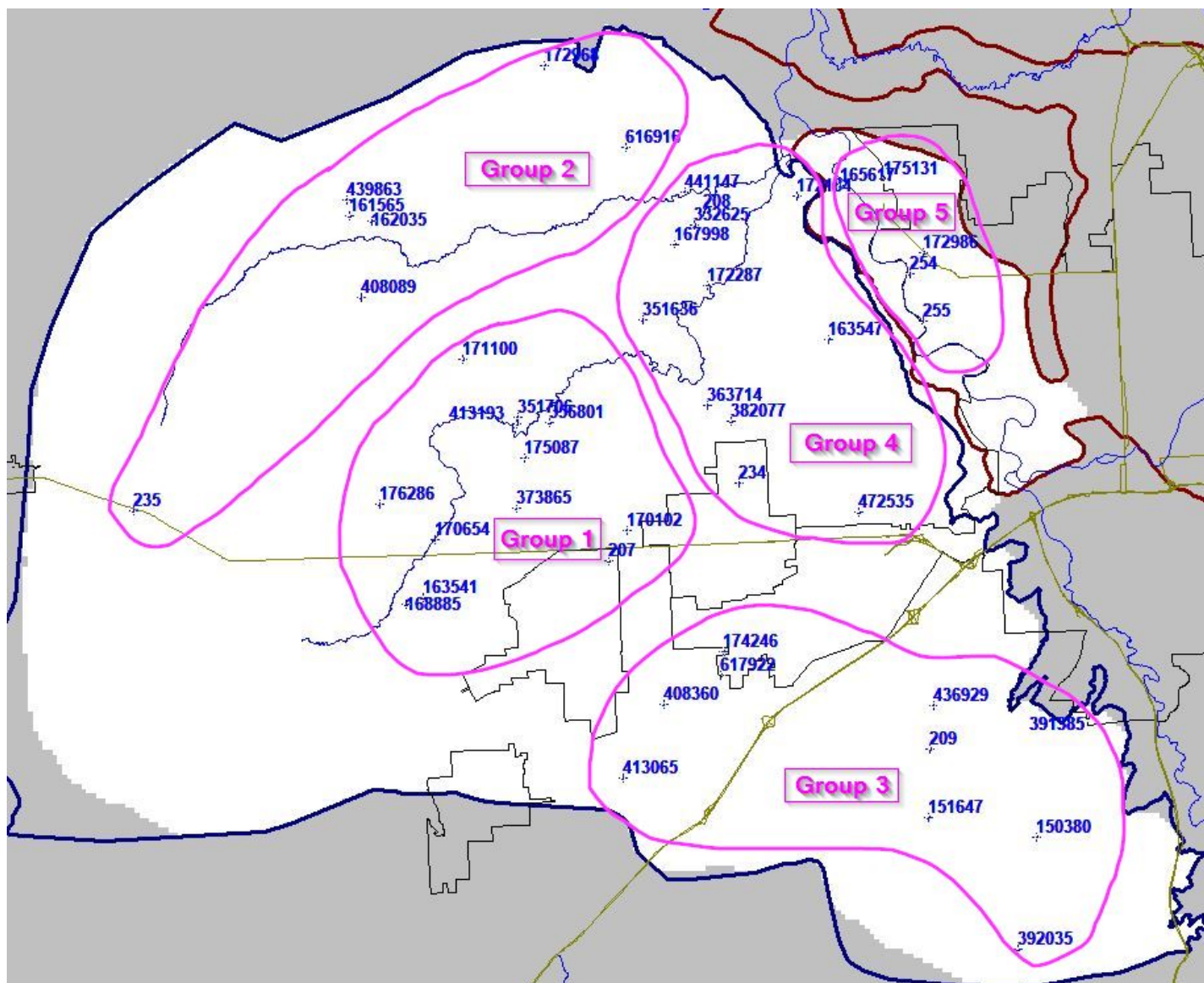


Figure C-1 Water Level Target Wells and Groups

Table C-1 Water Level Targets and Residuals

Well ID	Name	Coordinates		Layer	Spr 2012 Observed	Weight	Group	Simulated GW Elev.	Residual
		X	Y						
207	Fairchild AFB - MWD1	2430102	249638.9	4	2289.36	1	1	2208.1	81.2
208	Garfield-Lincoln Rd. Well	2439899	285759.2	4	1747.05	1	4	1816.9	-69.8
209	Green, Walter A III & Amber J	2463321	230277.3	4	2278.59	0.1	3	2035.3	24.3
234	Raceway Park MW-4	2443559	257743.5	4	2057.15	1	4	2011.0	46.1
235	Reardan Muni Well	2380930	254849.3	4	2370.46	0.1	2	2261.9	10.9
254	Unknown	2461177	279382.7	4	1611.03	1	5	1631.0	-20.0
255	Unknown	2462537	274458	4	1631.47	1	5	1640.2	-8.8
150380	Carlson, Christel L	2474326	221180.8	2	2330.61	0.1	3	2284.4	4.6
151647	Linn, Richard L	2463114	223199.9	5	2116.44	0.5	3	2080.8	17.8
161565	Brown, Bernard L & Beverly G	2403268	285301.8	2	2283.84	0.5	2	2321.3	-18.8
162035	Lee, Christopher D & Amy M	2405568	284810.6	4	2272.96	0.5	2	2215.7	28.6
163541	Connor, Kelley & Ann	2410882	245858.1	2	2371.75	0.8	1	2323.6	38.5
163547	Brown, William	2452781	272576.4	4	1798.47	1	4	1737.2	61.3
165617	Riggs, Dick	2453981	288484.4	4	1609.62	1	5	1607.2	2.4
167998	Indian Village Estates	2436852	282414.2	2	2306.5	0.5	4	2228.4	39.0
168885	Maher Living Trust	2409112	245191.2	4	2151.92	0.5	1	2241.5	-44.8
170102	Croy, John E & Cheryl A	2431948	252877.5	2	2396.96	0.5	1	2335.3	30.8
170654	Brumgard, Ruthanna	2412068	251824.1	4	2184.06	1	1	2226.1	-42.0
171100	Turner, William	2415025	270483	4	2175.54	1	1	2175.5	0.1
172184	Riverside ORV	2449577	287379.1	5	1632.54	0.5	4	1645.3	-6.4
172287	Hanks, Robert G	2440254	278165.6	5	1770.65	1	4	1833.7	-63.1
172968	Fire District #5 Four Mound	2423450	300904.8	2	2404.89	0.5	2	2330.6	37.1
172986	Spokane Sanitary Landfill	2462630	281548.8	4	1619.13	1	5	1629.7	-10.6
174246	Terry, Wayne (Thorpe Rd. Well)	2441887	240349.1	2	2339.75	0.5	3	2262.4	38.7
175087	Finke, Mark & Cindy	2421419	260348.3	4	2147.32	1	1	2176.0	-28.7
175131	Meilke, Fred & Todd	2458523	289198.7	4	1607.79	1	5	1612.1	-4.3
176286	Lawson, Scott A & Marianne A	2406354	255560.5	4	2291.4	1	1	2231.2	60.2
332625	Indian Village Estates 4	2438962	284383.4	5	1725.68	0.5	4	1820.6	-47.5
351636	Hamacher, Eugene C	2433578	274617.2	4	1997.75	1	4	1932.4	65.4
351706	Williams, Robert M & Sheryll L	2420641	264580.3	4	2132.76	1	1	2170.3	-37.5
356801	Lorenzo, Michael/Jacoby	2423934	263942.3	2	2292.62	0.8	1	2247.5	36.1
363714	McKervey, John E	2440285	265757.5	4	1977.46	1	4	1973.9	3.6
373865	Headrick, Melody	2420507	255075.5	4	2225.47	1	1	2192.2	33.3
382077	Wofford, James L	2442733	264072.1	2	2273.88	0.5	4	2229.7	22.1
391385	Larsen, Carl F & Kathleen A	2479643	233522.5	2	2236.48	0.5	3	2289.6	-26.5
392035	Chain, Brian L & Crystal S	2472384	209532.4	4	2138.87	0.5	3	2227.7	-44.4
408089	Hoskins, Gerald L & Nancy C	2404456	276909.5	5	2372.85	0.5	2	2306.7	33.1
408360	Johnson, Richard	2435744	234833.3	2	2346.99	0.5	3	2267.9	39.6
413065	Oliver, Greg B & Sheila R	2431524	227245.7	2	2370.96	0.1	3	2278.8	9.2
413193	Edgar, Mitchell B	2420597	263830.1	5	2129.72	1	1	2172.8	-43.1
436929	Gibson, Michael	2463615	234780.9	2	2338	0.5	3	2278.6	29.7
439863	F.D. Coulee Hite/Wood Rd	2402955	287023.2	2	2403.13	0.5	2	2324.1	39.5
441147	Dreisbach Living Trust	2437930	287826.5	5	1754.79	0.5	4	1821.0	-33.1
472535	Spok Co Stormwater WP-5/Polo Club	2455898	254685.2	2	2125.63	0.8	4	2243.9	-94.6
616916	Purdy, Alan D & Angela J	2431886	292366.2	2	2321.84	0.5	2	2277.4	22.2
617922	Spokane International Airport	2441709	237888.2	4	2263.11	0.1	3	2118.3	14.5

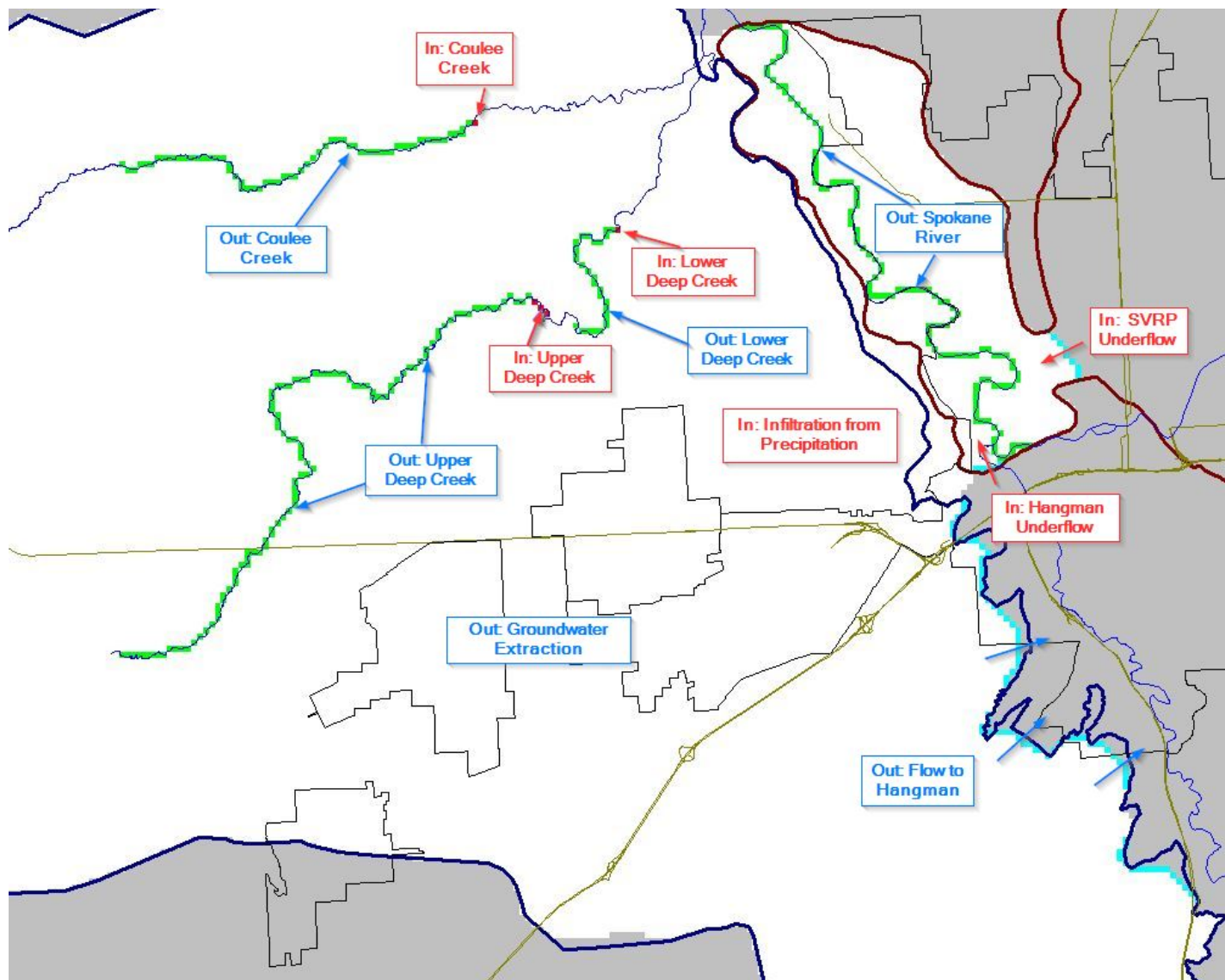


Figure C-2 Groundwater Budget Components

Table C-2 Groundwater Budget Components and Model Values

Groundwater Water Balance

Component	Flow (ft ³ /d)			Flow (ft ³ /d)
	Min	Max	Est	Model
Inflow				
Underflow In (SVRP)	11,652,273	75,511,364	37,800,000	72,809,310
Underflow In (Hangman)	450,000	5,040,000	2,400,000	4,877,776
Upper Deep Creek	129,600	768,960	399,168	480,000
Lower Deep Creek	51,840	319,680	145,152	110,000
Coulee Creek	25,920	267,840	139,968	3,670
Infiltration: Total	2,524,261	10,097,042	5,048,521	10,022,777
Infiltration: West Plains	2,322,370	9,289,479	4,644,739	
Infiltration: SVRP	201,891	807,564	403,782	
Total In	14,626,533	90,648,406	45,248,521	88,303,533
Outflow				
Underflow Out (SVRP)				
Underflow Out (to Hangman)	475,000	9,500,000	2,375,000	1,048,737
Spokane River	29,708,640	146,942,117	111,388,320	86,426,173
Upper Deep Creek	129,600	768,960	399,168	409,261
Lower Deep Creek	51,840	319,680	145,152	183,783
Coulee Creek	25,920	267,840	139,968	3,697
Groundwater Extraction	139,871	326,367	233,119	231,886
Total Out	30,530,871	158,124,964	114,680,727	88,303,535

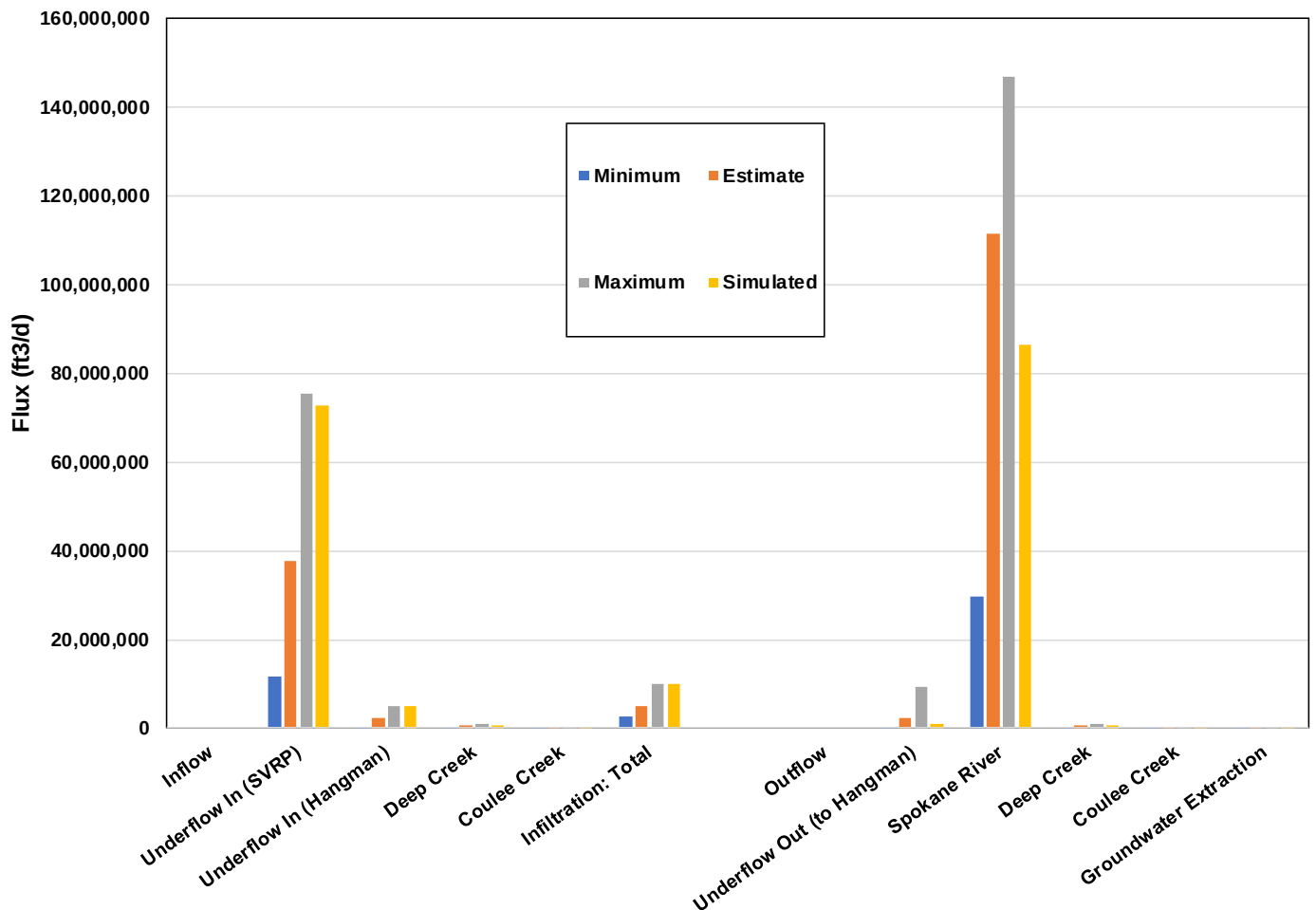


Figure C-3 Groundwater Budget Components and Model Values

APPENDIX D
SIMULATED DRAWDOWN AT WELLS

Table D-1. Simulated Drawdown at Wells: New Pumping Well in SVRP

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
645100	2464638.6	269705.4	0.80
172186	2465227.1	270272.1	0.20
183649	2465373.1	267613.2	0.19
493268	2464223.8	266895.2	0.16
168990	2460638.0	269454.9	0.14
168992	2460638.0	269454.9	0.14
293895	2460638.0	269454.9	0.14
172093	2460638.0	269454.9	0.14
257184	2460638.0	269454.9	0.14
493269	2464535.1	266767.1	0.12
493270	2464619.6	266726.2	0.11
493273	2464689.0	266700.7	0.09
163879	2464539.8	270915.4	0.09
293505	2464539.8	270915.4	0.09
293506	2464539.8	270915.4	0.09
652157	2464921.3	266939.2	0.09
175727	2460081.6	267453.2	0.09
493271	2464849.6	266768.5	0.08
517788	2460785.9	266818.0	0.08
826478	2460785.9	266818.0	0.08
832969	2460785.9	266818.0	0.08
638901	2460785.9	266818.0	0.08
852516	2463433.1	266905.0	0.08
175674	2466755.8	266324.6	0.05
413094	2465442.1	266292.7	0.05
183650	2465442.1	266292.7	0.05
295685	2465442.1	266292.7	0.05
295686	2465442.1	266292.7	0.05
165135	2466063.5	266968.9	0.04
168548	2466063.5	266968.9	0.04
175739	2462811.8	266225.8	0.04
168488	2462811.8	266225.8	0.04
171798	2462811.8	266225.8	0.04
163689	2464127.4	266257.7	0.02
163690	2464127.4	266257.7	0.02

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
652034	2397025.1	249957.3	7.92
652035	2395276.9	250021.0	7.90
652036	2395363.5	250011.6	7.90
428157	2393011.3	251694.7	7.52
652076	2397765.6	249197.7	7.52
493162	2399905.0	249837.1	7.43
1825281	2395492.7	254448.3	7.22
826327	2394132.1	254396.3	7.20
652038	2401019.3	251307.3	7.15
652078	2392491.2	248351.6	7.13
168442	2391011.3	252294.3	7.09
169923	2391011.3	252294.3	7.09
652033	2391198.9	249788.6	7.08
652031	2390655.9	250125.6	7.02
652032	2390618.7	250024.7	7.01
493164	2390400.8	249461.8	6.97
493163	2390401.6	249311.9	6.96
652075	2394550.3	246419.7	6.96
652037	2399185.4	254668.0	6.93
493142	2399018.4	254992.8	6.90
645198	2399025.1	255056.0	6.89
376600	2389182.1	248909.1	6.83
493140	2393132.0	258521.6	6.80
652077	2393281.3	245049.1	6.75
170495	2387801.6	250180.8	6.73
652079	2387884.3	248245.3	6.72
493166	2388586.6	246894.7	6.71
171385	2387560.1	255486.1	6.69
645210	2395638.2	244455.3	6.66
171725	2387444.4	258132.2	6.64
171726	2387444.4	258132.2	6.64
294424	2385700.0	252072.8	6.57
493165	2384824.4	249070.9	6.55
493139	2398154.8	258555.2	6.53
493167	2387414.0	242872.7	6.53
166793	2383892.7	247341.9	6.51
652080	2384748.4	242753.7	6.49
652013	2382664.3	244774.7	6.48
163647	2384111.0	242068.5	6.47
652012	2382669.7	244643.6	6.47
163369	2384167.8	240754.9	6.46

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
163370	2384167.8	240754.9	6.46
411179	2384167.8	240754.9	6.46
493323	2384540.5	237991.6	6.46
652089	2397350.3	243185.3	6.45
852668	2389546.2	239630.8	6.42
852668	2389546.2	239630.8	6.42
652090	2397368.4	242817.6	6.41
494442	2388789.4	238745.6	6.40
652081	2392412.9	239721.6	6.38
161569	2391451.9	238115.9	6.35
493361	2385265.9	257281.0	6.34
493141	2385260.9	257380.9	6.32
652008	2381663.7	251904.8	6.31
494441	2390566.6	236012.6	6.31
494444	2386702.2	234563.0	6.31
1644279	2401256.7	245308.2	6.30
494443	2392174.3	236588.0	6.30
652025	2397280.6	261833.4	6.28
162480	2386445.8	232434.3	6.27
160262	2387738.4	232483.0	6.27
1906481	2385153.1	232385.6	6.27
408361	2386505.9	230859.8	6.25
494445	2387181.6	230226.5	6.25
490708	2382262.8	253911.8	6.25
490710	2382262.8	253911.8	6.25
154751	2389107.1	230973.2	6.25
158247	2389107.1	230973.2	6.25
652010	2379394.1	251137.1	6.23
494431	2382788.3	226727.8	6.23
154752	2390478.5	229729.4	6.22
1603054	2391740.2	231119.9	6.22
158214	2392990.6	232758.3	6.22
494460	2388090.3	224363.6	6.21
158296	2389322.4	225709.7	6.21
494439	2396133.9	237387.7	6.21
494440	2396133.9	237387.7	6.21
493322	2393285.9	232123.1	6.21
495903	2392539.1	227850.3	6.20
494459	2390814.1	222021.7	6.20
494457	2391250.5	223582.5	6.20
407021	2382548.8	232280.2	6.20

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
411170	2382548.8	232280.2	6.20
413067	2382548.8	232280.2	6.20
652009	2378934.0	251523.6	6.19
494458	2393496.3	222986.3	6.18
494456	2394586.2	223422.4	6.17
256946	2395076.5	230628.3	6.17
156157	2395940.4	226010.1	6.16
252886	2395769.7	229994.9	6.16
332182	2381854.1	232502.3	6.16
645184	2395762.8	230366.2	6.16
493325	2396465.0	229359.4	6.15
645186	2396679.6	226648.9	6.15
493330	2397389.9	224542.6	6.15
159725	2397272.0	226069.0	6.15
653775	2380844.7	254821.9	6.14
493331	2398555.6	224492.8	6.14
494426	2381209.2	232194.1	6.14
493321	2396820.0	232049.2	6.14
162091	2397045.5	231379.4	6.14
653774	2397173.3	231618.1	6.13
653774	2397173.3	231618.1	6.13
493332	2398675.4	223221.8	6.13
653773	2397235.0	231925.1	6.13
653773	2397235.0	231925.1	6.13
151370	2397739.7	230745.1	6.12
164270	2380863.3	255198.4	6.12
164560	2380863.3	255198.4	6.12
645212	2402324.8	244514.4	6.12
493324	2398589.6	229403.0	6.12
254275	2405041.0	250759.4	6.12
253605	2405041.0	250759.4	6.12
174517	2405041.0	250759.4	6.12
156758	2398433.9	230110.7	6.12
544283	2398433.9	230110.7	6.12
150362	2398377.1	231437.3	6.11
158603	2398377.1	231437.3	6.11
1565107	2398377.1	231437.3	6.11
493320	2398097.2	232575.8	6.11
334404	2398798.6	239057.4	6.10
494446	2401813.1	228246.1	6.10
645180	2399047.2	238964.1	6.08

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
645180	2399047.2	238964.1	6.08
155069	2401761.5	229580.1	6.08
152024	2401761.5	229580.1	6.08
1632108	2399700.7	231495.2	6.07
645188	2399625.4	232074.1	6.07
645188	2399625.4	232074.1	6.07
645188	2399625.4	232074.1	6.07
645183	2399609.0	232157.0	6.07
491715	2378322.7	252475.5	6.06
163167	2402645.2	244025.5	6.05
163168	2402645.2	244025.5	6.05
163170	2402645.2	244025.5	6.05
171777	2402645.2	244025.5	6.05
494425	2379184.6	233044.0	6.05
292881	2399636.6	233052.8	6.05
153822	2399426.8	238394.3	6.04
645182	2399863.0	233454.4	6.03
645209	2404819.8	247555.0	6.03
157211	2399567.3	234834.3	6.03
652082	2400793.8	240647.0	6.02
493356	2379779.6	255685.8	6.01
652072	2405154.0	248095.9	6.01
257181	2405667.3	251443.6	6.00
151630	2400951.2	233109.6	6.00
652011	2377954.5	253248.7	5.98
1909510	2378255.8	253800.0	5.98
1915431	2378255.8	253800.0	5.98
1915433	2378255.8	253800.0	5.98
1915446	2378255.8	253800.0	5.98
494430	2377334.7	229131.3	5.97
150351	2377333.5	229126.4	5.97
167951	2403336.5	243391.2	5.94
191699	2405547.4	254113.7	5.94
252904	2405547.4	254113.7	5.94
459392	2404800.2	256087.6	5.94
172053	2404800.2	256087.6	5.94
170834	2405782.2	248777.4	5.93
309136	2401480.2	240015.8	5.93
165911	2380094.3	257158.2	5.92
163758	2403981.9	244071.5	5.92
645211	2403991.5	243400.1	5.88

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	

645211	2403991.5	243400.1	5.88
645211	2403991.5	243400.1	5.88
645226	2379368.2	256776.2	5.88
645226	2379368.2	256776.2	5.88
149728	2401497.1	235798.2	5.88
493326	2403074.5	232209.9	5.86
153858	2402192.6	234937.9	5.86
652026	2399853.2	264559.9	5.85
876169	2405261.7	245437.0	5.85
876171	2405261.7	245437.0	5.85
254276	2405261.7	245437.0	5.85
165139	2405261.7	245437.0	5.85
439859	2405261.7	245437.0	5.85
168836	2405261.7	245437.0	5.85
501491	2405261.7	245437.0	5.85
1785217	2405261.7	245437.0	5.85
169300	2405261.7	245437.0	5.85
169387	2405261.7	245437.0	5.85
170195	2405261.7	245437.0	5.85
167952	2404025.7	242753.8	5.85
166510	2404758.4	257392.2	5.84
171521	2404758.4	257392.2	5.84
493121	2377432.3	254571.5	5.83
645227	2377473.0	254744.5	5.83
150438	2402050.1	238486.9	5.82
158083	2402050.1	238486.9	5.82
652074	2405406.7	245042.8	5.81
160973	2402121.3	236713.4	5.81
172051	2405893.0	246120.3	5.80
652030	2405446.0	256753.5	5.80
384115	2405448.7	256753.9	5.80
453780	2405448.7	256753.9	5.80
168609	2405448.7	256753.9	5.80
570903	2405448.7	256753.9	5.80
315952	2405448.7	256753.9	5.80
555790	2405448.7	256753.9	5.80
171439	2405448.7	256753.9	5.80
172880	2405448.7	256753.9	5.80
652042	2406774.3	252799.7	5.78
493314	2402852.5	239252.8	5.78
577846	2405311.5	244113.4	5.78

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	

493319	2403024.6	234937.3	5.77
652040	2406930.8	252802.9	5.76
1235427	2404715.6	258696.9	5.75
493318	2403088.9	235043.3	5.75
493168	2403534.9	239744.3	5.75
494437	2403334.5	239263.2	5.74
160056	2402740.5	237623.6	5.74
645181	2402755.8	237636.1	5.74
645181	2402755.8	237636.1	5.74
645181	2402755.8	237636.1	5.74
652041	2407051.5	252805.4	5.74
645215	2405378.9	243167.9	5.73
645213	2404889.2	242033.1	5.73
645213	2404889.2	242033.1	5.73
493313	2403209.9	234984.9	5.73
494438	2403135.2	235271.5	5.73
167834	2376866.4	255075.7	5.73
165473	2405355.4	242796.8	5.72
293596	2405355.4	242796.8	5.72
413090	2405355.4	242796.8	5.72
153821	2403360.8	238532.7	5.71
158974	2403360.8	238532.7	5.71
171347	2406581.3	245476.9	5.68
294094	2406581.3	245476.9	5.68
294095	2406581.3	245476.9	5.68
294096	2406581.3	245476.9	5.68
443630	2405995.8	243473.0	5.68
443632	2405995.8	243473.0	5.68
175105	2405995.8	243473.0	5.68
170526	2405995.8	243473.0	5.68
165149	2407151.8	247481.7	5.67
172444	2407151.8	247481.7	5.67
172445	2407151.8	247481.7	5.67
385270	2404671.9	260001.5	5.66
166152	2404671.9	260001.5	5.66
493161	2407569.5	249928.2	5.66
848159	2403434.0	236762.2	5.66
504520	2403434.0	236762.2	5.66
645222	2407414.2	248389.8	5.66
645222	2407414.2	248389.8	5.66
1634530	2378388.5	251149.0	5.66

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
172469	2378695.7	258447.8	5.65
652070	2407715.4	249487.9	5.63
493133	2392510.7	262167.2	5.63
169519	2407724.3	249489.5	5.63
169521	2407724.3	249489.5	5.63
493315	2403660.7	235087.6	5.62
163881	2405442.1	240161.4	5.61
645221	2407897.7	249941.2	5.61
645221	2407897.7	249941.2	5.61
149293	2404696.4	238576.7	5.60
517239	2404696.4	238576.7	5.60
152298	2404696.4	238576.7	5.60
155807	2404696.4	238576.7	5.60
165732	2406681.1	242833.7	5.59
163458	2406087.5	240835.7	5.58
165696	2406087.5	240835.7	5.58
169077	2406087.5	240835.7	5.58
170094	2406087.5	240835.7	5.58
176798	2406087.5	240835.7	5.58
170517	2406087.5	240835.7	5.58
363991	2406087.5	240835.7	5.58
166684	2406047.3	258734.8	5.58
493316	2403823.6	232464.0	5.56
1897092	2407469.7	256141.5	5.55
766537	2408299.8	251501.3	5.55
165409	2408299.8	251501.3	5.55
645216	2407223.0	243429.4	5.55
652087	2406735.3	241345.4	5.54
164966	2406745.6	258096.5	5.53
171875	2406745.6	258096.5	5.53
172705	2406745.6	258096.5	5.53
652083	2406746.2	241042.1	5.53
494436	2404348.2	235152.2	5.53
169518	2408408.6	248843.1	5.52
169520	2408408.6	248843.1	5.52
173323	2408408.6	248843.1	5.52
252906	2408408.6	248843.1	5.52
293427	2376738.7	257722.8	5.51
292879	2406055.1	238617.7	5.51
370113	2406055.1	238617.7	5.51
154377	2406055.1	238617.7	5.51

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
154395	2406055.1	238617.7	5.51
493317	2404191.3	232632.3	5.51
165821	2406777.8	240194.4	5.51
176718	2406777.8	240194.4	5.51
652084	2407369.8	242190.9	5.50
174219	2407372.4	242186.3	5.50
493312	2404518.5	233683.1	5.48
170432	2407956.9	244190.2	5.48
172934	2407956.9	244190.2	5.48
652073	2408119.1	245134.3	5.47
645177	2405488.3	234907.3	5.47
645177	2405488.3	234907.3	5.47
645177	2405488.3	234907.3	5.47
652086	2407485.3	240777.6	5.46
645208	2408227.3	245183.3	5.46
652088	2408058.7	244070.7	5.46
253462	2408936.2	252178.5	5.45
1116449	2408936.2	252178.5	5.45
163433	2408529.4	246195.0	5.45
336569	2408529.4	246195.0	5.45
171788	2408529.4	246195.0	5.45
294430	2408529.4	246195.0	5.45
165320	2408008.8	242869.6	5.45
172328	2408008.8	242869.6	5.45
172401	2408008.8	242869.6	5.45
173590	2408008.8	242869.6	5.45
160437	2406184.5	235081.7	5.45
171738	2408890.2	253509.2	5.44
175081	2409035.0	249521.3	5.44
645214	2407599.2	239828.5	5.43
493120	2374529.9	255485.4	5.42
169454	2409095.9	248197.8	5.41
162944	2408644.2	243547.8	5.39
1067184	2408644.2	243547.8	5.39
493311	2407983.5	238794.5	5.39
493122	2377107.2	259535.8	5.39
493123	2377087.2	259535.7	5.38
168658	2409156.8	246875.2	5.38
169486	2409156.8	246875.2	5.38
175583	2409156.8	246875.2	5.38
652039	2409519.2	250613.8	5.38

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
171171	2408801.4	256165.4	5.37
171172	2408801.4	256165.4	5.37
493124	2376907.2	259534.7	5.37
252907	2408753.0	240903.6	5.36
176785	2408753.0	240903.6	5.36
652085	2408833.7	241569.0	5.36
652071	2409032.7	245266.1	5.36
504518	2408120.2	237794.6	5.36
160684	2408120.2	237794.6	5.36
158271	2408120.2	237794.6	5.36
645178	2408674.9	239561.8	5.35
493158	2409672.4	250138.9	5.35
168884	2409219.7	245552.6	5.34
168885	2409219.7	245552.6	5.34
1802524	2409219.7	245552.6	5.34
169379	2409219.7	245552.6	5.34
1116480	2409219.7	245552.6	5.34
170708	2409219.7	245552.6	5.34
1116503	2409219.7	245552.6	5.34
171395	2409219.7	245552.6	5.34
176192	2409219.7	245552.6	5.34
154127	2408769.5	238696.9	5.34
154127	2408769.5	238696.9	5.34
652045	2409827.5	250387.5	5.33
493169	2409006.7	239608.3	5.33
645207	2409792.7	248871.4	5.33
163899	2404403.4	266623.4	5.33
169690	2404403.4	266623.4	5.33
172973	2404403.4	266623.4	5.33
172974	2404403.4	266623.4	5.33
493157	2409859.7	250145.8	5.33
343559	2409279.6	244230.1	5.32
163742	2409279.6	244230.1	5.32
308791	2409279.6	244230.1	5.32
663391	2409279.6	244230.1	5.32
169929	2409279.6	244230.1	5.32
173287	2409279.6	244230.1	5.32
866435	2409335.5	242906.5	5.31
163678	2409390.4	241582.9	5.31
172233	2409390.4	241582.9	5.31
645179	2409199.3	238699.7	5.31

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
163353	2409446.3	240260.3	5.30
1711585	2409446.3	240260.3	5.30
169889	2409446.3	240260.3	5.30
170709	2409446.3	240260.3	5.30
437578	2409446.3	240260.3	5.30
652046	2410128.9	250684.0	5.30
652043	2410146.1	250448.9	5.29
652052	2410155.1	250172.6	5.29
493170	2409703.6	239962.6	5.29
652057	2410167.6	250092.5	5.29
164706	2410304.8	250887.8	5.28
842700	2410304.8	250887.8	5.28
1655178	2410304.8	250887.8	5.28
645205	2410035.9	247754.7	5.28
1757735	2407288.2	261412.0	5.28
163007	2410356.7	249561.2	5.26
163102	2410356.7	249561.2	5.26
167811	2410356.7	249561.2	5.26
1595060	2410356.7	249561.2	5.26
175546	2410356.7	249561.2	5.26
252905	2410356.7	249561.2	5.26
417180	2410356.7	249561.2	5.26
151985	2410110.1	238741.9	5.26
156527	2410110.1	238741.9	5.26
151985	2410110.1	238741.9	5.26
156527	2410110.1	238741.9	5.26
1629221	2410218.9	253545.1	5.25
493144	2410453.2	250397.8	5.25
652068	2410056.8	246227.7	5.25
766554	2410421.6	248239.7	5.24
166010	2410421.6	248239.7	5.24
167193	2410421.6	248239.7	5.24
176343	2410421.6	248239.7	5.24
493148	2410375.8	247840.8	5.24
493160	2410509.9	250028.5	5.24
645201	2410522.5	249928.5	5.24
172168	2405787.9	265344.7	5.23
645194	2406193.2	264473.7	5.23
493309	2410800.5	237881.6	5.21
645176	2410889.1	238114.6	5.21
165995	2410484.5	246917.1	5.21

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)	Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y			X	Y	
309418	2410484.5	246917.1	5.21	685944	2411592.5	252261.4	5.09
173522	2410484.5	246917.1	5.21	166758	2411592.5	252261.4	5.09
173523	2410484.5	246917.1	5.21	424486	2411592.5	252261.4	5.09
173588	2410484.5	246917.1	5.21	169641	2411592.5	252261.4	5.09
174781	2410132.1	256200.4	5.20	170289	2411592.5	252261.4	5.09
493152	2410728.8	248164.4	5.20	171790	2411592.5	252261.4	5.09
493147	2410528.0	246920.7	5.20	165241	2407121.5	265386.7	5.08
292880	2409059.1	230512.0	5.20	175089	2407121.5	265386.7	5.08
652065	2410415.8	245463.8	5.19	163077	2411689.3	249607.1	5.08
338673	2373443.4	258237.7	5.19	163078	2411689.3	249607.1	5.08
645202	2410925.0	249676.3	5.18	163079	2411689.3	249607.1	5.08
645206	2410771.5	247479.3	5.18	545169	2411689.3	249607.1	5.08
168211	2410547.4	245594.6	5.18	551046	2411689.3	249607.1	5.08
169544	2410547.4	245594.6	5.18	1116478	2411689.3	249607.1	5.08
493153	2410645.0	246373.0	5.18	168550	2411689.3	249607.1	5.08
645200	2411030.7	249546.6	5.17	375775	2411689.3	249607.1	5.08
163103	2411056.0	248922.9	5.17	173156	2411689.3	249607.1	5.08
163104	2411056.0	248922.9	5.17	494634	2411754.2	248283.6	5.08
322666	2411056.0	248922.9	5.17	165728	2411754.2	248283.6	5.08
166309	2411056.0	248922.9	5.17	168982	2411754.2	248283.6	5.08
168342	2411056.0	248922.9	5.17	168983	2411754.2	248283.6	5.08
169212	2411056.0	248922.9	5.17	645199	2411762.9	252143.3	5.07
257182	2411056.0	248922.9	5.17	493360	2411532.2	246109.3	5.07
451220	2411056.0	248922.9	5.17	652049	2411534.7	245190.3	5.06
172357	2411056.0	248922.9	5.17	652054	2411571.2	245495.2	5.06
173267	2411056.0	248922.9	5.17	349421	2411817.1	246961.1	5.05
493151	2410990.4	247986.8	5.17	1064790	2411817.1	246961.1	5.05
333516	2405760.6	266815.4	5.16	168195	2411817.1	246961.1	5.05
652063	2411291.6	247982.7	5.13	168270	2411817.1	246961.1	5.05
333515	2405694.9	267998.3	5.12	413063	2405142.0	227698.8	5.04
163033	2411182.7	246277.8	5.11	167088	2411881.0	245637.5	5.03
411177	2411182.7	246277.8	5.11	254184	2411881.0	245637.5	5.03
165730	2411182.7	246277.8	5.11	174330	2411881.0	245637.5	5.03
293844	2411182.7	246277.8	5.11	157226	2414146.2	237129.0	5.01
443628	2411182.7	246277.8	5.11	652055	2412149.2	246679.2	5.01
443629	2411182.7	246277.8	5.11	650098	2412055.5	245401.5	5.01
385956	2411182.7	246277.8	5.11	652053	2412054.7	245319.9	5.01
343538	2411637.4	250933.7	5.10	645220	2412470.5	252297.4	5.00
173202	2411637.4	250933.7	5.10	172495	2412234.9	252944.7	5.00
493159	2411456.1	247430.2	5.09	331618	2407184.1	266933.6	4.99
164943	2411592.5	252261.4	5.09	163541	2412454.5	247642.3	4.99

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
166712	2412454.5	247642.3	4.99
167810	2412454.5	247642.3	4.99
167816	2412454.5	247642.3	4.99
168817	2412454.5	247642.3	4.99
170722	2412454.5	247642.3	4.99
172249	2412454.5	247642.3	4.99
173521	2412454.5	247642.3	4.99
493143	2412316.2	252795.9	4.99
164066	2409950.5	261498.9	4.99
164203	2409950.5	261498.9	4.99
169562	2409950.5	261498.9	4.99
645218	2412501.2	252497.0	4.99
493155	2412500.9	248607.5	4.99
652056	2412365.0	246680.3	4.99
652067	2412355.9	245994.5	4.98
645219	2412542.9	252747.1	4.97
493146	2412497.8	246394.7	4.97
652066	2412678.7	249843.9	4.96
652062	2412689.9	250123.3	4.96
493150	2412694.6	246895.5	4.96
652058	2412669.8	246681.9	4.96
652050	2412745.9	249133.1	4.96
645203	2412689.1	245935.7	4.94
493134	2408544.5	264960.0	4.94
1918156	2412968.0	250979.7	4.94
168316	2412968.0	250979.7	4.94
171735	2412968.0	250979.7	4.94
172674	2412968.0	250979.7	4.94
1757756	2412923.1	252304.3	4.94
162956	2413086.9	248328.6	4.93
168821	2413086.9	248328.6	4.93
445291	2413086.9	248328.6	4.93
1116488	2413086.9	248328.6	4.93
167671	2413024.0	249651.1	4.92
1116501	2413024.0	249651.1	4.92
166808	2408457.1	265429.6	4.92
171049	2413150.8	247004.0	4.92
166133	2409896.6	262823.4	4.92
334149	2407707.9	267212.7	4.92
163820	2413215.7	245679.5	4.89
163606	2414075.6	241079.4	4.88

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	
419021	2413722.2	249012.8	4.86
169476	2413722.2	249012.8	4.86
163150	2413611.4	251664.0	4.86
191678	2413611.4	251664.0	4.86
170654	2413611.4	251664.0	4.86
317569	2413611.4	251664.0	4.86
317570	2413611.4	251664.0	4.86
168505	2411273.1	261535.8	4.86
175138	2411273.1	261535.8	4.86
171956	2411273.1	261535.8	4.86
165249	2413851.1	246362.7	4.85
688641	2413851.1	246362.7	4.85
169209	2413851.1	246362.7	4.85
617113	2413851.1	246362.7	4.85
171754	2413851.1	246362.7	4.85
429665	2413851.1	246362.7	4.85
439860	2413967.9	243716.6	4.82
169920	2412690.6	258925.4	4.79
1757728	2409790.8	265468.6	4.76
168076	2410483.1	264825.3	4.74
166202	2409741.9	266785.2	4.69
164469	2411175.3	264180.9	4.68
165380	2411863.6	263541.6	4.67
170071	2411863.6	263541.6	4.67
166157	2409694.1	268096.8	4.62
176107	2412551.9	262893.3	4.59
168855	2412551.9	262893.3	4.59
545142	2411125.5	265503.5	4.58
413228	2410385.3	267461.4	4.56
1621491	2413963.4	260283.9	4.55
175820	2413236.2	262250.9	4.53
294254	2413236.2	262250.9	4.53
436937	2413878.6	262927.2	4.42
367508	2413878.6	262927.2	4.42
367515	2413878.6	262927.2	4.42
174216	2413878.6	262927.2	4.42
166809	2412459.1	265537.5	4.40
408150	2412459.1	265537.5	4.40
253903	2413149.4	264895.2	4.35
373896	2413149.4	264895.2	4.35
1570131	2413149.4	264895.2	4.35

Table D-2. Simulated Drawdown at Wells: New Pumping Wells West of Airway Heights (contd.)

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	

923799	2413149.4	264895.2	4.35
252903	2413149.4	264895.2	4.35
435792	2413835.7	264249.8	4.33
165935	2413835.7	264249.8	4.33
171853	2412412.2	266863.1	4.30
388528	2412358.3	268189.7	4.21
167070	2413053.6	267546.4	4.14
167071	2413053.6	267546.4	4.14
173503	2413053.6	267546.4	4.14
493327	2405675.4	229627.6	4.10
166826	2412306.4	269514.2	4.08
175743	2412306.4	269514.2	4.08
175443	2413691.9	268235.6	3.96
322664	2413691.9	268235.6	3.96
323015	2413691.9	268235.6	3.96
1825280	2410974.8	269461.3	3.92
172296	2410974.8	269461.3	3.92
169214	2409644.3	269407.3	3.91
164992	2413637.0	269567.2	3.79
168593	2413637.0	269567.2	3.79
1576896	2413062.0	230676.9	3.64
651996	2381231.4	261154.5	3.46
494429	2377423.0	227653.9	2.67
494427	2376699.3	234014.3	2.43
256945	2374474.6	233793.3	1.93
163898	2406331.6	268648.2	1.86
152754	2411850.3	227953.7	1.85
157428	2412428.6	229985.6	1.63
150021	2377384.4	227795.8	1.02
158711	2413176.9	228006.7	0.93
494428	2376457.2	235078.4	0.71
1643017	2414279.5	233618.0	0.63
1643045	2414279.5	233618.0	0.63
836724	2414279.5	233618.0	0.63
494447	2405702.3	230411.9	0.59
662675	2404954.1	269922.8	0.09
163794	2410287.6	270091.6	0.09
164902	2410287.6	270091.6	0.09
167509	2410287.6	270091.6	0.09
152301	2414504.5	228059.6	0.09
152302	2414504.5	228059.6	0.09

Well ID	Coordinates		Simulated Drawdown (ft)
	X	Y	

165387	2383151.6	263214.4	0.03
175566	2402933.3	270515.2	0.02
359355	2395007.4	268949.2	0.02
1111524	2405029.1	230377.0	0.01
167123	2383032.9	265859.4	0.01
1067164	2378764.7	243186.7	0.01
448306	2390367.1	268147.2	0.00
170063	2413581.0	270900.7	0.00
254274	2404264.9	270560.2	0.00
176121	2404264.9	270560.2	0.00