Quality Assurance Project Plan
for the
Paleochannel Water Quality Monitoring Study
Water Resource Inventory Area (WRIA) 54
Department of Ecology Grant Number G0800004

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BACKGROUND

INTRODUCTION

An evaluation of the potential for water quality impacts to paleochannel aquifers within the West Plains area of Spokane County, Washington is being addressed by the Water Resource Inventory Area (WRIA) 54 Planning Unit. The approximate boundaries of the West Plains area, as defined during the WRIA 54 Multi-Purpose Water Storage Study (Tetra Tech/KCM and GeoEngineers 2007b), are presented in the West Plains Vicinity Map, Figure 1.

Paleochannels within the West Plains area represent ancestral drainage-ways filled with sediment during Pleistocene-age (about 1.8 million to 10,000 years ago) glacial flooding events. Because paleochannel sediments have a significantly higher vertical permeability and storage capacity than the surrounding basalt rock, they are of interest for water supply projects, aquifer storage and recovery projects, and the disposal/infiltration of stormwater and/or reclaimed water. Studies to date have focused on:

- Mapping the extent of the paleochannels (SAIC 1992; Deobald and Buchanan 1995; Budinger & Associates 2001; CH2M Hill 2003; and GeoEngineers 2002, 2003, and 2007).
- Determining their infiltrative capacity, permeability, and other aquifer characteristics to evaluate groundwater flow conditions (GeoEngineers 2002, 2003, and 2007).
- Detailed study of aquifer geometry and properties within specific sites, such as the planned city of Airway Heights Water Reclamation Plant (GeoEngineers 2007).
- Groundwater quality and potential nitrate sources to city of Airway Heights Wells 1 and 4 (GeoEngineers 2003).

Few water quality studies have focused on the paleochannel aquifers. This presents a significant data gap in the water quality information for WRIA 54. This study is being undertaken to assess water quality in paleochannel aquifers and to comprehensively evaluate the potential impacts of the numerous stormwater, wastewater, and water supply projects already under consideration, planning, and/or construction. This Quality Assurance Project Plan (QAPP) has a number of investigative components ranging from field subsurface exploration to office-based hydrogeologic analyses. It is intended to be modular; each component could be independently conducted as funding sources are identified.

WEST PLAINS GEOLOGIC SETTING

The surficial geology of the West Plains area has been described in various publications including: Griggs (1966), Joseph (1990), and Stoffel et al. (1991). Aspects of the subsurface geology of the area have been documented in Deobald and Buchanan (1995), Drost and Whiteman (1986), Luzier and Burt (1974), and Whiteman et al. (1994).

Basement rocks in the vicinity of the site generally consist of metasedimentary rocks of the Precambrian Belt Supergroup (age greater than about 570 million years [Ma]). These rocks were intruded by granitic plutonic rocks during the Mesozoic (245 to 65 Ma) and Tertiary (65 to 1.5 Ma) (Stoffel et al. 1991).

Basement rocks are stratigraphically overlain by basalt flows associated with the Columbia River Basalt Group (CRBG). The CRBG was deposited during an extended period of Miocene (23 to 5 Ma) volcanism that extruded a series of very fluid lava flows. The lava flowed from north-northwest trending fissures as much as 90 miles long which were located primarily in northeastern Oregon and southeast Washington

(Hooper 1982). The resulting basalt deposits are hundreds to thousands of feet thick and extend throughout the Columbia Plateau. The CRBG has been subdivided into five formations that include, from oldest to youngest, the Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Two of these formations, the Grande Ronde and Wanapum, have been identified within the West Plains area (Drost and Whiteman 1986).

The Grande Ronde Basalt is the most voluminous of the CRBG formations, comprising 85 to 88 percent of the total volume of the CRBG (Whiteman et al. 1994). The Grande Ronde Basalt Formation underlies the entire West Plains area except where the elevation of pre-Miocene basement rocks were higher than the top of the formation; generally this occurred at steptoes. The Grande Ronde has been observed at up to 514 feet in thickness in area wells. The top of the Grande Ronde Basalt is often marked by (1) a weathered zone frequently described in water well reports as a water-bearing, fractured or vesicular zone with minor clay and/or (2) a sedimentary interbed (Latah Formation) that separates it from the overlying Wanapum Basalt Formation (Deobald and Buchanan 1995).

The Wanapum Basalt is the second-most voluminous of the CRBG formations, comprising about 6 percent of the total volume of the CRBG (Whiteman et al. 1994). It stratigraphically overlies the Grande Ronde Basalt. It occurs throughout the Airway Heights area except where it pinches out at steptoes or has been removed by erosion within drainages. Surface exposures are abundant (Stoffel et al. 1991). The Wanapum Basalt has been observed at up to 292 feet in thickness in area wells

The CRBG is overlain by Pleistocene-age glaciofluvial (flood) deposits that consist of unsorted mixtures of silt, sand, gravel, cobbles and boulders. Recent geologic mapping by the Washington State Department of Natural Resources (Derkey and Hamilton 2008) suggests that, in some areas, glaciofluvial deposits contain large clasts of fine-grained sedimentary rock (presumably from the Latah Formation). Flood deposits are frequently interbedded with glaciolacustrine sediments that were deposited in a low-energy depositional environment (such as a lake); these deposits typically consist of clay, silt, or silty fine sand. Quaternary (less than about 1.5 Ma) loess (wind-blown clay, silt and fine sand) frequently overly the glaciofluvial and glaciolacustrine deposits, and, in some areas, directly overlie the CRBG.

The top of the CRBG surface is incised and undulatory, creating a relatively complex distribution in overlying sediment thickness. Studies performed by Science Applications International Corporation (SAIC) (1992), Deobald and Buchanan (1995), Budinger and Associates (2001), and GeoEngineers (2002) defined a minimum of three eroded depressions in the basalt within the West Plains area. These depressions are up to 400 feet in depth and interpreted to represent past drainage features, or paleochannels, that were filled by permeable flood deposits during the Quaternary. The three identified paleochannels are herein termed the Airport, Airway Heights, and Deep Creek Paleochannels and are approximately located as shown in Paleochannel Boundaries and Surficial Geology, Figure 2.

WEST PLAINS HYDROGEOLOGIC SETTING

General

The Airway Heights area generally is underlain by a minimum of four aquifers. These aquifers occur within the (1) unconsolidated surficial deposits, (2) Wanapum Basalt Formation, (3) Grande Ronde Basalt Formation, and (4) basement rocks. The Wanapum Basalt and Grande Ronde Basalt Formations generally are the most suitable for extracting groundwater of sufficient quantity for municipal supply and distribution systems. However, the unconfined aquifer, within paleochannels, can yield significant supply and quantities of groundwater.

Unconfined Surficial Aquifer

Unconsolidated surficial deposits consist primarily of glaciofluvial and glaciolacustrine deposits. The glaciofluvial deposits typically consist of relatively free-draining sand and gravel with relatively high permeability that in places forms an unconfined aquifer, perched on the underlying bedrock surface. Saturated aquifer thickness is generally less than 10 feet outside of the boundaries of the paleochannels, resulting in low aquifer transmissivity and limited reliability as a long-term groundwater supply (Buchanan 1992). Within the paleochannels, saturated aquifer thickness can exceed 200 feet, resulting in relatively high aquifer transmissivity. In all areas, the unconfined aquifer water quality is relatively susceptible to degradation from point and non-point sources of contamination because of the lack of an overlying confining unit and the generally shallow depth to the groundwater table. Recharge to the unconfined aquifer is primarily from precipitation, applied irrigation, septic systems and potentially through leakage from the underlying Wanapum Basalt.

Wanapum Basalt Formation Aquifer

The Wanapum Basalt Formation consists of a series of individual basalt flows. Groundwater is most readily transmitted through the broken vesicular and scoriaceous interflow zones that characterize the top of each flow. The interflow zones are separated by the less porous and less transmissive entablature and colonnade, which comprise 90 to 95 percent of the total flow volume (Whiteman et al. 1994). The flows are locally interlayered with sedimentary deposits of the Latah Formation. This system of multiple flows and interlayered sedimentary deposits creates multiple stacked confined to semi-confined aquifers which can yield significant volumes of groundwater to wells (Buchanan 1992).

The Wanapum Basalt Formation is overlain, in places, by relatively coarse-grained Quaternary deposits. In other locations, the Wanapum Basalt directly crops out on the surface. Recharge to the Wanapum Basalt occurs through direct precipitation, vertical infiltration from the overlying unconfined aquifer, and lateral recharge from upgradient areas to the north and east. A minor component of recharge could migrate upward as leakage from the underlying Grande Ronde Basalt or Latah Formation, depending on head conditions. Discharge from the Wanapum Basalt Formation occurs through leakage to adjacent aquifers, (such as the paleochannel aquifer), along gaining reaches of streams, and to water supply wells.

Grande Ronde Formation Aquifer

Like the Wanapum Basalt, the Grande Ronde Basalt consists of a series of basalt flows, with groundwater most readily transmitted through the interflow zones at the top of each flow. This series of flows, coupled with local interbedding with coarse-grained sedimentary deposits, creates multiple stacked confined aquifers and relatively high well yields.

Recharge to the Grande Ronde Formation occurs primarily through outcrops along the margins of the Columbia Plateau, with groundwater flowing laterally to discharge areas within the plateau interior. Recharge could also occur through leakage from the overlying Wanapum Basalt or underlying basement rocks, depending on head conditions. Discharge from the Grande Ronde Basalt Formation occurs through leakage to adjacent aquifers (such as the Wanapum and paleochannel aquifers), along gaining reaches of streams, and to water supply wells.

Basement Rock Aquifer

Groundwater occurs in basement rocks, which underlie the CRBG, in fractured and/or weathered zones. Porosity and permeability are generally low. The yield of water wells penetrating into the basement rock aquifer generally is low, typically on the order of several gallons per minute or less.

Recharge to the basement rock aquifer occurs primarily within upgradient areas to the north and east, with groundwater flowing laterally to discharge areas within the plateau interior. Recharge could also occur through leakage from the overlying Grande Ronde Basalt.

EXISTING INFORMATION

General

Geologic mapping investigations within the West Plains area (Deobald and Buchanan 1995; Derkey and Hamilton 2008) have delineated a total of three main paleochannels, commonly designated the Airway Heights Paleochannel, Airport Paleochannel, and Deep Creek Paleochannel. The locations of the three paleochannels, as defined by recent mapping completed by the Washington State Department of Natural Resources, are presented in Paleochannel Boundaries and Surficial Geology, Figure 2.

Existing Wells

Paleochannel boundaries generally were located through review of well logs and surficial geologic mapping. Domestic and public water supply well locations used to define paleochannel boundaries are presented in Paleochannel Boundaries and Well Locations, Figure 3.

Group A and B water supply wells and private wells in the vicinity of the three paleochannels were located using GIS. Data for Group A and B wells was obtained from the Washington State Department of Health (DOH). Private well locations were supplied by the Department of Natural Resources (Derkey and Hamilton 2008). Available well logs were obtained from the Washington State Department of Ecology to verify if the Group A and B wells are screened within paleochannel aquifers. A summary of Group A and B paleochannel wells is provided in Table 1A, and private paleochannel wells are detailed in Table 1B.

Few investigations have been conducted within the paleochannels to determine aquifer hydraulic properties. Two water balances have been conducted by GeoEngineers, performed within the Airport and Airway Heights paleochannels (GeoEngineers 2002; GeoEngineers 2003). Hydrogeologic studies have also been conducted by GeoEngineers in the Airport and Airway Heights Paleochannels (GeoEngineers 2002; GeoEngineers 2007). A compilation of paleochannel aquifer hydraulic properties is presented in Tables 2 and 3.

Airway Heights Paleochannel

General

The Airway Heights Paleochannel originates east of Fairchild Air Force Base and generally trends north through the city of Airway Heights towards Deep Creek and the Spokane River, as shown in Figure 2. It is the longest of the three paleochannels, extending a distance of about 12 miles. Maximum sediment thickness increases from about 50 feet at its southern terminus to over 200 feet within the northern portion of the paleochannel.

The Airway Heights Paleochannel is penetrated by an estimated 55 domestic and public water supply wells, including City of Airway Heights Wells 1 and 4.

Geology

The paleochannel limits were delineated by SAIC (1992) and refined by Deobald and Buchanan (1995) and GeoEngineers (2007) using a combination of monitoring and water well logs, outcrop data, and geophysical methods. Outside of the boundaries of this paleochannel, depth to the unconfined water table, where present, is generally less than about 20 feet and saturated aquifer thickness is generally less than about 10 feet. Groundwater in these areas migrates vertically into the Wanapum Basalt Formation and/or follows basalt surface topography before discharging to the paleochannel.

Well logs have penetrated up to 349 feet of glaciofluvial material within the Airway Heights paleochannel without encountering in-place rock. SAIC (1992) depicted the paleochannel as a closed depression that terminates south of State Route 2. Deobald and Buchanan (1995) used additional data to interpret the paleochannel as a drainage way that extends northeast from State Route 2 to suspected discharge areas near Deep Creek and/or the Spokane River.

Sediment along the margins of the Airway Heights Paleochannel is underlain by the Wanapum Basalt Formation. Geologic studies performed by SAIC (1992) and CH2M Hill (2003) for the Craig Road Landfill (located about 4,700 feet west of City Wells 1 and 4 as shown on Figure 3) identified two flow sequences, Basalt Flow A and Basalt Flow B, within the Wanapum Basalt Formation in the site area. Flow sequences A and B are separated by a sedimentary interbed termed Interbed A. The Airway Heights Paleochannel completely truncates Basalt Flow A and Interbed A, exposing the top of Basalt Flow B within the interior of the paleochannel.

Hydrogeology

Near the Airway Heights Paleochannel, groundwater occurs under variable conditions within glaciofluvial sediments, the CRBG, sedimentary interbeds within CRBG and basement rock. Outside of the boundaries of the paleochannel, depth to the water table within glaciofluvial sediments, where present, is generally less than about 20 feet and saturated aquifer thickness is generally less than about 10 feet. Groundwater in these areas migrates vertically into Basalt Flow A and/or follows basalt surface topography before discharging to the paleochannel (SAIC 1992). Unconfined aquifer thickness is a minimum of about 89 feet at City of Airway Heights Well 4, but has not been well defined throughout much of the paleochannel.

SAIC (1992) measured groundwater elevations in several paleochannel wells in September 1991. Groundwater ranged from about Elevation 2,245 to Elevation 2,256 feet. Groundwater flow direction was to the northwest, under a hydraulic gradient of about 0.004 feet per foot (ft/ft).

Outside of the boundaries of the paleochannel, the uppermost confined aquifer occurs within Basalt Flow A, which was found by SAIC (1992) to be about 90 to 141 feet thick. Potentiometric surface mapping performed by SAIC (1992) indicates that groundwater flows from Basalt Flow A into the paleochannel along each side of the paleochannel perimeter. Potentiometric levels ranged from Elevation 2,380 feet at the west end of Craig Road Landfill to Elevation 2,270 feet at the margins of the paleochannel. SAIC (1992) interpreted that Interbed A is relatively impermeable and continuous and that Basalt Flow A is truncated by the paleochannel; this suggests that the paleochannel captures water from the entire thickness of Basalt Flow A. The unconfined aquifer within the paleochannel, because of its relatively high permeability and low head, acts as a drain resulting in subsurface discharge from Basalt Flow A into the paleochannel with subsequent groundwater flow along the paleochannel, through the channel infill deposits to down-gradient discharge areas.

Interbed A is underlain by Basalt Flow B. Though water level data for Basalt Flow B is sparse, SAIC (1992) determined that the flow direction within Basalt Flow B in the vicinity of Craig Road Landfill is to the northeast. The paleochannel intersects the top portion of Basalt Flow B, and head conditions reported in SAIC (1992) suggest that some groundwater also discharges from Basalt Flow B into the Airway Heights paleochannel.

Proposed Water Reclamation Facility

Extensive investigation has been performed in the vicinity of the city of Airway Height's planned Water Reclamation Facility (GeoEngineers 2003 and 2007), the proposed location of which is in the southeast quarter of Section 26, Township 25 North, Range 41 East. The investigation included deep monitoring well drilling and installation, seismic refraction survey, aquifer testing, and groundwater modeling. Conclusions relevant to this study include the following:

- At the site, paleochannel sediments are at least 198 feet thick and consist of a complex assemblage of glaciofluvial (primarily sand and gravel) and glaciolacustrine (primarily silt and clay) sediment.
- Depth to water in the paleochannel aquifer was about 120 feet below ground surface in February 2007.
- Aquifer transmissivity was estimated from a pumping test at about 34,000 square feet per day, hydraulic conductivity was estimated at about 570 feet per day, and storativity was estimated at about 0.002.
- The time required for infiltrated water to travel from the ground surface to the paleochannel aquifer's groundwater table could range from as short as 10 days to years, depending on the thickness and continuity of glaciolacustrine sediments.
- The cation exchange capacity (CEC) of unsaturated soil ranged from 3.78 to 9.87 milliequivalents per 100 grams of soil.

Airport Paleochannel

General

The Airport Paleochannel is the eastern-most of the identified paleochannels and originates north of Spokane International Airport (SIA) and west of Spotted Road near Airway Heights, Washington. The paleochannel generally trends north from SIA for a distance of about 3 ½ miles, where it shifts to the east and extends about 2 miles before intersecting the Spokane River valley. Maximum sediment thickness is thought to exceed 200 feet throughout most of the paleochannel's length.

The Airport Paleochannel only is penetrated by an estimated four domestic and public water supply wells (see Figure 3).

Geology and Hydrogeology

A portion of the Airport Paleochannel situated immediately south of State Route 2 within the northeast quarter of Section 29, Township 25 North, Range 42 East was evaluated by Budinger & Associates (2001) and GeoEngineers (2002) for the feasibility of disposing stormwater on-site. The investigation included deep monitoring well drilling and installation, seismic refraction survey, hydraulic testing, and hydrogeologic analysis. Conclusions relevant to this study include the following:

- Geophysical work, as well as area water well reports, suggest that the Airport Paleochannel is a minimum of about 1,000 feet wide, extends to a maximum depth of at least 250 feet below ground surface, and trends to the north-northeast where it merges with the Spokane River valley in the vicinity of Spokane Falls Community College.

- At the site, paleochannel sediments are at least 150 feet thick and consist of a complex assemblage of glaciofluvial (primarily sand and gravel) and glaciolacustrine (primarily silt and clay) sediment.
- Depth to water in the paleochannel aquifer was about 130 feet below ground surface in February 2002.
- Hydraulic conductivity is about 560 feet per day, hydraulic gradient is about 0.012 feet per foot and, groundwater velocity is about 26 feet per day.
- The concentration of nitrate/nitrite nitrogen in groundwater from the paleochannel aquifer was about 12 milligrams per liter (mg/L), which exceeds the drinking water standard of about 10 mg/L.
- The CEC of unsaturated soil ranged from about 7.1 to 50 milliequivalents per 100 grams of soil.

Deep Creek Paleochannel

The Deep Creek Paleochannel is the western-most of the identified paleochannels and originates about 2 miles north of the City of Airway Heights. The paleochannel generally trends northeast for a distance of about 4 miles before intersecting the Spokane River valley. Maximum sediment thickness is believed to exceed 200 feet.

The Deep Creek Paleochannel is located within a relatively undeveloped portion of the study area and is only penetrated by two domestic wells. No hydrogeologic reports specific to the Deep Creek Paleochannel were encountered during our review.

EXISTING WATER QUALITY DATA

A total of 24 Group A and B wells are believed to penetrate the paleochannel aquifers. Water quality data from 23 of these wells was obtained from the Washington State Department of Health (DOH) and is compiled in the report, “Background Data Compilation and Data Gap Evaluation, Paleochannel Aquifers Water Resources Inventory Area 54,” (GeoEngineers 2008).

A review of readily available well logs from the Group A and B wells confirmed that five wells penetrate paleochannel aquifers. The Airway Heights Paleochannel aquifer is penetrated by Airway Heights well 4 and Hunt-Mayfield well 1, and is likely penetrated by an additional 18 of the 26 identified Group A and B wells.

The Airport Paleochannel is confirmed to be penetrated by two Group A wells, including the Riverside State Park Equestrian well 1 and the City of Spokane Baxter well. Both of these wells are located near the outlet of the paleochannel, toward the northeast. Two additional wells are likely located in the Airport Paleochannel aquifer, near the southern portion of the paleochannel.

None of the Group A and B wells identified in this study are likely located in the Deep Creek Paleochannel aquifer.

PROJECT DESCRIPTION

INTRODUCTION

The WRIA 54 Planning Unit intends to evaluate existing and future groundwater quality within paleochannel aquifers in the West Plains area of Spokane County, Washington. To do so, characterization of paleochannel aquifer geometry and properties, background groundwater quality, and deviation from background conditions as a function of area development will be necessary.

GOALS AND OBJECTIVES

Goals of this study include assessment of water quality in paleochannel aquifers within the West Plains area, and the comprehensive evaluation of potential impacts of the numerous stormwater, wastewater, and water supply projects already under consideration, planning, and/or construction.

Several objectives have been developed to assess paleochannel aquifer water quality. Subsurface exploration, baseline and long-term groundwater monitoring, hydrogeologic analyses, geophysical investigations, and source water quality monitoring can be used in conjunction to achieve project goals. The following goals and objectives have been developed to use separately or in sequence as funding becomes available.

NECESSARY INFORMATION

Subsurface exploration, baseline groundwater quality monitoring, long-term groundwater quality monitoring, hydrogeologic analyses, and geophysical exploration will be performed to obtain the information necessary to achieve project objectives.

Subsurface Exploration Program

A subsurface exploration, testing, and analysis program is necessary to mitigate identified data gaps. The subsurface exploration program should be focused on large areas that do not currently contain wells and in the paleochannel outlets near the Spokane River. Land use will be considered during monitoring well siting. Future land use within WRIA 54 is presented in WRIA 54 Land Use, Figure 4. The subsurface exploration program should have the following components:

- Siting of new groundwater monitoring wells.
- Incorporation of existing wells that meet project-specific well construction criteria.
- Hydraulic (slug) testing in selected monitoring wells to establish aquifer hydraulic conductivity. This parameter will be critical to any contaminant transport and/or loading calculations that are performed in future project phases.
- Installation of dedicated bladder pumps in monitoring wells that are to be included in the monitoring program and use of low-flow sampling techniques. Relative to conventional sampling techniques, the benefits of this approach include reduced sample turbidity, reduced sampling purge volume, reduced sampling and decontamination time, reduced likelihood of cross-contamination, and greatly improved sample quality.
- Installation of pressure transducers and data loggers for the continuous collection of water level and temperature data in selected site monitoring wells.

- Install equipment for continuously monitoring barometric pressure in the study area. Barometric pressure data will be used to correct water level data for barometric fluctuation, which can be a significant source of error during long-term monitoring projects.

Baseline Groundwater Quality Monitoring

Baseline groundwater quality should be established within selected paleochannel wells over a 1-year monitoring period. Wells should be sampled for nutrients, metals, bacteria, and water quality parameters such as turbidity, temperature, pH, dissolved oxygen, conductivity, and oxidation reduction potential. Other parameters, such as total dissolved solids, total organic carbon, selected anions and cations, and petroleum hydrocarbons also should be considered. Wells should be selected based on the following:

- To achieve adequate coverage of the areal extent of the paleochannels. Water quality within the study aquifers likely will vary considerably between paleochannels and within each paleochannel.
- Within and down-gradient of areas characterized by key future land-uses, such as industrial and residential.
- Down-gradient of specific potential contaminant sources. Contaminant sources could include stormwater and/or reclaimed water disposal facilities that are currently being sited and/or designed by area municipalities.
- Within paleochannel discharge areas. Paleochannel discharge areas generally are located within the north portion of the study area, and are suspected to discharge water either to Deep Creek or the Spokane River.

Long-Term Groundwater Monitoring

A long-term groundwater elevation and water quality monitoring program will be established to obtain the following information:

- Groundwater flow direction and gradient
- Contaminant concentrations
- Prediction of future hydraulic and contaminant trends

Hydrogeologic Analysis

The following hydrogeologic analyses are necessary to gain an understanding of paleochannel hydraulic conditions:

- Define approximate boundaries and recharge areas for the paleochannel aquifers.
- Evaluate seasonal variability in aquifer hydraulic gradient and groundwater flow direction.
- Estimate the volume of groundwater (flux) transported by the paleochannel aquifers to down-gradient discharges areas.
- Estimate the quantity of contaminants, such as phosphorus, that are discharged from paleochannel aquifers to down-gradient surface water.

Geophysical Investigation

The following geophysical investigation is necessary to evaluate the geometry and extent of the Deep Creek Paleochannel:

- Conduct a geophysical investigation of the Deep Creek Paleochannel by performing seismic refraction surveys in the area.
- Extend the seismic refraction surveys south of the existing paleochannel contours.

Source Water Quality Monitoring

A source water quality monitoring program is necessary to evaluate concentrations in potential stormwater sources and should consist of the following:

- Identify existing and future stormwater sources.
- Sample source water over time to establish trends in potential contaminant concentrations.

ORGANIZATION, SCHEDULE, AND PRELIMINARY COST ESTIMATE

ORGANIZATION

WRIA 54 Initiating Governments	Spokane County (Lead Agency) Stevens County Lincoln County City of Spokane Stevens PUD Spokane Tribe
Lead Agency Contact	Mike Hermanson Spokane County (509) 477-7260 mhermanson@spokanecounty.org
Ecology Contact	Sara Hunt Department of Ecology (509) 329-3579

SCHEDULE

Table 4. Project Activities and Targeted Completion Timeframe

Report/Field Event	Targeted Completion Timeframe
Completion of Final Approved QA Project Plan	July 2008
Subsurface Exploration Program	May 2009 through June 2009
Baseline Groundwater Quality Monitoring	1 year after completion of subsurface exploration program (June 2010)
Long-term Groundwater Monitoring	10 years after completion of baseline groundwater quality monitoring (June 2020)

Report/Field Event	Targeted Completion Timeframe
Hydrogeologic Analysis	Six months after completion of baseline groundwater quality monitoring (December 2010)
Geophysical Investigation	May 2009 through June 2009
Source Water Quality Monitoring	Concurrent with long-term groundwater monitoring (June 2010 through June 2020)
Draft Study Report	Four months after completion of field event
Final Study Report	Two months after completion of draft study report
Submittal of Data to the Environmental Information Management System (EIM)	At completion of the final study report

The proposed schedule is subject to funding of each portion the project. Funding currently has not been secured. In addition, the project lead, project assistants and laboratories have not currently been chosen to complete the above tasks. The timeline is dependent on selecting personnel to complete each portion of the project.

PRELIMINARY COST ESTIMATE

The cost estimate presented in this section is based on typical costs for the study components presented in the *Project Description* portion of this QAPP (and described in more detail in the below *Sampling Process Design* section) at the time that this QAPP was prepared. It is designed to be used as a planning tool and should be considered approximate.

Table 5. Preliminary Cost Estimate

Study Component	Approximate Cost Per Event	Number of Events	Approximate Total Cost
Subsurface Exploration	--	--	--
Drilling and Monitoring Well Installation[1]	$140,000	1	$140,000
Installation of Monitoring Equipment[2]	$19,000	1	$19,000
Subtotal			**$159,000**
Baseline Groundwater Quality Monitoring[3]	--	--	--
Sampling and Reporting	$6,250	8	$50,000
Laboratory Analysis[4]	$8,180	8	$65,440
Subtotal			**$115,440**
Long-term Groundwater Monitoring[5]	--	--	--
Sampling and Reporting	$6,250	40	$250,000
Laboratory Analysis[4]	$8,180	40	$327,200
Subtotal			**$577,200**
Hydrogeologic Analysis	$10,000	1	**$10,000**
Geophysical Investigation[6]	$80,000	1	**$80,000**
Source Water Quality Monitoring[7]	--	--	--
Sampling and Reporting	$2,500	40	$100,000
Laboratory Analysis[8]	$2,445	40	$97,800
Subtotal			**$197,800**

[1]Assumes ten 2-inch PVC monitoring wells are installed with air rotary drilling methods to depths of about 160 feet each.

[2]Assumes ten pressure transducers for monitoring groundwater level and temperature, one barometric pressure transducer, and ten dedicated bladder pumps.

[3]Assumes a total of eight sampling events using a total of 20 wells will be performed.

[4]Assumes samples will be analyzed for the analyte list and methods presented in Table 6.

[5]Assumes quarterly sampling will be performed in 20 wells for a period of ten years.

[6]Assumes eight seismic refraction lines, each about 2,500 feet in length, will be performed.

[7]Assumes four source water sampling events will be performed per year for a period of ten years. Each event will sample a total of five sources.

[8]Assumes samples will be analyzed for the analyte list and methods presented in Table 7.

Approximate costs for laboratory analyses are summarized in Tables 6 and 7. Tables 6 and 7 are based on the anticipated analytical suite for groundwater and source water samples, respectively.

Table 6. Laboratory Analytical Costs – Groundwater Samples[1]

Analyte[2]	Method[3]	Cost Per Sample
TPN, dissolved	SM 4500N-C	$40
Nitrate-N, dissolved	EPA 300.0	$20
Nitrite-N, dissolved	EPA 300.0	$20
Total phosphorus	SM 4500	$30
Coliform, total	SM 9223B-PA	$40
Coliform, fecal	SM 9223B-PA	$25
TSS	EPA 160.2	$15
TDS	EPA 160.1	$20
Chloride, dissolved	EPA 300.0	$5
Total petroleum hydrocarbons	EPA 8015 MOD	$35
Iron, dissolved	EPA 200.8	$27
Manganese, dissolved	EPA 200.8	$12
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead Selenium, Mercury)	EPA 6020/EPA 7471A	$120
	Total	**$409**

[1]Analytical costs are based on Anatek Labs, Inc.'s 2008 Price List.

[2]TPN = total persulfate nitrogen; N = nitrogen; BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids; TDS = total dissolved solids; RCRA = Resource and Recovery Act.

[3]SM = Standard Method; EPA = Environmental Protection Agency Method

Table 7. Laboratory Analytical Costs – Source Water Samples[1]

Analyte[2]	Method[3]	Cost Per Sample
TPN, dissolved	SM 4500N-C	$40
Nitrate-N, dissolved	EPA 300.0	$20
Nitrite-N, dissolved	EPA 300.0	$20
Total phosphorus	SM 4500	$30
Coliform, total (MF)	SM 9223B-PA	$40
Coliform, fecal (MF)	SM 9223B-PA	$25
BOD	SM 5210B	$45
COD	EPA 410.4	$35
TSS	EPA 160.2	$15

Analyte[2]	Method[3]	Cost Per Sample
TDS	EPA 160.1	$20
Chloride, dissolved	EPA 300.0	$5
Total petroleum hydrocarbons	EPA 8015 MOD	$35
Iron, dissolved	EPA 200.8	$27
Manganese, dissolved	EPA 200.8	$12
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead Selenium, Mercury)	EPA 6020/EPA 7471A	$120
	Total	**$489**

[1]Analytical costs are based on are based on Anatek Labs, Inc.'s 2008 Price List.

[2]TPN = total persulfate nitrogen; N = nitrogen; BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids; TDS = total dissolved solids; RCRA = Resource and Recovery Act.

[3]SM = Standard Method; EPA = Environmental Protection Agency Method

QUALITY OBJECTIVES

Measurement quality objectives (MQOs) for field and laboratory paleochannel water quality monitoring are listed in Tables 8a, 8b, and 8c. Laboratory quality objectives are based on the reported bias and precision limitations of each analytical method (Ecology 1993). Standard field methods will be used throughout each portion of the project to improve precision and bias associated with random and systematic errors in field measurements. Groundwater purging and sampling will be performed consistent with the EPA's low-flow groundwater sampling procedure, as described in EPA (1996) and Puls and Barcelona (1996). Source water sampling will be performed according to Ecology's document, "How to do Stormwater Sampling" (Ecology 2002) and the EPA's NPDES Storm Water Sampling Guidance Document (EPA 1992). Chemical analysis of groundwater samples will be performed by an accredited laboratory.

Table 8a. Field Measurement Quality Objectives

Parameter[1]	Check Standard (LCS)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference[2] (RPD)	Units of Concentration[4]
Turbidity	± 10 NTU	± 10%	NA	NA	NA
Conductivity	± 10 mS/cm	± 10%	NA	NA	25 umhos/cm @25 C
pH	± 0.2	± 0.1	NA	NA	NA
Temperature	± 0.1 C	± 5%	NA	NA	NA
Dissolved Oxygen	± 0.2 mg/L	NA	NA	NA	0.2 mg/L
ORP[3]	± 10 mV	± 10%	NA	NA	NA

[1]Turbidity, conductivity, pH, temperature, ORP and dissolved oxygen are measured in the field. Accuracy will be ensured daily by calibration and standard checks.

[2]RPD values are stated as maximum allowable differences from field check standards.

[3]ORP = oxidation reduction potential

[4]NTU = nephelometric turbidity units; mS/cm = milliSiemens per centimeter; C = degrees Celsius; mg/L = milligrams per liter; mV = millivolts; umhos/cm = micromhos per centimeter.

Table 8b. Groundwater Laboratory Measurement Quality Objectives[1]

Parameter[2]	Check Standard (LCS)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	Units of Concentration[3]
TPN, dissolved	80-120%	± 20%	75-125%	± 20%	0.1 mg/L
Nitrate+Nitrite-N, dissolved	90-110%	± 20%	75-125%	± 20%	0.1 mg/L
Total Phosphorus	80-120%	± 20%	75-125%	± 20%	0.01 mg/L
Coliform, total	NA	± 40%	NA	NA	1 CFU
Coliform, fecal	NA	± 40%	NA	NA	1 CFU
Chloride, dissolved	90-110%	± 20%	75-125%	± 20%	1 mg/L
TSS	80-120%	± 20%	75-125%	± 20%	1 mg/L
TDS	80-120%	± 20%	75-125%	± 20%	1 mg/L
TPH	80-120%	± 20%	75-125%	± 20%	0.2 mg/L
Iron, dissolved	85-115%	± 20%	75-125%	± 20%	50 ug/L
Manganese, dissolved	85-115%	± 20%	75-125%	± 20%	10 ug/L
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead Selenium, Mercury)	85-115%	± 20%	75-125%	± 20%	NA

[1]Note that this table is constructed with the same units used to report results for laboratory QC analyses. Information on the default QC sample types and QC limits can be obtained from the laboratory that will be performing the analyses.

[2]TPN = total persulfate nitrogen; TSS = total suspended solids; TDS = total dissolved solids; TPH = total petroleum hydrocarbons; RCRA = Resource Conservation and Recovery Act.

[3]mg/L = milligrams per liter; CFU = colony-forming units; ug/L = micrograms per liter; NA = not applicable.

Table 8c. Surface Water Laboratory Measurement Quality Objectives[1]

Parameter[2]	Check Standard (LCS)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	Units of Concentration[3]
TPN, dissolved	80-120%	± 20%	75-125%	± 20%	0.1 mg/L
Nitrate+Nitrite-N, dissolved	90-110%	± 20%	75-125%	± 20%	0.1 mg/L
Total Phosphorus	80-120%	± 20%	75-125%	± 20%	0.01 mg/L
Coliform, total	NA	± 40%	NA	NA	1 CFU
Coliform, fecal	NA	± 40%	NA	NA	1 CFU
BOD	80-120%	± 20%	NA	NA	1 mg/L
COD	80-120%	± 20%	NA	NA	1 mg/L
TSS	80-120%	± 20%	75-125%	± 20%	1 mg/L

Parameter[2]	Check Standard (LCS)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	Units of Concentration[3]
TDS	80-120%	± 20%	75-125%	± 20%	1 mg/L
TPH	80-120%	± 20%	75-125%	± 20%	0.2 mg/L
Chloride, dissolved	90-110%	± 20%	75-125%	± 20%	1 mg/L
Iron, dissolved	85-115%	± 20%	75-125%	± 20%	50 ug/L
Manganese, dissolved	85-115%	± 20%	75-125%	± 20%	10 ug/L
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead Selenium, Mercury)	85-115%	± 20%	75-125%	± 20%	NA

[1]Note that this table is constructed with the same units used to report results for laboratory QC analyses. Information on the default QC sample types and QC limits can be obtained from the laboratory that will be performing the analyses.

[2]TPN = total persulfate nitrogen; BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids; TDS = total dissolved solids; RCRA = Resource Conservation and Recovery Act.

[3]mg/L = milligrams per liter; CFU = colony-forming units; ug/L = micrograms per liter; NA = not applicable.

SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

GENERAL

The objectives of this study will be achieved through collection of field data and performance of analyses. Experimental design in this section is divided into six subheadings including a subsurface exploration program, baseline groundwater quality monitoring, long-term groundwater monitoring, hydrogeologic analyses, geophysical investigation, and source water quality monitoring.

SUBSURFACE EXPLORATION PROGRAM

Monitoring Well Drilling and Installation

Drilling

Monitoring wells will be drilled and installed in each of the three paleochannels for groundwater quality monitoring and subsurface exploration. A total of about 10 monitoring wells, MW-1 through MW-10, will be installed in the approximate locations shown in Experimental Design, Figure 5. Drilling will be performed using conventional air-rotary or rotosonic drilling techniques. Drilling and well installation activities will be continuously monitored by a geologist or engineer who will collect, examine, and classify representative soil samples and maintain a detailed log of the explorations. During drilling, soil samples will be obtained at a maximum 5-foot-depth interval using a an approximate 2-inch-diameter split spoon sampler driven by a 140-pound hammer free falling a distance of about 30 inches. The number of hammer strokes required to drive the sampler the last 12 inches, or other indicated distance, will be recorded on boring logs.

Monitoring wells will be located in the field by pacing and taping from existing physical features or by using a GPS locating device. The elevation of the top of the PVC monitoring wells will be surveyed. Monitoring well locations and elevations should be considered accurate to the degree inferred by the methods which are used.

Soil will be classified in general accordance with the Unified Soil Classification System. A boring and well construction log will be completed for each monitoring well.

Well Construction and Development

Monitoring wells will be constructed using approximate 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) riser and well screen material. Well screen slot size will be about 0.010 inches. Well screen length will be a minimum of 20 feet and placed across the groundwater table. Clean 10-20 Colorado silica sand will be used as filter pack. Bentonite grout and/or medium bentonite chips should be used as impermeable backfill. At the ground surface, the wells will be protected by locking steel above-ground monuments.

After installation, monitoring wells will be developed by a combination of pumping and surging until purge water is relatively clear and free of suspended sediment.

Installation of Monitoring Equipment

Dedicated bladder pumps outfitted with dedicated polyethylene tubing will be installed in newly constructed monitoring wells that are to be included in the monitoring program. Compressed gas is delivered to the pump, which contains a bladder filled with groundwater. The compressed gas exerts pressure on the bladder, forcing groundwater to the surface. A pump controller is connected to the compressed gas and pump tubing, controlling the amount of pressure and timing the release of gas. Low-flow purging and sampling is achieved through the repeated filling and emptying of the bladder using a compressed gas such as nitrogen. Relative to conventional sampling techniques, the benefits of this approach include reduced sample turbidity, reduced sampling purge volume, reduced sampling and decontamination time, reduced likelihood of cross-contamination, and greatly improved sample quality.

Pressure transducers and data loggers will be installed in a selected number of monitoring wells for the continuous collection of water level and temperature data. The transducer consists of a data logger, pressure transducer, long-life battery, and temperature sensor encapsulated in a sealed stainless steel housing. Water level and temperature measurements will be accurate to within 0.05 percent and able to withstand from 13 feet to 325 feet of water level fluctuation depending on the model selected. The temperature sensor will be able to withstand temperatures of -10 degrees to 40 degrees Celsius.

Equipment will also be installed for continuously monitoring barometric pressure in the study area. Barometric pressure data will be used to correct water level data for barometric fluctuation, which can be a significant source of error during long-term monitoring projects. The barologger consists of a sensor which records pressure fluctuations in air rather than water. Algorithms are used to correct for discrepancies in the transducer related to moisture buildup or lag in the water level compensation calculations. It is accurate to within 0.003 feet. Barologgers will be installed within 5 miles of each pressure transducer installed for the purpose of monitoring groundwater levels.

Existing Wells

About an additional 10 existing water supply wells will be selected for use in the subsurface exploration program and baseline and long-term groundwater monitoring. Ten wells preliminarily have been recommended for use in this study, the approximate locations of which are shown in Figure 5. Water well reports for these wells are included in Appendix A. Table 9 presents well ownership and location of these existing wells. The following criteria were used to preliminarily select existing wells for sampling, and will be confirmed before use in this study:

- A well log must be available for the well, and include the well owner's name, well location, geologic description, and well construction information.
- The well must be constructed in compliance with Chapter 173-160 of the Washington Administrative Code (WAC), including an adequate surface seal.
- The well must be completed in a paleochannel aquifer, preferably in the upper portion of the aquifer.
- The current well owner must grant access to the well for monitoring and sampling.
- The well should not have a water treatment device or a large storage tank that can not be bypassed during purging and sampling.
- Wells should be distributed to provide representative coverage of each paleochannel aquifer.

Wells will be located in the field using a global positioning system (GPS) locating device. Well owners will be contacted to discuss participation in the study and confirm well suitability. The ground surface elevation of the top of the wells will be surveyed. Locations will be plotted using geographic information system (GIS) software.

Table 9. Recommended Existing Wells

Well Owner	Location of Well[1]	Paleochannel
Darrell Whippell	SE SE S2, T 25N, R 41E	Deep Creek

Well Owner	Location of Well[1]	Paleochannel
George Wilson	SW NE S11, T 25N, R 41E	Deep Creek
W Scott Barratt	SE SE S10, T 25N, R 41E	Deep Creek
Harold Brady	SE NE S6, T 26N, R 41E	Airway Heights
City of Airway Heights	SE SE S26, T 25N, R 41E	Airway Heights
Clarence Moore	SE SE S3, T 24N, R 41E	Airway Heights
Hunt-Mayfield	SW SE S15, T 24N, R 41E	Airway Heights
WSDP Riverside State Park	NW SE S3, T 26N, R 41E	Airport
Keith Worley	NW SE S8, T 25N, R 42E	Airport
ABC Mini Storage	SE SE S20, T 25N, R 42E	Airport

[1]Well location given in quarter section, section (S), township (T), and range (R).

BASELINE GROUNDWATER QUALITY MONITORING

Baseline groundwater quality and water level elevation within selected paleochannel wells will be established over a 1-year monitoring period. Wells will be sampled for nutrients, metals, bacteria, total dissolved solids, total organic carbon, selected anions and cations, petroleum hydrocarbons and water quality parameters such as turbidity, temperature, pH, dissolved oxygen, conductivity, and oxidation reduction potential. Newly installed monitoring wells and existing source water wells selected in the subsurface exploration program will be used for baseline groundwater quality monitoring. Wells were selected based on the following objectives:

- To achieve adequate coverage of the areal extent of the paleochannels. Water quality within the study aquifers likely will vary considerably between paleochannels and within each paleochannel.
- Within and down-gradient of areas characterized by key future land-uses, such as industrial and residential.
- Located down-gradient of specific potential contaminant sources. Contaminant sources could include stormwater and/or reclaimed water disposal facilities that are currently being sited and/or designed by area municipalities.
- Within paleochannel discharge areas. Paleochannel discharge areas generally are located within the north portion of the study area, and are suspected to discharge water either to Deep Creek or the Spokane River.

A total of 20 wells preliminarily have been selected for baseline paleochannel groundwater quality monitoring. About 10 monitoring wells will be constructed within the three known paleochannels, and about 10 additional existing public and private water supply wells will be used for groundwater quality monitoring. The approximate location of each preliminary well is shown in Figure 5.

Wells will be sampled for a period of 1 year. A total of eight sampling events will be conducted throughout the year, two per quarter, from June 2009 to June 2010 or other suitable time period. No two sampling events will be conducted in the same calendar month or separated by more than 60 days. One duplicate sample will be collected per 10 samples taken in the field, for a total of two duplicates. One duplicate will be taken from a monitoring well, and one from an existing source water well. Sample containers will be filled in the following sequence:

1. Unfiltered, unpreserved samples (TDS, coliform bacteria, total petroleum hydrocarbons);
2. Filtered, unpreserved samples (chloride);

3. Filtered, preserved nutrient samples (nitrate, nitrite, TPN);
4. Filtered, preserved inorganic samples (metals).

Each sample will be decanted into sample containers supplied by the laboratory. All groundwater samples collected for chemical analysis will be kept cool during on-site storage and transport to the laboratory. Chain-of-custody procedures will be observed during transport of the groundwater samples.

The accredited laboratory used for this study will maintain an internal quality assurance/quality control program as documented in its laboratory quality assurance manual. The laboratory will use a combination of blanks, surrogate recoveries, duplicates, matrix spike recoveries, matrix spike duplicate recoveries, blank spike recoveries and blank spike duplicate recoveries to evaluate the analytical results. The laboratory also will use data quality goals for individual chemicals or groups of chemicals based on the long-term performance of the test methods. The data quality goals will be included in the laboratory reports. The laboratory will compare each group of samples with the existing data quality goals and note any exceptions in the laboratory reports.

LONG-TERM GROUNDWATER MONITORING

Long-term groundwater elevation and water quality will be established through a monitoring program to evaluate background concentrations and identify future trends. A similar program to baseline groundwater quality monitoring will be used. Wells will be sampled for nutrients, metals, bacteria, total dissolved solids, total organic carbon, selected anions and cations, petroleum hydrocarbons and water quality parameters such as turbidity, temperature, pH, dissolved oxygen, conductivity, and oxidation reduction potential. Newly installed monitoring wells and existing source water wells selected in the subsurface exploration program and used for baseline groundwater monitoring will be used for long-term groundwater monitoring.

The approximately 20 wells preliminarily selected for baseline monitoring will be incorporated into the long-term groundwater monitoring program.

Wells will be sampled for a period of about 10 years following the completion of baseline groundwater monitoring. A total of four sampling events will be conducted each year, one per quarter, from June 2010 to June 2020. One duplicate sample will be collected per ten samples taken in the field, for a total of two duplicates per sampling event. One duplicate will be taken from a monitoring well, and one from an existing source water well. Sample containers will be filled in the following sequence:

1. Unfiltered, unpreserved samples (TDS, coliform bacteria, total petroleum hydrocarbons);
2. Filtered, unpreserved samples (chloride);
3. Filtered, preserved nutrient samples (nitrate, nitrite, TPN);
4. Filtered, preserved inorganic samples (metals).

Each sample will be decanted into sample containers supplied by the laboratory. All groundwater samples collected for chemical analysis will be kept cool during on-site storage and transport to the laboratory. Chain-of-custody procedures will be observed during transport of the groundwater samples.

The accredited laboratory used for this study will maintain an internal quality assurance/quality control program as documented in its laboratory quality assurance manual. The laboratory will use a combination of blanks, surrogate recoveries, duplicates, matrix spike recoveries, matrix spike duplicate recoveries, blank spike recoveries and blank spike duplicate recoveries to evaluate the analytical results. The laboratory also will use data quality goals for individual chemicals or groups of chemicals based on the long-term performance of the test methods. The data quality goals will be included in the laboratory reports. The laboratory will compare each group of samples with the existing data quality goals and note any exceptions in the laboratory reports.

HYDROGEOLOGIC ANALYSES

Hydrogeologic analyses will be conducted using data obtained during subsurface exploration and the baseline groundwater quality monitoring program. The following hydrogeologic analyses will be performed:

- Define approximate boundaries and recharge areas for the paleochannel aquifers, based on interpreted paleochannel aquifer geometry and the regional hydrogeologic conceptual model developed during project execution.
- Evaluate seasonal variability in aquifer hydraulic gradient and groundwater flow direction. Seasonal hydraulic gradient and flow direction in each paleochannel aquifer will be estimated based on collected groundwater level monitoring data.
- Estimate the volume of groundwater (flux) transported by the paleochannel aquifers to down-gradient discharges areas. Flux will be calculated at a minimum of two locations (perpendicular to flow direction) within each paleochannel aquifer. One of the two locations will be the respective paleochannel aquifer outlet. Flux will be calculated using a Darcy's Law-based approach.
- Estimate the quantity of contaminants (loading), such as phosphorus, that are discharged from paleochannel aquifers to down-gradient surface water. Loading will be calculated based on the flux estimates calculated above, groundwater quality data, and baseflow contribution estimates.

GEOPHYSICAL INVESTIGATION

The purpose of the geophysical investigation is to obtain supplemental information about the geometry and extent of the Deep Creek Paleochannel. Seismic refraction surveys will be conducted to estimate the depth to bedrock within the Deep Creek Paleochannel and to potentially define the southern terminus of the Deep Creek Paleochannel.

A seismic refraction survey involves transmitting a physical wave through the subsurface and recording select components of the return signal at highly sensitive electronic receivers (geophones) placed in the ground. Specifically, seismic refraction directly measures travel time between the source and geophone of the first arrival compression waves generated by striking a sledge hammer on a metal plate placed on the ground. The signal travels through subsurface material until a reflective surface is encountered. This reflective surface is created by a change in seismic velocity interpreted to be a change in lithology. The depths and seismic velocities of subsurface units encountered can therefore be interpreted from the recorded travel times. The seismic array for each survey line will consist of multiple geophones, placed in-line at 10-foot to 20-foot intervals.

A total of seven planned seismic refraction lines are presented in Figure 5. Each is situated perpendicular to the long axis of the paleochannel and extends across the full width of the channel. Each seismic refraction line will be located in an open area relatively free of obstructions. Landowner agreement will first be secured before seismic refraction surveys are conducted on private property. Permits will be acquired from area municipalities for investigative work performed on public property.

SOURCE WATER QUALITY MONITORING

A source water quality monitoring program will be employed to evaluate contaminant concentrations in potential stormwater sources. Sampling procedures are based on the EPA NPDES Storm Water Sampling Guidance Document (EPA 1992). The source water quality monitoring study will be conducted concurrent with the long-term groundwater monitoring study for a period of 10 years, from about June 2010 to June 2020. Four sampling events will be conducted each year when stormwater runoff volumes are significant. Existing and future stormwater sources will be identified as more information becomes available.

Source water reconnaissance will be conducted during significant storm events to evaluate the hydraulic flow regime of the drainage way and to delineate areas with significant infiltration capacity. The primary purpose of the proposed chemical analytical data is to assist in the evaluation of the impact that infiltrated stormwater has on water quality in the aquifer beneath the site and down-gradient areas. Drainage way surficial soil type, vegetative coverage and other pertinent features will be noted. A field log will be maintained and photographs collected to document field conditions. Source water hydrologic data will be collected during at least two precipitation events each spring and two events each fall. Each precipitation event will include the following:

- Manually measure the groundwater level in each nearby monitoring well.
- Measure flow near the storm drain outlet that directs stormwater to the paleochannel.
- Collect one sample at the storm drain outlet for water quality and chemical analysis.

Each stormwater sample will be decanted into sample containers supplied by the laboratory. All samples collected for chemical analysis will be kept cool during on-site storage and transport to the laboratory. Chain-of-custody procedures will be observed during transport of the groundwater samples.

The accredited laboratory used for this study will maintain an internal quality assurance/quality control program as documented in its laboratory quality assurance manual. The laboratory will use a combination of blanks, surrogate recoveries, duplicates, matrix spike recoveries, matrix spike duplicate recoveries, blank spike recoveries and blank spike duplicate recoveries to evaluate the analytical results. The laboratory also will use data quality goals for individual chemicals or groups of chemicals based on the long-term performance of the test methods. The data quality goals will be included in the laboratory reports. The laboratory will compare each group of samples with the existing data quality goals and note any exceptions in the laboratory reports.

SAMPLING PROCEDURES

Groundwater and surface water sampling will be conducted for this study. Groundwater well sampling will be applicable for baseline and long-term groundwater monitoring programs, and surface water sampling will be applicable for the source water quality monitoring program. A summary of required containers, sample size, preservation, holding time requirements for each laboratory parameter is listed in Table 10. Note that all parameters will be analyzed for in surface water samples, and all but BOD and COD will be analyzed for in groundwater samples.

Table 10. Sample Containers, Preservation and Holding Times

Parameter[1]	Matrix	Minimum Quantity Required[2]	Container[3]	Preservative[4]	Holding Time
TPN, dissolved	Water	125 mL	125mL HDPE	NA	48 hours

Parameter[1]	Matrix	Minimum Quantity Required[2]	Container[3]	Preservative[4]	Holding Time
Nitrate+Nitrite-N, dissolved	Water	125 mL	125mL HDPE	NA	48 hours
Total Phosphorus	Water	1 L	500 mL HDPE	H_2SO_4 pH<2	7 days
Coliform, total	Water	125 mL	125mL HDPE	Sodium Thiosulfate	30 hours
Coliform, fecal	Water	125 mL	125mL HDPE	Sodium Thiosulfate	30 hours
BOD	Water	500 mL	500 mL HDPE	NA	30 hours
COD	Water	500 mL	500 mL HDPE	H_2SO_4 pH<2	30 hours
TSS	Water	1 L	1 L HDPE	NA	ASAP[5]
TDS	Water	1 L	1 L HDPE	NA	7 days
Chloride, dissolved	Water	125 mL	125mL HDPE	NA	48 hours
TPH	Water	1 L	1 L Amber Glass	NA	7 days
Iron, dissolved	Water	125 mL	125mL HDPE	HNO_3 pH<2	6 months
Manganese, dissolved	Water	125 mL	125mL HDPE	HNO_3 pH<2	6 months
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead, Selenium, Mercury)	Water	500 mL	500mL HDPE	HNO_3 pH<2	6 months

[1]TPN = total persulfate nitrogen; BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids; TDS = total dissolved solids; TPH = total petroleum hydrocarbons.

[2]mL = milliliters; L = liter.

[3]HDPE = high density polyethylene

[4]H_2SO_4 = sulfuric acid; HNO_3 = nitric acid; NA = no preservative required.

[5]ASAP = as soon as possible.

Monitoring wells, groundwater supply wells, and source water will be sampled during portions of this study. Each monitoring well, groundwater supply well, and stormwater source will be sampled separately stored in laboratory-prepared bottles. Each sample bottle will be labeled with the sample name according to the following format:

Monitoring well samples will be named using the following format:

MW-*Well Number-Date(MMDDYY)*

Groundwater supply well samples will be named using the following format:

Well Name-Date(MMDDYY)

Source water samples will be named using the following format:

SW-*Source Number-Date(MMDDYY)*

For example, a sample collected from monitoring well MW-1 on June 1, 2009 would have the following sample name: MW-1-060109. Following the sample name, the time and date of collection, sampler's name, analyte, and preservative will be noted. Sample names, the date and time of collection, and the analyte will be noted on a standard chain of custody form. Samples will be stored in a chilled container and delivered to an accredited laboratory within holding time limits.

Field notes will be prepared for each sampling event. The field representative's name, date, time, weather conditions, field procedures used, and all measurements taken in the field will be noted in each log. Each sample name, date, and sample time will also be recorded along with any field QA/QC procedures employed. Photographs of the site will be taken periodically as appropriate.

GROUNDWATER SAMPLING, MONITORING WELLS

Groundwater samples will be collected from selected monitoring wells for water quality and chemical analysis. Groundwater purging and sampling will be performed consistent with the EPA's low-flow groundwater sampling procedure, as described in EPA (1996) and Puls and Barcelona (1996). During purging activities, water quality parameters, including pH, temperature, conductivity, dissolved oxygen, and turbidity will be measured. The water quality meter used to collect these parameters will be calibrated prior to use following manufacturer procedures. Groundwater samples will be collected after (1) water quality parameters are stabilized or (2) a maximum purge time of one-half hour is achieved. During purging and sampling, drawdown will not exceed 0.3 feet and purge rate will not exceed 400 milliliters per minute. Water quality parameter stabilization criteria include the following:

- Turbidity: ±10 percent for values greater than 5 NTU;
- Conductivity: ±3 percent;
- pH: ±0.1 unit;
- Temperature: ±3 percent; and
- Dissolved oxygen: ± 10 percent.

Duplicate samples will be collected at a frequency of one per 10 primary samples to verify laboratory accuracy.

The samples will be transferred in the field from the sampling device to laboratory-prepared containers for analysis of nutrients, metals, bacteria, total suspended solids, total dissolved solids, total organic carbon, selected anions and cations, and petroleum hydrocarbons. Samples will be placed into a chilled cooler and transported to the analytical laboratory following completion of sampling. Chain-of-custody procedures will be observed and groundwater samples kept cool during transport to the laboratory.

GROUNDWATER SAMPLING, EXISTING GROUNDWATER SUPPLY WELLS

Groundwater samples will be collected from selected existing groundwater supply wells for water quality and chemical analysis. Both public and private wells were selected for this study. Access must be granted by the well owner before sampling can proceed.

Groundwater purging and sampling will be performed consistent with the US Geological Survey (USGS) National Field Manual for the Collection of Water Quality Data (USGS 2006). Because pumps and other equipment are anticipated to be in each water supply well, low-flow sampling procedures are not feasible. Samples will be collected from an existing sampling port or tap. The tap will be turned on and allowed to discharge groundwater for approximately 10 minutes at two gallons per minute or until at least one well volume has been evacuated before sampling. Groundwater will be discharged at least 150 feet from the well.

Water quality parameters including pH, temperature, conductivity, dissolved oxygen, and turbidity will be measured prior to sampling. The water quality meter used to collect these parameters will be calibrated prior to use following manufacturer procedures. Duplicate samples will be collected at a frequency of one per ten primary samples to verify laboratory accuracy.

The samples will be transferred in the field from the sampling device to laboratory-prepared containers for analysis of nutrients, metals, bacteria, total suspended solids, total dissolved solids, total organic carbon, selected anions and cations, and petroleum hydrocarbons. Samples will be placed into a chilled cooler and transported to the analytical laboratory following completion of sampling. Chain-of-custody procedures will be observed and groundwater samples kept cool during transport to the laboratory.

SOURCE WATER SAMPLING

Stormwater samples will be collected from source water locations for water quality and chemical analysis. Sampling techniques will be performed consistent with Ecology's document, "How to do Stormwater Sampling" (Ecology 2002) and the EPA's NPDES Storm Water Sampling Guidance Document (EPA 1992).

Optimally, samples will be collected after four individual storm events each year, two in the spring and two in the fall. A storm event should be preceded by at least 24 hours of zero to trace precipitation and have an intensity of at least 0.1 inches of rainfall in 24 hours. Snowmelt events may also be sampled during winter or spring after at least 24 hours of zero to trace precipitation and a rain or warm weather event on a standing snow pack producing at least 1 inch of water.

Grab samples will be collected at each selected stormwater outlet using laboratory-prepared bottles for analysis of nutrients, metals, bacteria, total suspended solids, total dissolved solids, total organic carbon, selected anions and cations, petroleum hydrocarbons, biochemical oxygen demand and chemical oxygen demand. Samples should be collected near the center of the stormwater flow. Sample containers should be held upstream during sampling, and not allowed to overfill. Water quality parameters such as temperature, pH, turbidity, dissolved oxygen, ORP and conductivity will be measured in the field consistent with groundwater sampling procedures.

MEASUREMENT PROCEDURES

FIELD MEASUREMENTS

Groundwater Elevations

Depth to groundwater will be measured relative to the monitoring well casing rims using an electric water level indicator. The probe of the water level indicator will be decontaminated between wells with a detergent wash, a tap water rinse, and a distilled water rinse. Groundwater table elevations will be calculated by subtracting the depth to the water table from the casing rim elevations.

Groundwater elevation and temperature will be measured continuously in monitoring wells. A pressure transducer and data logger will be installed below the seasonal low groundwater elevation and programmed to record data at a 4-hour interval. Barometric pressure transducers will also be installed in selected monitoring wells to continuously monitor barometric pressure in the study area. Barometric pressure data will be used to correct water level data for barometric fluctuation, which can be a significant source of error during long-term monitoring projects

Hydraulic Conductivity

Slug tests will be employed to provide a point estimate of hydraulic conductivity in the immediate vicinity of the tested well. A slug test is performed by rapidly raising or lowering the water level in a well and measuring the subsequent change in water level as it recovers to a static position. Raising the water level is achieved by quickly lowering a slug (in this case a sealed PVC pipe filled with impermeable material) used to displace water in the well. The subsequent decrease in water level to the static position constitutes a falling-head slug test. Lowering the water level is achieved by quickly removing the slug from the water column. The subsequent increase in water level to the static position constitutes a rising-head slug test.

Water level data will be recorded by a pressure transducer and data logger. After slug testing, the data will be downloaded, reduced, and analyzed for hydraulic conductivity using a solution derived by Bouwer and Rice (1976) and updated by Bouwer (1989).

Groundwater Quality

During purging activities, water quality parameters, including turbidity, conductivity, pH, oxidation-reduction potential (ORP), and temperature will be measured using a Horiba U-22XD-10 multi-parameter meter equipped with a flow-through cell (or equivalent) and recorded. The meter will be calibrated on a daily basis in a manner consistent with manufacturer procedures.

Dedicated well discharge tubing will be connected to the Horiba flow-through cell, allowing groundwater to continuously flow through the cell. Each water quality parameter will be measured simultaneously using a series of sensors. After the completion of water quality measurement, the flow-through cell will be disconnected from the discharge tubing prior to sampling. Table 11 presents the suggested measurement method and expected range of results for each water quality parameter.

Table 11. Measurement Methods (Field)

Parameter	Measurement Method	Expected Range of Results[2]
Turbidity	Horiba U-22XD-10 multi-parameter meter equipped with flow-through cell	0 – 50 NTU
Conductivity		30 –1500 umhos/cm
pH		5.5 – 8.0
ORP[1]		25 – 300
Temperature		8 – 15 °C
Dissolved Oxygen		0.1 – 18

[1]ORP = oxidation reduction potential

[2]NTU = nephelometric turbidity units; umhos/cm = micromhos per centimeter; °C = degrees Celsius.

LABORATORY MEASUREMENTS

Chemical analysis of groundwater and surface water will be performed by an accredited laboratory. Sample containers will be provided by the laboratory, as described in Table 9. After collection in the field, samples will be transferred to laboratory-prepared containers. Samples will be placed into a chilled cooler and transported to the analytical laboratory following completion of sampling. Laboratory measurement methods are detailed in Table 12.

Table 12. Measurement Methods (Laboratory)[1]

Analyte[2]	Method[3]	Reporting Limit	Expected Range of Results
TPN, dissolved	SM 4500N-C	0.05 mg/L	0.05 – 5.0 mg/L
Nitrate-N, dissolved	EPA 300.0	0.5 mg/L	0.5 – 15.0 mg/L
Nitrite-N, dissolved	EPA 300.0	0.5 mg/L	0.5 – 1.0 mg/L
Total phosphorus	SM 4500 PF	0.01 mg/L	0.01- 0.5 mg/L
Coliform, total (MF)	SM 9223B-PA	NA	P – A
Coliform, fecal (MF)	SM 9223B-PA	NA	P – A
BOD	SM 5210B	4.0 mg/L	4 – 25 mg/L
COD	EPA 410.4	5.0 mg/L	5 – 25 mg/L
TSS	EPA 160.2	10 mg/L	
TDS	EPA 160.1	150 mg/L	150 – 350 mg/L
Chloride, dissolved	EPA 300.0	20 mg/L	20 – 25 mg/L
TPH	EPA 8015 MOD	0.250 mg/L	0.250 – 0.50 mg/L
Iron, dissolved	EPA 200.8	0.1 mg/L	0.1 – 1.0 mg/L
Manganese, dissolved	EPA 200.8	0.01 mg/L	0.01 – 0.10 mg/L
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead Selenium, Mercury)	EPA 6020/EPA 7471A	Varies	Varies

[1]Laboratory QA manuals for Anatek Labs in Spokane, Washington were used as an example for standard laboratory procedures, and are available at http://www.anateklabs.com.

[2]TPN = total persulfate nitrogen; N = nitrogen; BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids; TDS = total dissolved solids; TPH = total petroleum hydrocarbons; RCRA = Resource and Recovery Act.

[3]SM = Standard Method; EPA = Environmental Protection Agency Method

QUALITY CONTROL

FIELD

Laboratory-blind duplicate samples for each parameter will be collected in the field to check for overall precision. One duplicate will be collected from one monitoring well and one existing groundwater supply well for each sampling event. One field blank will also be collected per sampling event to check for contamination from ambient sources. Temperature blanks will be collected in the field and added to each cooler transported to the laboratory.

Industry standard methods for groundwater level measurements will be followed throughout this study. Water level meters will be decontaminated between each well, and inspected to verify they are working properly. Water level measurements will be recorded to the nearest 0.01 feet and checked twice to ensure accuracy.

Sample collection will be conducted using standard methods to prevent sample contamination. The following procedures will be followed for each site to promote quality control during field activities:

- Clean sampling gloves will be worn by field personnel and changed regularly. New gloves will be worn prior to handle any equipment or bottles that could potentially come into contact with sample groundwater.
- Sampling equipment and non-dedicated fittings and tubing will be decontaminated between each site, thoroughly cleaned before use, and prevented from coming in contact with sample bottles.
- Each meter will be calibrated prior to use at the beginning of each sampling day and at midday.
- Samples will be kept cool during field activities and transported to the laboratory at the conclusion of each day.
- Standard chain-of-custody procedures will be followed for all samples.

Accurate field records will be collected for each field activity. Well sampling records will include the well owner information, location, water level measurement, date and time of sampling, samples taken in the field, sampling staff, and other observations pertinent to the field activity. Source water sampling field logs will include the source name, location, date and time of sampling, weather and precipitation information, nearby water level measurements taken, sampling staff, and other pertinent observations. Well drilling and construction logs and seismic refraction survey logs will be recorded as necessary. Standard forms for field records will be prepared before each activity, and reviewed by the project manager.

Field Quality Control Evaluation

A field quality control evaluation will be conducted by reviewing field log books and daily reports, discussing field activities with staff, and reviewing field quality control (QC) samples (trip blanks, equipment rinsates, and field duplicates). Field blanks will be evaluated using the same criteria as method blanks.

LABORATORY

The accredited laboratory used for this study maintains an internal quality assurance/quality control program as documented in its laboratory quality assurance manual. The laboratory uses a combination of blanks, surrogate recoveries, duplicates, matrix spike recoveries, matrix spike duplicate recoveries, blank spike recoveries and blank spike duplicate recoveries to evaluate the analytical results. The laboratory also uses data quality goals for individual chemicals or groups of chemicals based on the long-term performance of the test methods. The data quality goals will be included in the laboratory reports. The laboratory will compare each group of samples with the existing data quality goals and note any exceptions in the laboratory reports. Table 13 presents the type and frequency of each QC sample as determined by standard operating procedures and environmental methods (NEMI 2008).

Laboratory Data Quality Control Evaluation

The laboratory data assessment will consist of a formal review of the following quality control parameters:

- Holding times
- Method blanks
- Matrix spike/spike duplicates
- Laboratory control spikes/spike duplicates
- Surrogate spikes
- Replicates

In addition to these quality control mechanisms, other documentation such as cooler receipt forms and case narratives will be reviewed.

Table 13. QC Samples, Types and Frequency

Parameter[1]	Laboratory[2]			
	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
TPN, dissolved	1/batch	1/batch	1/batch	10% of samples
Nitrate-N, dissolved	1/batch	1/batch	1/batch	10% of samples
Nitrite-N, dissolved	1/batch	1/batch	1/batch	10% of samples
Total Phosphorus	1/batch	1/batch	1/batch	10% of samples
Coliform, total (MF)	NA	2/batch	NA	NA
Coliform, fecal (MF)	NA	2/batch	NA	NA
BOD	1/batch	NA	1/batch	NA
COD	NA	1/batch	1/batch	1/batch
TSS	NA	1/batch	1/batch	NA
TDS	NA	1/batch	1/batch	NA
Chloride, dissolved	1/batch	1/batch	1/batch	10% of samples
Total petroleum hydrocarbons, gasoline	1/12 hours	1/12 hours	1/batch	1/batch
Total petroleum hydrocarbons, diesel	1/batch	1/batch	1/batch	1/batch
Iron, dissolved	1/batch	1/batch	1/batch	10% of samples
Manganese, dissolved	1/batch	1/batch	1/batch	10% of samples
RCRA 8 Metals (Silver, Arsenic, Barium, Cadmium, Chromium, Lead Selenium, Mercury)	1/batch	1/10 samples	1/20 samples	1/12 hours or each analytical run

[1]TPN = total persulfate nitrogen; N = nitrogen; BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids; TDS = total dissolved solids; RCRA = Resource and Recovery Act.

[2]One batch may not exceed 20 samples.

DATA MANAGEMENT PROCEDURES

FIELD DATA

Field data will be recorded by field personnel during field activities and reviewed at the end of each day for accuracy and completeness. Data and field information will be checked by the project manager. Forms will be prepared prior to field activities and follow a standard format throughout the study. Field data documentation includes the following criteria as applicable:

- Well or land ownership.
- Sample collection information.
- Field instrumentation and calibration.
- Climate and precipitation information.
- Sample collection protocol.
- Sample containers, preservation and volume.
- Field QC samples collected at the frequency specified.
- Sample documentation and chain of custody (COC) protocols.
- Sample shipment.

LABORATORY DATA

Data obtained by the laboratory will be recorded and reported to the project manager. An Excel spreadsheet will be created in preparation for reporting and submittal to Ecology. The laboratory data will include measurements of each parameter as well as the following quality control parameters:

- Holding times
- Method blanks
- Matrix spike/spike duplicates
- Laboratory control spikes/spike duplicates
- Surrogate spikes
- Replicates

In addition to these quality control mechanisms, other documentation such as cooler receipt forms and case narratives will be reviewed to evaluate laboratory QA/QC.

DATA STORAGE

Laboratory data and data collected during field activities will be entered into Microsoft Excel spreadsheets (or equivalent) and stored in a project database. Hard copies of each Excel spreadsheet will be kept on file in a project folder.

OBTAINING EXISTING DATA

Readily obtainable existing water quality and paleochannel geometry information has been collected by GeoEngineers and included in the report, "Background Data Compilation and Data Gap Evaluation, Paleochannel Aquifers," (GeoEngineers 2008).

AUDITS AND REPORTS

The WRIA 54 Planning Unit is responsible for assigning the preparation and peer review of reports. Consultants are yet to be selected to complete these tasks for each portion of this study. One report will be written after each of the main field events, including the subsurface exploration program, baseline water quality monitoring program, geophysical investigation, and after each year of the long-term groundwater quality monitoring program and source water monitoring program.

Each report will follow a standardized format and include the following elements:

- Executive Summary
- Table of Contents
- Introduction
- Site Background
- Scope of Services
- Field Activities
- Results and/or Analysis
- Summary and Conclusions
- Appendices
    - Field Methods
    - Field Data
    - Laboratory Analytical Data
    - Field and Laboratory QA/QC Review
    - Significant QA/QC Problems and Suggested Solutions

Finalized results for each report will be prepared and imported to the Environmental Information Management System (EIM) upon completion of the report.

DATA VERIFICATION AND VALIDATION

FIELD MEASUREMENT EVALUATION

Field data will be reviewed at the end of each day by following the quality control checks outlined below and procedures in the QAPP. Field data documentation will be checked against the applicable criteria as follows:

- Well or land ownership.
- Sample collection information.
- Field instrumentation and calibration.
- Climate and precipitation information.
- Sample collection protocol.
- Sample containers, preservation and volume.
- Field QC samples collected at the frequency specified.
- Sample documentation and chain of custody (COC) protocols.
- Sample shipment.

Cooler receipt forms and sample condition forms provided by the laboratory will be reviewed for out-of-control incidents. The final report will contain what effects, if any, an incident has on data quality. Sample collection information will be reviewed for correctness before inclusion in a final report.

FIELD QUALITY CONTROL EVALUATION

A field quality control evaluation will be conducted by reviewing field log books and daily reports, discussing field activities with staff, and reviewing field QC samples (trip blanks, equipment rinsates, and field duplicates). Trip blanks and equipment rinsates will be evaluated using the same criteria as method blanks.

LABORATORY DATA VALIDATION

The data validation will be performed by the Quality Assurance Leader to determine if the MQOs have been met. Data validation will include reviewing laboratory reports for data quality exemptions and review of surrogates, matrix spike/matrix spike duplicates, duplicates, and blank data. Data validation will also include reviewing field reports for procedures that might affect laboratory results, reviewing hold times relative to extraction and analysis times, and estimating data quality relative to data quality objectives.

DATA QUALITY (USABILITY) ASSESSMENT

The data collected during this study will be used to assess water quality in the Deep Creek, Airway Heights, and Airport paleochannels. A data quality assessment will be performed to evaluate if the field and laboratory data collected in each portion of this study has met the goals and objectives in this QAPP. Data will be assessed to assess if (a) sufficient data were collected and if (b) these data can be relied on to estimate paleochannel aquifer water quality. Ecology's Credible Data Policy will be followed to ensure data is sufficient to meet goals and objectives for each portion of the study (Ecology 2006).

Data will be evaluated for compliance with Ecology's Credible Data Policy. Four main objectives are used to determine if data is acceptable for use in this study. Data are considered credible if:

1. QA/QC procedures were documented and followed for each field activity;
2. The samples and measurements collected were representative of current paleochannel aquifer conditions;
3. An adequate number of samples were collected; and
4. Acceptable industry standard field and laboratory procedures were followed.

Draft data reports will be checked for data usability, reviewed by the WRIA 54 Planning Unit, and finalized within six months of the conclusion of field activities.

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ACRONYMS

BOD = Biochemical Oxygen Demand
CEC = Cation Exchange Capacity
CFU = Colony-Forming Unit
COC = Chain of Custody
COD = Chemical Oxygen Demand
CRBG = Columbia River Basalt Group
DO = Dissolved Oxygen
DOH = Washington State Department of Health
EIM = Environmental Information Management System
EPA = Environmental Protection Agency
GIS = Geographic Information System
GPS = Global Positioning System
MQO = Measurement Quality Objective
MW = Monitoring Well
NA = Not Applicable
NEMI = National Environmental Methods Index
NPDES = National Pollutant Discharge Elimination System
ORP = Oxidation-Reduction Potential
PVC = Polyvinyl Chloride
QA = Quality Assurance
QAPP = Quality Assurance Project Plan
QC = Quality Control
RCRA = Resource Conservation and Recovery Act
RPD = Relative Percent Difference
SAIC = Science Applications International Corporation
SIA = Spokane International Airport
TDS = Total Dissolved Solids
TPH = Total Petroleum Hydrocarbons
TPN = Total Persulfate Nitrogen
TSS = Total Suspended Solids
USGS = United States Geological Survey
WRIA = Water Resource Inventory Area

Table 1A
Group A and B Paleochannel Wells[1]
WRIA 54
Lower Spokane River Watershed

PWSID[2]	System Name	Well Group	Owner Type	Source Name	Source Number	Well Depth (feet)	Qtr Qtr Section	Section	Township	Range	Paleochannel Well[3]	Well Log Available
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	InAct 02/04/2008 Well #2 - AGG476	02	170	SW NW	25	25N	41E	Likely Airway Heights	No
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	Park West Well - AGG475	09	152	NE SW	2	24N	41E	Likely Airway Heights	No
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	Well #1 - AGG477	01	175	SE SE	26	25N	41E	Likely Airway Heights	No
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	Well #3	03	80	SE NE	26	25N	41E	Likely Airway Heights	No
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	Well #4 - AGG479	04	180	SE SE	26	25N	41E	Confirmed Airway Heights	Yes
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	Well #5	05	200	SE SW	25	25N	41E	Likely Airway Heights	No
650	AIRWAY HEIGHTS, CITY OF	A	City/Town	WF/S01,S04	08	175	SE SE	26	25N	41E	Likely Airway Heights	No
51061	COLES WATER SYSTEM	B	Private	WELL 1	01	202	SW NE	10	24N	41E	Likely Airway Heights	No
24595	FAIRVIEW HEIGHTS TRAILER COURT	B	Investor	Well #1 - AHC192	01	100	NE NW	27	25N	41E	Likely Airway Heights	No
545	FOUR LAKES ANG WATER SYSTEM	B	State	WELL 1	01	270	SW SW	11	24N	41E	Likely Airway Heights	No
56251	GARY S WELL WATER SYSTEM	B	Investor	WELL #1	01	55	SW SW	14	25N	41E	Likely Airway Heights	No
29335	GREAT NORTHERN SCHOOL DIST #312	A	Special District	Well #1 - ABR581	01	180	NE NE	8	25N	42E	Likely Airport	No
56514	GRUBER WATER SYSTEM	B	Investor	WELL #1	01	1	NE NE	31	26N	42E	Likely Airway Heights	No
51144	HUNT-MAYFIELD	B	Private	WELL 1	01	160	SE SW	15	24N	41E	Confirmed Airway Heights	Yes
12070	MOSS WATER SYSTEM	B	Investor	WELL 1	01	144	--	15	24N	41E	Likely Airway Heights	No
51896	OLD TRAILS COUNTRY ESTATES	B	Association	Well A	01	723	NW SW	5	25N	42E	Likely Airway Heights	No
51226	PATCHEN WATER WORKS	B	Investor	PATCHEN WELL	01	135	SW NW	25	25N	41E	Likely Airway Heights	No
67394	PINE GROVE APARTMENTS	B	Investor	Well 01	01	128	NW NE	5	25N	42E	Likely Airway Heights	No
30852	ROBBINS, JON	B	Investor	WELL #1	01	--	--	6	25N	42E	Likely Airway Heights	No
62239	SPOKANE CO FIRE DIST 10 STA 5	B	Special District	WELL 1	01	160	NW NE	18	25N	42E	Likely Airway Heights	No
7605	SPOKANE ROCK PRODUCTS	B	Investor	WELL 1	01	--	--	14	24N	41E	Likely Airway Heights	No
83100	SPOKANE, CITY OF	A	City/Town	InAct 08/23/1995 SIA 1(abandoned)	10	367	SE SE	29	25N	42E	Likely Airport	No
83100	SPOKANE, CITY OF	A	City/Town	InAct 11/15/2001 Baxter - AHC726	07	126	SE NE	29	25N	42E	Confirmed Airport	Yes
SP727	WSDP RIVERSIDE SP EQUESTRIAN	A	State	Well #1 - DOE ABR 835	01	217	NW SE	3	25N	42E	Confirmed Airport	Yes

Notes:

[1]Group A and B system data obtained from the Washington State Department of Health

[2]Department of Health Public Water System ID Number

[3]Paleochannel wells verified from well logs. Wells with "likely" designation are likely located in the paleochannel, but could not be confirmed because well logs were unavailable or provided insufficient information.

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Table 1B
Private Paleochannel Wells[1]
WRIA 54
Lower Spokane River Watershed

Ecology Well ID	Total Depth (feet)	Owner Name	Well Depth (feet)	Qtr Qtr Section	Section	Township	Range	Paleochannel Well[2]	Well Log Available
173888	475	Vietzke Excavating Company	475	N 1/2	26	25N	41E	None	Yes
164297	400	Charles Danner	400	NW SE	8	25N	42E	Confirmed Airport	Yes
163293	370	Arthur Tyrrell	370	SW SE	8	25N	42E	Confirmed Airport	Yes
168687	490	Jim Etter/ Etter Ranch	490	NE	7	25N	42E	None	Yes
363714	811	John McKervey	811	SE SW	1	25N	41E	Confirmed Deep Creek	Yes
165156	123	Darrell Whippell	120	SE SE	2	25N	41E	Confirmed Deep Creek	Yes
413189	160	Minnie Mollet	160	SE NE	10	24N	41E	Confirmed Airway Heights	Yes
170569	120	May Harma	120	NE SE	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
169112	120	John Lund	120	NE SE	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
171426	160	Paul Cunha	160	SE SE	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
418381	260	Dee Konen	260	NE NE	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
417169	200	Dave Tareski	200	SE	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
455610	260	Douglas Dibiasi	260	NE SW	15	24N	41E	Confirmed Airway Heights (shallow)	Yes
170534	62	Mary Wilson	62	SW NE	15	24N	41E	Confirmed Airway Heights (shallow)	Yes
253282	120	Karen Nelson	120	SW SE	15	24N	41E	Confirmed Airway Heights (shallow)	Yes
439849	220	Robert Prenguber	220	SE	15	24N	41E	Confirmed Airway Heights	Yes
169218	596	John Szabo	596	SE SW	15	24N	41E	Confirmed Airway Heights (shallow)	Yes
176823	580	Max Jermain	172	SW	15	24N	41E	Confirmed Airway Heights (shallow)	Yes
170714	172	Michael Murphy	240	SW	15	24N	41E	None	Yes
171808	48	Ramona L. DiBiasi-Yates	48	NE SW	15	24N	41E	Confirmed Airway Heights	Yes
171448	130	Paul Kopplin	130	SW NW	11	24N	41E	Confirmed Airway Heights	Yes
417168	180	Terry Nabokowski	180	SE SE	9	24N	41E	Confirmed Airway Heights	Yes
455974	240	Jud Foutz	240	NW NE	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
293816	115	Irene Griffin	115	NE NW	10	24N	41E	Confirmed Airway Heights (shallow)	Yes
256947	220	Steve Stimson	144	S 1/2 SE	3	24N	41E	Confirmed Airway Heights	Yes
164652	140	Clarence Moore	140	SE SE	3	24N	41E	Confirmed Airway Heights	Yes
164651	239	Clarence Moore	239	E 1/2 SE	3	24N	41E	Confirmed Airway Heights	Yes
170959	225	Jack Woods	225	SW SE	3	24N	41E	Confirmed Airway Heights (shallow)	Yes
416216	260	Harry Wilson	260	SE SE	3	24N	41E	Confirmed Airway Heights	Yes
408360	180	Dick Johnson	180	SE	3	24N	41E	Confirmed Airway Heights	Yes
169075	250	John Jarvis	250	--	3	24N	41E	Confirmed Airway Heights (shallow)	Yes
363971	320	Gary Erickson	320	SE NE	3	24N	41E	Confirmed Airway Heights (shallow)	Yes
166683	175	Frank Holler	175	NE NW	3	24N	41E	Confirmed Airway Heights (shallow)	Yes
254314	100	Ron Cooper	100	NE NE	3	24N	41E	Confirmed Airway Heights (shallow)	Yes
174418	120	William Lash	120	S 1/2 NW	2	24N	41E	Confirmed Airway Heights (shallow)	Yes
172667	85	Ross Jenson	85	NW NE	35	25N	41E	Confirmed Airway Heights	Yes
174265	223	Welk Bros. Metal	223	SE SE	25	25N	41E	Confirmed Airway Heights (shallow)	Yes
165632	204	Dix Corporation	264	SW SW	25	25N	41E	Confirmed Airway Heights (shallow)	Yes

Notes:

[1]Private well data obtained from the Washington State Department of Ecology

[2]Paleochannel wells verified from well logs. Wells with "shallow" designation intersect less than 25 feet of surficial sand and gravel.

P:\0\0188120\02\Finals\[018812002Table1B.xls]Table

Table 2
Paleochannel Aquifer Hydraulic Properties
WRIA 54
Lower Spokane River Watershed

Project Location	Project Name	Source	Type of Test	Transmissivity (square feet/day)	Hydraulic Conductivity (feet/day)	Storativity	Groundwater Velocity (feet/day)
Northwest Technology Park and Spokane Internation Airport	Hydrogeologic Study, Technology Park Stormwater Disposal	GeoEngineers, 2002	Drywell Infiltration Test	NA	900	NA	26
			Grain-Size Distribution	NA	60 (Unsaturated Zone)	NA	
			Grain-Size Distribution[1]	NA	560 (Saturated Zone)	NA	
Airway Heights	Hydrogeologic Evaluation, Proposed Water Reclamation Plant, City of Airway Heights (Revision 2 Report)	GeoEngineers, 2007	Grain-Size Distribution[2]	NA	590 (Unsaturated Zone)	NA	NA
			Grain-Size Distribution[2]	NA	770 (Saturated Zone)	NA	
			Pumping Test	34,000	570	0.0021	

Notes:

[1]Average of two grain-size distribution-based hydraulic conductivity calculations.

[2]Geometric mean of several grain-size distribution-based hydraulic conductivity calculations.

NA = Not Applicable

P:\0\0188120\02\Finals\[018812002Table2_3.xls]T, K, S

Table 3
Paleochannel Aquifer Water Balances
WRIA 54
Lower Spokane River Watershed

Project Location	Project Name	Source	Type of Analysis	Effective Porosity	Hydraulic Conductivity (feet/day)	Hydraulic Gradient	Specific Yield	Velocity (feet/day)
Airway Heights	Hydrogeologic Evaluation, City of Airway Heights	GeoEngineers, 2003	Nitrate Mass Balance	0.30 [1]	570 [2]	0.004 [3]	NA	NA
NW Technology Park	Hydrogeologic Study, Technology Park StormwaterDisposal	GeoEngineers, 2002	Groundwater Mounding	NA	NA	NA	0.25 [1]	NA
			Breyer Analysis	NA	0.2	NA	NA	NA
			Darcy Groundwater Velocity	NA	NA	NA	NA	26

Notes

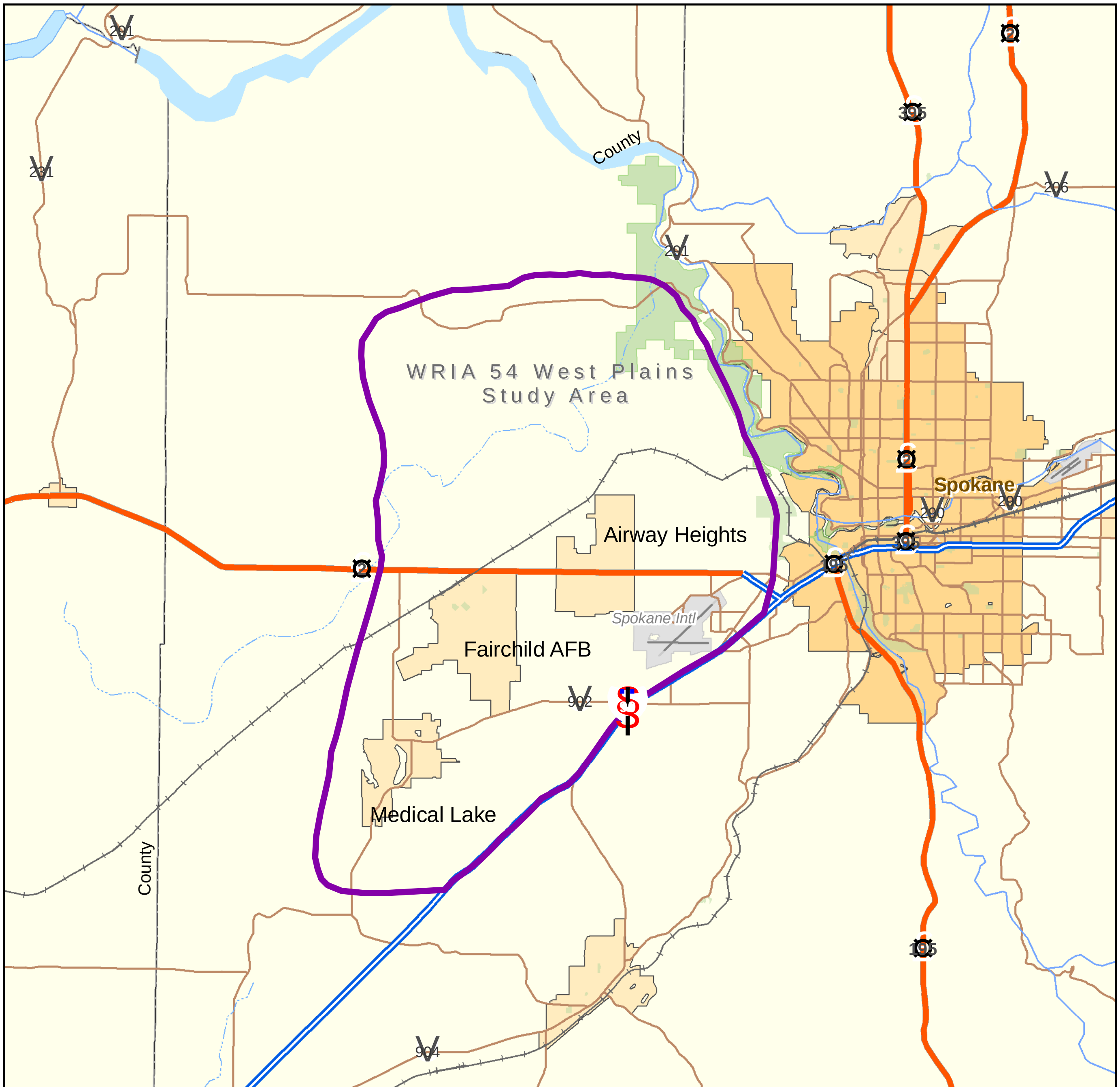
[1]Referenced from Domenico, P.A., and F.W. Schwartz, 1990, Physical and Chemical Hydrogeology: New York, John Wiley and Sons, 824 p.

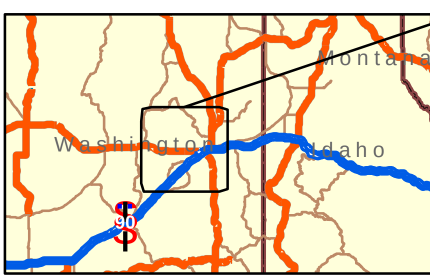
[2]Referenced from GeoEngineers, Inc., 2002, Report, Hydrogeologic Study, Pacific Northwest Technology Park, Spokane, Washington.

[3]Referenced from Science Applications International Corporation (SAIC), 1992, Installation Restoration Program (IRP), Remedial Investigation Report, Craig Road Landfill, Fairchild AFB, Washington.

NA = Not Applicable

P:\0\0188120\02\Finals\[018812002Table2_3.xls]Balances





4 2 0 4 Miles

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.

Data Sources: ESRI Data & Maps, Street Maps 2005

Transverse Mercator, Zone 11 N North, North American Datum 1983
North arrow oriented to grid north

West Plains Vicinity Map

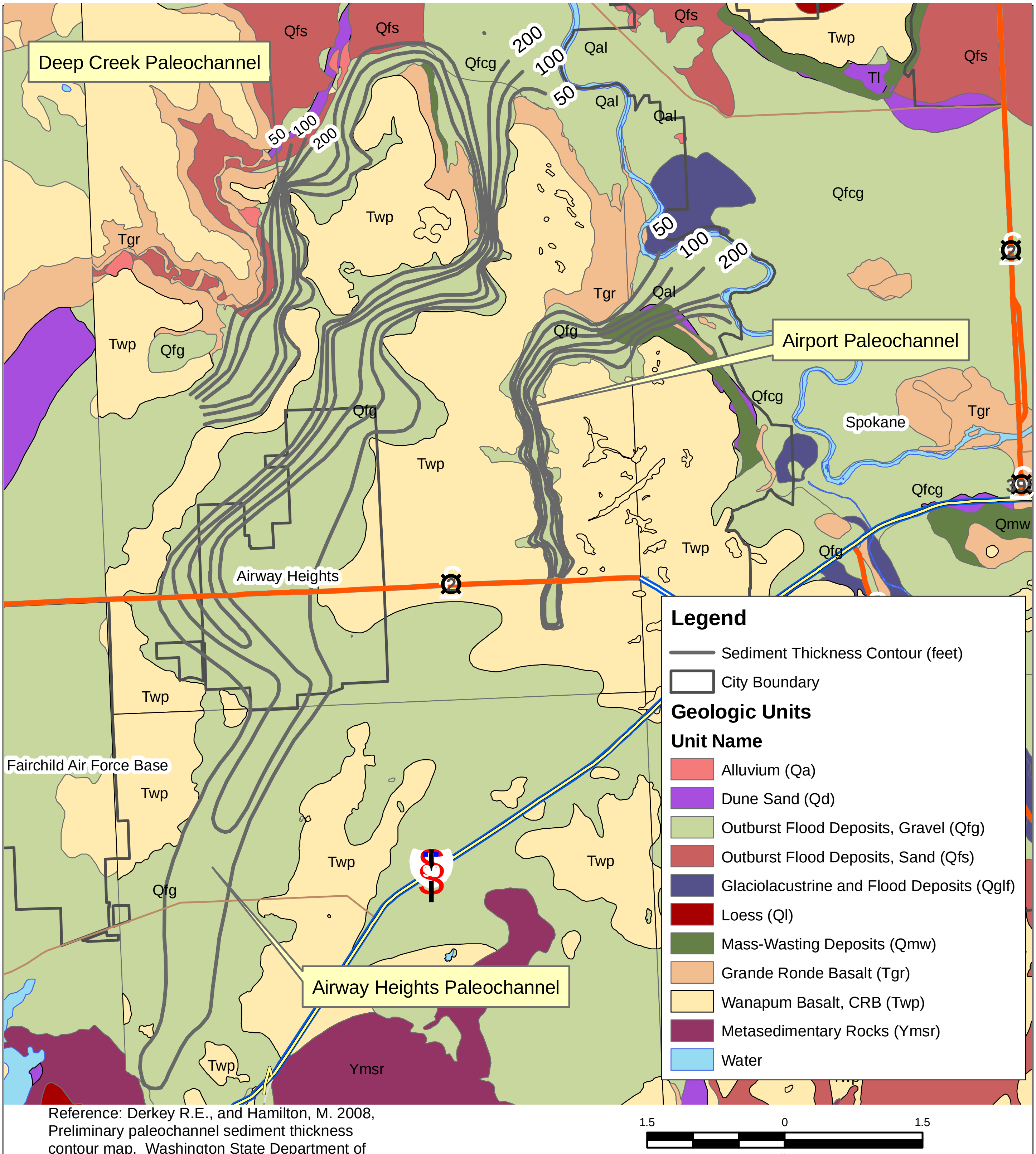
WRIA 54
Lower Spokane River Watershed

GEOENGINEERS

Figure 1

Office: SPOK Path: P:\00\0188120\02\GIS\MXDs\WestPlainsVM.mxd

Map Revised: March 25, 2008



Reference: Derkey R.E., and Hamilton, M. 2008, Preliminary paleochannel sediment thickness contour map. Washington State Department of Natural Resources Geologic Mapping.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Paleochannel Boundaries and Surficial Geology

WRIA 54
Lower Spokane River Watershed

GEOENGINEERS

Figure 2

Map Revised: March 25, 2008

Path: P:\01\0188120\02\GIS\MXDs\018812002Figure2.mxc

Spokane

Reference: Derkey R.E., and Hamilton, M. 2008, Preliminary paleochannel sediment thickness contour map. Washington State Department of Natural Resources Geologic Mapping.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Paleochannel Boundaries and Well Locations

WRIA 54
Lower Spokane River Watershed

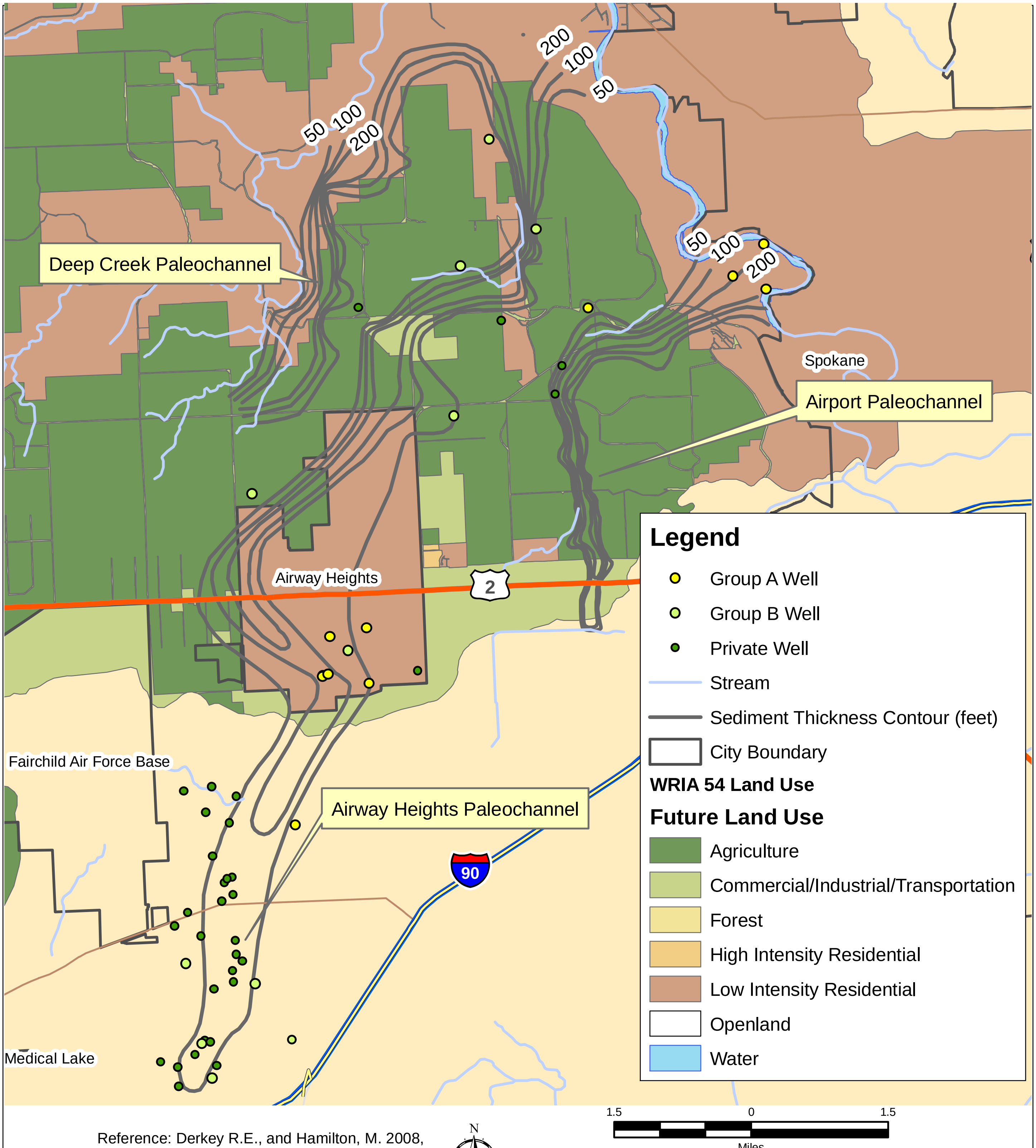
GEOENGINEERS

Figure 3

Map Revised: January 15, 2008

Path: P:\01\0188120\02\GIS\MXDs\018812002Figure3.mxc

Spokane



Reference: Derkey R.E., and Hamilton, M. 2008, Preliminary paleochannel sediment thickness contour map. Washington State Department of Natural Resources Geologic Mapping.
Future land use data provided by Spokane County.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

WRIA 54 Future Land Use

WRIA 54
Lower Spokane River Watershed

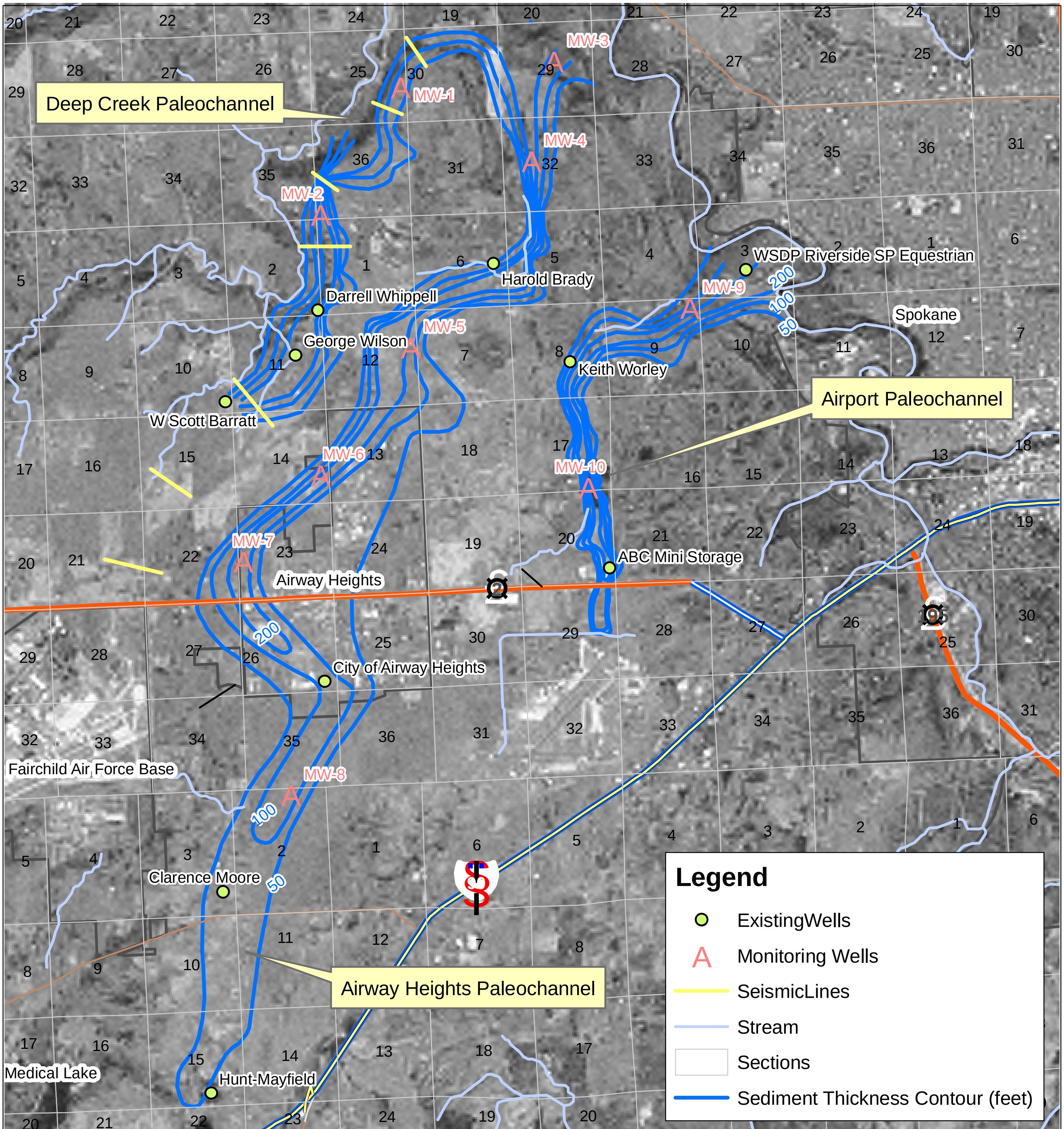
GEOENGINEERS

Figure 4

Map Revised: March 25, 2008

Path: P:\01\0188120\02\GIS\MXDs\018812002Figure4.mxd

Spokane



1.5 0 1.5
Miles

Reference: Derkey R.E., and Hamilton, M. 2008, Preliminary paleochannel sediment thickness contour map. Washington State Department of Natural Resources Geologic Mapping.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Experimental Design

WRIA54
Lower Spokane River Watershed

GEOENGINEERS

Figure 5

Map Revised: May 20, 2008

Path: P:\01\0188120\02\GIS\MXDs\0188120020QAPPExperimentalDesign.mxd

Spokane

GeoEngineers

Appendix A
Recommended Existing Groundwater Supply Well Logs

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. ~~[illegible]~~ W 26774

Water Right Permit No. ______

(1) OWNER: Name Darrell Whipple Address 4910 N. Garfield

LOCATION OF WELL: County Spokane SE ¼ SE ¼ Sec. 02 T. 25 N., R. 41 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) 4910 N - Garfield Rd

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) 1
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 123 feet. Depth of completed well 120' ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" " Diam. from +2 ft. to 118 ft.
Welded [X] ______ " Diam. from ______ ft. to ______ ft.
Liner installed [ ]
Threaded [ ] ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 20' ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 90 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 25 gal./min. with stem set at 118 ft. for 1 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
top soil	0	1
fine sand	1	15
sand & gravel	15	35
gravel & sand	35	65
clay & sand & gravel	65	105
gravel & sand	105	123

DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work started 7/20, 19__ Completed 7/21, 1992

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME TIP TOP WATER WELL Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 13511 Blanchard Rd ELK, 99009
(Signed) [signature] (WELL DRILLER) License No. 1352
Contractor's Registration No. TIPTOWW101JB Date 7/21, 1992

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

ECY 050-1-20 (10/87) -1329-

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W081566
Unique Well I.D. # ACR481
Water Right Permit No.

(1) OWNER: Name **WILSON, GEORGE** Address **W. 1403 - 3RD AVE. SPOKANE, WA 99204-**

(2) LOCATION OF WELL: County **SPOKANE** - **SW** 1/4 **NE** 1/4 Sec **11** T **25** N., R **41E** WM

(2a) STREET ADDRESS OF WELL (or nearest address) ,

(3) PROPOSED USE: **DOMESTIC**

(4) TYPE OF WORK: Owner's Number of well (If more than one) **1**
NEW WELL Method: **ROTARY**

(5) DIMENSIONS: Diameter of well **6** inches
Drilled **360** ft. Depth of completed well **360** ft.

(6) CONSTRUCTION DETAILS:
Casing installed: **6** " Dia. from **+1** ft. to **310** ft.
WELDED **4** " Dia. from **-20** ft. to **360** ft.
" Dia. from ft. to ft.

Perforations: **NO**
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: **YES**
Manufacturer's Name **PVC**
Type **PVC** Model No.
Diam. **4** slot size **.20** from **340** ft. to **360** ft.
Diam. slot size from ft. to ft.

Gravel packed: **NO** Size of gravel
Gravel placed from ft. to ft.

Surface seal: **YES** To what depth? **20** ft.
Material used in seal **BENTONITE**
Did any strata contain unusable water? **NO**
Type of water? Depth of strata ft.
Method of sealing strata off **CASING**

(7) PUMP: Manufacturer's Name
Type **NONE** H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level ft. below top of well Date **07/17/97**
Artesian Pressure lbs. per square inch Date
Artesian water controlled by **CAP**

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? **NO** If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test **25** gal/min. w/ stem set at **360** ft. for **3** hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? **NO**

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
SAND GRAVEL	0	25
BASALT BOULDERS COBBLES	25	47
SAND GRAVEL	47	157
BROKEN BASALT	157	170
SAND GRAVEL	170	183
BROKEN BASALT	183	197
SAND GRAVEL COBBLES	197	320
BASALT BOULDERS SAND	320	360
	360	

Work started 07/14/97 Completed 07/17/97

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME **FOGLE PUMP & SUPPLY, INC.**
(Person, firm, or corporation) (Type or print)

ADDRESS **316 W 5TH**

(SIGNED) [signature] License No. 2109

Contractor's Registration No. **FOGLEPS095L4** Date 08/21/97

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No.
Permit No.

(1) OWNER: Name W. Scott Barratt Address Route 3, Box 701, Spokane, WA 99203

(2) LOCATION OF WELL: County SPOKANE — SE ¼ SE ¼ Sec 10 T 25 N., R 41E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic XX Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 360 ft. Depth of completed well 360 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from +1 ft. to 350 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No XX
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type stainless steel Model No.
Diam. 6" Slot size 12 from 350 ft. to 355 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 2370 ft.
Static level 295 ft. below top of well Date 2/09/84
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: 30+ gal./min. with ft. drawdown after hrs.
ESTIMATED AIRLIFT

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

3/6/84 [initials]

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	2
Sand, course, black	2	150
Sand & gravel, medium	150	200
Sand, course	200	320
Basalt, extremely fractured with sand	320	355
Sand, course with water	355	360
NO PVC Liner Installed		
8" Drive Shoe Installed		

RECEIVED
MAR 6 1984
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/01/ 19 84 Completed 2/09/ 19 84

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME PONDEROSA DRILLING & DEVELOPMENT INC. (Person, firm, or corporation) (Type or print)

Address E. 6010 Broadway, Spokane, WA 99212

[Signed] Keith Vermillion (Well Driller)
Keith Vermillion

License No. 1079 Date 2/09/ 19 84

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

154971

State of Washington — **Water Well Report**

Washington Water Right Permit No:

Unique Well ID: AGC-364
Notice of Intent: WE02692

(1) Owner: Brady, Harold J — **Address:** 9710 W. Glass Lane, Spokane, WA 99224

(2) Location of Well: County SPOKANE — NE 1/4: SE 1/4 SEC: 06 T 25 NR 42 W

(2a) Street Address of Well: 9710 W. Glass Lane

(3) Proposed Use: DOMESTIC

(4) Type of Work: NEW WELL — Owner's number of well (if more than one):
Drilling Method: ROTARY

(5) Dimensions Diameter of well: 6 inches
Drilled: 290 feet — Depth of completed well: 290

(6) Construction Details

Casing Installed	Diameter	From	To
STEEL	5	-277	290
STEEL	6	+2	280

Perforations ☐ Screens ☑
Type of Perforator Used:
Screen Type: Stainless Steel
K-Pac Location:

Diam: 5 *Slot* 20 *From* 283 *To* 288

Gravel/Filter packed ☐ Size of gravel/sand:
Material placed from: ft. to

Surface seal used ☑ To what depth: 18 ft.
Did any strata contain unusable water? ☐
Type of water: Depth of strata:
Method of sealing strata off:

(7) Pump Pump Manufacturer:
Pump Type: H.P.

(8) Water Levels
Land-surface elevation above mean sea level: ft.
Static level: 180 Date: 9/10/2004
Artesian Pressure: Date:
Artesian water is controlled by:

(9) Well Tests Drawdown is amount water level is lowered below static
Was a pump Test performed? ☐

Yield	Drawdown	Pumping Level	Hours

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Level	Time	Level	Time	Level

Bailer Test: gal per min drawdown: after
Airtest gal/min: 6 gal per min
Artesian flow gpm: ☐ Chemical test

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of informaiton. Indicate all water encountered.

☑ Construction
☐ Decommission

From	To	Remarks: Lithology, Water Quality, Temperature
0	3	Top Soil
3	35	Gravels clay sand
35	65	Basalt w/broken layers
65	130	Basalt w/gravels & sand
130	225	Gravels-small w/sand
225	250	Gravels 3/4multicolor w/sand w/h2o
250	285	Sand, Small gravel, some tan clay
285	288	Basalt broken
288	290	Basalt Black Med
0	0	H2O starts @ 250'

RECEIVED SEP 22 2004 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date: 9/8/2004 Completed 9/10/2004

Well Construction Certification
I constructed and/or accept responsiblity for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Type or Print Name: McLeslie, Jim License No: 2257
Trainee Name: License No:
Drilling Company: **H20 Well Service, Inc.**
(signed) [signature] License No: 2257
(Licensed Driller/Engineer)
Address: 582 W. Hayden Ave, Hayden Lake, ID 83835
Contractor's Registration No: H20WESI101DW Date: 09/13/04

Well #4

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

Appli. 9535
Permit 8796

WELL LOG

Record by: Driller
Source: Driller's Record

Location: State of WASHINGTON
County: Spokane
Area:
Map:
SE ¼ SE ¼ sec. 26 T. 25 N., R. 41 E.

Diagram of Section: 26

Drilling Co.: Holman Drilling Corp
Address: E. 3410 - 9th, Spokane, Wash.
Method of Drilling: Cable   Date: October 6, 1967
Owner: Town of Airway Heights
Address: Airway Heights, Wash.
Land surface, datum: ft. above/below
SWL: 43.7'   Date: Oct. 6, 1967   Dims.: 12"x200'

Correlation	Material	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Municipal		
	Gravel & boulders	0	31
	Gravel & sand	31	136
	Gravel & sand (water bearing)	136	160
	Sand w/clay layers	160	175
	Hardpan	175	180
	Sand (coarse)(water bearing)	180	200
	Casing: 12" from +1' to 181'		
	Screens: from 180' to 200'		
	Sealed with Bentonite		
	Yield:		
	300 gpm with 36.4' DD after 2 hrs.		
	400 " " 72.1' " " 2 hrs.		
	Recovery data:		
	0 sec. - 149' 60 sec. - 87.5'		
	30 sec. - 122' 90 sec. - 92.3'		

Turn up

Sheet ... of ... sheets

WELL LOG.—Continued App 9535 No. ....1..........-...............

CORRELATION	MATERIAL	From (feet)	To (feet)
	Depth forward		
	120 sec. - 93.3' 150 sec. -	93.5'	
	180 sec. - 93.5'		
	Date of Test: October 5, 1967		
	Temp. : 50°		
	Pump: 30 H.P., Peerless, V.H.S.		

S. F. No. 7449—OS—12-65.

Well ID 164651

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) **OWNER:** Name CLARENCE MOORE Address Rt. 2, Box 114A, Cheney, Wa. 99004

(2) **LOCATION OF WELL:** County Spokane E½ E½ — SE¼ ¼ Sec. 3 T24 N., R41EW.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 239 ft. Depth of completed well 239 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from +1½ ft. to 59 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☒ No ☐
Type of water? SURFACE Depth of strata 41
Method of sealing strata off 6" CASING + Clay

(7) **PUMP:** Manufacturer's Name.....
Type: ..... H.P. .....

(8) **WATER LEVELS:** Land-surface elevation above mean sea level... +2000 ft.
Static level 54 ft. below top of well Date 9/4/86
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? DRILLER
Yield: 100 gal./min. with total ft. drawdown after 1 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Air test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water 56 Was a chemical analysis made? Yes ☐ No ☒

10/14/86

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil firm	0	3½
Sand grav loose	3½	7
Sand grav rock cl bind loose firm		
area 12' static head surface wtr	7-41	
Bas blk frac brok loos to m h	41	53
Bas blk hard	53	63½
Bas blk grey seams h si hard	63½	71
Bas blk hard	71	75
Bas grey blk hard	75	86
Bas grey blk frac gr se h si	86	88
Bas grey blk hard	88	106
Bas blk vas gr se h side	106	110
Bas blk gr se frac h side	110	113
Bas blk vas frac blk shale se m h		
to hard side moisture	113	115
Bas blk vas h side	115	119
Bas blk vas frac blk shale med		
hard hard hard side	119	126
Bas grey blk hard	126	129
Bas blk vas frac med hard	129	134
Bas blk frac hard side	134	138
Bas blk hard	138	141
Bas blk frac blu grey se ha side		141-145
Bas blk frac gr grey se m hard		
hard side	145	151
Bas blk tan se frac h side	151	154
Bas blk hard	154	156
Bas grey blk frac vas gr coat		
med hard hard side (2 gpm)	156	162
Bas grey blk hard	162	167
Bas grey blk frac vas h si (5gpm)		167-177
Bas grey blk tan seams hard	177	191
Bas grey blk hard	191	212
Bas blk gr se frac hard side	212	214
Bas grey frac grey shale seams		
hard side (CONT. ON ...)		

Work started Aug 22, 1986 Completed Sept 4, 1986

RECEIVED
OCT 14 1986
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME ZINKGRAF'S WELL ..... (Person, firm, or corporation) (Type or print)

Address E. 1606 Sharp Ave., Spokane, 99202

[Signed] Jack F. Zinkgraf
Jack F. Zinkgraf (Well Driller)

License No. 0545 Date Sept 9, 1986

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

Bas brn frac vas brn wood h si med hard (10 gpm)	216	221
Bas lite grey lite weight vas grey coat med hard	221	223
Bas grey frac hard side (25 gpm)	223	226
Bas grey hard	226	227
Bas blk gey blk frac vas h side (40 gpm)	227	228
Bas grey blk hard	228	230
Bas blk frac vas brn coat hard side (100 gpm)	230	239

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. ______

Water Right Permit No. ______

(1) **OWNER:** Name Janiet Hunt Address Rt-14 Box 552 Spokane WA. 99204

(2) **LOCATION OF WELL:** County Spokane SE ¼ SW ¼ Sec 15 T. 24 N., R. 41 W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) Four Lakes - Medical Lk. Rd-

(3) **PROPOSED USE:** [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 160 feet. Depth of completed well 160 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6" Diam. from +1 ft. to 113 ft.
Welded [X] ______" Diam. from ______ ft. to ______ ft.
Liner installed [ ]
Threaded [ ] ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 20+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) **PUMP:** Manufacturer's Name ______
Type: ______ H.P. ______

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ______ ft.
Static level 30 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
APPROX. 75-100 GPM BY AIRTEST

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [ ]

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
TOPSOIL	0	1
SANDY BRN. CLAY-FIRM	1	10
BRN. SAND & GRAVEL	10	20
BRN. CLAY-FIRM W/STRIPS SAND & GRAVEL	20	110
DECOMP. GRANITE W/ VERY FRACT. AREAS, WATER 24 GPM @ 140' 75-100 GPM @ 160'	110	160
WELL SHOWS 75 GPM @ BOTTOM OF CASING		
MAY NEED LINER TO SET PUMP BELOW CASING		

RECEIVED
SEP - 7 1988
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 7/29, 19 Completed 7/30, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S. 5613 Lake Rd. Greenacres WA.
(Signed) [signature] (WELL DRILLER) License No. 1278
Contractor's Registration No. ______ Date 8/3, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 32720

Permit No. ....

(1) OWNER: Name Riverside State Park (Equestrian Trail) c/o Washington State Parks Address 2201 N. Duncan Dr. Wenatchee

(2) LOCATION OF WELL: County .... SW NW 1/4 SE 1/4 Sec. 3 T. 25 N., R. 42 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 220 ft. Depth of completed well 217 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from +1½ ft. to 205 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type .... Model No. ....
Diam. 6 Slot size 20 from 207 ft. to 217 ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 122 ft. below top of well Date ....
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 100+ gal./min. with .... ft. drawdown after 2 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand & gravel	0	57
Granite boulder	57	60½
Sand & gravel	60½	73
Sand	73	129
Granite boulders	129	130
Gravel with sand	130	135
Gravel with sand & water	135	220

RECEIVED
FEB - 4 1982
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 11/9 1979 Completed 11/21 1979

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Bartholomew Drilling, Inc. (Person, firm, or corporation) (Type or print)

Address Nine Mile Falls, Wa 99026

[Signed] .... (Well Driller)

License No. 0051 Date 12/11 1979

2/18/82

(USE ADDITIONAL SHEETS IF NECESSARY)

DOH = 1140

WASHINGTON STATE DEPARTMENT OF ECOLOGY

UNIQUE WELL I.D. NUMBER ABR835
X Y Z 1 2 3

WELL TAGGING FORM

Date of Field Visit 9-6 1994 By R. Handley

ADDITIONAL WELL IDENTIFIERS

Department of Health System ID Number SP-727 K Source Number-SO 01

USGS Site Identification ______

RECORD VERIFICATION

☒ Well Report available *(please attach)*
☐ Well Report not available
☐ Verification inconclusive

WELL OWNERSHIP, IF DIFFERENT FROM WELL REPORT

Name ______

Street address ______

City ______ State ______

LOCATION OF WELL, IF DIFFERENT FROM WELL REPORT

Well Address ______

City ______ County ______

T. 25 N. R 42 E WM Sec. 03 NW ¼ of the SE ¼

Latitude ____ ° ____ ' ____ "
Longitude ____ ° ____ ' ____ "

☐ GPS (raw data)
☐ GPS (corrected)
☐ Topographic Map
☐ Survey
☐ Computer generated
☐ Other ______

Elevation at land surface ______ feet/meters *(circle one)*

☐ Digital Altimeter
☐ Topographic Map

Additional information, if available:

☐ Location marked on topographic map *(please attach)*

☐ Location marked on air photo *(please attach)*

Water Right # ____________ Priority Date ____________

Circle one Application Permit Certificate Claim Exempt

WELL CHARACTERISTICS

Physical Description of Well (size of casing, type of well, housing, etc.): ____________

Location of Well Identification Tag: ____________

Was Supplemental Tag needed for ease of identifying well?
☒ NO ☐ YES

If yes, where was tag placed? ____________

Scale 1:24,000 (1" =2,000')

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Indicate the location of the well within the Section by drawing a dot at that point.

SECTION ______

COMMENTS: ____________

Please attach this form to the Well Report and submit it to the Department of Ecology Water Resources Program Headquarters, [illegible]

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. W46411
Unique Well I.D. # AAN559
Water Right Permit No.

(1) OWNER: Name MORLEY, KEITH Address BOX 1622 AIRWAY HEIGHTS, WA 99001-

(2) LOCATION OF WELL: County SPOKANE - NW 1/4 SE 1/4 Sec 09 T 25 N., R 42 WM
(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's number of well (If more than one) 2
NEW WELL Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 390 ft. Depth of completed well 390 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from +1 ft. to 390 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: NO
Manufacturer's Name
Type Model No.
Diam. slot size from ft. to ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 19 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off OVERBORE

(7) PUMP: Manufacturer's Name
Type H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 320 ft. below top of well Date 06/14/94
Artesian Pressure lbs. per square inch Date
Artesian water controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test 20 gal/min. w/ stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
TOPSOIL	0	2
BASALT GRAVEL COBBLES	2	36
BASALT GRAVEL SAND	36	179
CLAY BROWN GRAVEL	179	376
BASALT BROKEN WITH WATER	376	390
	390	

JUN 22 1994

Work started 06/09/94 Completed 06/14/94

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME PONDEROSA DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS E 6010 BROADWAY

[SIGNED] Brad Fo[illegible] License No. 2100

Contractor's
Registration No. PO-ND-EI*240JE Date 06/15/94

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W101614
Unique Well I.D. # ACP587
Water Right Permit No.

(1) OWNER: Name ABC MINI STORAGE Address 275 CORPORATE AVE #800 KALISPELL, MT 59901-

(2) LOCATION OF WELL: County SPOKANE - 1/4 SE 1/4 Sec 20 T 25 N., R 42E WM
(2a) STREET ADDRESS OF WELL (or nearest address) SUNSET HWY,

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 180 ft. Depth of completed well 180 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from +1.5 ft. to 175 ft.
WELDED 5 " Dia. from 172 ft. to 175 ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: YES
Manufacturer's Name JOHNSON
Type STAINLESS Model No.
Diam. 5 slot size .018 from 175 ft. to 180 ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type NONE H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 140 ft. below top of well Date 03/02/98
Artesian Pressure lbs. per square inch Date
Artesian water controlled by

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
SAND WITH COARSE	0	
------- GRAVEL	0	4
SAND GRAVEL WITH	4	
------- COBBLES	4	21
SAND WITH COARSE	21	
------- GRAVEL	21	46
CLAY BROWN	46	52
SAND GRAVEL	52	66
CLAY BROWN	66	74
SAND AND GRAVEL	74	137
SAND GRAVEL WITH	137	
------- BROWN CLAY	137	157
COARSE SAND GRAVEL	157	
------- W/WATER	157	180

DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work started 02/27/98 Completed 03/02/98

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test 15+ gal/min. w/ stem set at 175 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME FOGLE PUMP & SUPPLY, INC.
(Person, firm, or corporation) (Type or print)

ADDRESS POB 1450, AIRWAY HTS. WA.

[SIGNED] Todd Lively/mo License No. 2321

Contractor's Registration No. FOGLEPS095L4 Date 03/04/98