WRIA 44/50
JAMESON LAKE AND MOSES COULEE FLOOD MITIGATION HYDROGEOLOGIC ASSESSMENT

July 2007

WRIA 44/50
JAMESON LAKE AND MOSES COULEE FLOODING MITIGATION HYDROGEOLOGIC ASSESSMENT REVIEW DRAFT

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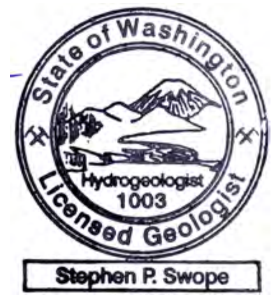
SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.



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EXECUTIVE SUMMARY

A hydrogeologic assessment of the Jameson Lake and Upper Moses Coulee area was conducted to assess artificial recharge of flood waters as a flood mitigation option for Jameson Lake and Upper Moses Coulee. This report provides a summary of the investigative tasks performed and a hydrogeologic interpretation of the area. The results of the flood mitigation assessment are summarized in a separate report (Anchor, 2007).

The hydrogeologic interpretation provided in this report is based on a number of investigative tasks performed. Existing data, including boring logs, NRCS soil survey data, and surficial geologic maps, was reviewed to support new data collected for the project. A deep groundwater monitoring well was installed and instrumented for long term monitoring north of Jameson Lake to assess vertical gradients beneath the lake. Two borings were also completed in the upper and lower Moses Coulee to evaluate recharge potential at locations proposed by Anchor. A snap-shot water level survey was conducted of existing wells both in the Coulee around Jameson Lake and along the uplands east and west of the Lake to assess horizontal gradients. An aquifer pump test was performed on an existing irrigation well in the Coulee to assess aquifer properties, and a series of six field permeability tests were conducted in the Upper and Lower Moses Coulee to estimate surficial vertical permeability values.

Much of the input to Jameson Lake is likely groundwater derived from the surrounding basalt uplands which flow towards the Upper Moses Coulee. During storm events, surface water discharging from tributary canyons also contributes to water in Jameson Lake. Large scale rain and snow melt events can raise the lake level above the outlet structures and cause surface flooding downstream of Jameson Lake. Normally the McCartney Creek channel downstream of Jameson Lake is dry for 10 miles before springs and seeps reemerge in the Rimrock Meadows area.

The hydrogeology of Jameson Lake is variable. North of the lake, a thick sequence (over 150-ft) of fine grained silt and clay occurs beneath the lake and groundwater gradient are upward indicating groundwater discharging into the lake. An 80-ft thick sequence of sand and gravel occurs south of the lake. Discharge from Jameson Lake likely occurs as seepage into the sand and gravel at the southern end of the lake in the direction of groundwater flow as indicated by monitoring well PGG-2.

South of Jameson Lake, the depth to groundwater dramatically decreases from 25-ft near the southern end of the lake to 130-ft at PGG-2. The subsurface basalt in the Upper Moses Coulee rises to the surface at the southern end of the Coulee and may form an impediment to groundwater flow.

The alluvial aquifer in the Upper Moses Coulee is quite variable with a thick sequence (up to 140-ft thick) of low permeability silt and clay near the southern end of the coulee, a high permeability gravel unit at depth below the silt and clay, and variable sand, silt and gravel throughout most of the Coulee. An aquifer test of the deep gravel unit towards the southern end of the Coulee indicates a high transmissivity aquifer (T = 1,600,000 gpd/ft). The extent of this deeper gravel unit beneath the Coulee is unknown. Existing wells in the northern part of the Coulee do not completely penetrate the unit.

An assessment of the alluvial aquifer in the Upper Moses Coulee for artificial recharge of Jameson Lake flood water suggests favorable conditions. An estimate of the unsaturated pore volume indicates the unsaturated zone in the Upper Moses Coulee could accept over 40 days of the simulated 100-year peak flood rate of 392 cfs (Anchor, 2007). The average linear velocity though the alluvial aquifer in the Upper Moses Coulee suggest recharged flood waters would take about 1.5 years to migrate down the length of the Coulee before discharging into springs and seeps or the subsurface basalt.

The biggest limitation for artificial recharge of flood waters is likely the uncertainty in vertical permeability. A relatively large vertical permeability (263 ft/dy) was measured at a sand and gravel aggregate pit about ½ mile north of Highway 2 where the fine-grained topsoil had been removed. Such large rates would be favorable for aquifer recharge of flood waters; however, the lateral extent of this unit is not known at this time.

1.0 INTRODUCTION

Jameson Lake lies within the McCartney Creek watershed in Water Resource Inventory Area (WRIA) 44/50 of Central Washington. **Figure 1** shows the location of WRIA 44/50 and the area of this current investigation. Since first surveyed in the mid-1880's, Jameson Lake has doubled in size and water levels have reportedly continued to rise several feet in the past 15 years, possibly as a result of agricultural practices in the surrounding watershed. Periodic floods have affected lake levels and flooded adjacent structures. The floods are caused by rapid snowmelt or thunderstorms in the large tributary basins (draws) that feed into Jameson Lake. Floods have been known to breach the outlet from Jameson Lake and occasionally flood the McCartney Creek channel downgradient. Such large scale floods have affected areas throughout the McCartney Creek channel.

This project was initiated by the WRIA 44/50 Douglas County Watershed Planning Association to address concerns of land loss to rising lake levels and impacts on surrounding structures during large scale flooding events. Previous assessments for WRIA 44/50 include the Final Phase 2 Basin Assessment (PGG, 2003a), the Foster Creek and Lower Moses Coulee Level 2 Hydrogeologic Assessment (PGG, 2003b), the Storage and Feasibility Study (2004a), the Jameson and Grimes Lakes Water Quality Assessment (PGG, 2004b), the Phase 1 Exempt Well Water Use Study (PGG, 2006a), and the annual report on Long Term Groundwater Elevation Monitoring (PGG, 2006b).

The work was performed, and this report prepared using generally accepted hydrogeologic practices used at this time and in this vicinity, for the exclusive use of WRIA 44/50 Douglas County Watershed Planning Association. This is in lieu of other warranties, expressed or implied.

1.1 PROJECT GOALS

The goals of this project are to investigate impacts of flooding from Jameson Lake to surrounding areas and to evaluate several mitigation options. The investigation includes evaluation of several flood reduction alternatives, including mitigation of flood waters through artificial recharge into the alluvial aquifer. The results of the flooding mitigation assessment are summarized in Anchor (2006).

1.1.1 Purpose of This Report

The purpose of this report is to provide a hydrogeologic assessment of the area for flood mitigation evaluations. Specifically this report presents the results of investigative work conducted for the project and a hydrogeologic interpretation of the area based on this work. Investigative work conducted for the project included a review of existing hydrogeologic data, analysis of water level data collected from long term monitoring stations, an assessment of groundwater gradients around Jameson and Grimes Lakes, an aquifer pump test to estimate aquifer transmissivity, and field permeability tests.

The hydrogeologic data provided in this report were used to evaluate flood mitigation design alternatives (Anchor, 2007).

1.2 BACKGROUND

Jameson and Grimes Lake are contained behind a glacial moraine in the upper most reaches of Moses Coulee. Grimes Lake is approximately 2 miles upgradient of Jameson Lake and as a result 40 feet higher in elevation. Outflow from Jameson Lake is dominated by groundwater seepage into the alluvial aquifer. The McCartney Creek channel immediately south of the lake is normally dry. The dry channel traces downstream through the Upper Moses Coulee (UMC) canyon for about 10 miles before springs and seeps contribute to stream flow. The channel flows for another 5 miles through the Rimrock Meadows area before its confluence with Rattle Snake Springs Creek. From here the channel enters the Lower Moses Coulee (LMC) canyon where stream flow is normally lost to groundwater seepage before the Douglas Creek confluence.

Throughout the first part of the 20th century, the lake level in Jameson Lake continued to rise, apparently as a result of agricultural practices in the surrounding watershed. The lake water elevation is now controlled by the outlet at the south end.

The following information and data were reported by landowner J.M Wittig Sr. in a letter of concern regarding the increase in water levels in Jameson Lake. In addition, a brief account of the recent flooding of the area surrounding Jameson and Grimes Lakes is included. This information was first presented in the Jameson and Grimes Lakes Water Quality Assessment (PGG, 2004b).

> ***"MY HISTORY OVERVIEW OF JAMESON LAKE***
>
> *I was born in 1918, so I can only use drawings, maps, and my memory of tree stumps to indicate the size of Jameson Lake's early years. The entire Grimes/Jameson Lake drainage basin was inhabited and farmed in the years from 1902 to 1918.*
>
> *The lake begin to rise, drowning out all but the extreme North end of the grove of trees in the 1881 drawing by the Military man.*
>
> *The lakes increased in size due to tillage of farmland (being that summer fallowed land is the first to run off, stubble land follows that, and brush land is the last to shed it's water). Summer fallow ground, due to moisture level is near the surface 1 or 1 1/2 inches of rain in October can leave the ground wet at the top making it easy to freeze. The stubble can be dry down 2 or 3 feet and even with a rain in November the moisture can leach down from the surface making less chance of freezing. The brush and grass land is usually able to absorb moisture, even the late moisture. Most runoffs are the result of mid-winter thaws leaving the ground surface bare and easy to freeze so when more moisture comes it is easy to runoff.*
>
> *By 1918 the people began to abandon their farms due to drought years. In the years following the land grew back to brush and the lake levels started to decrease. Between 1925 and 1935 the lake levels dropped 10 feet, and all down Coulee run-off was handled by a 12" culvert.*
>
> *Beginning in 1935 and during the next 20 years much of the abandoned land was again being cultivated due to the introduction of tractors and disc plows to the area. During this period of time the lake level again began to rise and has continued off and on until the present time. According to the soil conservation maps, the Jameson Lake drainage basin is over 200 square miles.*
>
> *The continued rise of the lake water has slowly devoured crop land until today we have lost a total of 147 acres. It has covered fresh water springs and has claimed two barn, (a third barn is flooded now,) loss of corral space for our cattle operation, and damage to the basements of two houses. Considerable loss and damage has also occurred to the Jameson Lake Resort, which is a land tenant of ours.*
>
> *I feel it is of utmost importance to maintain the lake at a lower level to avoid future property loss, road destruction, and loss of income.*
>
> *I would like to request your help in establishing the lake level of Jameson Lake at the 1,781 foot elevation. At this level, Jameson Lake could handle most large runoffs in the future without causing further damage…*
>
> *Your time and consideration of this matter is greatly appreciated.*
>
> *Sincerely,*
>
> *J.W. Wittig"*

The following statement by J.W. Wittig Sr. refers to **Table 1**, which documents variations in the Jameson Lake level. Lake level readings were recorded on May 1st each year.

> *The average evaporation and seepage out of Jameson Lake from 1925 thru 1944 was about*

3 foot a year. From that time on, due to new dams and water storage above the lakes, it dropped that rate to about 26 to 28 inches a year.

1925 thru 1935 the lake level dropped approximately 10 feet.

The following historic report was sent by Peter Ringstrud. The author of the historic document is unknown.

Prior to 1989 the county road had been raised several times because of the rise in lake level. The flooding in 1989 brought the lake level up (4½ft) to an old constructed irrigation ditch at the South end of Jameson. The County again raised the road 4 feet and installed 2-24" pipes at the irrigation ditch.

In 1995 the flooding raised the lake level again causing overland flooding from the lake for the first time in historic times. KCM estimated approximately 3500 Acre feet of water entering the lake in four days. A large majority of that storm water runoff was added to the flow that heads down to the Palisades area. Jameson Lake has acted as a significant retention area that attenuated flooding down stream. This 20% increase in the drainage basin influencing flooding in the Palisades could significantly increase down stream impacts."

An estimated increase in Jameson Lake levels is derived from the map below. The topographic is from USGS Topographic maps the contour map overlying was created in 1953 (Wolcott, 1973)

2.0 HYDROGEOLOGIC INVESTIGATION

Existing geologic data was reviewed and field investigations were conducted to assess groundwater flow and aquifer characteristics in the Jameson Lake and Moses Coulee area. The following tasks were completed as part of the investigation:

- A deep groundwater monitoring well was drilled and installed on the north end of Jameson Lake to assess vertical groundwater gradients beneath the lake.
- Two borings were drilled in June 2007 to assist in background and evaluate the recharge potential at two recharge basin sites identified by Anchor (2007). A 198 ft well south of Jameson Lake was completed, while a 178 ft dry borehole was drilled and cased in the Lower Moses Coulee.
- The northing (y), easting (x), and elevation (z) of the long-term monitoring stations (except PGG-2 and PGG-3) in the Jameson Lake area were professionally surveyed by Erlandsen and Associates, Inc. of Brewster, Washington in order to convert water level measurements to absolute elevations.
- Boring logs of existing wells, Washington State Department of Natural Resources (WDNR) 1:100,000 digital geologic data, and National Resources Conservation Services (NRCS) soil survey data were reviewed to identify any extensive coarse sedimentary layers that would be favorable for artificial recharge of flood waters.
- Snap-shot groundwater elevations were collected in May 2006 from 15 existing wells on the basalt uplands east and west of Jameson Lake to assess regional horizontal groundwater gradients in the basalt aquifer towards the Coulee. Well positions were surveyed using a Garmin GPSMAP 60CS hand held GPS receiver with +/- 10-ft vertical and horizontal accuracy.
- Snap-shot groundwater elevations were also collected in May 2006 from 3 existing water supply wells in the vicinity of Jameson Lake to assess horizontal groundwater gradients in the alluvial aquifer surrounding the lake. The positions of these wells were included in the professional survey by Erlandsen and Associates, Inc.
- An aquifer test was performed on an existing irrigation well in the Upper Moses Coulee channel to provide information on alluvial aquifer properties for transmitting artificially recharged flood water.

- Field permeability tests were performed in six locations in the Upper and Lower Moses Coulee (three tests in each) to estimate the variability in vertical permeability which could limit artificial recharge rates.

2.1 MONITORING WELL AND BOREHOLE INSTALLATIONS

Two monitoring wells and one borehole were drilled in 2006 and 2007 in WRIA 44/50. This section describes the lithology encountered and construction of each boring. Copies of the boring logs and well construction reports are included in **Appendix A**.

2.1.1 Monitoring well PGG-1

A new deep groundwater monitoring well (PGG-1) was drilled and installed on July 18, 2006 along the north shore of Jameson Lake. **Figure 2** shows the Jameson and Grimes Lake area and the location of PGG-1. The well was drilled and constructed with the purpose of monitoring vertical groundwater gradients beneath the lake.

Environmental West Explorations, Inc. from Spokane, Washington performed the drilling and well installation. Pacific Groundwater Group observed the drilling, installation, and development of the well.

An 8-inch borehole was drilled using air rotary to a total depth of 152 ft below ground surface (bgs). The first 7 ft consisted of a dry, fine, sandy silt. Below this a wet fine to medium sand with trace amounts of gravel and silt was encountered. At a depth of about 20 ft (bgs), the fine to medium sand transitioned to very silty fine sand alternating with very fine sandy silt with trace amounts of clay. The clay content increased noticeably at a depth of 107 ft bgs. The material encountered is interpreted to be predominantly former lake deposits. The subsurface bedrock was not encountered nor was a substantial water bearing sand and gravel layer.

The monitoring well was constructed with 4-inch schedule 40 PVC screen and riser. A 10-ft long screen with 0.01-inch slot was set from 139 to 149 ft bgs with a sand filter pack. The annulus above the screen and filter pack was backfilled with bentonite grout. An 8-inch steel monument with a 3-ft long stick up above ground surface was set in concrete to protect the well head. Approximately 25 to 30 gallons of water was bailed from the well upon completion. The bailed water contained some fine silt and had a noticeable sulfur odor, suggesting a deep mineralized water source.

A Solinst Level Logger transducer was installed in the well on August 31, 2006. The static depth to water on this date was 2.71 ft below the top of PVC casing, which is slightly above ground surface, indicating confined conditions. The data logger was programmed to collect water levels in the well every hour and will be downloaded in the spring and fall of each year along with other long term monitoring wells in Douglas County (PGG, 2006).

2.1.2 Monitoring Well PGG-2

Monitoring well PGG-2 was drilled from June 14 to 15, 2007, with screen installation completed on June 27, 2007. PGG-2 was installed southwest of the southern tip of Jameson Lake. The well was drilled and constructed to monitor regional groundwater elevations, allow for future aquifer testing, and to improve the hydrogeologic understanding of an area recommended by Anchor (2007) for future infiltration pits.

Empire Well Drilling, based out of Ephrata, Washington, performed drilling and well installation. PGG-2 was drilled without drilling circulation water. Personnel from Pacific Groundwater Group observed drilling and casing installation of the well. Screen installation was completed by Empire Well Drilling on June 27, 2007.

A 6-inch borehole was drilled using air rotary to a total depth of approximately 198 ft below ground surface (bgs). The first 29 ft were cobbles and boulders with a dry, slightly fine sandy, silt matrix. The lithology is mostly interpreted from drilling action as sample recovery was poor due to the size of the sediments encountered. Below 29 feet, layers of moist gravel and sand were encountered. At a depth of about 90 ft bgs, the silt content of the samples increased, while from 96 to 129 ft bgs thin silt layers were interbedded with sandy gravel layers. These sediments likely represent former river or lake deposits. From 129 ft bgs to the bottom of the hole, wet highly fractured basalt with trace subrounded gravel was observed. As the well casing was easily driven through the basalt, it the unit is interpreted to represent either colluvial deposits (such as a talus slope) or a highly weathered flow top.

The monitoring well was constructed with 6-inch steel casing with welded joints. A 20-ft long screen with 0.02-inch slot was set from approximately 178 to 198 ft bgs. A surface seal was set from 0 to 15 ft bgs in a 10-inch borehole during drilling. Casing Seal, a bentonite mixture used for surface seals and as steel casing lubricant, was used for the seal. Casing Seal was added periodically during drilling to accommodate settlement of the seal. A square steel plate was welded on top of the casing and will be replaced with a PVC slip-cap to allow access for groundwater monitoring. During drilling the stem was run at approximately 176 ft bgs for 45 minutes, producing a discharge of approximately 15 gallons per minute.

2.1.3 Boring PGG-3

Boring PGG-3 was drilled from June 11 to 13, 2007, but was not completed as a well as unexpected lithology was encountered and budgetary constraints prohibited deeper drilling. PGG-3 was installed approximately 0.9 miles northwest of the Billingsley Ranch in the Lower Moses Coulee. The boring was drilled with the intention of monitoring regional groundwater elevations and to gather hydrogeologic data in the vicinity of an additional area recommended by Anchor (2007) for future infiltration pits.

Empire Well Drilling drilled and installed casing for the borehole, which was observed by Pacific Groundwater Group. PGG-3 was drilled with circulation water.

An 8-inch borehole was drilled using air rotary to a total depth of approximately 178 ft bgs. The initial 18 feet consisted of cobbles with a dry, sandy silt matrix. From 18 to 77 ft bgs, sample recovery was poor, but the lithology was interpreted based on drill action as cobbles and boulders with varying percentages of fines. Below this a 78 ft thick basalt unit was encountered. As the basalt unit was underlain from 155 ft bgs to the hole bottom by fractured, weathered basalt (likely a flow top), it is interpreted to be the local bedrock unit.

The water table was not encountered in boring PGG-3.

The borehole was cased to a depth of approximately 77 ft with 8-inch welded-steel casing. A surface seal was set from 0 to 15 ft bgs in a 10-inch borehole during drilling. Casing Seal was used as the sealant, and was added periodically during drilling to account for seal settlement. Casing could not be driven through the basalt interval encountered from 77 to 155 ft bgs so the borehole was completed as open hole.

Future drilling could be performed at PGG-3, as the borehole was not backfilled, but was welded shut with a square steel plate. However, as the lithology encountered at PGG-3 was unexpected (only alluvial sediments were expected to be present between the surface and water table), PGG recommends that any future monitoring wells be located south of the Rattlesnake Creek streambed. This area would more likely have thick alluvial deposits, as observed in local irrigation wells.

2.2 REVIEW OF BORING LOGS

Boring logs of existing wells in the Jameson Lake area and in the Upper Moses Coulee were obtained from the Ecology well database and reviewed for subsurface geology and groundwater levels. The information provided on the boring logs was used with other data for developing hydrogeologic cross-sections and hydrogeologic interpretations. **Figure 2** and **Figure 3** shows the location of the wells and copies of the well boring logs are included in **Appendix A**.

2.2.1 Jameson Lake Boring Logs

The Holmquist water supply well is located on the west side of the Coulee at the mouth of an unnamed tributary canyon (draw) between Jameson and Grimes Lake (**Figure 2**). The boring log for the Holmquist well indicates 30 ft of sand and gravel above 6 ft of broken basalt. Basalt bedrock was encountered at 36 ft bgs.

The Matthiesen (Smullen) water supply well is located at the Matthiesen Resort on the northeast side of Jameson Lake at the mouth of another unnamed tributary canyon (**Figure 2**). The boring log for the Matthiesen well indicates 41 ft of sand and gravel mixed with some broken basalt near the bottom. Basalt bedrock was not encountered.

The Long water supply well is located at the south end of Jameson Lake near the mouth of Burton Draw (**Figure 2**). The boring log for the Long well indicates 20 ft of sand and gravel above 60 ft of sand. Basalt bedrock was not encountered.

The Wittig-Domestic water supply well is located on the west side of the Coulee near the north end of Jameson Lake (**Figure 2**). The boring log for the Wittig-Domestic well indicates 80 ft of sandy silt and silty sand above 41 ft of silt and clay followed by 6 ft of basalt gravel. Basalt bedrock was not encountered.

The fine-grained material indicated on the Wittig-Domestic boring log is similar to the material encountered during drilling of deep monitoring well PGG-1 (**Figure 2**) and are interpreted as former lake deposits.

The Holmquist, Matthiesen, and Long boring logs indicate coarser-grained material interpreted as fluvial (river) deposits from historic glacial meltwater and or more recent flood deposits.

2.2.2 Moses Coulee Boring Logs

The Bechtol and Irmer water supply wells are old irrigation wells no longer in use located about ½ mile north of Highway 2 (**Figure 3**). The boring logs for both wells describe 5 to 7 ft of topsoil and silt above a sequence of coarse grained sand and gravel to a depth of 120 ft bgs. The static water level at time of drilling was 113 ft bgs for the Bechtol well and 111-ft for the Irmer well indicating the presence of a thick unsaturated zone at this location in the Coulee.

The Hensel water supply wells are located about 3.5 miles south of Highway 2 (**Figure 3**). All three wells are within 1000 ft of each other. Two of the wells are 85-ft deep; the third well is 87-ft deep. The boring logs describe 10 ft of soil above coarse grained sand and gravel with the static water levels at time of drilling recorded as 52, 54 and 61 ft bgs.

The Johnson and Toland water supply wells are located about 1 mile south of the Hensel wells (**Figure 3**). The Johnson well (191-ft deep) is located in the middle of the Coulee and the Toland well (102-ft deep) is located along the east side of the Coulee. Boring logs for both wells describe a thick sequence of silt and clay (about 100-ft thick) above a deep water bearing gravel unit. The static water depth at time of drilling was 37 ft and 28 ft bgs in the Johnson and Toland wells respectively indicating confined conditions (groundwater levels rise above the top of the water bearing unit).

The Schick water supply well is 240-ft deep and located about ¾ of a mile south of the Johnson well (**Figure 3**). The boring log describes 5 ft of soil above 30 ft of water bearing sand and gravel followed by 142 ft of silt and clay. Below the silt and clay, a 63-ft thick sequence of "black" gravel was encountered before reaching bedrock at 240 ft bgs. The well is fully cased with perforations open to the "black" gravel unit. The static water depth at time of drilling was 30 ft bgs indicating confined conditions.

The PK&T, Inc. water supply well is 80-ft deep and located about 1 mile south of the Schick well (**Figure 3**). The boring log describes 60 ft of clay with some gravel before encountering basalt bedrock at 60 ft bgs. The well was drilled another 20 ft into the basalt bedrock. The static water depth at time of drilling was 65 ft bgs.

2.3 REVIEW OF NRCS SOIL SURVEY

The Natural Resource Conservations Service (NRCS) soils survey for Washington State (U.S. Department of Agriculture, 1994) was reviewed for the Jameson Lake area and the Upper Moses Coulee to identify variability in soil texture and estimate saturated vertical permeabilities which could limit artificial recharge rates. A discussion of the soils from each area is discussed below.

2.3.1 Jameson Lake Area Soils

The NRCS soil unit in the vicinity of the Holmquist well is classified as a Tubspring fine sandy loam on 0 to 8 percent slopes. The unit is described as being formed in somewhat excessively drained loess and volcanic ash overlying glacial outwash. The sub-stratum (non-weather soil horizon) is characterized as a gravelly loamy coarse sand and extremely gravelly coarse sand. The saturated vertical permeability is described as increasing with depth in the soil horizon from 2 to 6 in/hr in the upper 20 inches of soil and increasing to 20 in/hr 20 to 60 inches bgs.

The NRCS soil unit in the vicinity of the Mattheisen well is classified as a Strat-Tubspring complex with about 50% Strat, 40% Tubsrping, and 10% inclusions on 8 to 30 percent slopes. The unit is described as being formed in glacial outwash mixed with loess and volcanic ash. The Strat unit is characterized as well drained with a very cobbly sandy loam and extremely gravelly coarse sand subsoil. The Tubspring unit is characterized as somewhat excessively drained with a gravelly loamy coarse sand and extremely gravelly coarse sand substratum. The saturated vertical permeability is described as increasing with depth in the soil horizon from 2 to 6 in/hr in the upper 20 inches of soil and increasing to 20 in/hr 20 to 60 inches bgs.

The NRCS soil unit in the vicinity of the Long well is classified as a Strat-Tubspring-Del Rio complex with about 35% Strat, 25% Tubspring, 25% Del Rio, and 15% inclusions on 0 to 30 percent slopes. The unit is also described as being formed in glacial outwash mixed with loess and volcanic ash. The Start and Tubspring units are characterized above. The Del Rio unit is characterized as well drained with a fine sandy loam and sandy loam subsoil. The saturated vertical permeability for the Strat and Tubsprings soil components are described above. The saturated vertical permeability for the Del Rio component is described as 2 to 6 in/hr throughout the 60-inch deep soil horizon.

The NRCS soil unit in the vicinity of the Wittig-Domestic and PGG-1 wells is classified as a Sanbee sandy loam on 0 to 8 percent slopes. The unit is described as being formed in somewhat excessively drained glacial outwash sand with loess and volcanic ash in the surface and a sand substratum. The saturated vertical permeability is described as 2 to 6 in/hr in the upper 12 inches of soil and 20 in/hr from 12 to 60 inches bgs.

The dominant soil units along most of the low lying areas of the Coulee between Grimes and Jameson Lake are classified as either Halaquepts complex or Aquolls-Halaquepts complex on nearly level grounds.

The Halaquepts complex is described as 40% Halaquepts, 40% Halaquepts cemented substratum, and 20% inclusions. The unit is described as being formed in loess and volcanic ash overlying colluvium and glacial till or outwash in depressions on uplands. The unit is characterized as poorly drained. The Halaquepts subsoil is characterized as layered silt loam, sandy loam, silty clay loam, sandy clay loam, and gravelly clay loam. The cemented substratum is described as having a hardpan at 34 inches depth with a fine to very fine sandy loam subsoil above the hardpan. The vertical permeability of the complex is described as 2 to 6 in/hr in the upper 8 inches of soils and 0.6 to 6 in/hr from 8 to 60 inches bgs. If the cemented substratum is present the vertical permeability can be as low as 0.06 to 0.2 in/hr.

The Aquolls-Halaquepts complex is described as 50% Aquolls, 40% Halaquepts cemented substratum, and 20% inclusions. The unit is described as being formed by moving water in low lying areas with a very poorly to poorly drained soil. The Aquolls component is described as having a clay loam subsoil. The saturated vertical permeability of the Halaquepts cemented substratum is described above. The saturated vertical permeability of the Aquolls component is described as 0.6 to 2 in/hr to a depth of 49 inches bgs and 0.2 to 0.6 in/hr from 49 to 60 inches bgs.

The soils data were reclassified in terms of relative soil texture (fine, medium or coarse grained) based on the descriptions of the subsoil. The results of the reclassification are shown in **Figure 2**, which shows coarse grained soils at the mouth of tributary draws and the south end of Jameson Lake and fine to medium grained soils within the coulee between Grimes and Jameson Lake.

2.3.2 Upper Moses Coulee Soils

The dominant NRCS soil units north of the Hensel wells in the Upper Moses Coulee are classified as either the Strat-Tubspring-Del Rio Complex (described above) or the Strat-Tubspring-Skaha Complex. The Strat-Tubspring-Skaha Complex is characterized as 30% Strat, 25% Tubspring, 20% Skaha and 25% inclusions on 0 to 15 percent slopes. The unit is described as being formed in glacial outwash mixed with loess and volcanic ash. The Strat unit is characterized as well drained with a very gravelly sandy loam and extremely gravelly coarse sand subsoil. The Tubspring unit is characterized as somewhat excessively drained with a fine sandy loam, gravelly fine sandy loam, and very gravelly coarse sand subsoil. The Skaha unit is characterized as excessively drained with a very gravelly course sand subsoil. The saturated vertical permeability of the Strat-Tubspring component is described above. The Skaha component is described as 2 to 6 in/hr in the upper 9 inches of soil and 20 in/hr from 9 to 60 inches bgs.

The NRCS soil units south of the Hensel wells are characterized as progressively finer-grained soils. The dominant soils units are Del Rio fine sandy loam, Durixerolls-Halaquepts complex, and Halaquepts complex.

The Del Rio fine sandy loam is characterized as a well drained soil formed on 0 to 8 percent slopes in loess mixed with volcanic ash and material deposited by running water. The subsoil is described as fine sandy loam and loamy fine sand. The saturated vertical permeability is described as 2 to 6 in/hr in the upper 45 inches of soil and 6 to 20 in/hr from 45 to 60 inches bgs.

The Durixerolls-Halaquepts complex is characterized as 40% Durixerolls, 40% Halaquepts, and 20% inclusions on nearly level slopes. The unit is described as being formed in loess mixed with volcanic ash overlying lake deposits or glacial till. The Durixerolls unit is characterized as moderately well drained with a cobbly loam subsoil overlying a hardpan at about 21 inches. The Halaquepts unit is characterized as somewhat poorly drained with a fine sandy loam and very fine sandy loam surface and subsoil overlying a hardpan at about 34 inches. The saturated vertical permeability of the Halaquepts component is described above. The saturated vertical permeability of the Durixerolls component is described as 0.6 to 2 in/hr in the upper 6 inches of soil, 0.6 to 6 in/hr from 6 to 32 inches bgs, 0.06 to 0.2 from 32 to 36 inches bgs, and 0.6 to 6 in/hr from 35 to 60 inches bgs.

The Halaquepts complex is characterized as poorly drained soils on nearly level slopes with a layered silt loam, sandy loam, silty clay loam, sandy clay loam and gravelly clay loam subsoil. The vertical permeability of the unit is described above.

The soils data were reclassified in terms of relative soils texture based on the descriptions of the subsoil. The results of the reclassification are shown in **Figure 3**, which shows coarser grained soils north of the Hensel wells and finer grained soils south of the Johnson well (**Figure 3**).

2.4 REVIEW OF 1:100,000 GEOLOGIC MAP

The Washington State Department of Natural Resources 1:100,000 digital geologic map of Washington State was reviewed for the Jameson Lake and Upper Moses Coulee area to help develop the hydrogeologic interpretation of the area and to identify favorable areas for artificial recharge. Discussions of the surficial geology from each area are discussed below.

2.4.1 Jameson Lake Surficial Geology

The surficial geology immediately north of Jameson Lake is differentiated from the rest of the Jameson Lake area on the 1:100,000 geologic map of the state. The geologic unit at the north end of Jameson Lake is mapped as Quaternary Alluvium, whereas the rest of the Jameson Lake area is mapped as either Quaternary Glacial Drift or Bedrock. The surficial geology of the Jameson Lake area is shown in **Figure 4.**

The Quaternary Alluvium north of Jameson Lake is likely associated with former lake deposits (fine-grained sediment) and the Quaternary Glacial Drift is likely associated with historic glacial meltwater and or more recent flood deposits (coarse-grained).

2.4.2 Upper Moses Coulee Surficial Geology

The surficial geology north of Highway 2 in the Upper Moses Coulee is mapped as Quaternary Glacial Drift across most of the Coulee floor. The recent channel of the McCartney creek is mapped as Quaternary Alluvium. South of Highway 2 the Quaternary Alluvium progressively covers a larger area of the Coulee floor. A large sloping terrace immediately south of Highway 2 on the west side of the Coulee is mapped as Quaternary Missoula Flood deposits. The surficial geology of the Moses Coulee area is shown in **Figure 5**.

2.5 GEOLOGY OF JAMESON LAKE AND UPPER MOSES COULEE

The following discussion of subsurface geology in the Jameson Lake and Upper Moses Coulee area is based on boring logs, geologic material encountered during drilling of PGG-1, NRCS soil survey data, and WDNR 1:100,000 geologic data presented above.

An east-west cross section across the north end of Jameson Lake is shown in **Figure 6** and a north-south cross section along the center line of the entire Upper Moses Coulee is shown in **Figure 7.** These cross-sections illustrate the subsurface geology in the area.

2.5.1 Jameson Lake Area Geology

Most of the low lying area of the Coulee between Grimes and Jameson Lake is probably underlain by a thick sequence of former lake deposits composed of fine-grained sand, silt and clay. Sediments at the base of tributary canyons entering the Coulee and at the south end of Jameson Lake are dominated by coarse-grained sand and gravel.

The sand and gravel at the south end of Jameson Lake was likely deposited by glacial meltwater associated with the end moraine, which formed in this location and may therefore cover a substantial area south of the lake. The sand and gravel sediments at the base of tributary canyons are likely deposited by both historic glacial meltwater and more recent flooding events and are expected to be less extensive. The Holmquist and Matthiesen wells (both located at the mouth of tributary canyons) indicate no more than 30 to 40 feet of sand and gravel above broken basalt (near bedrock) whereas the Long well (south of Jameson Lake) indicates over 80 feet of sand and gravel and monitoring well PGG-2 indicated 110 feet of sand and gravel.

Currently there is insufficient data to infer the extent of the coarse-grained sand and gravel beneath Jameson Lake.

2.5.2 Upper Moses Coulee Geology

The silt and clay described in the Johnson, Toland, Schick, and PK&T, Inc. wells indicate a thick sequence of fine-grained sediment near the southern end of the Upper Moses Coulee which likely represents former lake deposits (**Figure 7**). The presence of a former lake in the lower part of the Upper Moses Coulee may be related to the subsurface bedrock topography. The depth to the basalt bedrock beneath the Coulee dramatically decreases between the Schick and PK&T, Inc. wells (from 240 ft bgs to 64 ft bgs in a little less than 1 mile) with the bedrock exposed at the Coulee surface less than ½ mile south of the PK&T, Inc well (**Figure 7**). This "wall" of basalt bedrock at the southern end of the Upper Moses Coulee may have caused historic flood waters to pond up and deposit the thick sequence of silt and clay encountered in the southern wells. Currently, there is insufficient subsurface data to define the northern extent of the fine-grained deposits.

As shown in the cross section (**Figure 7**), the area north of the Hensel wells is likely dominated by coarse-grained sand and gravel sediments deposited by historic glacial meltwater and more recent flooding events. The thickness of the coarse-grained sediments is at least 120-ft (Bechtol and Irmer wells) with an unsaturated zone over 100-ft thick. Unfortunately there are no deep wells in the area to define the exact thickness of the coarse-grained sediment. A terrace of potentially very coarse-grained sediments associated with the Missoula Outburst flood may occur along the east side of the Coulee immediately south of Highway 2 (**Figure 5**) based on the state surficial geologic map; however, there are no boring logs from this area to verify this.

South of the Hensel wells, the subsurface geology of the Upper Moses Coulee is likely dominated by fine-grained silt and clay, although a water bearing gravel unit appears to exist at depth below the silt and clay (**Figure 7**). The silt and clay sediments in the southern part of the Upper Moses Coulee were likely deposited as flood waters pooled up against the basalt bedrock at the southern end of the Coulee.

A fine-grained silty topsoil forms a layer 5 to 10 ft thick above the geologic material across most of the Coulee as indicated in boring logs and observed in the field. The fine-grained top-soil may represent loess deposits, slack-water deposits from floods, and/or soil development in the native material.

2.6 LONG TERM MONITORING STATIONS

Long-term monitoring in the Jameson Lake area was originally initiated as part of the Exempt Well Water Use Long Term Monitoring Plan for WRIA 44/50 (PGG, 2006). All monitoring stations around Jameson Lake were professionally surveyed on September 22, 2006 by Erlandsen and Associates, Inc. from Brewster, Washington. The horizontal and vertical datum is NAD83/91 and NAVD88 respectively with a position and elevation accuracy of +/- 0.10 feet. The results of the professional survey are shown in **Table 2**.

2.6.1 Jameson and Grimes Lake Level Monitoring

Long term monitoring of the lake water levels was initiated in May 2004. Lake levels are monitored at the southern end of Grimes Lake and the northern end of Jameson Lake (**Figure 2**). The Grimes Lake station was moved in the fall of 2006 to reduce station movement in the spring due to ice thaw. The transducers are housed in 2" PVC pipe attached on a steel fence post within the lake. Water levels are measured every hour and downloaded in the spring and fall.

Hydrographs of Jameson and Grimes Lake are shown in **Figure 8 and Figure 9** respectively. The water level in Grimes Lake is about 40 ft higher than Jameson Lake throughout the year. Water level elevations in both lakes display similar seasonal fluctuations of about 1.5 to 2.0 feet. Both lakes reached their peak levels by early May and declined to their lows by early October before the start of the wet winter months. The hydraulic gradient (slope) between the two lakes is 0.004 ft/ft.

The response to a large scale flood event has not been observed since monitoring was initiated. Continued monitoring should eventually capture lake level responses to a large flood event and indicate whether there are any long-term trends in lake water levels.

2.6.2 Groundwater Elevation Monitoring

Long-term groundwater elevations in the alluvial aquifer surrounding Jameson Lake are monitored continuously in two wells. Shallow groundwater monitoring on the northeast side of Jameson lake was initiated in March 2005 (Mattheisen water supply well) and deep groundwater monitoring on the north side of the lake was initiated in August 2006 (monitoring well PGG-1).

Hydrographs of the monitoring wells are plotted with the Jameson Lake hydrograph in **Figure 8**. Groundwater elevations in the Mattheisen water supply well are closely tied to the Jameson Lake elevation indicating a strong hydraulic connection between the aquifer and the lake in this vicinity. Groundwater elevations in deep monitoring well PGG-1 have been fairly constant since monitoring was initiated in August 2006 suggesting a deep groundwater source less influenced by seasonal variations (**Figure 8**). Continued monitoring will indicate if there are any long term trends.

2.7 GROUNDWATER GRADIENTS

Groundwater gradients in the Jameson Lake area and surrounding uplands were evaluated using snap-shot groundwater level measurements collected from existing water supply wells and long term-monitoring data presented above. A discussion of each area is presented below.

2.7.1 Groundwater Gradients in Jameson Lake Area

Groundwater monitoring in the deep monitoring well (PGG-1) indicates the vertical groundwater gradient beneath the north end of Jameson Lake is upward (deep groundwater sources discharge into the lake). The groundwater elevation in PGG-1 is about 8 feet higher than the lake level (**Figure 8**) with an upward gradient of 0.05 ft/ft. The vertical gradient is derived from the difference between the groundwater elevation monitored in PGG-1 and the lake level elevation monitored in Jameson Lake and the vertical distance between the two stations. Long-term monitoring of lake levels and PGG-1 will indicate how the vertical gradient at the northern end of the lake may vary throughout the year and whether trends in deep groundwater levels may be affecting lake levels.

Snap-shot groundwater measurements were collected on May 10^{th} and 11^{th}, 2006 from existing water supply wells in the Jameson Lake area. The results of the snap-shot groundwater measurements are presented in **Table 3** and **Figure 10.** All wells in the Jameson Lake area were included in the survey by Erlandsen and Associates, Inc. The measurements indicate a horizontal groundwater gradient of about 0.004 ft/ft between Grimes and Jameson Lakes towards the south along the axis of the Coulee. The groundwater gradient is similar to the surface gradient observed between the two lakes.

The dominant discharge from Jameson Lake is most likely groundwater seepage at the south end of the lake into the coarse sand and gravel; there is usually no surface water outflow. Variability in geology beneath the lake (i.e. silt and clay versus sand and gravel) may contribute to complex variations in groundwater gradients and seepage rates beneath the lake. Currently, there is no groundwater monitoring station at the south end of the lake to assess the magnitude of the downward gradients.

2.7.2 Groundwater Gradients in Uplands around Jameson Lake

A snap-shot groundwater elevation survey was performed on May 10, 2006 in surrounding wells on the basalt uplands around Jameson and Grimes Lake.

Groundwater elevations were measured in five wells on the west side of the Coulee (a sixth well was dry) and ten wells on the east side Coulee (**Table 3 and Figure 10**). The east-side wells were fairly uniform in their distribution but the west-side wells were limited to the northwest area of Grimes Lake. Only one well was available immediately west of Jameson Lake (Wittig-Pasture well).

All well locations and elevations were surveyed with a Garmin GPSMAP 60CS hand held GPS receiver with +/- 10-ft vertical and horizontal accuracy. Only five of the 16 wells surveyed have well logs available (**Appendix A**). All groundwater levels and the total depth (except the Dormaier Northeast well) were measured with a weighted electronic sounder.

Well depths and groundwater elevations indicate at least two basalt aquifers on the uplands. A fairly shallow basalt aquifer occurs on average less than 100-ft below ground surface (bgs). All but three of the wells surveyed tapped the shallow aquifer. A deeper basalt aquifer occurs on average over 250-ft bgs. The remaining three wells surveyed tapped the deep aquifer.

Contours of groundwater elevations in the shallow basalt aquifer are shown in **Figure 10**. The contours show groundwater in the basalt aquifer flows towards the Coulee with horizontal groundwater gradients of about 0.01 to 0.02 ft/ft Groundwater in both the shallow and deep basalt aquifers likely discharges into the Coulee either as springs above ground surface or as seepage into the alluvial aquifer in the subsurface.

2.8 AQUIFER TESTING

An aquifer test was performed in an existing irrigation well in an effort to evaluate aquifer properties of the alluvial aquifer in the Upper Moses Coulee.

The test consisted of three phases:

1. A pre-test phase lasting about two weeks, during which water levels were monitored at one minute intervals to assess static water levels, pumping water levels and antecedent trends.

2. A pumping phase lasting about 3 hours, during which water levels were monitored at one second time intervals in order to assess aquifer response to pumping.

3. A recovery phase lasting about one hour after pumping stopped, during which water levels were monitored while they recovered to pre-pumping conditions.

2.8.1 Copper-Jacob Method

Graphs of logarithmic elapsed time versus drawdown were used to compute the aquifer transmissivity. For the pumping phase the elapsed time (t) represents time since pumping began and for the recovery phase the elapsed time is calculated as t/t', where t' is the elapsed time since the pump shut off.

Transmissivity reflects the rate water flow through a vertical strip of the aquifer that is a unit width and under a unit hydraulic gradient. The following Cooper and Jacob (1946) equation was selected for the analysis:

$$T = 264Q/\Delta s$$

Where:

T= transmissivity, in gallons per day per foot (gpd/ft)

Q= pumping rate, in gallons per minute (gpm)

$\Delta s =$ drawdown over one log cycle

2.8.2 Aquifer Test Results

The Edwin Johnson irrigation well (currently operated by Rod Peterson) was chosen for the aquifer test based on physical access, permission, and well construction. The location of the Edwin Johnson well is shown in **Figure 3**. The 10-inch diameter well, constructed in 1955, is cased to a depth of 191 feet below ground surface (bgs) and perforated from 163 to 189 feet bgs. The well log **(Appendix A**) indicates 168 ft of predominantly silt and clay before water bearing gravel is encountered. The static depth to water at time of drilling is recorded as 37 ft bgs and the static depth to water prior to the pump test was 26.82 ft bgs. These levels are over 100 ft above the top of the aquifer indicating confined aquifer conditions.

The well is hard lined to distribution lines feeding three irrigation circles. The sprinklers and end guns for each circle are fitted with a pressure regulator to maintain a constant rate of application. The maximum flow rate when all end guns are operating is 610 gpm per the manufacturer. According to Rod Peterson, the distribution system takes about 5 to 10 minutes to stabilize to this constant pumping rate.

Pre-Test Phase: The results of the pre-test phase indicated pumping water levels would be about 3-ft below static water level. The pre-test phase also indicated a boundary is encountered after a number of hours of pumping. The exact amount of time until the boundary is encountered is not known because the pump was turned on at an unknown time in the morning before data collection began. Boundary effects were observed about 1.5 hours after data collection began. The boundary is indicated by a sudden increase in drawdown and likely represents the cone of depression reaching the basalt canyon walls about 475-ft to the east and 875-ft to the west.

Pumping and Recovery Phase: The results of the pumping test are shown in **Figure 11**. Drawdown data is plotted against elapsed time for both the pumping and recover phase. The drawdown during the first five minutes was highest while the distribution lines to the irrigation circles were being filled. After about 5 minutes the pumping rate stabilized to the regulated rate. Except for a 12-minute interval where one end gun shut off, the pumping rate was held constant at 610 gpm for the duration of the test. The pumping phase lasted a little more than 3 hours and recovery was monitored for about 45 minutes. Boundary effects observed during the pre-test phase were not observed during the pumping test phase. The transmissivity for both the pumping and recovery phase was calculated to be about 1,600,000 gpd/ft.

2.9 FIELD PERMEABILITY TESTING

Field permeability tests were performed in the Upper and Lower Moses Coulee to estimate the variability in vertical permeability (k) which may limit artificial recharge rates. The location of the test sites are shown in **Figure 5**.

2.9.1 Field Permeability Test Method

The field permeability test design uses methods described in the U.S. Department of Interior Earth Manual Appendix E-18, Field Permeability Tests in Boreholes (U.S. Department of Interior, 1985). The test involves driving an open ended pipe into the soil and supplying water into the pipe at a rate that achieves a constant head in the pipe. The permeability is derived using the following equation:

$$k = \frac{Q}{5.5rH}$$

Where:

- k = permeability (ft/dy)
- Q = constant rate of flow into the pipe (ft^3/dy)
- r = internal radius of pipe (ft)
- H = constant head of water in pipe

The Moses Coulee tests consisted of placing a 20-inch diameter, 4-ft long, stainless-steel ring into a 2-ft deep excavated pit. Test pits were excavated using a back hoe. The ring was placed into the bottom of the pit and the outer annulus was backfilled and compacted with excavated material. The bottom of the inside of the ring was filled with about ¼ to ½ ft of cobbles to provide a splash guard for the native soil. A water truck was on site to supply water to the inside of the ring.

2.9.2 Field Permeability Test Results

Three permeability tests were performed in the Lower Moses Coulee and three tests were performed in the Upper Moses Coulee. The results from each area are described below and summarized in **Table 4**. It should be noted that all test results represent high estimates of vertical permeability because the horizontal cross section of the wetting front likely expanded downward. The calculation assumes all infiltration occurs vertically through the cross sectional area of the ring.

2.9.2.1 Lower Moses Coulee

Field permeability tests were performed in the Lower Moses Coulee on Dave Billingsley's property at the head of the Lower Moses Coulee (**Figure 5**). The site was chosen along the northern edge of the Coulee in the vicinity of the McCartney Creek channel approximately 1 mile downgradient from where the Creek first enters the Coulee. The site was chosen for its known coarser-grained sediment relative to the rest of the Coulee. The WDNR 1:100,000 geologic data maps this area as Quaternary Missoula Flood deposits and the NRCS soil survey data maps this area as Finley Stony Loam. The Finley Stony Loam is characterized as a well drained soil formed in outwash with an extremely gravelly sandy loam and gravely loamy sand substratum.

Three tests were performed.

- Test #1 was performed in a cobbly silt and sand up on a terrace north of the McCartney Channel.
- Test #2 was performed in sandy cobbles in the floor of the McCartney Channel.
- Test #3 was performed in a silt layer on top of the terrace just north of Test #2.

The results indicate that permeability values range over four orders of magnitude (**Table 4**). The k values were calculated to be 3,178 ft/day for LMC Test #1, over 18,665 ft/day for LMC Test #2, and 9 ft/day for LMC Test #3. The maximum flow rate achievable with the water truck was 133 gallons per minute which was not enough to maintain a constant head during Test #2. A constant head of 0.3 ft was assumed for the calculation which was the height of the splash guard rocks in the bottom of the ring.

2.9.2.2 Upper Moses Coulee

Field permeability tests were performed in the Upper Moses Coulee north of Highway 2 on The Nature Conservancy's property (**Figure 5**). Three sites were chosen based on accessibility for back hoe and water truck and variability in soil types.

- Test #1 was performed in a cobbly silt on an upland terrace.
- Test #2 was performed in a sand and gravel in a small road side aggregate pit.
- Test #3 was performed in a silty fine sand within a dry channel.

At the Test #2 site, about 2 to 3 ft of cobbly silt material was scrapped away to expose the sand and gravel material.

The Upper Moses Coulee tests resulted in variable but generally lower permeability values than observed at the Lower Moses Coulee site (**Table 3**). The k values were calculated to be 7 ft/dy for UMC Test #1, 263 ft/dy for UMC Test #2, and 9 ft/dy for UMC Test #3.

3.0 HYDROGEOLOGIC INTERPRETATION

The results of the hydrogeologic investigation presented above were integrated with existing information to develop a hydrogeologic interpretation of the Jameson Lake and Lower Moses Coulee. The alluvial aquifer south of Jameson Lake was also assessed for feasibility of artificial recharge of flood waters.

3.1 HYDROGEOLOGY SUMMARY

Groundwater in the McCartney Creek basin is derived from precipitation and snow melt that recharges the upland basalt aquifer. In general, groundwater in the upland basalt aquifers flows toward the Moses Coulee and discharges as springs and seeps in the Moses Coulee or in the subsurface as recharge to the alluvial aquifer or into Jameson and Grimes Lake. Groundwater in the alluvial aquifer is derived from both direct precipitation recharge and subsurface discharge from the basalt aquifer.

Jameson and Grimes Lakes represent surface expressions of the groundwater table in the alluvial aquifer. Field investigations indicate upward groundwater flow at the northern end of Jameson Lake suggesting some groundwater inflow component to the lake at this location. Since there is no surface water outlet except under flooding conditions, the dominant discharge from Jameson Lake is likely discharge to the alluvial aquifer on the south end of the lake in the direction of groundwater flow. However, the variability in geology beneath the lake (i.e. silt and clay versus sand and gravel) may contribute to complex variations in groundwater gradients and seepage rates beneath the lake. See A-A' cross section **(Figure 6**).

The McCartney Creek channel south of Jameson Lake is normally dry (except during large flood events) for about 10 miles before groundwater reemerges as springs and seeps in the Rimrock Meadows area. The creek bed is dry because the depth to groundwater increases rapidly downgradient of Jameson Lake as shown in cross section B-B' (**Figure 7**). At the southern end of the lake, the depth to water is about 25-ft (Long well), and about 5 miles down the axis of the Coulee, the depth to water increases to over 100-ft (Irmer and Bechtol well).

Groundwater in the Upper Moses Coulee alluvial aquifer south of Jameson Lake is derived from direct precipitation, groundwater outflow from Jameson Lake, surface water seepage from McCartney Creek during flooding events, and groundwater seepage from the subsurface basalt (**Figure 7**). Groundwater discharge from the Upper Moses Coulee alluvial aquifer occurs at the southern end of the Coulee as springs and seeps near McCartney Creek in the Rimrock Meadows area and possibly into the subsurface basalt where it rises to the surface as illustrated in the cross section B-B' (**Figure 7**).

The topography of the subsurface basalt may play an important role in the groundwater gradient through the Upper Moses Coulee. The groundwater gradient north of Highway 2 is steeper (0.006 ft/ft) than south of Hwy 2 (0.002 ft/ft) as shown in the cross section B-B' (**Figure 7**). The flatter gradient south of HWY 2 may be due to the subsurface basalt rising to the surface and forming a subsurface impediment to groundwater flow in the alluvial aquifer, effectively pooling up the groundwater at the southern end of the Coulee.

The alluvial aquifer in the Upper Moses Coulee is heterogeneous as indicated in the cross section B-B' (**Figure 7**). A thick sequence of low permeability silt and clay (up to 140-ft thick) occurs near the southern end of the Coulee. These sediments likely represent former lake deposits. However, beneath the low permeability sediments occurs a highly permeable gravel unit (Transmissivity = 1,600,000 gpd/ft based on the Johnson aquifer test presented in Section 3.8). The extent of this deeper gravel unit beneath the Coulee is unknown. Existing wells in the northern part of the Coulee do not penetrate this deep.

Fine-grained silty topsoil forms a layer 5 to 10 ft over most of the Coulee floor as indicated in boring logs and observed in the field. Two to three feet of fine grained sediment was removed to expose sand and gravel at a road side aggregate site (UMC permeability Test #2, Section 3.9.2.2). The fine-grained top-soil may represent loess deposits, slack-water deposits from floods, and/or soil development of the native material.

3.2 AQUIFER ASSESSMENT FOR ARTIFICIAL RECHARGE

The alluvial aquifer in the Upper Moses Coulee was assessed for feasibility of artificial recharge of Jameson Lake flood waters.

Significant depths to groundwater (over 100-ft north of Highway 2) indicate a large unsaturated zone for storage of flood waters.

The approximate unsaturated pore volume in the Upper Moses Coulee alluvium was estimated to assess the storage capacity of the aquifer. The pore volume was calculated by integrating the thickness and width of the unsaturated zone along the Coulee and estimating porosity (n=0.2). The unsaturated pore volume is estimated to be about 34,000 acre-feet (ac-ft). Based on this estimate the unsaturated zone could accept over 40 days the simulated 100-year peak flood rate of 392 cubic feet per second (cfs).

The groundwater travel time through the Upper Moses Coulee under current conditions was estimated by calculating the average linear velocity of groundwater:

$v = K*i/n_e$

Where

v = average linear velocity (ft/day)
K = hydraulic conductivity (ft/day)
i = hydraulic gradient (ft/ft)
n_e = effective porosity (unitless)

The hydraulic conductivity was estimated from the transmissivity of the Johnson aquifer test and assuming an aquifer thickness of 40-ft (1.5 times the screen length), an average hydraulic gradient of 0.003 ft/ft, and an effective porosity of 0.2. The calculation results in an average linear velocity of 80 ft/day which indicates a travel time of about 1.5 years through the length of the Upper Moses Coulee. Under artificial recharge conditions the average hydraulic gradient through the Coulee could be has high as 0.005 ft/ft. Under these conditions the average linear velocity through the Coulee would be 135 ft/day and the travel time would be reduced to a little less than 1 year.

The biggest limitation for artificial recharge of flood waters is likely the uncertainty in vertical permeability. Fine-grained topsoil covers most of the Coulee floor making it difficult to assess the extent of coarse grained sand and gravel areas favorable for infiltration. The field permeability tests conducted in the Upper Moses Coulee indicate a wide range of permeabilities. A relatively large vertical permeability (263 ft/dy) was measured at a sand and gravel aggregate pit about ½ mile north of Highway 2 where the topsoil had been removed. The lateral extent of this unit is not known.

3.2.1 Infiltration Capacity at PGG-2

Field observations and soil survey data at PGG-2 indicate that its shallow sediments are composed of cobbles and boulders with a matrix of loess and volcanic ash (the soil is of the Strat-Tubspring-Skaha complex). Observed ponding of purge water during drilling suggest that the loess may limit infiltration, though soil survey data indicate the soil should have a high infiltration rate. Local infiltration tests may be necessary to confirm that local sediments exhibit suitable vertical hydraulic conductivities for large-scale infiltration.

The unsaturated thickness observed at PGG-2 was 129 ft. At depth, no obviously limiting layers were encountered until 96 ft bgs, where thin silt layers were observed. The regional extent of the interbedded silt layers is not known, but the silt potentially could limit the available sediment thickness for accommodating groundwater mounding to 96 ft. As the depth to water in the nearby Long well is approximately 25 ft, the 96 ft of effective unsaturated thickness is more favorable than expected.

3.2.2 Infiltration Capacity at PGG-3

PGG-3 was drilled using circulation water, which can provide hydrogeologic information when drill water is present or absent. The loss of drill water indicates that the unit where the drill stem is located can transmit water well, while if drill water is not lost, the unit is relatively less transmissive. Observed circulation loss data suggests that shallow soils (from 0 to 18 ft bgs) have lower infiltration rates, while sediments between 18 and 42 ft bgs have higher infiltration rates.

The total thickness of unsaturated sediments at PGG-3 is 76 ft. The expected sediment thickness was approximately 160 ft (as suggested by local well logs), and therefore a larger groundwater mound could likely be accommodated closer to the central axis of the Lower Moses Coulee (where basalt is likely to deeper).

No obvious silt or clay layers (which could constrain infiltration rates and unsaturated thicknesses) were encountered, though sample recovery was poor from 18 to 71 ft bgs. It is most likely that between 18 and 71 ft bgs sediments were predominately cobbles and boulders with varying matrix compositions (affecting retention or absence of circulation water). Based on the observed lithology, large-scale infiltration near PGG-3 is favorable, though pond or trench sizes may need to be large if, as suggested by circulation retention in PGG-3, the hydraulic conductivity of shallow soils limits the infiltration rate.

4.0 RECOMMENDATIONS

The hydrogeologic investigations performed for this project have provided an improved understanding of the hydrogeologic conditions in the Jameson Lake and Upper Moses Coulee area. Further information could be gathered from the following tasks:

- Drill and install a monitoring well south of Jameson Lake to assess vertical gradients south of Jameson Lake. Understanding the vertical gradients up gradient and down gradient of the Lake would improve our understanding of groundwater seepage to and from the Lake.
- Drill a test well north of Highway 2 and perform aquifer pump test. The area north of Highway 2 would be the likely area for artificial recharge of flood waters. A test well in this area would provide a better understanding of the subsurface geology and aquifer properties for assessing aquifer favorability for recharge of flood waters.
- The lateral extent of permeable sand and gravel north of Highway 2 is unknown because of a layer of fine-grained top soil. The biggest limitation for artificial recharge of flood waters is likely the uncertainty in vertical permeability. Therefore knowing the extent of sand and gravel would be required for assessing the feasibility of infiltrating flood waters. The extent of sand and gravel could be explored by excavating a number of text pits or borings north of Highway 2.

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Table 1. Historic Water Levels Reported by J.W. Wittig Sr.

Year	Jameson Lake Water Level Observations
1936	2 feet rise over 1935
1937	1 foot rise over 1936
1938	3 feet rise over 1937
1939-1940	1½ rise over 1940
1942	2 feet rise over 1941
1943	1½ feet rise over 1942
1944	10 inches lower than 1943
1945	5 feet rise over 1944
1946	3 feet rise over 1945
1947	1 foot lower than 1946
1948	Same level as 1947
1949	1½ rise over 1948
1950	1½ lower than 1949
1951	6 feet rise over 1950
1952	Same level as 1951
1953	½ foot rise over 1952
1954-1955	22 inches lower than 1953
1956	½ foot rise over 1955
1957	4 feet rise over 1956
1958	½ foot rise over 1957
1959	11 feet rise over 1959
The rise from 1936 through 1959 was 37 ½ feet	
1960-1966	40 inches lower
1966-1980	28 inches lower
From 1960 through 1980 the lake dropped 88 inches	
1981	20 inches rise over 1980
1982	22 inches rise over 1981
1983	4 feet rise over 1982
1984	3 foot rise over 1983
1985	3 inches rise over 1984
1986	Same as 1985
1987	2 inches lower than 1986
1988	10 inches lower than 1987
1989	53 inches higher than 1988
(Lake reached overflow level)	
1990	14 inches lower than 1989
1991	8 inches lower than 1990
1992	4 inches lower than 1991
1993	8 inches higher than 1992
1994	2 inches higher than 1993

Table 2. Jameson Lake Survey

Station	Northing (y)	Easting (x)	Elevation (z)
Holmquist Well	262878.2	1941055.3	1854.6
Grimes Lake Old (BM)	265690.7	1943976.5	1844.5
Grimes Lake New (Station)	267457.4	1945312.8	1837.6
Grimes Lake New (BM)	267432.3	1945291.0	1835.6
Jameson Lake (Station)	257846.2	1937518.5	1797.7
Jameson Lake (BM)	257885.7	1937618.8	1802.1
PGG-1 Well	257969.5	1938510.9	1805.4
Matthiesen (Smullen) Well	256340.1	1939910.4	1800.9
Wittig-Domestic Well	259100.1	1937417.8	1824.7

All stations were professionally surveyed by Erlandsen and Associates, Inc. of Brewster, Washington

Horizontal Datum is NAD83/91

Vertical Datum is NAVD88

Accuracy is +/- 0.10 feet

Table 3. Snap-Shot Water Levels (May 10-11, 2006)

Station ID	Location	Elevation (feet)**	Well Depth (feet)	Aquifer	Depth to Water (feet)	Groundwater Elevation (feet)	Date
Dormaier, Dave (North)	Uplands East	2114	95	Shallow Basalt	69.59	2044.41	5/10/06
Miller-Pasture	Uplands East	2102	25	Shallow Basalt	17.42	2084.58	5/10/06
Dormaier, Dave (South)	Uplands East	2204	110	Shallow Basalt	45.44	2158.56	5/10/06
Pigmy-Rabbit	Uplands East	2175	83	Shallow Basalt	55.13	2119.87	5/10/06
Dormaier, George and Sons	Uplands East	2173	225	Deep Basalt	164.12	2008.88	5/10/06
Dormaier (North East)	Uplands East	2073	NM	Shallow Basalt	170.93	1902.07	5/10/06
Behne, Tim (New)	Uplands East	2228	140	Shallow Basalt	84.02	2143.98	5/10/06
Behne, Time (Old)	Uplands East	2225	200	Shallow Basalt	74.87	2150.13	5/11/06
Behne, Keith (New)	Uplands East	2289	90	Shallow Basalt	53.20	2235.80	5/10/06
Behne, Keith (Old)	Uplands East	2296	352	Deep Basalt	255.38	2040.62	5/10/06
Wittig-Pasture	Uplands West	2143	10	Shallow Basalt	5.14	2137.86	5/10/06
Eidson-2	Uplands West	2134	70	Shallow Basalt	>70	<2064	5/10/06
Eidson-Barn	Uplands West	2083	98	Shallow Basalt	13.52	2069.48	5/10/06
Eidson-1	Uplands West	2117	242	Deep Basalt	138.90	1978.10	5/10/06
Henton-Pasture	Uplands West	2104	17	Shallow Basalt	12.86	2091.14	5/10/06
Mattheisen-Pasture	Uplands West	2236	31	Shallow Basalt	27.50	2208.50	5/10/06
Holmquist	Jameson Lake Coulee	1855	80	Shallow Basalt	25.78	1828.82	5/10/06
Wittig-Domestic	Jameson Lake Coulee	1825	127	Alluvial	10.60	1814.08	5/11/06
Mattheisen	Jameson Lake Coulee	1801	41	Alluvial	4.94	1795.92	5/10/06

**Elevations NAVD88

Table 4. Field Permeability Results

Test	Permeability (ft/day)	Site	Soil Type
LMC #1	3074	Lower Moses Coulee	Cobbly Sand
LMC #2	>18665	Lower Moses Coulee	Coarse Gravel
LMC #3	9	Lower Moses Coulee	Compact Silt
UMC #1	7	Upper Moses Coulee	Cobbly Silt
UMC #2	263	Upper Moses Coulee	Sand and Gravel
UMC #3	9	Upper Moses Coulee	Sandy Silt

Notes:

Results may be slightly overestimated due to lateral seepage during testing.

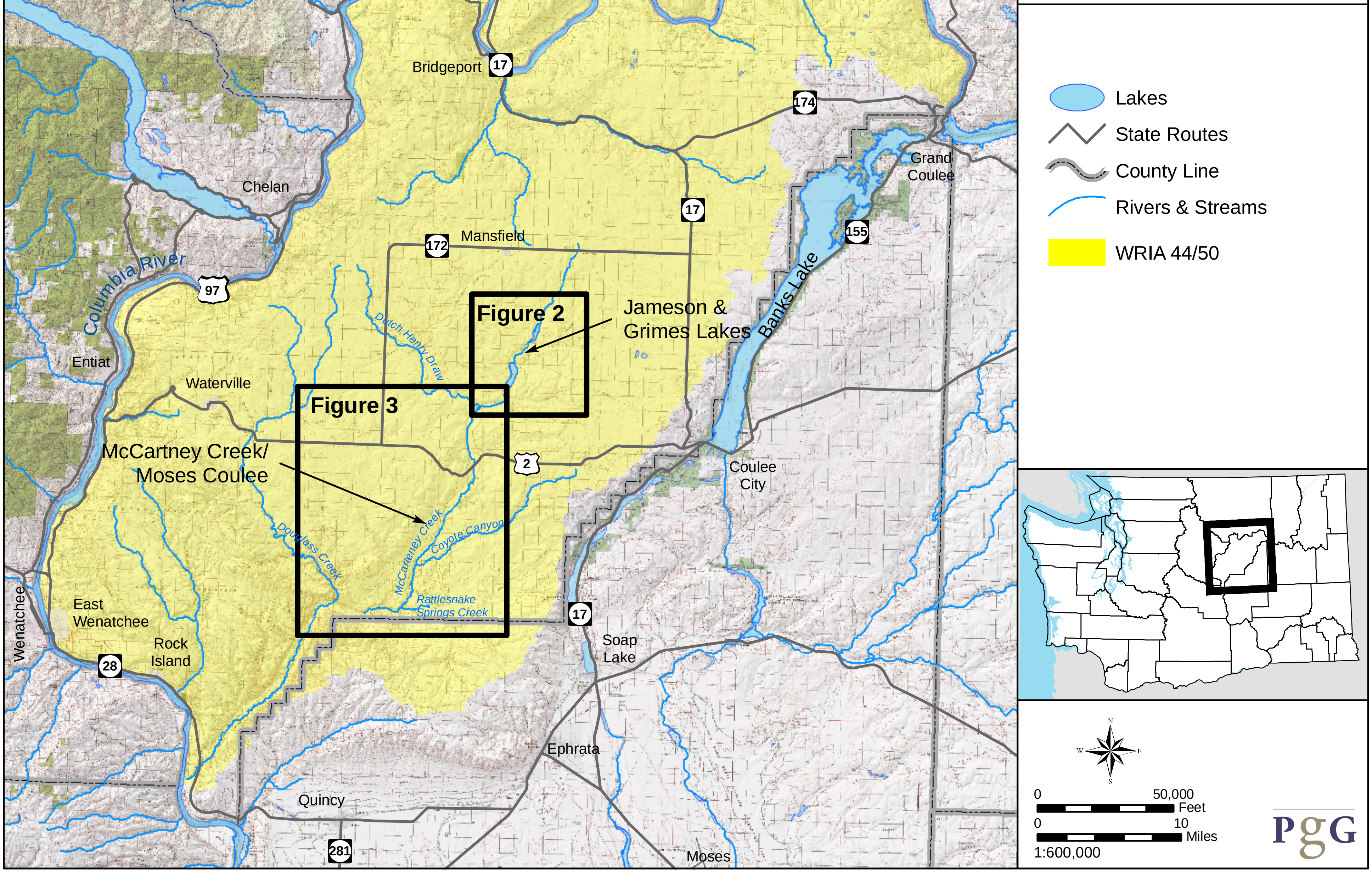
LMC #2 is a minimum value. The rate of seepage was greater than the rate at which water could be supplied to the pipe.

The results of LMC#1, LMC#2, and UMC#2 represent averages of more than one test.

WRIA 44/50 - Flooding Mitigation Hydrogeologic Assessment

FIGURE 1

Vicinity Map



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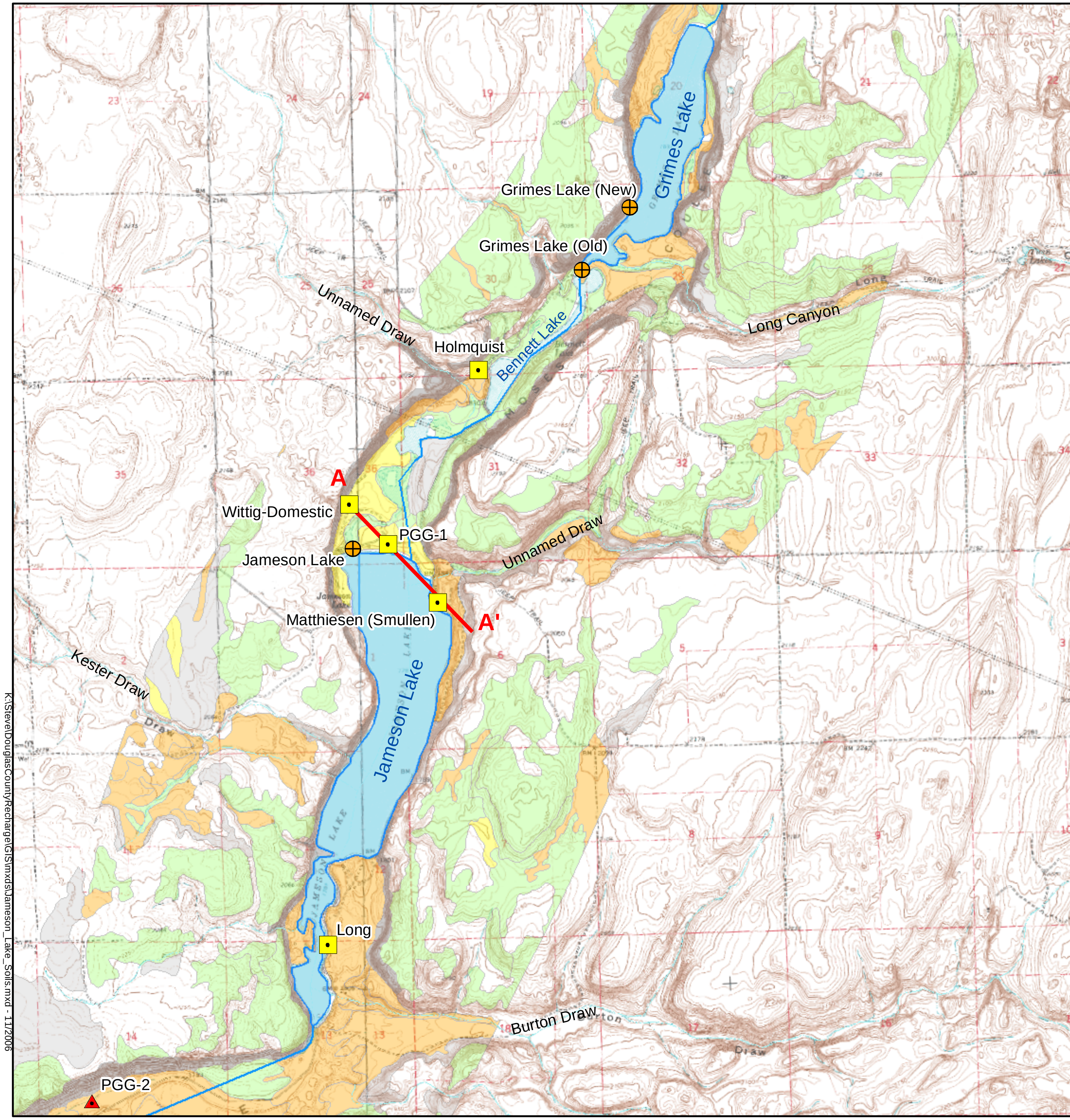
WRIA 44/50 - Flooding Mitigation
Hydrogeologic Assessment

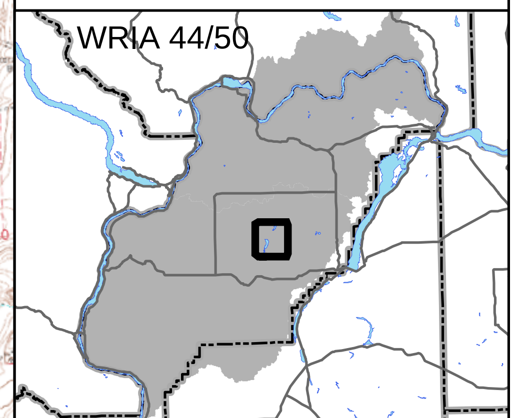
FIGURE 2

Jameson & Grimes Lakes Area Soil Textures



General Soil Texture (WA soils Data)

- Fine
- Medium
- Coarse
- Talus
- Bedrock
- Monitoring Well
- Lake Stations
- Alluvial Wells
- A-A' Cross-Section



0 1 Kilometers
0 4,000 Feet
0 0.5 Miles
1:48,000

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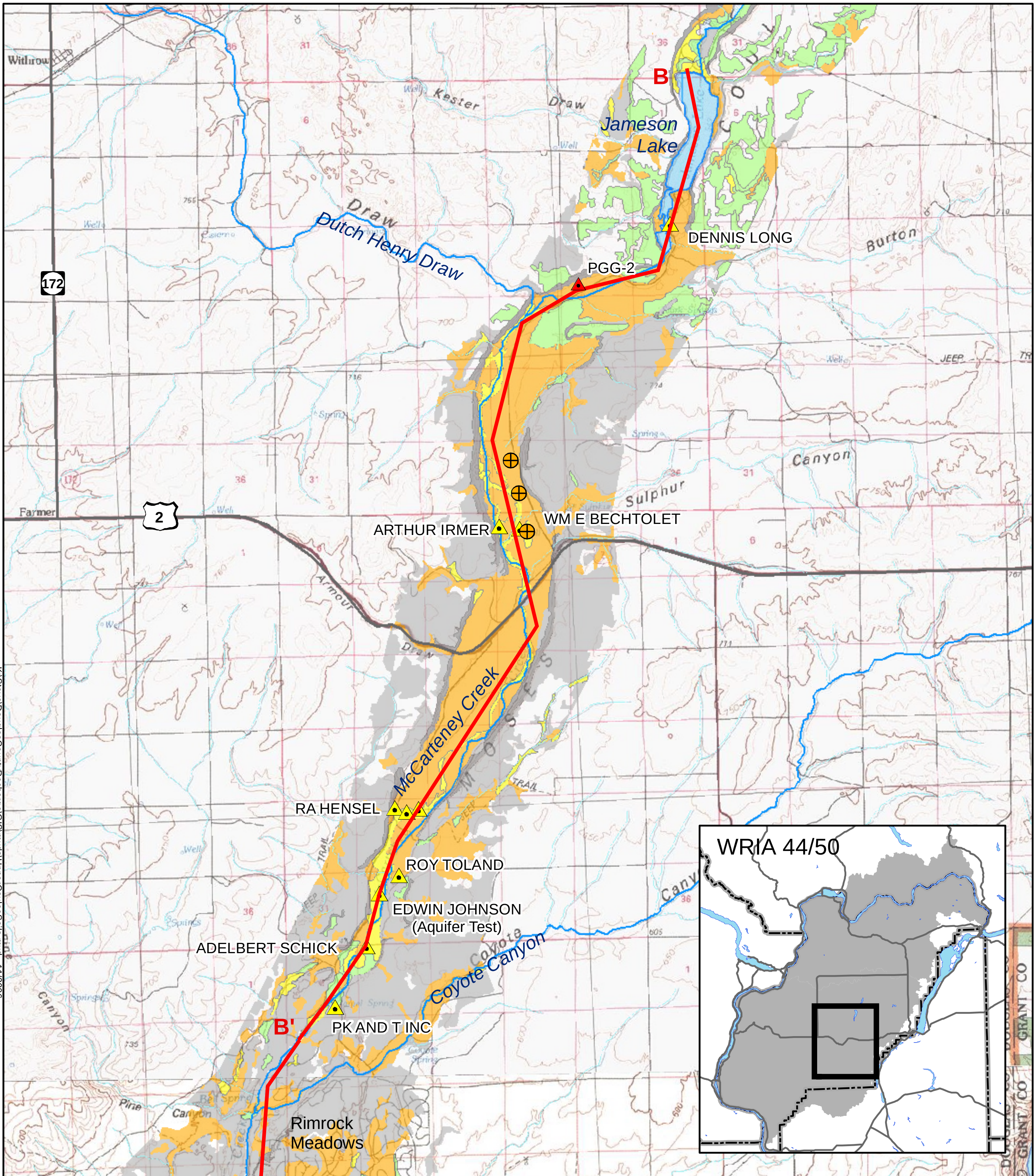

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General Soil Texture (WA Soils Data)

- Fine
- Medium
- Coarse
- Bedrock
- Talus

Permeability Field Test Locations

- Lower Moses Coulee
- Upper Moses Coulee
- B-B' Cross-Section
- Upper Moses Coulee Wells
- Monitoring Well

WRIA 44/50 - Flooding Mitigation
Hydrogeologic Assessment

FIGURE 3
Upper Moses Coulee Soil Textures

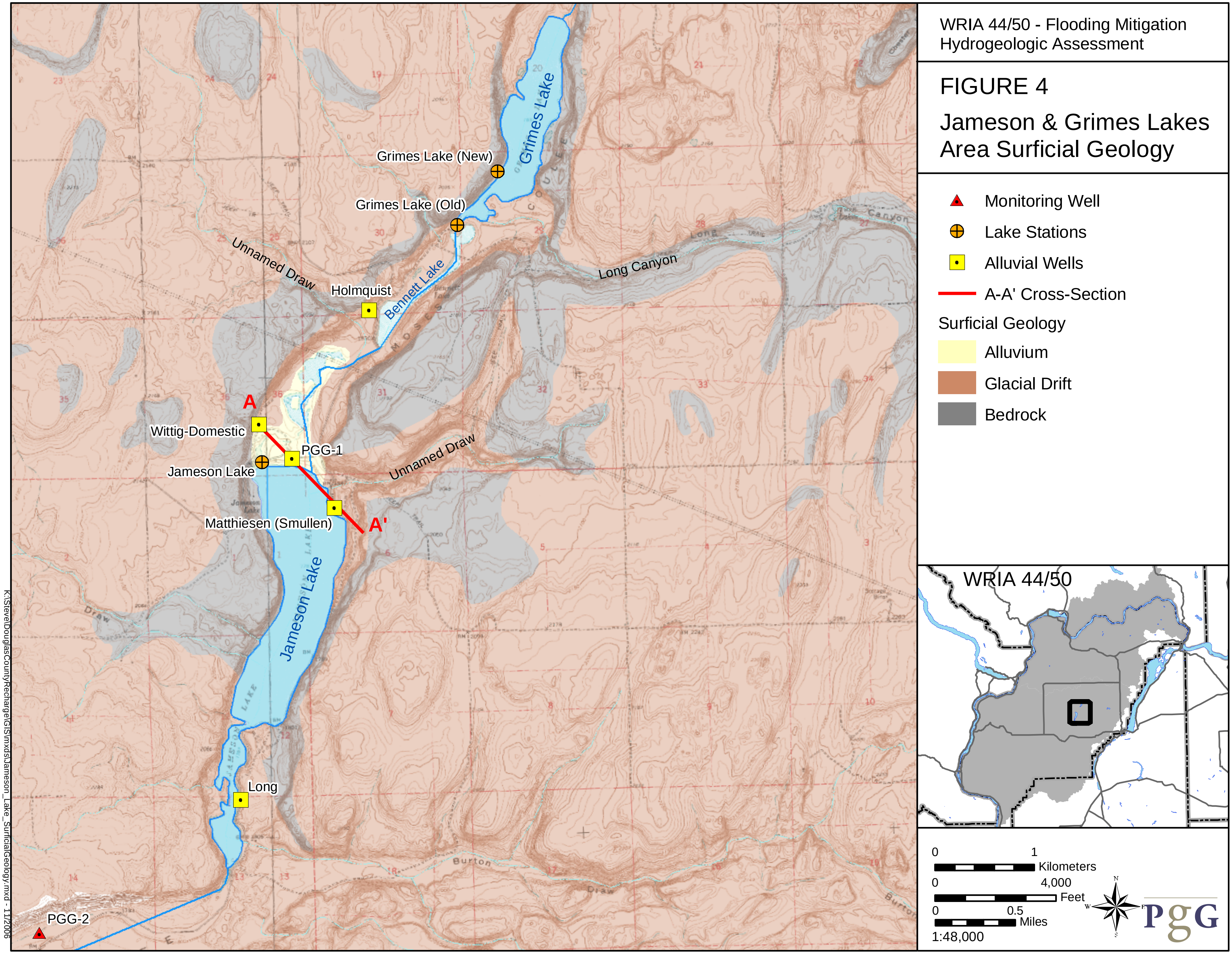
0 2 Kilometers
0 10,000 Feet
0 2 Miles
1:120,000

PGG

WRIA 44/50 - Flooding Mitigation
Hydrogeologic Assessment

FIGURE 4

Jameson & Grimes Lakes Area Surficial Geology



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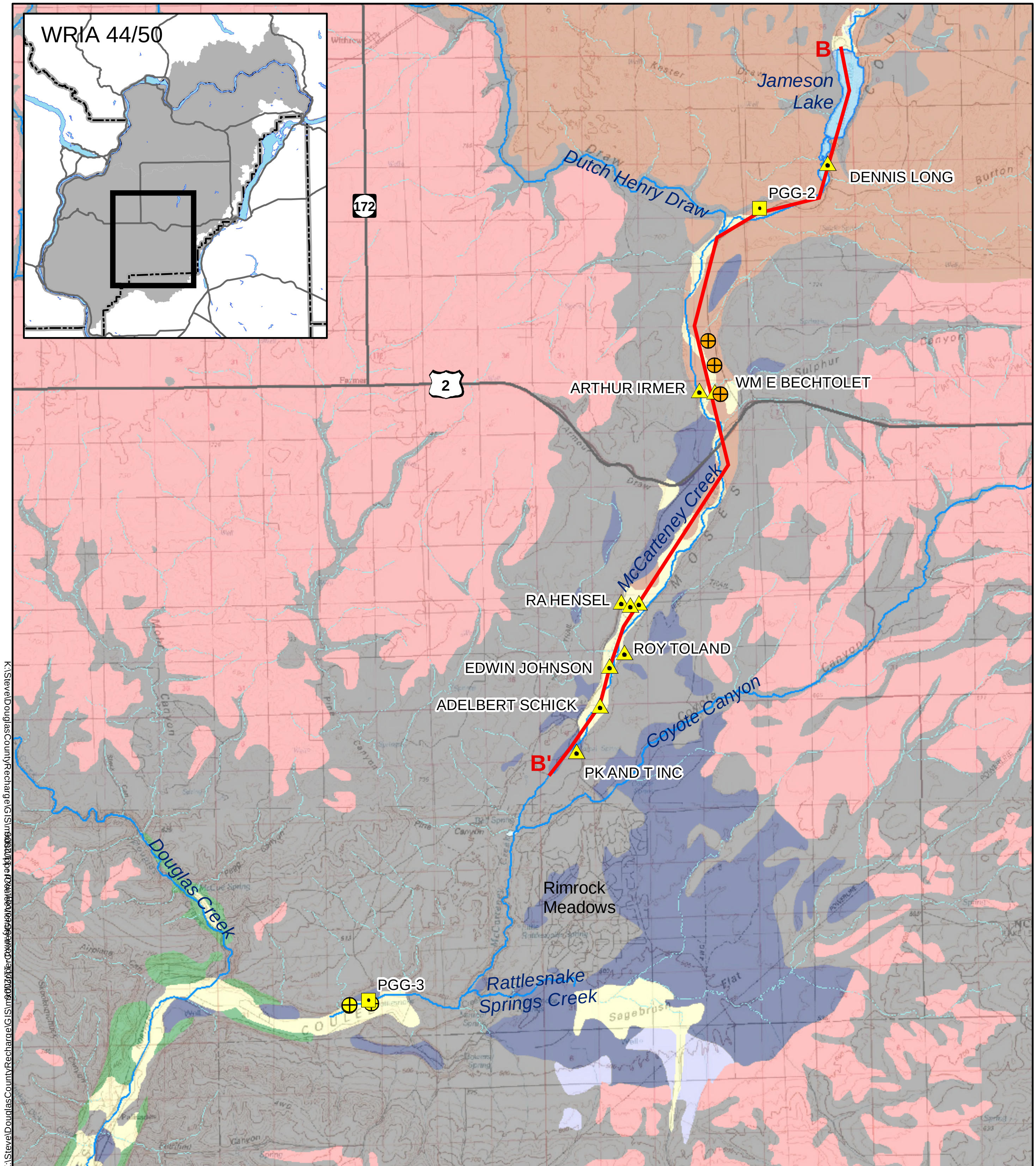


Surficial Geology

- Alluvium
- Glacial Drift
- Flood Deposits
- Loess
- Landslides
- Older Alluvium
- Bedrock

- B-B' Cross-Section
- Upper Moses Coulee Wells
- Monitoring Wells

Permeability Field Test Locations

- Lower Moses Coulee
- Upper Moses Coulee

WRIA 44/50 - Flooding Mitigation
Hydrogeologic Assessment

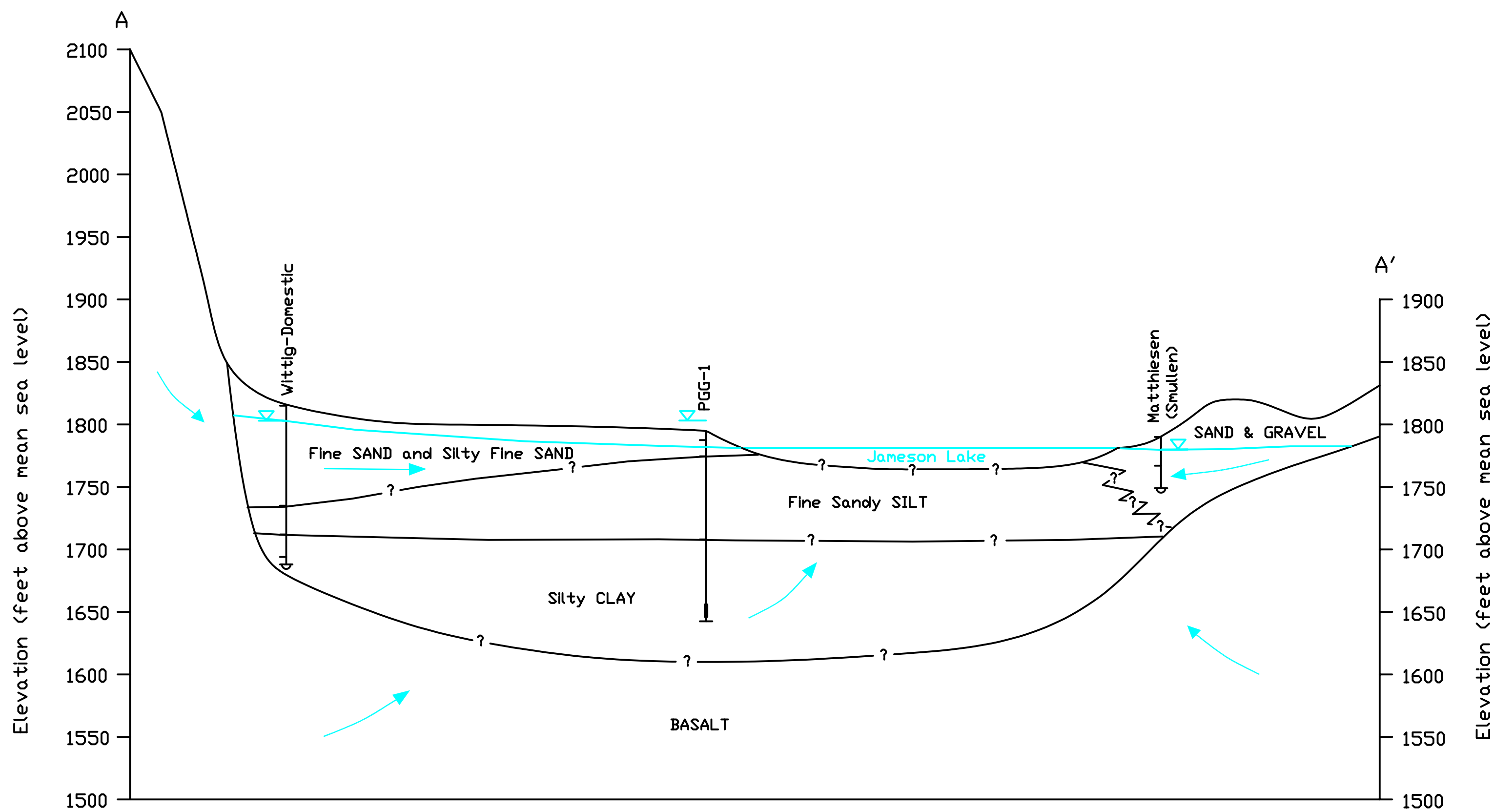
FIGURE 5

Moses Coulee Surficial Geology

0 2 Kilometers
0 10,000 Feet
0 2 Miles

1:158,400

PGG



Groundwater Flow Direction

Static Groundwater Level

Contact Inferred

?

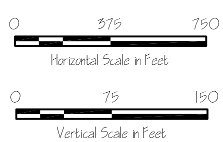


FIGURE 6

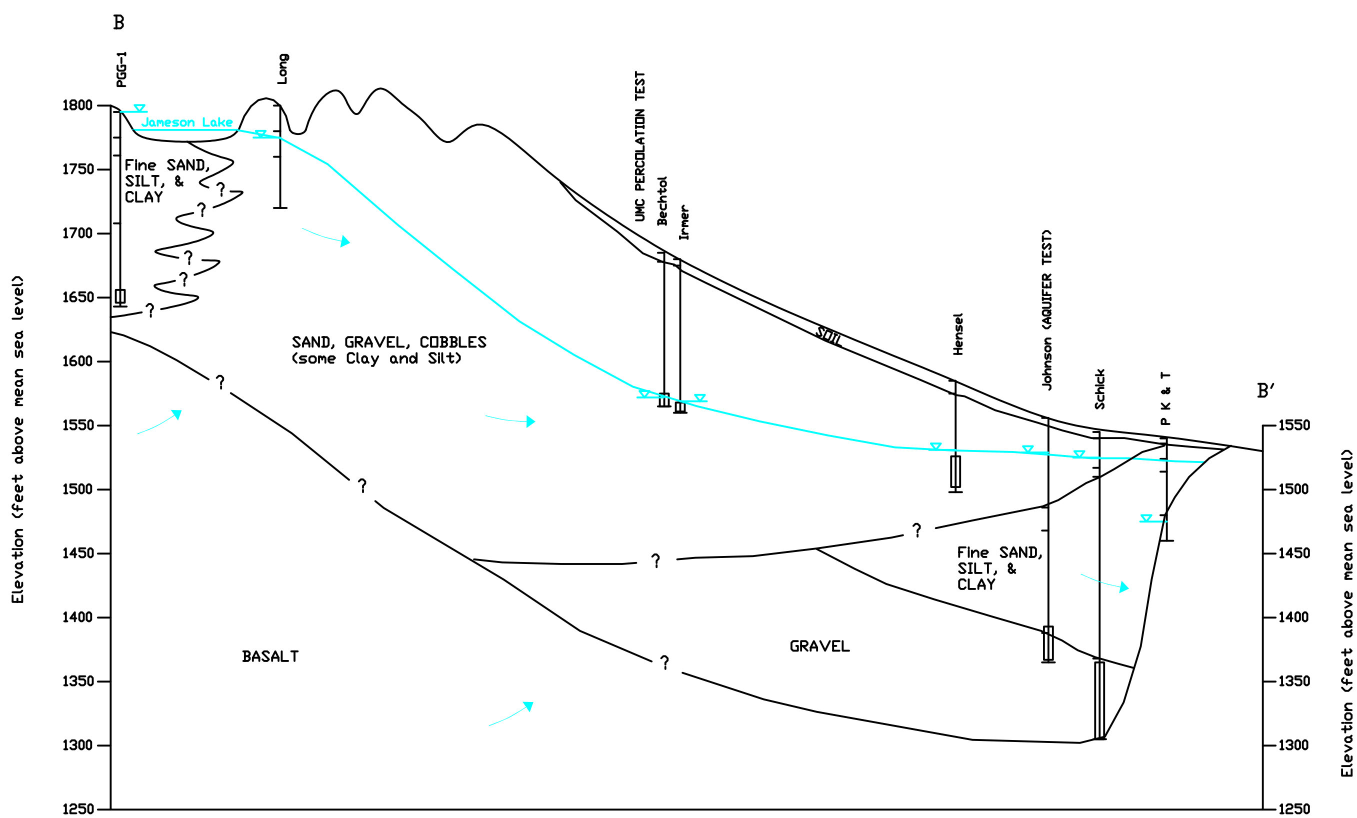
Jameson Lake

A-A' HYDROGEOLOGIC CROSS-SECTION

WRIA 44/50 Flooding Mitigation
Hydrogeologic Assessment
JS0604

A-A'_xsec.dwg

PGG



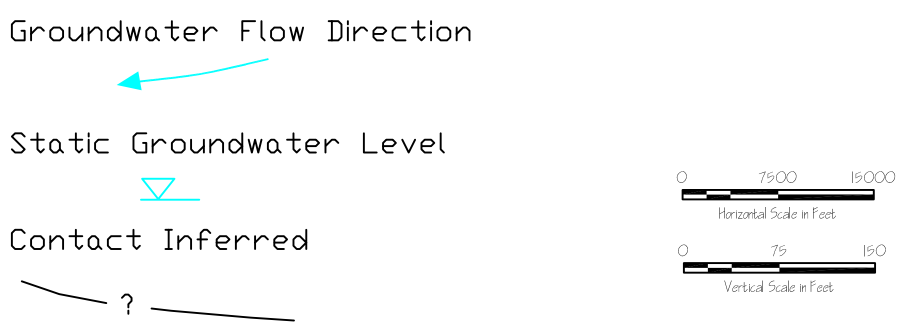


FIGURE 7

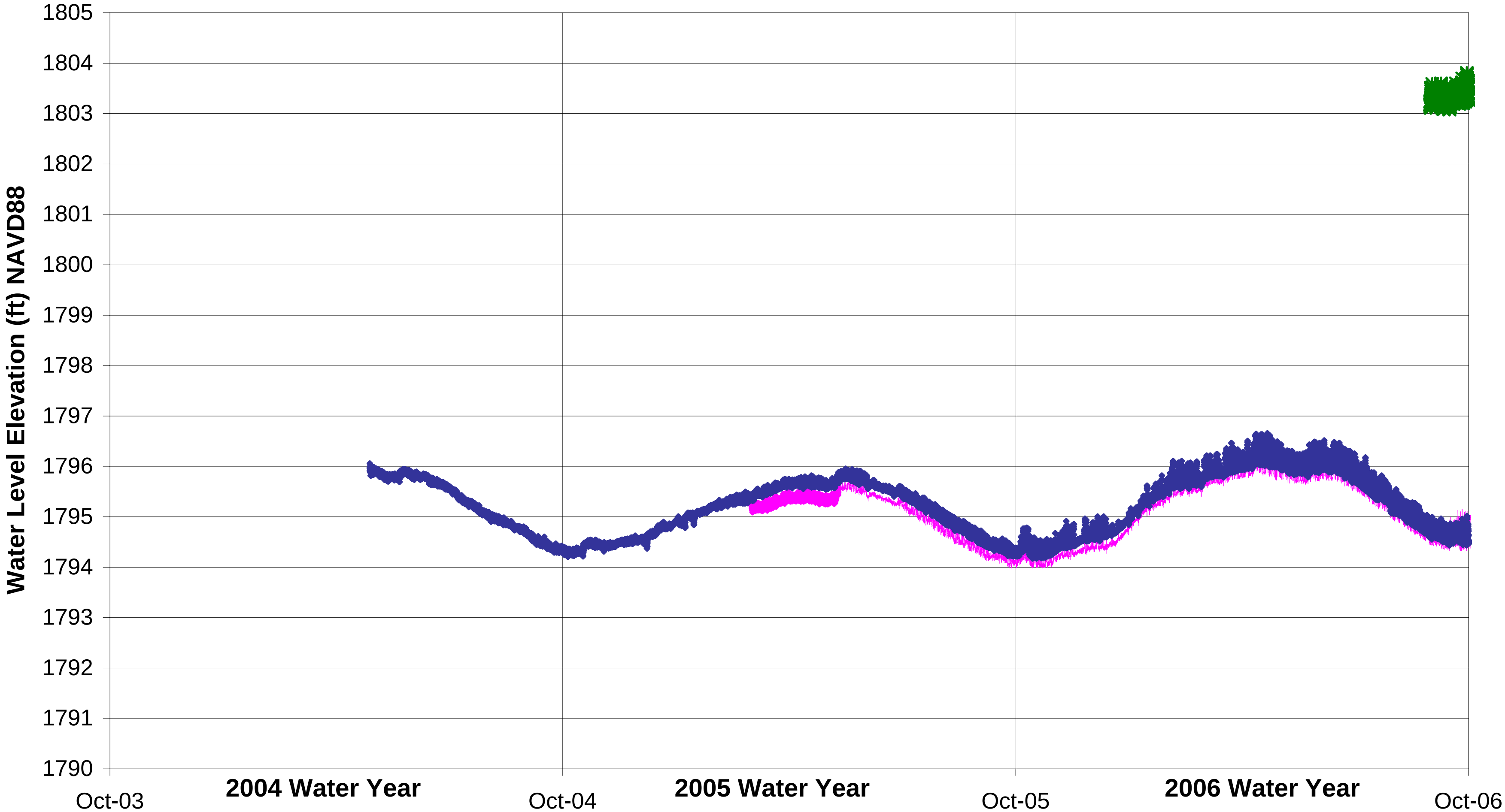
Upper Moses Coulee

B-B' HYDROGEOLOGIC CROSS-SECTION

WRIA 44/50 Flooding Mitigation
Hydrogeologic Assessment
JS0604

A-A'_xsec.dwg

PgG



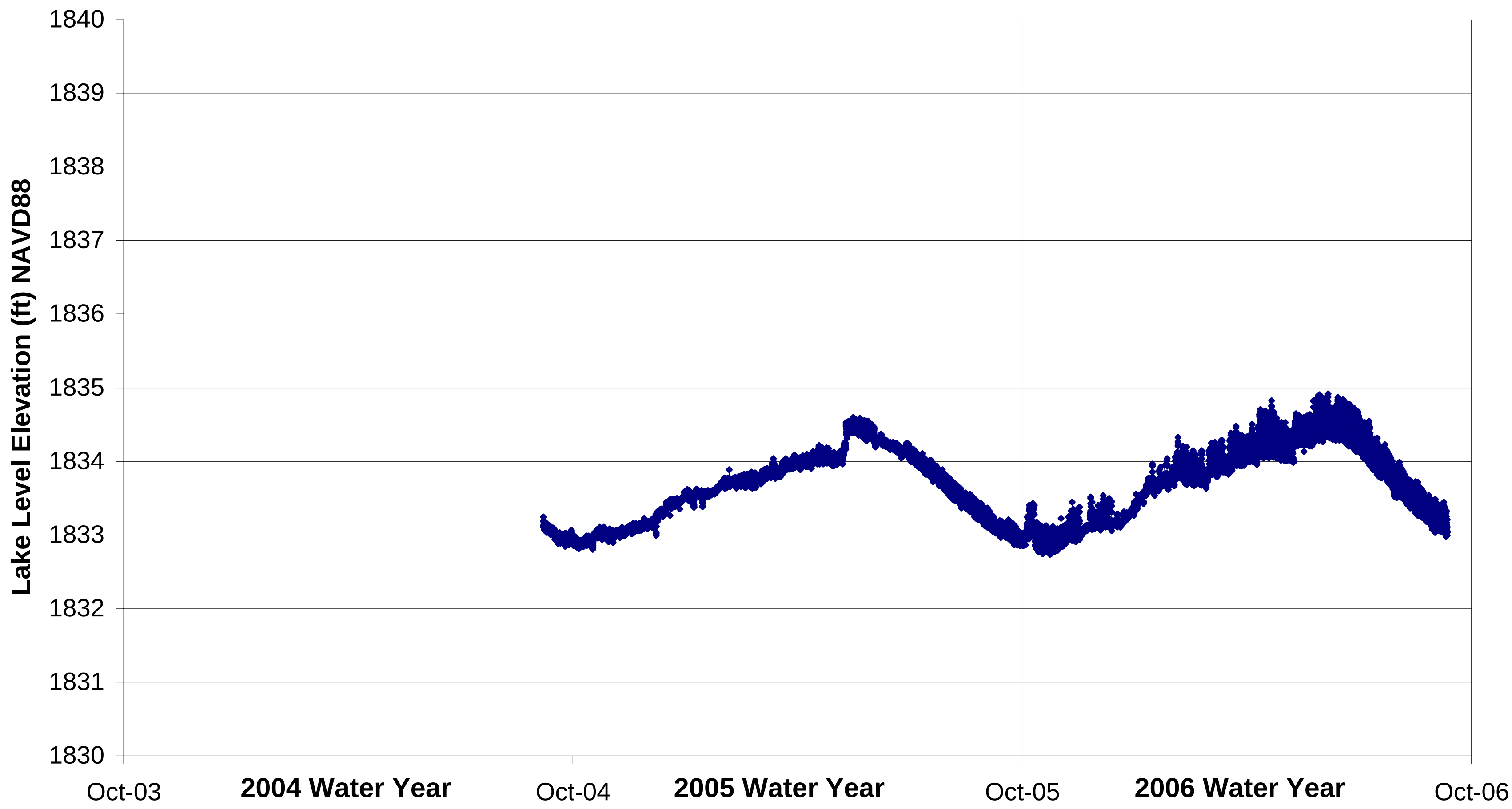
LEGEND

Jameson Lake
Matthiesen (Smullen) Well
PGG-1 Well

FIGURE 8
Jameson Lake, Matthiesen, and PGG-1 Hydrographs

WRIA 44/50
Flooding Mitigation - Hydrogeologic Assessmtn
JS0604

PGG



History of Grimes Station:
Originally 7.87' below Bench Mark (BM) = 1836.6
Spring 05 moved up 0.25 (7.62' below BM) = 1836.9
Spring 06 moved up anoth 0.47' (7.15' below BM) = 1837.4
Station Moved 9/12/06 to new location where less ice expected

FIGURE 9
Grimes Lake Hydrograph

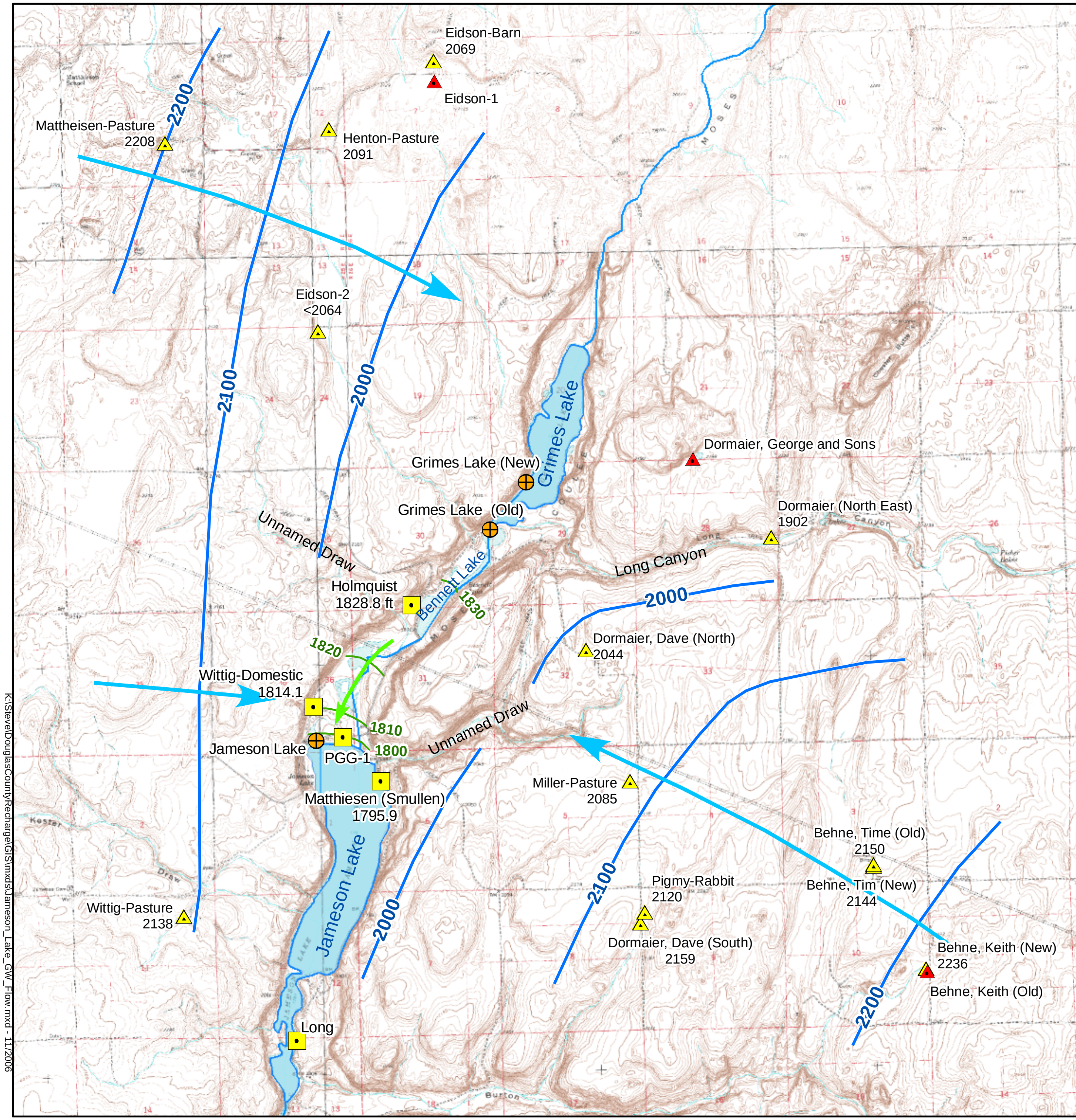
WRIA 44/50
Flooding Mitigation - Hydrogeologic Assessment
JS0604

PGG

WRIA 44/50 - Flooding Mitigation
Hydrogeologic Assessment

FIGURE 10

Jameson & Grimes Lakes Area Groundwater Elevations May 2006



2069 Shallow Basalt Wells With Groundwater Elevations

Deep Basalt Wells

Basalt Groundwater Elevation (ft)

Basalt Groundwater Flow Direction

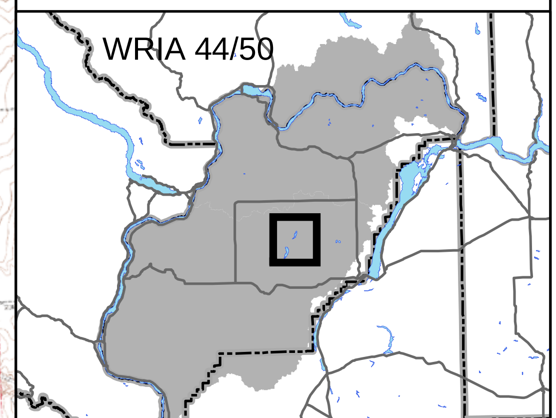
Lake Stations

Holmquist 1828.8 ft Alluvial Wells With Groundwater Elevations

Alluvial Groundwater Elevation (ft)

Alluvial Groundwater Flow Direction

Groundwater Elevations in NAVD88



0 1 Kilometers

0 5,000 Feet

0 1 Miles

1:63,360

PgG

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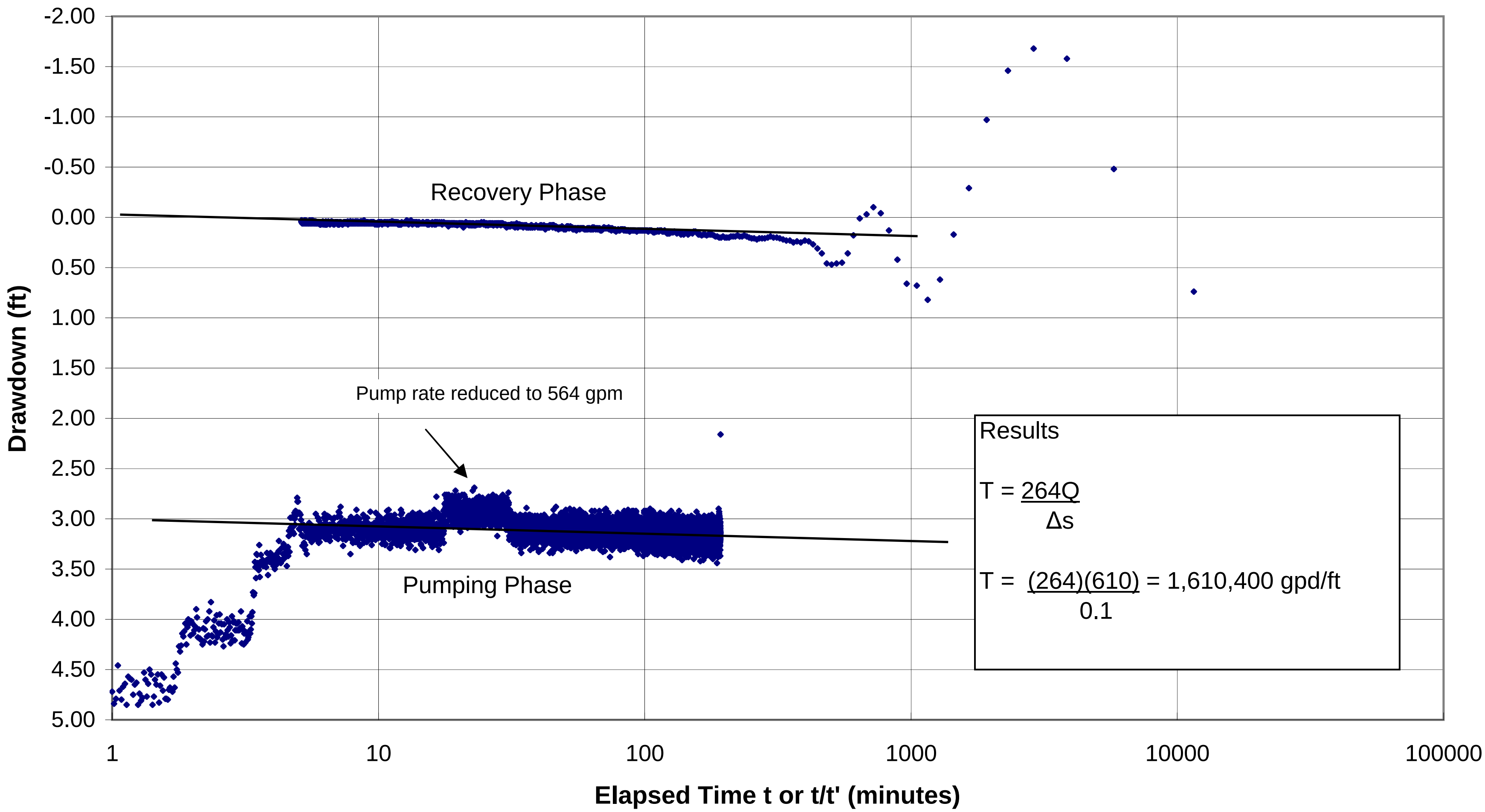


LEGEND

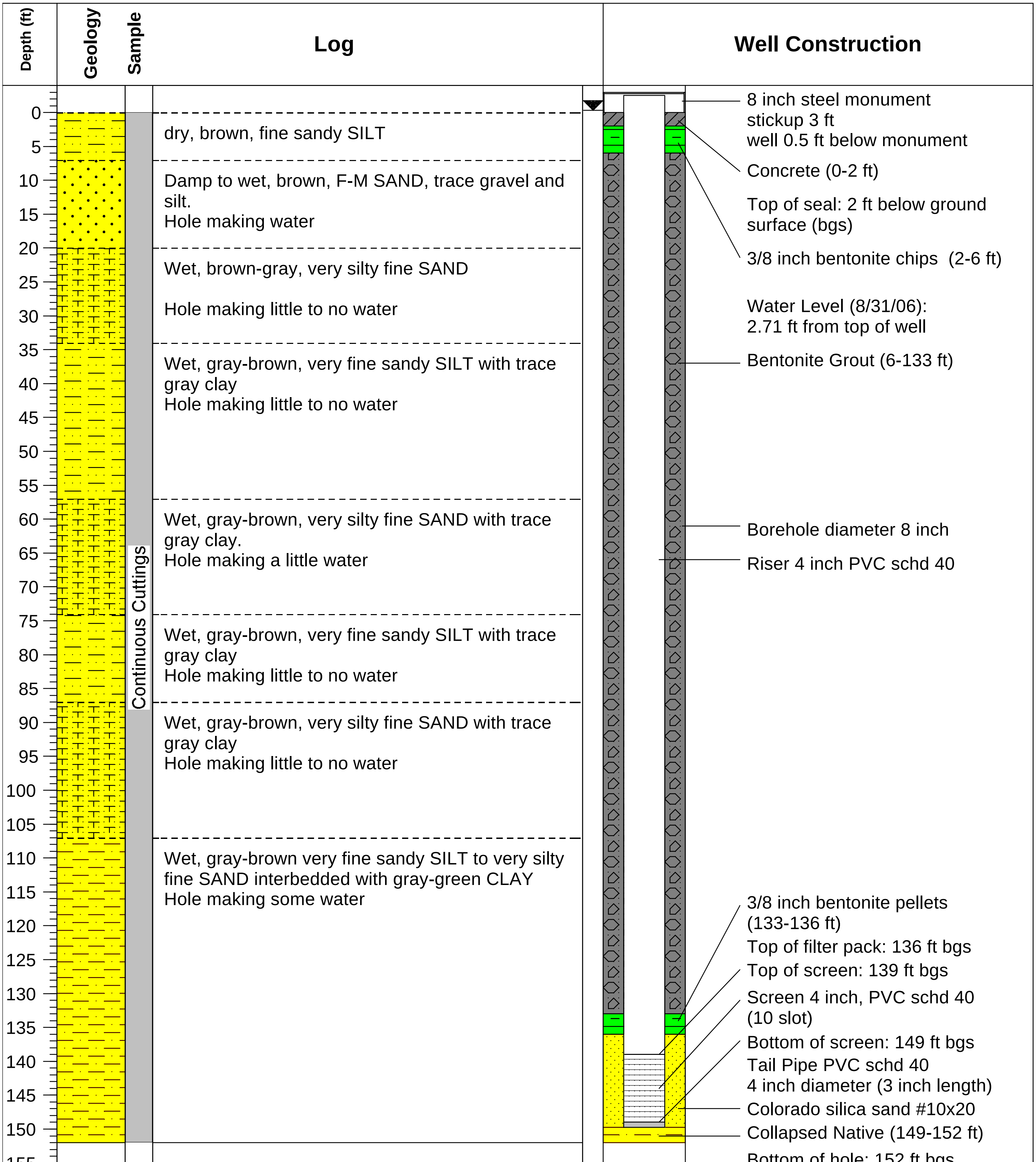
Pump Started: 9/19/06 11:20
Pump Stopped: 9/19/06 14:32
Pumping Rate = 610 gpm (except 15 minutes where one end gun off; 564 gpm)

FIGURE 11
Groundwater Level Drawdown
Johnson (Peterson) Pump Test

WRIA 44/50
Flood Mitigation
Hydrogeologic Assessment
JS0604

PgG

APPENDIX A
WELL LOGS



Project Name: Douglas County Recharge
Drilling Method: Air Rotary
Driller: Roy Sink
Firm: Environmental West Explorations
Consulting Firm: PGG
Logged by: Dawn Chapel
Location: Jameson Lake, Douglas County

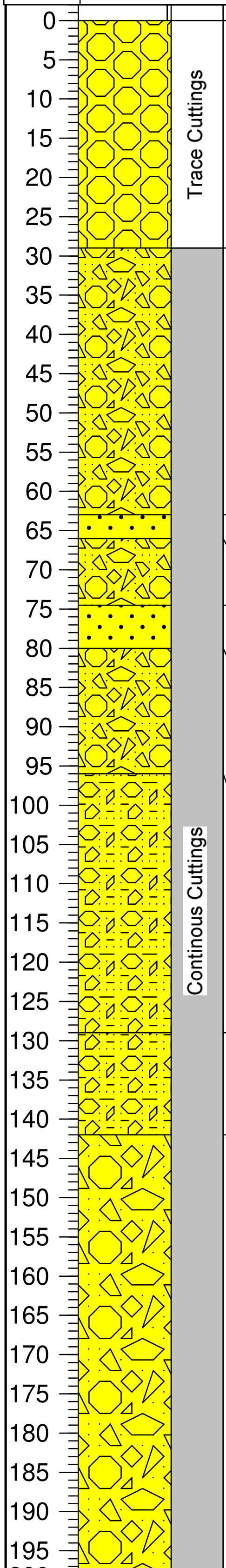
Well Name: PGG-1
UWID: APK319
MP Elevation: 1805.4059
Datum: NAVD88
Installed: 7/18/2006

Figure
GEOLOGIC LOG AND AS-BUILT FOR MONITORING WELL PGG-1

Douglas County Recharge
JS0604, PGG-1.ldf, 9/2006

PGG

Depth (ft)	Geology	Sample	Log	Well Construction



Sample: Trace Cuttings (0–30 ft); Continous Cuttings (30–200 ft)

Log

GRAVEL (predominantly rounded boulders and cobbles). Dry, light gray-brown slightly fine sandy, silt (loess) matrix (grain supported). Lithology mostly interpretive due to poor sample recovery (intermitant small, brown or white loess clouds, otherwise no cuttings. White loess clouds interpreted as volcanic ash).

Moist, dark gray, GRAVEL and SAND. Intermittant sand layers, mostly rounded to subrounded gravel and cobbles.

40 ft: sand content increases, is mixed with gravel and not limitted to intermittant sand layers.

Moist, dark brown, slightly gravelly, fine to coarse SAND

Moist, dark brown, fine to coarse SAND AND GRAVEL

Moist, dark brown, fine to medium SAND. Gravelly sand interbeds present.

Moist, dark brown, very fine to coarse sandy, fine GRAVEL.

90 ft: trace silt now present

95 - 95.5 ft: brown, slightly silty, fine SAND

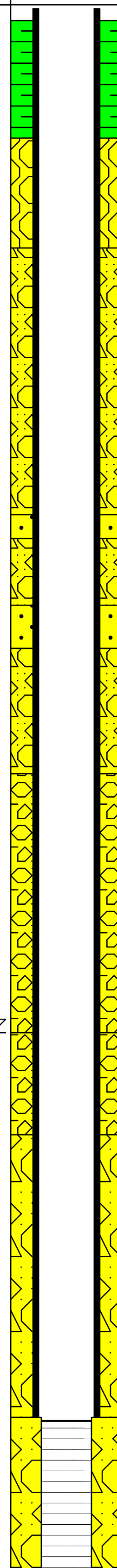
Moist, dark brown, sandy, GRAVEL. Fine sandy silt layers (<5 " thick) periodically interbedded.

120 ft: moisture content increases

Wet, dark brown, silty, very fine to coarse sandy, GRAVEL

Highly fractured BASALT and trace river alluvium (subrounded gravel). Purge water brown, high silt/clay content. Basalt is interpretted as large, poorly sorted boulders (colluvium/talus slope) or a highly fractured flow top since casing drives easily.

Well Construction



Monument: approximately 1.5 ft stickup, steel plate welded over opening

0 - 15 ft: 10" borehole, 6" steel casing

Seal Material: 0 - 15 ft Casing Seal (bentonite of various sizes), Casing Seal added as needed and as steel casing lubricant.

15 - 178 ft: 6" borehole, steel casing with welded joints

Depth to water while drilling: ~129 ft

178 - 198 ft: 4.5" stainless steel screen with 0.020" slots.

Project Name: Douglas County Flood Mitigation
Drilling Method: Air Rotary
Driller: Larry Webley
Firm: Empire Well Drilling
Consulting Firm: Pacific Groundwater Group
Logged by: Glenn Mutti
Location: SW1/4 of Section 14 T25N R25E

Well Name: PGG-2
Ecology ID: APC-575
MP Elevation: not surveyed
Installed: 6/14/2007 - 6/15/2007
6/27/2007
DTW: 129 ft

GEOLOGIC LOG AND AS-BUILT FOR WELL PGG-2

Douglas County Flood Mitigation
Coulee City, Washington

PGG

JE0604, 7/2007

Depth (ft)	Geology	Sample	Circ Water	Log
0 - 18	Gravel	Contn Cuttings	Circ Water Pres	Dry, light brown-gray, GRAVEL. Rounded to subrounded cobbles, sandy silt (loess) matrix. Circulation water present.
18 - 77	Gravel	Cuttings Generally Absent (to ~71 ft)	Circulation Water Lost (18 - 42 ft)	GRAVEL (cobbles and boulders). Rough drill action, no sediments ejected, circulation water lost. Lithology mostly interpretive due to limitted sample recovery. 42 - 53 ft: circulation water returns, trace ground basalt in drill fluid 53 ft: circulation water lost, rough and slow drilling. 55 ft: circulation water retained, trace ground basalt in drill fluid. 56 - 63 ft: circulation water lost, no cuttings ejected. 63 - 67 ft: circulation water returns, small quantities of ground basalt cobbles and trace gravel (subrounded, weathered brown-gray gravel of basalt composition) ejected in drill fluid. 67 - 71 ft: lost circulation fluid 71 - 77 ft: circulation fluid returns, substantial cuttings present (gravel and cobble composition).
77 - 155	Basalt	Continuous Cuttings	Circulation Water Present	Black BASALT. 103 - 155 ft: purge water clay and silt rich
155 - 178	Fractured basalt	Continuous Cuttings	Circulation Water Present	Dark brown, fractured BASALT. Interpreted as basalt flow top due to weathered apperance, presence of soft brown secondary minerals, trace pumice from 155 - 170 ft, and recurring hole collapse.

Well Construction

Monument: approximately 1.5 ft stickup, steel plate welded over opening

0 - 15 ft: 10" borehole, 8" steel casing

Seal Material: 0 - 15 ft Casing Seal (bentonite of various sizes), Casing Seal added as needed and as steel casing lubricant.

15 - 77 ft: 8" borehole, 8" steel casing with welded joints

77 - 178 ft: 8" borehole, no casing

Bottom of Hole: ~178 ft. Drilling terminated as repeated side-wall collapses required additional casing.

Project Name: Douglas County Flood Mitigation
Drilling Method: Air Rotary
Driller: Larry Webley
Firm: Empire Well Drilling
Consulting Firm: Pacific Groundwater Group
Logged by: Glenn Mutti
Location: NE1/4 of Section 33 T23N R24E

Well Name: PGG-3
Ecology ID: BAC-664
MP Elevation: not surveyed
Installed: 6/11/2007 - 6/13/2007
DTW: Dry

GEOLOGIC LOG AND AS-BUILT FOR BOREHOLE PGG-3

Douglas County Flood Mitigation
Palisades, Washington

JE0604, 7/2007

PGG

Summary of Water Well Report

Start Card 56839
UWID ABQ 377

Owner: Norm Holmquist
Address: 623 N Jameson Lake Road, Mansfield, WA 98830
Well Location: SE1/4 SW1/4 Sec 30 T25 R25

Propsed Use: Domestic
Drilling Method: Rotary

Dimensions: 6-inch diameter well, drilled 80 feet, depth of completed well 80 feet

Construction details: 6-inch casing installed 0 feet to 37 feet

Perforations: No
Well Screen: No

Seal: Bentonite to 18 feet

Water level: 27 feet below top of well

Well Test Yield: 15 gpm

Work Started 3/12/1997
Work Completed 3/25/1997

Well Log:

Material	From	To
Sand and gravel	0	30 ft
Broken Basalt	30	36 ft
Med. Hard Basalt	36	80 ft

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

Start Card No. 029000

Water Right Permit No. ____

(1) OWNER: Name Denny Smullen Address 23331 Woods Cr. Rd Snohomish WA

(2) LOCATION OF WELL: County Douglas Lot 4 ¼ NW ¼ Sec 5 T 25 N., R 26 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Jamison Lake Resort

(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) 2
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [ ] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 40 feet. Depth of completed well 41 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 39 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? 18 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 1600 ft.
Static level 12 ft. below top of well Date 10/18/90
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 [X] If yes, by whom? ____
Yield: 30 gal./min. with ____ ft. drawdown after ____ hrs.
" EST AIR Lift " "

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 [X]

(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
Overburden	0	3
Sand & Gravel, Dk Brown, Dry	3	12
Sand & Gravel, Moist	12	23
Gravel, Water bearing, w/ Broken Basalt	23	41

31090

Work started 10/17, 1990 Completed 10/18, 1990

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 (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 316 W 5th Colville WA. 99114
(Signed) Mike Lozen (WELL DRILLER) License No. 1451
Contractor's Registration No. PS194MF Date 10/18, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

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

2064

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. ...... B

(1) OWNER: Name Dave Dormaier Address Box 117 Hartline 99135

(2) LOCATION OF WELL: County Douglas NW ¼ NE ¼ Sec 32 T 26 N., R 26 W.M.

Bearing and distance from section or subdivision corner

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

(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 95 ft. Depth of completed well 95 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 20 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? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name Grundfos
Type: Submersable H.P. 1/2

(8) WATER LEVELS: Land-surface elevation above mean sea level ...... ft.
Static level 40 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: 20 gal./min. with 0 ft. drawdown after 1 1/2 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.
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
Soil	0	2'
Hard Basalt	2	70
Med Brown Rock & Water	70	90
Hard Basalt	90	95

RECEIVED [illegible] 17 1989 DEPARTMENT OF [illegible] CENTRAL REGION [illegible]

RECEIVED AUG - 2 1989 DEPARTMENT OF ECOLOGY SPOKANE REGIONAL [illegible]

Work started 4-10, 1989 Completed 4-14-, 1989

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 Four Star Drilling (Person, firm, or corporation) (Type or print)

Address Box 37 Hartline Wa.

[Signed] [signature] (Well Driller)

License No. 124 Date 4-30, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

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. W056804
AAK 351

Water Right Permit No.

(1) OWNER: Name Dave Dormaier Address Hartline Wa.

(2) LOCATION OF WELL: County Douglas SE ¼ NE ¼ Sec. 8 T. 28 N., R. 26 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

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

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

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 110 feet. Depth of completed well 110 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6 " Diam. from 0 ft. to 18 ft.
Welded ☐ " Diam. from ft. to ft.
Liner installed ☒ " Diam. from ft. to ft.
Threaded ☐

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? 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 40 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: 5-6 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 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
Soil	0	4
Med Brn Basalt	4	110
4" Liner Instulled		

Work started 10-11, 19. Completed 10-13, 1994

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 Four Star Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Box 37 Hartline Wa.
(Signed) [signature] (WELL DRILLER) License No. 124
Contractor's Registration No. FOURSDW06 Date 10-20-, 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

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

Start Card No. W056834
UNIQUE WELL I.D. # ABB 371
Water Right Permit No. ______

(1) OWNER: Name Dennis Long Address 2405 Park St. Snohomish 98290

(2) LOCATION OF WELL: County Douglas NW 1/4 NW 1/4 Sec 13 T. 25 N., R. 25 W.M.

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

(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 [X] New well [ ] Deepened [ ] Reconditioned
Method: [ ] Dug [ ] Cable [X] Rotary [ ] Bored [ ] Driven [ ] Jetted

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 80 feet. Depth of completed well ______ ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 55 ft.
[ ] Welded ______" Diam. from ______ ft. to ______ ft.
[ ] Liner installed ______" Diam. from ______ ft. to ______ ft.
[ ] Threaded

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? 18 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 ______ ft.
Static level 25' 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: 15 gal./min. with 0 ft. drawdown after 4 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 ______ 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
Sand & gravel	0	20
Sand	20	40
Fine Sand	40	80

RECEIVED OCT 3 DEPARTMENT OF ECOLOGY

RECEIVED SEP 18 1996 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 10-3, 19__. Completed 10-7, 1996

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 Four Star Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Box 37 Hartline Wa.
(Signed) [signature] (WELL DRILLER) License No. 124

Contractor's Registration No. FOURSD110D6 Date 10-7, 1996

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

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

4040

Start Card No. 029000

Water Right Permit No. ____

D

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

(1) OWNER: Name Denny Smullen Address 23331 Woods Cr. Rd Snohomish WA

(2) LOCATION OF WELL: County Douglas Lot 4 ¼ NW ¼ Sec 5 T. 25 N., R. 26 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Jamison Lake Resort

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

(4) TYPE OF WORK: Owner's number of well (if more than one) 2
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 40 feet. Depth of completed well 41 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 39 ft.
Welded ☒ Liner installed ☐ Threaded ☐
____ " Diam. from ____ ft. to ____ ft.
____ " 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? ____ 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 1600 ft.
Static level 12 ft. below top of well Date 10/18/90
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.
" EST AIR Lift " "
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
Overburden	0	3
Sand & Gravel, Dk Brown, Dry	3	12
Sand & Gravel, Moist	12	23
Gravel, Water bearing, w/ Broken Basalt	23	41

31090

Work started 10/17, 1990 Completed 10/18, 1990

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 (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 316 W 5th Colville WA. 99114
(Signed) Mike Loopm (WELL DRILLER) License No. 1451
Contractor's Registration No. PS194MF Date 10/18, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

WATER WELL REPORT

Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

179926

Construction/Decommission *("x" in circle)*
- ○ Construction
- ○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ______

CURRENT Notice of Intent No. W 211151

Unique Ecology Well ID Tag No. AHC 857

Water Right Permit No. ______

Property Owner Name George Dormaier & Son's

Well Street Address 8.5 & I Roads

City Mansfield County: Douglas

Location SE 1/4-1/4 SE 1/4 Sec 21 Twn 26 R 26 EWM or WWM *circle one*

Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☒ Other Stock

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

DIMENSIONS: Diameter of well 6 inches, drilled 225 ft.
Depth of completed well 214 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam. from 0 ft. to 20 ft.
☐ Liner installed ___" Diam. from ___ ft. to ___ ft.
☐ Threaded ___" Diam. from ___ ft. to ___ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ___ in. by ___ in. and no. of perfs ___ from ___ ft. to ___ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ___ Slot Size ___ from ___ ft. to ___ ft.
Diam. ___ Slot Size ___ from ___ ft. to ___ ft.

Gravel/Filter packed: ☐ Yes ☐ No ☐ Size of gravel/sand ______
Materials placed from ___ ft. to ___ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 178 ft. below top of well Date ______
Artesian pressure ___ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

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.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
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 1.5 gal./min. with stem set at 212 ft. for 1 hrs.
Artesian flow ___ g.p.m. Date ______
Temperature of water ___ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
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 information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Grey Silt Clay	0	3
gravel Bolders	3	20
Med Basalt & Brasilt	20	90'
Hard Basalt	90	180
Brn Basalt	180	185
Hard Basalt	185	220
Brn Basalt Cracces	220	225

RECEIVED SEP 15 2005 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 8-10 Completed Date 8-12-05

WELL CONSTRUCTION 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.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Fred Emerson
Driller/Engineer/Trainee Signature Fred Emerson
Driller or Trainee License No. 2604

If trainee, licensed driller's Signature and License no. ______

Drilling Company Four Star Drilling
Address PO Box 37
City, State, Zip Hartline Wa. 99135
Contractor's Registration No. FOURSDI10D6 Date 7-15-05

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

97455

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 W090981
UNIQUE WELL I D # AEH 213
Water Right Permit No. ______

(1) OWNER: Name Keith Behne Address Hartline Wa 99135

(2) LOCATION OF WELL County Douglas NE 1/4 NE 1/4 Sec 10 T 25 N, R 26 WM

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

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

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

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 360 feet Depth of completed well 90 ft

(6) CONSTRUCTION DETAILS.
Casing installed: 6" Diam from 0 ft to 45 ft
Welded ☒ ______" Diam from ______ ft to ______ ft
Liner installed ☐ ______" Diam from ______ ft to ______ ft
Threaded ☐

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? ______ 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 23 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 2-5 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 ______ 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
Soil Bolders	0	20
Broken Basalt & Clay	20	45
Med Brn Basalt & Clay	45	60
Med Basalt	60	130
Brn Basalt	130	140
Hard Basalt	140	230
Red & Brn Basalt	230	240
Hard Basalt	240	360

DEPT OF ECOLOGY Received NOV 3 2000 CENTRAL REGION OFFICE

RECEIVED OCT 25 2000 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 10-2, 19 Completed 10-10, 19 00

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 Four Star Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P.O. Box 37 Hartline Wa.
(Signed) [signature] (WELL DRILLER) License No 124
Contractor's Registration No FOUR SD*40 D6 Date 10-11, 19 00

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer For special accommodation needs, contact the Water Resources Program at (206) 407-6600 The TDD number is (206) 407-6006

628

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. 006214

Water Right Permit No. ______

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

(1) OWNER: Name Paul Wittig Address P O Box 286 Mansfield Wa.

(2) LOCATION OF WELL: County Douglas SE ¼ NE ¼ Sec 2 T 25 N., R 25 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) ______

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

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

(5) DIMENSIONS: Diameter of well 12 10 inches.
Drilled Reamed feet. Depth of completed well 387 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 12 " Diam. from 0 ft. to 208 ft.
Welded ☒ 12 " Diam. from 0 ft. to 208 ft.
Liner installed ☒
Threaded ☐ ______ " 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? ______ ft.
Material used in seal Do not know
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 157 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 ______ 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
This well was already drilled to 387 and Joy Drilling Co just reamed it. we reamed 11/78 from 208 t0 259 then 10 in. from 259 to 387		
broken brown basalt	208	238
black basalt	238	288
Brown basalt	288	301
black basalt	301	379
brown red black basalt (water)	379	387
A vidio picture was taken of this well and that is where the liner depth came from, it was already installed.		
Lost all gage buttons out of bit at 259 that is the reason for reducing to 10 in.		

Work started 4-6-89, 19. Completed 4-12-89, 19

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 Joy Drilling Co. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Moses Lake Wa.
(Signed) Jim Stens (WELL DRILLER) License No. 0469
Contractor's Registration No. JOY DRC 1370 H Date 4-19-89, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

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

File Original with Department of Ecology 104295
Second Copy - Owner's Copy
Third Copy - Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W129781
UNIQUE WELL I.D. # AEQ589
Water Right Permit No.

(1) OWNER: Name Paul Wittig Address 645 N Jameson Lk Rd, Mansfield WA

(2) LOCATION OF WELL: County Douglas SW 1/4 SW 1/4 Sec 36 T 26 N R. 25 ~~WM~~

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

TAX PARCEL NO.: N

(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)
[X] New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method: ☐ Dug ☐ Cable [X] Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 127 feet. Depth of completed well 125 ft.

(6) CONSTRUCTION DETAILS
Casing Installed:
[X] Welded 6" Diam from +1 ft to 125 ft
☐ Liner installed " Diam. from ft. to ft
☐ Threaded " Diam. from ft to ft

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

Screens: ☐ Yes [X] No ☐ K-Pac Location
Manufacturer's Name
Type Model No
Diam. Slot Size from ft to ft
Diam. Slot Size from ft to ft

Gravel/Filter packed: ☐ Yes [X] No ☐ Size of gravel/sand
Material 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 [X] 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 12' ft. below top of well Date 7-30-01
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
Yield: gal./min with ft drawdown after hrs.
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 6 gal./min with 124 ft drawdown after 4 hrs
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ☐ Yes ☐ No

(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 information. Indicate all water encountered.

MATERIAL	FROM	TO
Top Soil - Broken Basalt	0	4
Sandy loam	4	13
Sandy loam - Broken Basalt	13	15
Sandy Loam	15	25
Silty Sand	25	80
grey clay	80	82
Fine Sandy Silt	82	103
Clay	103	119
Clay - Broken Basalt	119	121
Basalt gravel	121	127

DEPT OF ECOLOGY Received JAN 02 2002 CENTRAL REGION OFFICE

DEPT OF ECOLOGY Received SEP 06 2001 CENTRAL REGION OFFICE

Work Started 7-30, 01 Completed 7-30, 01

WELL CONSTRUCTION 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.

Type or Print Name David B OConnell License No 0358 (Licensed Driller/Engineer)
Trainee Name License No
Drilling Company O'Connell Drilling
(Signed) David B OConnell License No 0358 (Licensed Driller/Engineer)
Address 650 Pearl Hill Rd, Bridgeport WA
Contractor's Registration No OCONND*042N6 Date 7-30, 01

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (360) 407-6600. The TDD number is (360) 407-6006.

ECY 050-1-20 (11/98)

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

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

179922

Construction/Decommission *("x" in circle)*
○ Construction
○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number*

CURRENT Notice of Intent No. W 166012
Unique Ecology Well ID Tag No. AHC 854
Water Right Permit No.
Property Owner Name Tim BeHne
Well Street Address 9161 Rd 5 NE
City Coulee City County: Douglas
Location SW 1/4-1/4 SE 1/4 Sec 3 Twn 25 R 24 EWM or WWM *circle one*
Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______
Tax Parcel No.

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

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

DIMENSIONS: Diameter of well 6 inches, drilled 140 ft.
Depth of completed well 140 ft.

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded 6" Diam. from 0 ft. to 18 ft.
☒ Liner installed 4" Diam. from 5' ft. to 140 ft.
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☐ No Liner PerfED.
Type of perforator used SKil saw
SIZE of perfs 1/8 in. by 4 in. and no. of perfs 100 from 100 ft. to 140 ft.

Screens: ☐ Yes ☐ No ☐ K-Pac Location
Manufacturer's Name
Type Model No.
Diam. ____ Slot Size ____ from ____ ft. to ____ ft.
Diam. ____ Slot Size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☐ No ☐ Size of gravel/sand
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off

PUMP: Manufacturer's Name
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 85 ft. below top of well Date
Artesian pressure ____ lbs. per square inch Date
Artesian water is controlled by ____ (cap,valve, etc.)

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.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
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 10 gal./min. with stem set at 139 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
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 information. Indicate all water encountered.
(USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Soil, Gravel e Bolders	0	8
Hard Basalt	8	124
Silt e Rock Blk. Brn. Grn	124	140

RECEIVED SEP 15 2005 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 5-18- Completed Date 5-20-05

WELL CONSTRUCTION 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.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Fred Emerson
Driller/Engineer/Trainee Signature Fred Emerson
Driller or Trainee License No. 2604

If trainee, licensed driller's Signature and License no.

Drilling Company Four Star Drilling
Address P.O Box 37
City, State, Zip Hartline Wa. 99135
Contractor's Registration No. FOUR SD 110 D6 Date 5-23-05

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG No. Appli. 4163

Date 1948, 19

Record by Wm. E. Bechtol

Source driller's record

Location: State of WASHINGTON

County Douglas

Area

Map

SE ¼ NW ¼ sec. 3 T 24 N., R 25 E.

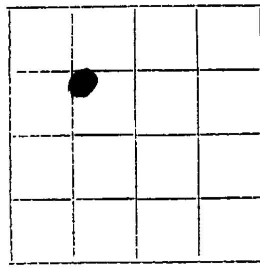


Diagram of Section

Drilling Co. unknown

Address

Method of Drilling Date 1948, 19

Owner Wm. E. Bechtolet al

Address Coulee City, Wash.

Land surface, datum ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (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.)		
	Silt	7	7
	Gravel & boulders	113	120
	Pump Test:		
	Diam. 120'x8"		
	SWL: 113 ft.		
	DD: -		
	Yield: 350 g.p.m.		
	Casing: 8" diam. from 0 to 120 ft.		
	Perforations: 8 per ft. ½"x1½"		
	from 110 to 120 ft.		

Turn up Sheet of sheets

CANCELLED

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Appli. #591
Permit #534

Date June 11, 1947

Record by Clarence Sly

Source Driller's record

Location: State of WASHINGTON

County Douglas

Area

Map

NW ¼ NW ¼ sec. 3 T. 24 N., R. 25 E.

DIAGRAM OF SECTION

Drilling Co Clarence Sly

Address 1105 Crescent St.; Wenatchee, Wn.

Method of Drilling Date August 1947

Owner Arthur Irmer

Address Farmer, Wash.

Land surface, datum ft above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (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.)		
	Topsoil & silt	5	5
	Boulders & small gr. & sed.	3	8
	Cement & medium gravel	10	18
	Boulders	2	20
	Cement & med. gravel & sand	48	68
	Boulders	2	70
	Med. & small gravel & clay	30	100
	Sand and sediment	5	105
	Med. gr. & boulders-w.b.	8	113
	Med. & small gr.	4	117
	Coarse gravel	3	120
Pump test:			
	Dim: 120' x 8"		
	SWL: 111'		
	(over)		

Turn up

Sheet ____ of ____ sheets

WELL LOG.—Continued No. A 571

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	Arthur Irmer Depth forward	——	
	D. D. 2'		
	Yield 400 g.p.m.		
	Casing: 8" dia. from 0 to 120'		
	Perforations: 1/8 x 1" from 112'		
	to 119'. 6 per foot - 3 rows		
	Reason for cancellation: Certificate		
	fees not sent in.		

S F. 7449-46 REMINGTON INC-20 20 745-24 8

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG No. Appli. #3067
Permit #2847

Date April, 1953.

Record by H. D. Snelson

Source well driller's record

Location: State of WASHINGTON

County Douglas

Area and

Map

SW¼ NE¼ NW¼ SE ¼ sec 29 T. 24 N., R. 25 E.

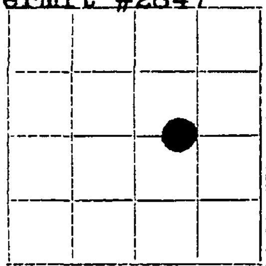


Diagram of Section

Drilling Co.

Address

Method of Drilling drilled Date Dec., 1952

Owner R. A. Hensel

Address Waterville, Washington

Land surface, datum ft. above/below

24N/25E-29J6

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (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.)		
	Soil	10	10
	Gravel & small rock	17	27
	Large boulders, gravel, mud	15	42
	Gravel, mud, boulders	18	60
	Water, boulders, mud, gravel	27	87
	Water strata is 60' to 85' thick		
Pump	Test:		
	Dim: 87' x10"		
	SWL: 54'		
	Dd: not known		
	Yield: 600 g.p.m.		
	Recovery data: 110 Dd. test made on this well		
	Casing: 10" well casing from 0		to 66'
	8" well casing liner from		57-83'
	(over)		

Turn up Sheet ..... of ..... sheets

WELL LOG.—Continued No. A 3067

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	RA Hensel Depth forward		
	Shoe: Liner is standard pipe-26 lbs. per ft. 10" casing weighs 32 lbs. per ft.		
	Perfor: perforated from 59 to 83' 4 per ft. 1/8" x 8"		

S. F. No. 7410—12-54—3M. 40108.

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Appli. #3066
Permit #2846

Date February 20, 1953
Record by H. D. Snelson
Source well driller's record

Location: State of WASHINGTON
County Douglas
Area
Map
NW ¼ NE ¼ sec 29 T. 24 N., R. 25 E.

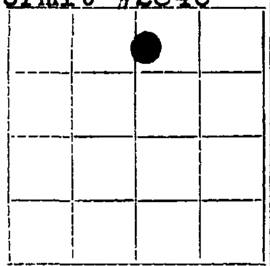


Diagram of Section

Drilling Co.
Address
Method of Drilling drilled Date none, 19
Owner R. A. Hensel
Address Waterville, Washington
Land surface, datum ft. above/below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (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.)		
	Well dug down 50' small		
	gravel	50	50
	Drilled, fine gravel from		
	1/8" to 3/8" size. Very		
	little sand	35	85
Pump	Test:		
	Dim: 85' x 8"		
	SWL: 61' Yield: 600 g.p.m. (permit)		
	Recovery data: no test		
	Casing: 8" standard pipe 26 per ft.		
	from o to 82'		
	Shoe: Depth of shoe 82' on the bottom		
	of pipe		
	Perfor: perforated from 59 to 82'		
	4 per ft. 1/8" x 8"		

Turn up

Sheet ... of ... sheets

WELL LOG.—Continued No. A / 19 -

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	RA Hensel Depth forward	——	
	Perforations: 3 to foot, 8" long, 1/8" wide from 57' to 80'		

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG No. Appli. #19-
Cert. #1843-A

Date Jan. 31, 1953

Record by H. D. Snelson

Source Driller's Record

Location: State of WASHINGTON

County Douglas

Area

Map

NW ¼ NE ¼ sec. 29 T. 24 N., R. 25 E.

DIAGRAM OF SECTION

Drilling Co H. D. Snelson

Address Palisades, Washington

Method of Drilling drilled Date Jan. 31 1953

Owner R. A. Hensel

Address Waterville, Washington

Land surface, datum ft. above/below

(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.)

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	Soil & coarse gravel	10	10
	Coarse gravel & boulders	2	12
	" " "	13	25
	Coarse sand, gravel & boulders	15	40
	" " " "	10	50
	" " " "	11	61
	Water in gravel	9	70
	Water gravel & mud & s/boulders	10	80
	Big boulders & gravel, some		
	mud & sand	5	85
PUMP	TEST:		
	Dim: 85' x 10"		
	SWL: 52'		
	Dd: 10'		
	Yield: 1000 g.p.m.		
	Casing: 10" diameter from 0 to 85'		

Turn up (over) Sheet ___ of ___ sheets

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG No. Appli. 3138

Date Feb. 15, 1955

Record by Edwin L. Johnson

Source Driller's Record

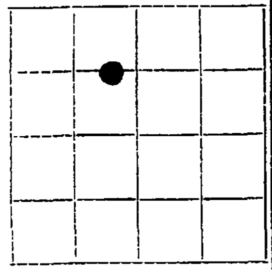


Diagram of Section

Location: State of WASHINGTON

County Douglas

Area

~~xxx~~ SE¼ of NW¼ &

NE ¼ SW ¼ sec 32 T. 24 N., R. 25E E./W.

Drilling Co. Courtney Bach

Address Quincy, Washington

Method of Drilling Drilled Date , 19

Owner Edwin L. Johnson

Address Farmer, Washington

Land surface, datum ft. above/below

Correlation	Material	Thickness (feet)	Depth (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.)		
	Gravel & clay	70	70
	Fine sand & silt	18	88
	Silt & clay	21	109
	Silt & clay	11	120
	Silt & clay	24	144
	Silt & clay	19	163
	Yellow clay & water	5	168
	gravel		
	Water gravel	23	191
	Pump Test:		
	Dia: 191' X 10"		
	SWL: 37'		
	DD: 10'		
	Yield: 900 g.p.m.		
	Casing 10 in dia from	o to	191'

Turn up

Sheet ...... of ...... sheets

WELL LOG.—Continued No. A,3138

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	Edwin L Johnson Depth forward	——	
	10" dia from	0 to 191'	
	10" dia from	0 to 191'	
	10" dia from	0 to 191'	
	Perforations: 8" by ¼ from 163 to 189'		

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG

No. Appli. #2718
Permit #2578

Date February 12, 1955

Record by John H. Pryer

Source well driller's record

Location: State of WASHINGTON

County Douglas

Area

~~xxx~~ Govt. Lot 4

x x sec. 5 T. 23 N., R. 25 E.

Diagram of Section

Drilling Co.

Address

Method of Drilling drilled Date Febr. 7, 19

Owner J. Adelbert Schick

Address Farmer, Washington

Land surface, datum ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (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.)		
	Soil	5	5
	Black rocks	23	28
	Brown sand & water	7	35
	Black silt & mud	140	175
	Yellow clay	2	177
	Black gravel	63	240
	Bedrock at 240		
Pump	Test:		
	Dim: 240' x 12"		
	SWL: 20'		
	Dd: 30'		
	Yield: 1500 g.p.m.		
	Casing: 12" from 0 to 240'		
	Shoe:		
	Perfor: 16 ¼ x 1 per ft.	from	
	180 to 240'		

Turn up

Sheet ..... of ..... sheets

over

WELL LOG.—Continued No. A,2718

Correlation	Material	Thickness (feet)	Depth (feet)
	J Adelbert Schick Depth forward	—	
	Pump: 12" deep well turbine		
	Motor: 471 GMC Diesel Engine		
	Note: instantaneous recovery		

S. F. No. 7440—12-54—3M. 40108.

File Original with Department of Ecology
Second Copy - Owner's Copy 97450
Third Copy - Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W 123727
UNIQUE WELL I D # AFL 121
Water Right Permit No. 98020

DEPT. OF ECOLOGY Received NOV 16 2000 CENTRAL REGION OFFICE

(1) OWNER: Name PK & T Inc. Address 1430 Olympic Ave Edmonds Wa.

(2) LOCATION OF WELL County Douglas SW 1/4 SE 1/4 Sec 6 T 23 N R 25E WM

(2a) STREET ADDRESS OF WELL (or nearest address) Rim Rock Rd.

TAX PARCEL NO

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

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

(5) DIMENSIONS Diameter of well 6 inches
Drilled 80 feet. Depth of completed well 80 ft

(6) CONSTRUCTION DETAILS
Casing Installed.
☒ Welded 6" Diam from +2 ft to 60 ft
☐ Liner installed " Diam from ft to ft
☐ Threaded " Diam from ft to ft

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

Screens ☐ Yes ☒ No ☐ K-Pac Location
Manufacturer's Name
Type Model No
Diam Slot Size from ft to ft
Diam Slot Size from ft to ft

Gravel/Filter packed ☐ Yes ☒ No ☐ Size of gravel/sand
Material 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 4-26
Method of sealing strata off Casing

(7) PUMP Manufacturer's Name
Type H P

(8) WATER LEVELS Land-surface elevation above mean sea level ft
Static level 65 ft below top of well Date 10/13/00
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
Yield gal./min with ft drawdown after hrs
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 27 gal./min with —0— ft drawdown after 2 hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? ☐ Yes ☒ No

(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 information Indicate all water encountered

MATERIAL	FROM	TO
Top Soil	0	4
Brown Clay & water	4	16
gravel & Clay & water	16	26
Sticky Clay	26	60
Brown Basalt & water	60	64
Black Basalt	64	80

RECEIVED NOV DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 10/11/00 Completed 10/12/00

WELL CONSTRUCTION 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

Type or Print Name Mitch Mathews License No 1267 (Licensed Driller/Engineer)
Trainee Name License No
Drilling Company Mathews Drilling
(Signed) Mitch Math License No 1267 (Licensed Driller/Engineer)
Address 2317 Rd 10.2 NE M.L. Wa 98837
Contractor's Registration No MATHEDC117B6 Date 10/17/00

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer For special accommodation needs, contact the Water Resources Program at (360) 407-6600 The TDD number is (360) 407-6006

ECY 050-1-20 (11/98)

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