# Section 7

# Ground Water Resources

This section summarizes ground water quantity and quality in the WRIA 35 basin, characterizes both the geology and hydrogeology in the area and evaluates the hydraulic continuity between aquifers and streams. The purpose is to document the known elements of the ground water system and identify data gaps that may be critical in developing a regional watershed management plan.

Ground waters generally supply a significant portion of water for agricultural and municipal/domestic uses in the basin. In fact, approximately 30 percent of total water rights are allocated from ground water resources. Where information exists it will be important to define the linkage between surface and ground water systems, especially with regards to the shallower ground water resources. However, ground water resources tend to be less well-defined compared with surface water resources, because the flow system is comprised of subsurface reservoirs (aquifers) with distinct recharge and discharge zones and is not readily visible or accessible. The transfer of water between the two systems makes it critical that both be understood and defined as much as practicable to develop an effective water resource management plan for the basin.

## 7.1 Geology

The focus of this subsection will be to describe the aquifers (water-bearing geologic units) of the basin. The principal geologic units are part of the Columbia River Basalt Group (CRBG), which underlie the entire area. Overlying these basalt units are diverse unconsolidated sediments. The most common is wind-deposited loess. Most of these sediments are present throughout the watershed in limited thickness and do not provide significant water-bearing or producing capacities. Most of the thicker overlying overburden sediments exist in the area near the mouth of Asotin Creek and along the Snake River mainstem near Clarkston, WA. Because most of the water-producing capacity is associated with the CRBG, a majority of the discussions in this section focuses on the CRBG. The discussions that follow are based on Whiteman et al. (1994), Hansen et al. (1994), and Vaccaro (1999).

Table 7-1 summarizes the general geologic units and hydrogeologic stratigraphy of the subsurface in WRIA 35. Each of the major aquifer units is discussed further in the subsections below from youngest (shallow) to oldest (deep). The areal extents of the units are based on the characterizations by Whiteman et al. (1994) and Vacarro (1999). Well logs were not reviewed to generate geologic cross-sections for these areas; however, a series of geologic maps from the Washington State Department of Natural Resources and the United States Geological Survey were reviewed to assist in generating the cross-sections.

Exhibit 7-1 shows the surficial geology of the WRIA 35 basin based on Drost and Whiteman (1986). Although the surficial geology map does not show the presence of the overlying sediment, it is present throughout the basin, but in limited thickness. The overlying sediment is not considered to be a significant hydrogeologic feature in terms of ground water resources.

### Table 7-1
### Geologic and Hydrogeologic Framework Beneath the Middle Snake Subbasin (WRIA 35)

| | **Period** | **Basalt Stratigraphy** | **Sediment Stratigraphy** | **Hydrogeologic Framework** | **Layer Thickness** | **Extent** |
|---|---|---|---|---|---|---|
| Youngest to ↓ Oldest | Pleistocene | | Overburden Sediments – glaciofluvial, fluvial, lacustrine, eolian materials | Overburden Aquifer | 50 feet to 200 feet | Present only in a very small area near the mouth of Asotin Creek and near Clarkston, WA; thin loess sediments present throughout the basin |
| | Miocene | Saddle Mountains Basalt | | Saddle Mountains Unit | 0 feet to 200 feet | Underlies a major portion of the eastern half of WRIA 35 in the Lower Snake River Mainstem and Asotin Implementation Areas along the Blue Mountain anticline |
| | | | Saddle Mountains – Wanapum Interbed | Confining Unit | 0 feet to 50 feet | |
| | | Wanapum Basalt | | Wanapum Unit | 0 feet to 400 feet | Underlies the northern portion of WRIA 35 in the Lower Snake River, Pataha, and Tucannon Implementation Areas |
| | | | Wanapum – Grande Ronde Interbed | Confining Unit | 0 feet to 50 feet | |
| | | Grande Ronde Basalt | | Grande Ronde Unit | 1,000 feet to 5,000 feet | Underlies entire WRIA 35 area |
| | Lower Tertiary to Precambrian | Basement Rocks (pre-Columbia River Basalt Group) | | | | Underlies entire WRIA 35 area |

*Source: Whiteman et al 1994; Hansen et al 1994; and Vacarro 1999.*

***Insert Exhibit 7-1 (Surficial Geology)***

### 7.1.1 Overburden and Overlying Sediments

Overburden is the term used for all materials thicker than 50 feet that overlies the Columbia River Basalt Group, including Miocene to Holocene fluvial, glaciofluvial, lacustrine, volcanic, eolian, and loess sediments. In the WRIA 35 watershed wind-deposited loess is the most prevalent, with some flood-deposited sediments along present-day floodplains.

Catastrophic flooding during the late Pleistocene age caused enormous volumes of water from western Montana and Idaho to flood eastern and central Washington along the Snake and Columbia Rivers. The surface of the land was greatly modified as floodwaters swept away overlying sediments, carving erosional features into the basalt plateau and leaving behind deep canyons and coulees, rugged cliffs and buttes, gravel bars giant ripple marks. Where floodwaters spread, slowed, and ponded, thick layers of sediment were deposited in low areas (Vacarro 1999). Overburden of this type is found near the mouth of Asotin Creek and along the Snake River by Clarkston, WA. Based on Ecology well log data in the area, the overburden consists of sand, silt, clay, sandy-clay, gravels and boulders.

The loess covers most of the highland areas between drainages. The loess is generally light-brown, massive, and homogeneous silt that often forms large dunes. The loess is generally 20,000 years old or less. The thickness of these deposits is typically 40- to 60 inches where present. The loess sediments affect the rate of infiltration of precipitation and the amount of runoff to streams. However, the limited extent and thickness of the sediment unit does not provide significant storage for infiltrating water and does not act as an aquifer. Therefore, it is not considered a significant feature with respect to ground water availability and impacts on the water balance in the system. Because of the limited extent and thickness in WRIA 35, these overburden sediments are not discussed further in this Level 1 Assessment.

### 7.1.2 Columbia River Basalt

The Columbia River Basalt (CRB) is an extensive formation of 6 to 17 million year-old lava that covers all of southeastern Washington and parts of northeastern Oregon and the panhandle of Idaho. The basaltic lava was extruded largely during the Miocene Epoch, but apparently continued into the early part of the Pliocene Epoch (Whiteman et al. 1994). Prebasalt topography had considerable relief; therefore, early lava flows filled narrow prebasalt valleys and gradually smoothed thin sheets across a flat, west-sloping surface with minor warps (Whiteman et al. 1994). Water was likely to be present on this surface causing rapid chilling of the molten lava and steam explosions, shattering the basalt and forming pillow lava complexes and structural irregularities. Later in the eruptive cycle, warping and folding of the plateau increased, forming various anticlines, synclines, uplifts, and numerous other geologic structures (Vacarro 1999).

The CRB is subdivided into three formations (from oldest to youngest): Grande Ronde, Wanapum, and Saddle Mountains. Sedimentary interbeds were deposited in shallow lake basins on the warped basalt surface between eruptive phases and separate the three main basalt formations. Each of these basalt formations and the interbeds that separate them are described further below based on Whiteman et al. (1994), Hansen et al. (1994), and Vaccaro (1999).

Geologic cross sections were developed based on information on depth and thicknesses of each basalt formation from these same references as shown in Exhibits 7-2 (a-d). Furthermore, geologic cross-section obtained from the Washington Department of Natural Resources is shown in Exhibits 7-3 (a-b) for the Clarkston area and south of Clarkston.

The Grande Ronde Basalt underlies the entire basin and is overlain by a zone of weathering and/or a sedimentary interbed separating it from the overlying Wanapum Basalt. The Grande Ronde Basalt consists of over 100 flows consisting primarily of fine-grained igneous material. The Wanapum-Grand Ronde interbed consists chiefly of claystone and siltstone with minor sand and gravel and sandstone beds. In the absence of the interbed, the contact between the Grand Ronde and Wanapum basalt is difficult to identify. The Wanapum Basalt consists of as many as 33 separate flows consisting of medium-grained, olivine-bearing igneous material. A sedimentary interbed is commonly present between the Wanapum Basalt and Saddle Mountains Basalt, and consists chiefly of clay, silt, claystone, or siltstone. The Saddle Mountain Basalts are the most diverse of the basalt formations in terms of the chemical composition of the flows even though it generally consists of only one or two basalt flows.

The internal structure of a typical flow consists of four sections: flow top, the entablature, the colonnade, and the flow base. Exhibit 7-4 illustrates a typical basalt flow in the Columbia River Basalt Group. The flow tops (or interflow zones) often times include clay and other wind-blown layers, which in turn are covered by another lava flow layers. The flow top is generally vesicular basalt, while the entablature consists of small-diameter columns. The upper part of the entablature is also commonly vesicular. The collonade is comprised mainly of vertical three- to eight-sided columns bounded by cooling joints. The columns average three feet in diameter and 25 feet long and are commonly crosscut by nearly horizontal joints. The base of the flow is typically glassy basalt. Although these zones are typically discernable in individual flows, the degree of development in each section varies both laterally within flows and vertically among them.

The basalt is a dense dark-gray, brown, or black rock with very finely felted crystallites set in a glassy groundmass. The basalt flows have two main sets of joints resulting from shrinkage during cooling and fracturing through tectonics and subsequent volcanic activity. These play an important role in how ground water is transmitted through the basalt. The first set of joints is vertical in nature and breaks the basalt into hexagonal columns between 6 inches and 5 feet or more in diameter. The other set are horizontal joints and cracks that extend from a few hundred to thousands of feet long.

***Insert Exhibit 7-2a (Geologic Cross Section A-A1)***

***Insert Exhibit 7-2b (Geologic Cross Section A1-A2)***

***Insert Exhibit 7-2c (Geologic Cross Section B-B1)***

*Insert Exhibit 7-2d (Geologic Cross Section C-C1)*

***Insert Exhibit 7-3a (Geologic Cross Section - Clarkston)***

***Insert Exhibit 7-3b (Geologic Cross Section - Asotin)***

***Insert Exhibit 7-4 (Generalized Diagram of Typical Basalt Flows)***

## 7.2 Hydrogeology

### 7.2.1 Basalt Aquifers

The basalt aquifer system can be described only generally because of the large number and complexity of individual flows. Due to the complex nature of the system and the inadequate data to describe the flow patterns for each aquifer zone, individual basalt flows have been combined conceptually. Although the flows are individually discontinuous they are interconnected to the degree that they act as single aquifer systems. The most recent conceptualization as described in Whiteman et al. (1994) define the hydrologic framework as shown in Table 7-1, wherein the major basalt and sediment stratigraphy groups correspond with the hydrologic units: the Saddle Mountains Unit, Wanapum Unit, and Grande Ronde Unit, Saddle Mountains-Wanapum interbed, and Wanapam-Grande Ronde interbed. The sedimentary interbeds between the major basalt formations are of smaller extent, and are thin compared to the overall thickness of the basalt formations as described above.

Depth to the water-bearing zones within the basalt varies widely due to the complicated nature of ground water occurrence in the basalt aquifer, which is under confined conditions. A confined aquifer[1] is generally overlain by a low permeability layer that causes a confining pressure, which is the combination of atmospheric pressure and pressure caused by overlying column of water and weight of the soil overburden. The variations in hydraulic gradient[2] within the basin are in part a result of the occurrence of secondary recharge and discharge and in part due to the spatial differences in hydraulic characteristics of the basalt aquifer system. Overlying and underlying aquifer zones within the basalt aquifer system provide the local recharge and discharge areas.

### 7.2.2 Hydraulic Parameters of Basalt Aquifers

The following discussion of hydraulic parameters and general flow patterns is based on the aquifer system model by Hansen et al (1994) and Vacarro (1999). The model study by Hansen et al. (1994) and Vacarro (1999) divided the aquifer system into seven hydrogeologic units: the overburden aquifer, three aquifer units in the permeable basalt rock, two confining units, and the basement-confining unit. The three basalt aquifer units are the Saddle Mountains, Wanapum, and Grande Ronde basalts; and the two confining units are equivalent to the Saddle Mountains-Wanapum and the Wanapum-Grande Ronde interbeds. The Grande Ronde unit was further divided into two layers, the upper Grand Ronde (thickness up till 2,000 ft) and the lower Grand Ronde, where the Grand Ronde unit is thicker than 2,000 ft (thickness ranges from 100 to 10,000 ft). The upper Grande Ronde unit underlies the entire implementation area, while the lower Grande Ronde underlies the area approximately south of the Blue Mountain anticline.

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[1] Also known as an artesian aquifer, the low permeability layer (or aquitard) overlies the aquifer which contains water under sufficient pressure to rise above the top of the aquifer. In some cases groundwater levels may be above land surface.

[2] The hydraulic gradient is the change in water level with change in distance in a given direction; it expresses the "driving force" of ground water flow.

Tables 7-2, 7-3, and 7-4 describe the water-level elevations[3], lateral hydraulic conductivity[4], and transmissivity[5] for the basaltic aquifer layers estimated by Hansen et al. (1994). The values are based on the regional survey (including areas outside WRIA 35) of studies and data collected for the basalt units and were derived from the ground water model developed (Hansel et al. 1994).

Generally, speaking the higher water level measurements in the lower Grande Ronde relative to the upper Grande Ronde units indicate a tendency for ground water flow to be upwards, since the hydraulic gradient is in the upward direction. There is less certainty with respect to flow direction between the Grande Ronde and Wanapum units. However, regionally the tendency is also for ground water flow between these units to be upward. There are situations locally or temporally when recharge occurs and flow is downward, e.g. in areas where the Wanapum unit is exposed to the surface and where significant rainfall events occur or near streams where stream flows are significant resulting in infiltration and rising of water levels in the Wanapum unit.

With respect to the hydraulic conductivities, the wide range reflects the heterogeneous nature of the basalts. The largest values are due to the local geologic structure and thickening of interflow zones. Low values could be a result of faults offsetting interflow zones or tightening pore spaces due to deposition of secondary minerals along faults. In any case, this variability results in some portions of the basalt having high ability to transmit water, while other areas are limited. In most cases, production wells are developed when high production zones are intercepted during drilling investigations. Overall, the Grande Ronde and Wanapum basalt units in WRIA 35 are considered to have medium to high transmissivity.

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[3] The static water level is a measurement made under non-pumping condition, when water levels in the aquifer are not changing in response to recent pumping.

[4] The hydraulic conductivity is a coefficient of proportionality describing the rate at which water can move through a porous medium, commonly expressed in units of feet per day or centimeters per second.

[5] The transmissivity is the hydraulic conductivity multiplied by the thickness of the aquifer; it is a measurement of the rate at which water can be transmitted horizontally by the full saturated thickness of the aquifer.

### Table 7-2
### Model Calculated Water Level of Basaltic Aquifers in the Middle Snake Subbasin (WRIA 35) where present

| **Implementation Area** | **Saddle Mountain Unit** (feet MSL) | **Wanapum Unit** (feet MSL) | **Upper Grande Ronde Unit** (feet MSL) | **Lower Grande Ronde Unit** (feet MSL) |
|---|---|---|---|---|
| Asotin | - | - | 1,000 to 4,000 | 3,000 to 3,500 |
| Middle Snake River | - | 1,000 to 2,500 | 600 to 1,400 | 700 to 1,600 |
| Pataha | - | - | 700 to 4,000 | 750 to 3,500 |
| Tucannon | - | 1,100 to 2,500 | 600 to 4,500 | 700 to 3,500 |

*Source: Hansen et al 1994, Plate 12.*

### Table 7-3
### Lateral Hydraulic Conductivity of Basaltic Aquifers in the Middle Snake Subbasin (WRIA 35) where present

| **Implementation Area** | **Saddle Mountain Unit** in $10^{-6}$ ft./second | **Wanapum Unit** in $10^{-6}$ ft./second | **Upper Grande Ronde Unit** in $10^{-6}$ ft./second | **Lower Grande Ronde Unit** in $10^{-6}$ ft./second |
|---|---|---|---|---|
| Asotin | - | - | 1.5 to 5 | 1 to 5 |
| Middle Snake River | - | 20 to 40 | 1.5 to 20 | 1 to 10 |
| Pataha | - | - | 1.5 to 40 | 1 to 20 |
| Tucannon | - | 10 to 40 | 1.5 to 80 | 1 to 74 |

*Source: Hansen et al 1994, Plate 5.*

### Table 7-4
### Transmissivity of Basaltic Aquifers in the Middle Snake Subbasin (WRIA 35) where present

| **Implementation Area** | **Saddle Mountain Unit** in $ft^2$/second ($ft^2$/day) | **Wanapum Unit** in $ft^2$/second ($ft^2$/day) | **Upper Grande Ronde Unit** in $ft^2$/second ($ft^2$/day) | **Lower Grande Ronde Unit** in $ft^2$/second ($ft^2$/day) |
|---|---|---|---|---|
| Asotin | - | - | 0.001 to 0.010<br>(86 to 864) | 0.0006 to 0.005<br>(52 to 432) |
| Middle Snake River | - | 0.001 to 0.050<br>(86 to 4320) | 0.001 to 0.050<br>(86 to 4320) | 0.0006 to 0.050<br>(52 to 4320) |
| Pataha | - | 0.001 to 0.005<br>(86 to 432) | 0.005 to 0.050<br>(432 to 4320) | 0.0006 to 0.050<br>(52 to 4320) |
| Tucannon | - | 0.001 to 0.010<br>(86 to 864) | 0.001 to 0.184<br>(86 to 15,898) | 0.010 to 0.480<br>(864 to 41,472) |

*Source: Hansen et al 1994, Plate 6.*

## 7.2.3 Ground Water Movement

### *Factors Affecting Ground Water Flow*

The presence and movement of water through the basalt formations are governed by several factors including the topographic surfaces over which the flows occurred, deposition of interbeds and tectonic activity. Through these processes, the lateral continuity, thickness, and composition of lava flows become highly varied. Typically only 5 to 10 percent of the thickness of an individual basalt flow is comprised of the interflow zone. The interflow zone is the extremely heterogeneous section between lave flows that transmits water readily. The interflow zones are separated by less transmissive (i.e. ability to move water through the aquifer) and more massive entablature and colonnades. Lateral flow through the entablature and colonnades, which occurs through fractures and joint systems, are likely negligible compared to the flow through the interflow zones, which occurs through primary features such as flow vesicles. Vertical movement of ground water in the interflow zones is significantly less than lateral movement per unit area, but overall vertical movement is large over the entire area. Vertical movement of ground water is also highly variable because of the heterogeneity of the interflow zones and interbeds.

The sedimentary interbeds between basalt formations are fairly extensive laterally, but are thin compared to the basalt formations. Locally, these interbeds can act as aquifers, but in general act to impede vertical movement of water. Based on water levels and well log data, the interbeds act as semi-confining to locally confining layers that transmit small amount of water laterally.

Regional structures could also affect the distribution of ground water within the basalt. The broad-crested Blue Mountain anticline, which extends west to east through the southern portion of the Asotin Implementation Area, is a rugged uplifted region consisting of remnants of a plateau surface and deeply dissected canyons. The core of the anticline is composed of folded, faulted, and metamorphosed rocks, and the crest of the anticline is crossed by a series of northwest-trending high-angle normal faults. On the flanks of the Blue Mountains, the folds and faults create a substantial vertical control, resulting in large water-level gradients (100 to 300 feet per mile). In this area, small amounts of vertical flow occur across the dense layers in the basalt. Further down valley, ground water flow is primarily horizontal along broken zones and there are few disruptive structures. The hydraulic gradients are also lower and controlled more by the down gradient boundary conditions, including the Snake River.

### *General Ground Water Flow Patterns*

The ground water flow patterns defined for the WRIA 35 watershed was based on information from a regional ground water flow study for the Columbia Plateau aquifer and ground water levels from well log data in the Ecology database.

A ground water model of the Columbia Plateau Regional aquifer system, which includes the basalt units in WRIA 35, was developed by the USGS (Hansen et al. 1994). As described earlier, the model consists of five hydrogeologic layers including: overburden aquifer, Saddle Mountain, Wanapum, and upper and lower Grande Ronde aquifers. The overburden aquifer is not represented in the model in the WRIA 35 area because it is thin or non-existent. The model allows flow between the units using leakage between the layers, and hence is a quasi-three-dimensional model. As part of the development of the model, other studies and information were reviewed to characterize other components of the hydrologic system including estimates of recharge and discharge from the ground water system. A time-averaged, steady-state approach was used to model pre-development (1850s) and post-development (1983-85 period) to study ground water flow patterns and develop a general water balance for the Columbia Plateau ground water system. For the purpose of this Level 1 Assessment, these estimates are used as the basis as a preliminary basis for the ground water flow patterns in WRIA 35.

This model was used to develop simulated ground water flow patterns in the basalt aquifers. Exhibit 7-5 shows the ground water potentiometric heads[6] ("head") for the upper portion of the Grande Ronde unit based on the model input and assumptions for conditions in the spring of 1983. The ground water flow direction is generally from higher to lower head and perpendicular to the poteniometric lines (or lines of equal value for potentiometric head) shown on Exhibit 7-5. Without comprehensive water level field data, this represents the best understanding of the ground water flow patterns in the basalt aquifers. The model was used to derive ground water flow directions for the Saddle Mountain, and Wanapum units as well. The Grande Ronde unit is shown here because it completely underlies the entire watershed. However, the model shows that ground water flow directions are generally similar for each of the units.

In addition to the model simulation results from Hansen et al. (1994), ground water level contours were generated from water level data compiled from well log information from Ecology's database. By using depth of the wells and the thicknesses of the aquifer units, the wells were grouped by whether they were most likely screened in the Saddle Mountain, Wanapum, or Grande Ronde aquifer unit. Because only a limited number of wells were shallow enough to be in the Saddle Mountain unit contours were not generated for the Saddle Mountain aquifer unit. Furthermore, because of the uncertainty in the exact extent and thickness of the Wanapum unit in some of the basin, a single set of contours was generated for the Wanapum and Grande Ronde. The contours are shown in Exhibit 7-6. It should be noted that water levels from the Ecology database were primarily measured at the time the wells were drilled. Therefore, the water levels used to generate contours are generally from different time periods.

The potentiometric contours generated from the well log data and those generated from the model simulation are relatively consistent in terms of the general flow patterns and the water level values. As Exhibits 7-5 and 7-6 both indicate, ground water in the basalt aquifers generally flows from the higher elevation recharge areas in the Blue Mountains toward the main surface water bodies, discharging toward the Snake River and Grande Ronde River. The primary tributaries such as the Tucannon River and Asotin Creek do not appear to control the regional flow patterns in the basalt aquifers, but baseflows (ground water discharge) to these tributaries are a significant portion of the total stream flows, which indicate that shallow ground water is affected by the smaller tributaries on a local level. This is discussed further in Section 7.3.

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[6] Potentiometric head refers to the level (elevation) to which water will rise in a well cased to the aquifer. In engineering or hydraulic terms, it is a measure of total energy per unit mass of water. Water will tend to flow from areas of greater potentiometric head to areas of lower head.

***Insert Exhibit 7-5 (Potentiometric contours – model simulation)***

***Insert Exhibit 7-6 (Potentiometric contours – Ecology well logs)***

### *Inter-Aquifer and Inter-Basin Movement*

Information summarized for the basalt aquifers suggest that the net direction of ground water flow between overlying and deeper aquifers is generally upward as ground waters discharge to surface streams (Vacarro et al, 1999; Hansen et al 1994). Furthermore, although direct recharge of the aquifers resulting from infiltration of precipitation occurs throughout the watershed, the primary recharge zones of the deeper aquifers are located at higher elevation than the shallower aquifers causing a general upward driving force for ground water.

Inter-basin flow is concerned with ground water moving between subbasins (or implementation areas) in response to areas of higher to lower water levels caused by boundary conditions (e.g. locations where ground water discharges to surface water). An estimate of the flow quantities transferred in the basalt aquifer among the various implementation areas has not been quantified, because an in-depth review of hydraulic properties has not been done to estimate flux (or flow) across the implementation area boundaries.

## 7.3 Hydraulic Continuity

Where streams recharge an aquifer or where an aquifer discharges to a stream, the surface and ground waters are said to be in hydraulic continuity. The baseflow[7] component of a stream's total flow due to ground water discharge is a result of this continuity. These interactions vary with location and occur over varying time periods of hours, days, or years, and these effects can be very difficult to quantify. Hydraulic continuity is an internal component of the overall water balance of a basin, with respect to the net inflow and outflow of water across the watershed boundaries. However, understanding surface-ground water exchange is critical in developing a management plan for the entire basin because of the potential impacts the ground water use could have on stream flows. For example, in the upper reaches of a stream ground water pumping may trigger increased water loss from the stream due to increased aquifer recharge rates to levels more than naturally occur. In the lower reaches of a stream where groundwater seeps out to the stream, pumping may reduce the seepage rate and decrease stream flow rate.

Decreased stream flow rate may adversely impact water rights and reduce water needed to maintain fish habitats. Thus, assessment of hydraulic continuity plays a major role in Ecology's review of new water rights applications. The effects of ground water pumping are discussed further in Section 7.3.3.

To effectively assess the hydraulic continuity of a surface-ground water system, the following key factors should to be considered:

- Hydraulic parameters of the aquifer
- Vertical and horizontal position of the aquifer in relation to the surface water body
- Presence (or absence) of confining units or low-permeability zones between the aquifer and stream or lake bed

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[7] Baseflow is the component of stream flow fed by ground water discharging to the stream; ground water discharge occurs as springs and seeps on slopes or as direct seepage to stream channels.

- The hydraulic (potentiometric) head difference between surface and ground water
- Amount of surface or ground water withdrawn from the system including the location and timing of withdrawal (refer to Section 7.3.3)

To effectively assess hydraulic continuity on a particular stream, water level data and stream flow data is needed over the same time period and measurement should be made in close proximity to each other. Much of this information is not readily available for the WRIA 35 watershed to be able to conduct a detailed assessment of hydraulic continuity on specific streams. Specifically, the following information was lacking or was beyond the scope of this Level 1 Assessment to obtain or develop:

- Groundwater level data – available ground water level data is mostly available only for the time when the well was originally drilled.
- Aquifer source of water to wells – well depth for most wells have not been correlated to aquifer source of water.
- Data on stream flow rates near any well with water level data - direct impact of pumping on stream flow rates cannot be quantified with the data available
- Data or analysis results from local studies evaluating continuity on a local basis – only a few local studies have been competed (e.g. near the Tucannon River)

Nevertheless, a general characterization of the surface-ground water exchange in the basin is possible by looking at the baseflow conditions, overall recharge-discharge patterns, and ground water pumpage impacts occurring in the watershed. These are described in the subsections below.

### 7.3.1 Baseflow Assessment

The Departmet of Ecology completed a baseflow analysis for Washington rivers entitled *Estimated Baseflow Characteristics of Selected Washington Rivers and Streams Water Supply Bulletin No. 60* (Ecology 1999). This report provides data on the amount of total stream flow attributable to ground water discharge to the stream. A summary of the relevant rivers with baseflow analyses completed is included in this subsection. Characterizing the baseflows in streams throughout the watershed indicates the relative connection between surface and ground waters.

In this study, Ecology estimated baseflow contributions to be used as basin-scale averages. Baseflow was estimated using data from various streamflow gauging stations and a hydrograph separation software, HYSEP (Sloto and Crouse, 1996) developed by the USGS. Gauging stations with at least three complete years of discharge data were selected and then categorized by the degree and type of regulation (flow control) reported to affect each gauge. Of the eight USGS gauging stations within WRIA 35, two stations in the Snake River (USGS 13334300 near Anatone, and USGS 13343500 near Clarkston) were categorized as highly influenced by streamflow regulation. Baseflow analysis was not performed for these stations because of the likelihood that the stream hydrograph would be considerably altered by regulation.

As the data presented below shows, baseflow is shown to be a significant portion of the total stream flow year-round due to the hydrology and hydrogeology in WRIA 35. Ground water discharge to streams is significant in the basin, ranging from approximately 30 percent in the winter months to over 90 percent of stream flow in the summer.

### *Asotin Implementation Area*

In the Asotin Implementation Area, baseflow was estimated at three streamflow gauging locations along Asotin Creek: two locations near Asotin, Washington (USGS 13334500 and USGS 13335050) and one below Kearney Gulch (USGS 13334700). All three stations in Asotin Creek were classified as being seasonally affected by significant snow melt or glacial-meltwater and therefore monthly baseflows were not estimated for the period of highest snowmelt between March and July. Table 7-5 shows the comparison between the mean streamflow, estimated mean baseflow, and mean surface runoff for the three stations.

In the late summer and fall months (August through October), baseflow as a percentage of mean streamflow is between 90% and 97%; whereas in the late fall and winter months (November through February), baseflow as a percentage of mean streamflow is between 47% and 85%. Exhibits 7-7 show the mean streamflow and estimated baseflow from the three stations in Asotin Creek.

### *Middle Snake River Mainstem Implementation Area*

In the Lower Snake River Mainstem Implementation Area, baseflow was estimated at Meadow Creek near Central Ferry, Washington (USGS 13343800). Table 7-6 shows the comparison between the mean streamflow, estimated mean baseflow, and mean surface runoff for USGS 13343800.

In Meadow Creek, baseflow as a percentage of mean streamflow is estimated between 63% and 93% for the majority of the year, except for December and January where it is estimated between 29% and 44%. Exhibit 7-8 shows the mean streamflow and estimated baseflow in Meadow Creek.

### *Tucannon River Implementation Area*

In the Tucannon River, baseflow was estimated at two streamflow gauging locations near Pomeroy, Washington (13344000) and near Starbuck, Washington (13344500). Baseflows were not estimated for the period of highest snowmelt between March and June at USGS 13344000 near Pomeroy due to seasonal snowmelt effects. Table 7-7 shows the comparison between the mean streamflow, estimated mean baseflow, and mean surface runoff for the two stations.

The estimated baseflow as a percentage of mean streamflow is between 91% and 98% in the late summer and fall months (July through October), and between 60% and 88% in the late fall and winter months (November through February). Exhibits 7-9 show the mean streamflow and estimated baseflow from the two stations in Tucannon River.

## Table 7-5
## Baseflow, Streamflow and Surface Runoff: Asotin Creek Implementation Area

| Station | | Jan. | Feb. | Mar. | Apr. | May | June | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USGS 13334500 Asotin Creek near Asotin, WA | Mean Baseflow, measured in inches (cfs) | 0.32 (43) | 0.33 (49) | * | * | * | * | * | 0.23 (31) | 0.22 (31) | 0.25 (34) | 0.27 (38) | 0.32 (44) |
| | Mean Surface Runoff, measured in inches (cfs) | 0.07 (9.6) | 0.11 (16) | * | * | * | * | * | 0.01 (1.1) | 0.01 (1.4) | 0.01 (1.8) | 0.03 (4.1) | 0.10 (14) |
| | Mean Streamflow, measured in inches (cfs) | 0.39 (53) | 0.44 (66) | 0.58 (78) | 0.94 (131) | 1.15 (156) | 0.69 (97) | 0.32 (44) | 0.24 (32) | 0.23 (32) | 0.26 (35) | 0.30 (42) | 0.42 (57) |
| USGS 13335050 Asotin Creek at Asotin, WA | Mean Baseflow, measured in inches (cfs) | 0.20 (55) | 0.27 (82) | * | * | * | * | 0.15 (43) | 0.11 (31) | 0.11 (31) | 0.12 (32) | 0.13 (38) | 0.18 (52) |
| | Mean Surface Runoff, measured in inches (cfs) | 0.22 (61) | 0.25 (77) | * | * | * | * | 0.03 (7.6) | 0.01 (3.4) | 0.01 (2) | 0.01 (1.4) | 0.02 (6.7) | 0.14 (38) |
| | Mean Streamflow, measured in inches (cfs) | 0.41 (116) | 0.52 (158) | 0.52 (146) | 0.66 (192) | 0.74 (206) | 0.33 (96) | 0.18 (51) | 0.12 (34) | 0.11 (33) | 0.12 (34) | 0.15 (45) | 0.32 (89) |
| USGS 13334700 Asotin Creek below Kearney Gulch | Mean Baseflow, measured in inches (cfs) | 0.35 (51) | 0.39 (63) | * | * | * | * | 0.31 (46) | 0.24 (35) | 0.22 (34) | 0.24 (35) | 0.27 (41) | 0.32 (46) |
| | Mean Surface Runoff, measured in inches (cfs) | 0.20 (30) | 0.16 (26) | * | * | * | * | 0.01 (2.1) | 0.01 (1.9) | 0.01 (1.8) | 0.01 (1.6) | 0.03 (4.1) | 0.12 (18) |
| | Mean Streamflow, measured in inches (cfs) | 0.55 (81) | 0.55 (89) | 0.61 (90) | 0.75 (114) | 0.98 (145) | 0.67 (102) | 0.33 (48) | 0.25 (37) | 0.24 (36) | 0.25 (37) | 0.29 (45) | 0.44 (65) |

*Source: Ecology (1999).*
*Note: cfs is cubic feet per second.*
** Indicates that flow was not estimated.*

## Table 7-6
## Baseflow, Streamflow and Surface Runoff: Middle Snake River Mainstem Implementation Area

| Station | | Jan. | Feb. | Mar. | Apr. | May | June | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USGS 13343800 Meadow Creek near Central Ferry, WA | Mean Baseflow, measured in inches (cfs) | 0.05 (2.6) | 0.06 (3.5) | 0.07 (3.8) | 0.05 (3.2) | 0.04 (2.1) | 0.02 (1.1) | 0.01 (0.8) | 0.01 (0.8) | 0.02 (1.2) | 0.02 (1.4) | 0.03 (1.7) | 0.04 (2.4) |
| | Mean Surface Runoff, measured in inches (cfs) | 0.11 (6.3) | 0.03 (1.9) | 0.02 (0.98) | 0.01 (0.3) | 0.01 (0.29) | 0.01 (0.47) | 0.01 (0.4) | 0 (0.23) | 0.01 (0.71) | 0 (0.11) | 0 (0.18) | 0.05 (3) |
| | Mean Streamflow, measured in inches (cfs) | 0.16 (8.9) | 0.09 (5.4) | 0.08 (4.8) | 0.06 (3.5) | 0.04 (2.4) | 0.02 (1.5) | 0.02 (1.2) | 0.02 (1.0) | 0.03 (1.9) | 0.03 (1.5) | 0.03 (1.9) | 0.1 (5.5) |

*Source: Ecology (1999).*
*Note: cfs is cubic feet per second.*

## Table 7-7
## Baseflow, Streamflow and Surface Runoff: Tucannon River Implementation Area

| Station | | Jan. | Feb. | Mar. | Apr. | May | June | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USGS 13344000 Tucannon River near Pomeroy, WA | Mean Baseflow, measured in inches (cfs) | 0.76 (106) | 0.77 (117) | * | * | * | * | 0.46 (63) | 0.38 (52) | 0.41 (59) | 0.49 (68) | 0.62 (89) | 0.67 (93) |
| | Mean Surface Runoff, measured in inches (cfs) | 0.2 (27) | 0.25 (38) | * | * | * | * | 0.02 (2.6) | 0.01 (1.2) | 0.02 (3.3) | 0.02 (2.8) | 0.16 (23) | 0.12 (16) |
| | Mean Streamflow, measured in inches (cfs) | 0.96 (133) | 1.02 (155) | 1.24 (172) | 1.48 (212) | 1.69 (234) | 0.9 (129) | 0.48 (66) | 0.38 (53) | 0.43 (62) | 0.51 (71) | 0.78 (112) | 0.79 (110) |
| USGS 13344500 Tucannon River near Starbuck, WA | Mean Baseflow, measured in inches (cfs) | 0.35 (131) | 0.41 (170) | 0.54 (201) | 0.57 (219) | 0.64 (240) | 0.44 (172) | 0.21 (79) | 0.15 (56) | 0.17 (65) | 0.21 (78) | 0.25 (96) | 0.31 (116) |
| | Mean Surface Runoff, measured in inches (cfs) | 0.23 (87) | 0.24 (98) | 0.13 (47) | 0.15 (56) | 0.16 (60) | 0.08 (31) | 0.02 (5.6) | 0.01 (4.9) | 0.02 (6.2) | 0.01 (5.2) | 0.03 (13) | 0.14 (51) |
| | Mean Streamflow, measured in inches (cfs) | 0.59 (219) | 0.65 (268) | 0.67 (249) | 0.71 (275) | 0.8 (300) | 0.52 (202) | 0.23 (84) | 0.16 (61) | 0.18 (71) | 0.22 (83) | 0.28 (109) | 0.45 (167) |

*Source: Ecology (1999).*
*Note: cfs is cubic feet per second.*
** Indicates that flow was not estimated.*

Exhibit 7-7

## Average of Mean Streamflow and Estimated Baseflow in Asotin Creek
## USGS 13334500: 1904 to 1907; 1910 to 1912; 1928 to 1960
## USGS 13335050: 1959 to 1982; 1989 to 1996
## USGS 13334700: 1991 to present

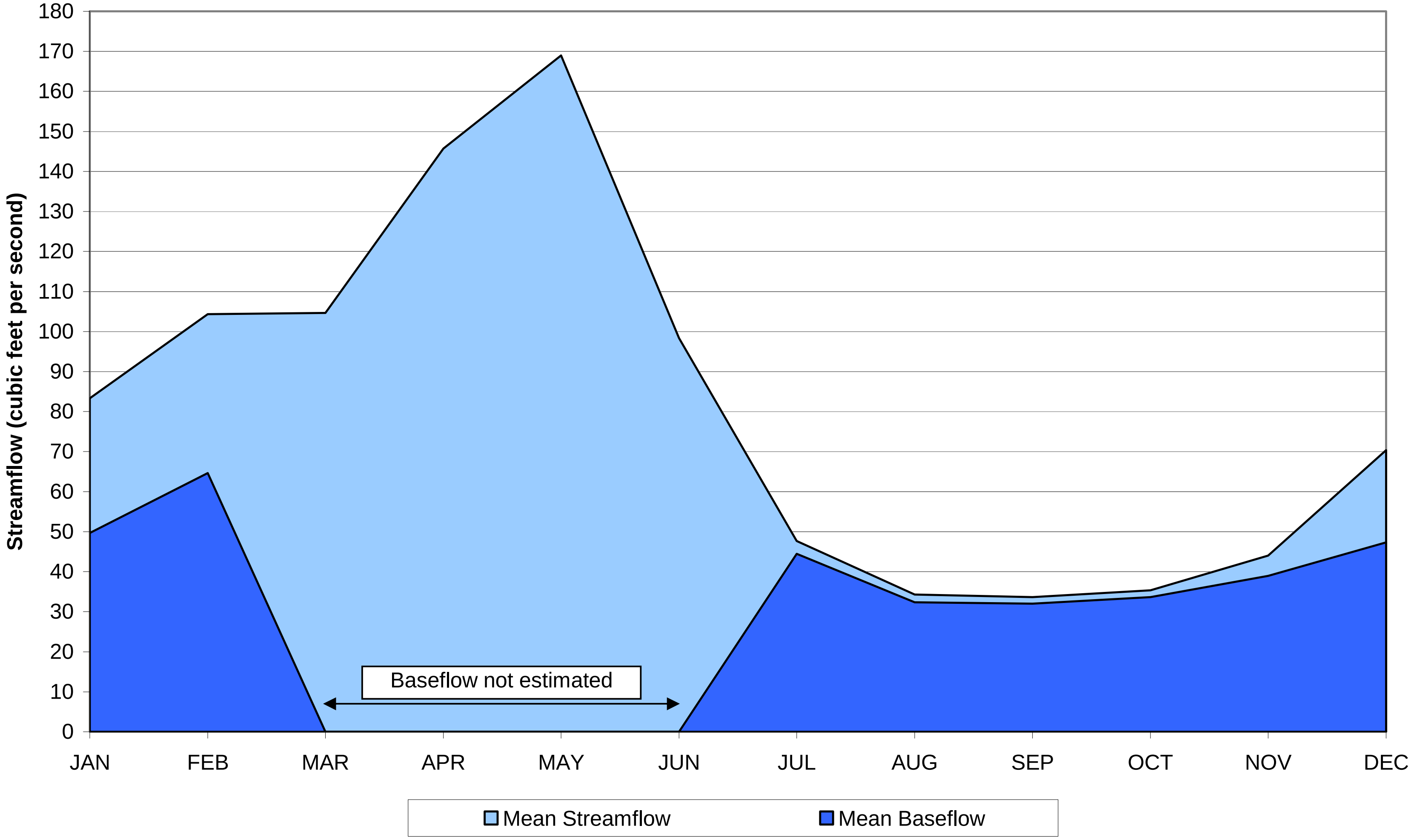


Exhibit 7-8

## Mean Streamflow and Estimated Baseflow in Meadow Creek
## USGS 113343800: 1963 to 1974

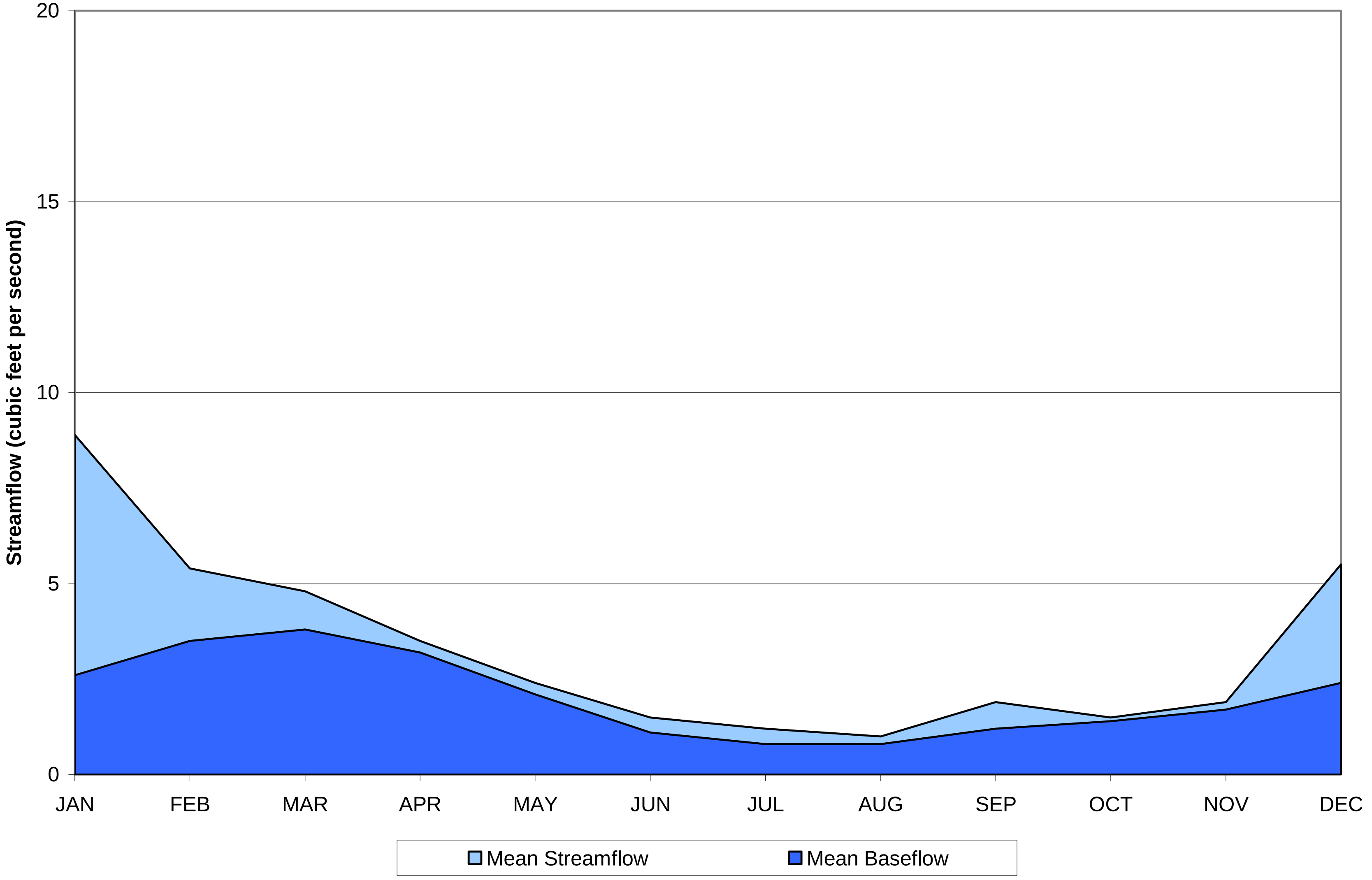
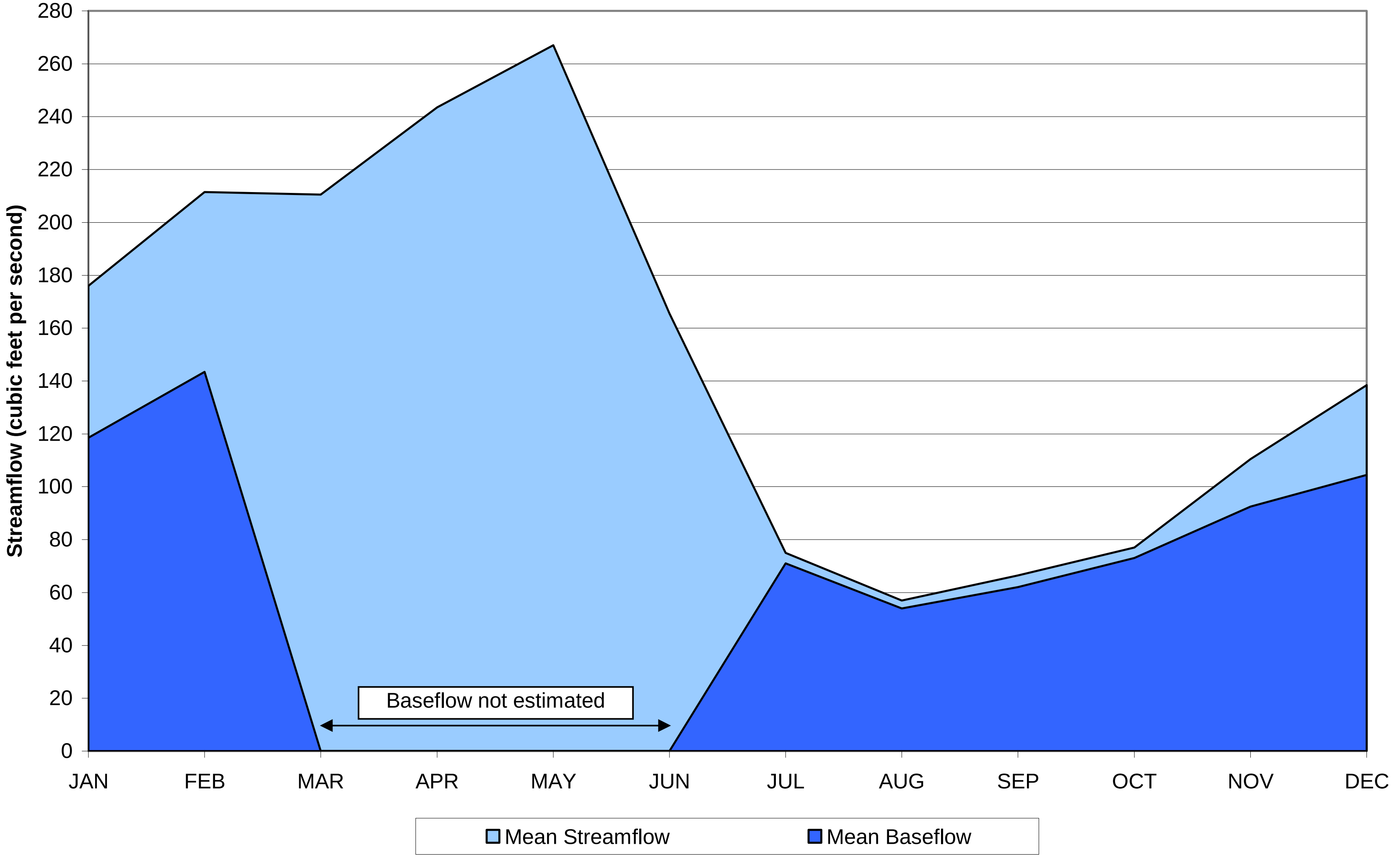


Exhibit 7-9

## Average of Mean Streamflow and Estimated Baseflow in Tucannon River
## USGS 13344000: 1913 to 1915; 1924 to 1930
## USGS 13344500: 1915 to 1917; 1928 to 1931; 1958 to 1990; 1994 to present



### 7.3.2 Aquifer Recharge and Discharge

Although a layer of loess sediments may overly most of the watershed, the basalt units are generally exposed or present near the surface. Surficial Wanapum basalts are predominant in the western and northern portions of WRIA 35; surficial Grande Ronde basalts are predominant in the central and southern portions of WRIA 35 and along the Snake River and Tucannon River; and finally, the Saddle Mountain basalts are exposed to the surface in the eastern portion of Asotin Creek Implementation Area south of Clarkston. Thus, the basalt aquifer system receives recharge directly from precipitation throughout most of the watershed. Recharge also occurs in the form of infiltration of irrigation water, and from stream and canal leakage where present. Because recharge is controlled by daily and climatic variations, there is significant variability and uncertainty in estimating recharge.

In general, ground water from the basalt aquifers discharges to surface streams, and as discussed previously, the Snake River and Grande Ronde Rivers behave as primary hydraulic controls directing the ground water flow patterns. However, it is difficult to determine the actual discharge to rivers because of large stream flows, impoundments, and regulation without studies such as those by Ecology (1999). Shallow ground water flow patterns are also locally controlled by ground water discharge to other tributaries and streams. During periods of low stream discharge where the water table lies below stream level, a large part of the stream flow percolates to ground water. During high water of spring and winter, significant flow infiltrates to ground water. Alternately, the aquifer system naturally discharges to the lower altitude streams and springs. Other discharge mechanisms from the aquifer can include downward leakage, and transpiration to plants in the areas where ground water is close to the ground surface. Water is also drawn from the aquifer system by numerous irrigation and domestic wells.

With limited information for the basin on estimating recharge and discharge, the model developed by Hansen et al. (1994) is used as the basis for the recharge and discharge estimates presented in this Level 1 Assessment. By varying land use and land cover based on pre-development (circa 1850s) and post-development (circa 1980s) conditions, the study by Hansen et al. (1994) shows that the recharge-discharge characteristics have not changed significantly between the two periods. The exceptions include a decrease of about 0.5 to 1 inch per year in a few areas near the Tucannon River and Pataha Creek confluence and also in the area near Pomeroy. Table 7-5 summarizes the range of recharge (in inches per year) in each of the implementation areas. Note that most of the aquifers receive less than 5 inches of recharge per year, but estimated recharge in the areas of the Tucannon and Pataha Implementation Areas within the Umatilla National Forest and Blue Mountain regions were estimated to range from 5 and 52.2 inches per year. This high rate of recharge to the aquifer in these areas is the “driving force” for the ground water flow patterns shown in Exhibits 7-5 and 7-6.

As with recharge, the estimated discharge from the aquifer system, not including groundwater pumpage, under 1980’s land-use conditions was very similar to the 1850 predevelopment land-use conditions based on Hansen et al. (1994). The discharge occurs primarily from the ground water to surface streams. There is a wider range of variability for discharge to the surface streams, especially along the Snake River.

Table 7-8
Summary of Recharge Estimates for Implementation Areas

| Implementation Area | Depth of Recharge (inches per Year) | Remarks |
|---|---|---|
| Asotin | 2 to 5 | Applies to most of the IA; 5 to 10 inches in the Blue Mountains area |
| Middle Snake River | 2 to 5 | Applies to most of the IA; 1 to 2 inches in the area near confluence of Tucannon River |
| Pataha | 0.02 to 0.5 | Applies to area near the mouth of Pataha Creek; increases to 2 inches per year near Pomeroy |
| Tucannon | 1 to 5 | Applies to most of IA outside of Umatilla National Forest; 0.02 to 1 inches in are near the confluence of Pataha Creek |

*Data based on Hansen et al. (1994)*

Table 7-9
Summary of Recharge Estimates for Implementation Areas

| Implementation Area | Depth of Recharge (inches per Year) | Remarks |
|---|---|---|
| Asotin | 2 to 10 | Most of the discharge occurs along George and Tenmile Creeks; significant discharge can occur in the North and South forks of Asotin Creek and upper tributaries (up to 100 inches per year for certain segments) |
| Middle Snake River | 0.1 to 5 | Discharge occurs along Alkali Flat Creek and Penawawa Creek; significant discharge occurs along Snake River (up to 100 inches per year for certain segment) |
| Pataha | Not estimated | Not estimated |
| Tucannon | 0.1 to 10 | Applies to area along Tucannon River outside of Umatilla National Forest; 0.1 to 1 inches per year from Marengo to confluence of Pataha Creek |

*Data based on Hansen et al. (1994)*

### 7.3.3 Ground Water Pumpage

The extent to which stream flow rates may be affected by groundwater pumping depends on the extent of hydraulic communication between the aquifer being pumped and the stream in question. This is determined based on presence of groundwater flow restricting features between the stream and the aquifer (confining units, low permeability zones, faults, folds, etc.), natural rate of groundwater flow within the aquifer media, pumping rate, groundwater flow rate and direction during pumping, time of the year, and stream flow rate.

Pumping of ground water creates a “capture-zone” where the potentiometric head decreases and ground water flow is directed toward the location pumping. Capture zone areas can affect stream flow through the local and regional flow systems over time. Pumping ground water has the potential to decrease flows in surface streams through two mechanisms: (1) by decreasing the amount of baseflow from ground water to gaining streams; and (2) by increasing the amount of water infiltrating from a losing stream as aquifer recharge. The same factors as those in Section 7.3 for hydraulic continuity affect the extent to which this occurs.

Ground water pumping in WRIA 35 ranges from small domestic wells to large municipal wells in the Clarkston area. Based on Vacarro (1999) and Hansen et al (1994), the only significant groundwater pumpage occurs near the mouth of Asotin Creek at the City of Asotin. There was no indication of any other locations or aquifers within the Implementation Area where significant pumpage occurred.

A comprehensive review of actual ground water pumpage was not conducted as part of this Level 1 Assessment, because agricultural (irrigation) use is the most prominent in the basin[8] but there is no readily available metered data for this type of use. However, an estimate can be made of the ground water pumpage in the basin based on the water rights data (refer to Section 2.9.2) Table 7-7 presents a summary of the ground water rights information. The total of approximately 28,000 afy of annual ground water rights does not include private (exempt) uses. As discussed in Section 7.4, this total is considered to be relatively small when compared to the size of the watershed. In addition, the total water rights are not likely used to the maximum allowable totals every year.

Furthermore, water use projections for municipal, domestic, exempt well, and agricultural usage indicates actual usage is smaller than these values. Table 7-7 also summarizes the projected water use based on the estimates described in Sections 3 through 6 for each implementation area. The total projected demands do not differentiate between surface and ground water sources; however, as discussed in Sections 3 through 6, most of the agricultural use is derived from surface water sources. Therefore, even though the total projected demands exceed the annual ground water rights for the Asotin Creek and Tucannon River implementation areas, most of this demand is for irrigation which relies on surface water. The large demands in the Middle Snake are for irrigation and industrial/municipal use by areas served by the Asotin County Public Utility District, which utilizes ground water sources to meet these demands.

Table 7-10
Total Annual Ground Water Rights and Projected Total Demands
for Pumpage Estimate

| Implementation Area | Approximate Annual Water Right (acre-ft. per year) | Projected Total Demands(1) (acre-ft. per year) |
|---|---|---|
| Asotin Creek | 600.48 | 1,284 |
| Middle Snake River | 21,465.75 | 8,300 |
| Pataha Creek | 2,506.36 | 2,182 |
| Tucannon River | 3,013.14 | 6,556 |

*(1) Totals calculated from Sections 3 through 6 are based on total demands from both surface and ground water sources.*

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[8] There are also large commercial/industrial and municipal uses in the Clarkston area based on water rights.

### 7.3.4 Adequacy of Data to Characterize Hydraulic Continuity

As demonstrated by the information in Section 7.3, ground water flow patterns are directly controlled by the discharge to the main river bodies in the watershed. Thus, it is apparent that hydraulic continuity is an important factor to consider in developing the watershed plan for WRIA 35. However, as as noted at the beginning of this subsection, much of the information necessary to conduct a detailed assessment of hydraulic continuity in the watershed is not available. With limited budgets and resources available for conducting further detailed assessment work, it is beneficial to prioritize areas where better understanding of hydraulic continuity is most important in terms of managing the water resource.

The general watershed characteristics considered important for evaluating the level of effort needed to characterize hydraulic continuity are presented in Table 7-8. Areas that could require a more intensive characterization of hydraulic continuity would be areas where regulatory constraints on stream flow exist; where the greatest potential for water quality impairments would result from reduced stream flow; where the hydrogeology is complex, or where current or projected future demands for ground water are greatest. However, with the exception of the Clarkston area, the entire watershed is projected to continue to have relatively low water use demand. Thus, if ground water contributes to flow in an impaired surface water body, there are less junior ground water rights that need to be regulated to protect senior rights.

Table 7-11
Implementation Area Characteristics Considered
for Future Hydraulic Continuity Assessment

| Factor | Asotin Creek | Middle Snake River | Pataha Creek | Tucannon River |
|---|---|---|---|---|
| Projected Water Use Demand | Low | Medium<br>(near Clarkston only) | Low | Low |
| Projected Population Change (Increase) | Low | Medium<br>(near Clarkston only) | Low | Low |
| Hydrogeologic Complexity | Medium | Medium | Medium | Medium |
| Regulatory Constraints on Stream Flow | Low<br>(2 SWSLs) | Low<br>(7 SWSLs not near Clarkston) | Low<br>(1 SWSL) | Medium<br>(2 SWSLs) |
| Potential for Decreased Water Quality from Reduced Stream Flow | Low | Low<br>(potential local impacts near Clarkston area) | Low | Medium |

*Notes: SWSL – Surface water source limitations (refer to Sections 3 through 6 for discussion on SWSLs.*

Areas near the Tucannon River and perhaps in tributaries near Clarkston where projected future demands are greatest, and which may require regulation of junior ground water rights to protect senior rights and instream flows, may require further characterization. This can be evaluated further as part of Level 2 instream flow assessment work.

## 7.4 Availability of Ground Water Resources in the Basin

One of the goals of the Level 1 Assessment is to estimate the availability of ground water resources in the watershed. However, due to the data limitations, a complete ground water availability estimate is not possible. Alternatively, by comparing estimates of the amount of water that enters and leaves the basin's aquifers with the estimates of the amount of ground water stored within the aquifer, implementation areas with critical ground water resource issues can be identified. Ground water entering the basin includes net recharge from precipitation; while the amount leaving includes natural discharge to surface water and pumpage from production wells.

As part of the modeling evaluation by Hansen et al (1994), two drainage basins within WRIA 35 were specifically analyzed to estimate recharge and discharge. The two drainange basins correspond with the Tucannon River-Pataha Creek implementation areas and the drainage area for Asotin Creek. For the purposes of this assessment the estimates provided in Hansen et al (1994) are used for a cursory ground water budget for these implementation areas. The results of that comparison are summarized in Table 7-9.

Table 7-12
Summary of Calculated Ground Water Recharge-Discharge
for Drainage Basins in WRIA 35

| Parameter | Tucannon-Pataha Drainage Area | Asotin Creek Drainage Area |
|---|---|---|
| Drainage Area(1) (sq. mi.) | 430 | 173 |
| Recharge(2) (acre-ft per year) | 147,334 | 57,920 |
| Discharge to surface waters(3) (acre-ft per year) | 122,139 | 54,517 |
| Recharge – discharge(4) (acre-ft per year) | 25,195 | 3,403 |
| Total Storage Volume (5) (acre-ft) | 55,040,000 | 22,144,000 |
| Total annual ground water rights (acre-ft per year) | 5,518 | 600 |

(1) *Data based on Hansen et al. (1994)*

(2) *Recharge includes contribution from irrigation; based on Hansen et al. (1994)*

(3) *Discharge to drains, rivers; based on Hansen et al. (1994)*

(4) *Difference between recharge and discharge is an estimate of the amount of ground water available for inter-aquifer transfer or pumpage from the aquifer without decreasing overall ground water stored (i.e. reducing aquifer water levels).*

(5) *Based on assumption of an average porosity of 0.20 over the entire thickness of the basalt unit and an aquifer thickness of 1,000 feet; storage volume is obtained by multiplying thickness by drainage area and porosity. A porosity of 0.20 is typical of rock units ( compared to sediment units which have porosities nearer to 0.35)*

As the values in Table 7-9 indicate, water usage in the basin is very small relative to the estimated amount of water stored in the aquifers and the difference between recharge and discharge. Even though the estimated values are cursory, the estimates indicate that generally ground water availability is not a critical issue in the basin when compared with the current and projected future demands. The critical issue is the local impacts that ground water pumping could have on stream flows on a local basis. Although these estimates are available only for two major drainage areas in the watershed, and discharge via pumping has been estimated using ground water rights, the general conclusion is considered to hold for the entire watershed. The main reason is that there is not much other usage in the remainder of the basin and exempt well use is not expected to be significant since population throughout the watershed is low.

## 7.5 Ground Water Quality

Ground water quality data is extremely limited for WRIA 35. A summary of the available information is presented in the following subsections along with a review of ground water quality regulations and an overview of the ground water quality monitoring programs relevant to the watershed.

## 7.5.1 Ground Water Quality Programs and Regulations

### *Federal and Statewide Regulations*

A number of federal environmental laws are directly or indirectly designed to protect ground water from contamination. Examples of these laws include the Safe Drinking Water Act (SDWA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Toxic Substances Control Act (TSCA), and the, Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and the Oil Pollution Act (OPA). In most cases, state agencies are responsible for promulgating regulations in the state of Washington in accordance with these federal laws. Examples of state agencies with regulatory authority to protect ground water quality under the aforementioned federal laws include the Washington Department of Health (DOH), Washington Department of Ecology (Ecology), and Washington Department of Agriculture (WSDA), and Washington Department of Natural Resources (DNR).

Federal provisions for ground water quality are found within the Safe Drinking Water Act (SDWA; USC Title 42, Chapter 6A-XII, Part C). These provisions are directed at public water systems and include requirements for monitoring water quality, development of Wellhead Protection Plans, and performance standards that protect ground water quality.

Ecology regulates ground water quality under the Water Pollution Control Act (RCW Chapter 90.48), the Water Resources Act of 1971 (RCW Chapter 90.54), and the Water Quality Standards for Ground Waters of the State of Washington (WAC Chapter 173-200). The intent of these standards is to protect against contamination from human activity, preserve the potable quality of various ground water resources, and preserve a level of quality for ground waters capable of meeting current state and federal safe drinking water standards. Additional groundwater regulations exist in WAC 246-290-310 that relate to public drinking water systems. Note that none of the local, state, or federal regulatory programs addressed here include comprehensive approaches to managing non-point sources of ground water degradation.

### *Regional Management Programs*

Statewide regulations have some important limitations with respect to protecting ground water supplies from contamination. Local government agencies often need to develop and implement a ground water management program to address the limitations of the regulations. Four existing ground water management programs provide a framework for local governments to protect ground water quality on a regional scale. The United States Environmental Protection Agency (EPA) has a Sole Source Aquifer (SSA) Program for qualifying ground water supplies. The Ground Water Management Area (GWMA) Program under Ecology’s Water Resource Program can be used to address ground water quality and quantity issues. The State of Washington legislature has also established guidelines for an Aquifer Protection Area (APA) Program. Finally, cities and counties are required to designate Critical Aquifer Recharge Areas (CARAs) in accordance with Washington’s Growth Management Act. Advantages and disadvantages of each of these programs are shown in Table 7-10.

## Table 7-13
## Regional Programs for Protecting Ground Water Quality

| **Program Name** | Advantages | Disadvantages | **Washington Examples** |
|---|---|---|---|
| Sole Source Aquifer (SSA) Program | • EPA review of federally financed projects<br>• Provides justification for receiving grants<br>• Increases public support for protecting ground water | • Have to apply for designation with EPA<br>• Federal involvement in local issues<br>• Additional bureaucracy | • Spokane Valley<br>• Lewiston Basin<br>• Whidbey Island |
| Ground Water Management Area (GWMA) Program | • Protect ground water quality **and** quantity<br>• Existing water rights are recognized<br>• Allows for coordinated management<br>• Increases potential for state grants | • Have to apply for designation with Ecology and satisfy statutory obligations<br>• Would require extensive coordination for implementation in three counties<br>• Additional bureaucracy | • Columbia Basin<br>• Kitsap County<br>• South King County<br>• None in WRIA 35 |
| Aquifer Protection Area (APA) Program | • Raises money for local ground water protection activities<br>• Provides local funding source | • Legislature would need to designate aquifer protection area<br>• Additional taxation for water & septic use<br>• Program sunsets in 2006 and may not be re-authorized by Washington Legislature | • Spokane County<br>• None in WRIA 35 |
| Critical Aquifer Recharge Area (CARA) Designation | • Ground water protection issues addressed during land use planning<br>• Developed at local level | • Local zoning and land use ordinances would be needed<br>• Designation does nothing to prevent degradation of ground water quality unless specific strategies are implemented | • Clark County<br>• None in WRIA 35 |

In WRIA 35, the SSA Program is the only currently applicable program from those discussed above. The Lewiston Basin Aquifer was designated as a sole source aquifer under this program in 1988. The boundaries of the Lewiston Basin Aquifer lie primarily within Asotin County and continues into Idaho. EPA defines a sole or principal source aquifer as one which supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer. EPA guidelines also stipulate that these areas can have no alternative drinking water source(s) which could physically, legally, and economically supply all those who depend upon the aquifer for drinking water. Sole source aquifer designation provides only limited federal protection of ground water resources which serve as drinking water supplies. It is not a comprehensive ground water protection program. For example, proposed federal financially-assisted projects which have the potential to contaminate the aquifer are subject to EPA review; however, proposed projects that are funded entirely by state, local, or private concerns are not subject to EPA review.

### 7.5.2 Ground Water Quality Characteristics

Very little information is available on the ground water quality of WRIA 35 the watershed. The information presented below is based on regional studies in the Columbia Plateau which covers most of central and eastern Washington (Vacarro, 1999; and Whiteman, et al., 1994). The Columbia Plateau study describes the regional water quality characteristics for the basalt units and geochemical evolution of ground water. Specific water quality problems and the water quality characteristics of the overburden aquifer (where present) in WRIA 35 were not studied.

Ground water in the basalt unit is generally of good quality and suitable for most uses (Vacarro, 1999). The chemical composition of ground water depends on the composition and solubility of the rocks through which the water flows, the chemical composition of the recharge water, and the amount of time the water is in the aquifer (residence time). The most prominent minerals to dissolve in the ground water in the basalt aquifers are calcium, magnesium, iron, sodium, potassium, silica, sulfate, chloride, fluoride, and bicarbonate. Concentrations of the dissolved solids in ground water generally increase in a down-gradient (or deeper) direction because of longer residence times in the aquifer. Dissolved concentrations may also increase as a result of recharge waters from irrigation that might have high dissolved solids concentrations.

Over the entire Columbia Plateau basalt aquifers, the dominant water type in all three units (Saddle Mountain, Wanapum, and Grande Ronde units) is calcium magnesium bicarbonate. Sodium bicarbonate is the next most prevalent water type. Sodium bicarbonate waters typically occur in deeper locations in the aquifer system since sodium concentrations tend to increase with longer residence times in these aquifers. It is assumed that similar water types exist in the basalt aquifers in WRIA 35.

Large nitrogen concentrations in ground water are generally observed in areas of surface water irrigation and where the overburden or sediment layer is thin. The recharging surface water moves nitrogen derived from agricultural chemicals.

The only local ground water information available at the time this Level 1 Assessment was completed was from the Asotin County Public Utility District. Ground water samples are collected by the City from their source of supply wells as required under the SDWA. The Asotin PUD has test results for synthetic organic compounds (SOC), volatile organic compounds (VOC) and inorganic compounds (IOC). The Asotin PUD also has test results for arsenic, nitrate and radionuclides. In addition, the Asotin PUD has performed water age dating tests at some of their well sites. No organic chemicals were detected in the samples and none of the maximum contaminant levels were exceeded. The source aquifers used by the Asotin PUD do not have any water quality issues with respect to drinking water parameters. Nitrate was detected at low concentrations (less than 1.0 mg/L) in two of the PUD's wells in the past three years. The MCL for nitrate is 10 mg/L.

### 7.5.3 Ground Water Contamination

Based on the land use in the WRIA 35 watershed, there are a limited number of potential anthropogenic sources of ground water contamination in the basin. To identify areas where ground water could potentially be contaminated several databases from the Department of Ecology were reviewed. These databases included:

- **Ecology Hazardous Sites List (HSL):** Sites are placed on this list as a precursor to determining whether they should be added to the Ecology Confirmed and Suspected Contaminated Sites List. Sites listed here have undergone a Site Hazard Assessment (SHA) and given a priority ranking using the Washington Ranking Method (WARM). If further investigation is warranted, the site is listed on the CSCS. All sites in Sunnyside on the HSL are also on the CSCS. As such, these sites are not summarized separately.

- **Washington State Department of Ecology (Ecology) Confirmed and Suspected Contaminated Sites (CSCS) List:** Upon discovery of a potential contamination issue, sites undergo a Site Hazard Assessment (SHA) and are ranked according to the potential severity of the hazard using the WARM. These sites are then listed on the Ecology Hazardous Sites List. If Ecology determines that the site warrants further investigation or cleanup under the Toxics Cleanup Program, the site is added to Ecology's CSCS list.

- **Ecology Underground Storage Tank (UST) list:** This database is comprised of regulated USTs, as defined by WAC 173-360, registered with Ecology. State UST regulations have been in effect since 1986. The UST list identifies the substance stored, quantity range, and status of each UST. Owners of a UST for heating oil, residential USTs with a capacity of 1,100 gallons or less, or any tank under 100 gallons are exempt from registering their UST with the State of Washington.

- **Ecology Leaking Underground Storage Tank (LUST) list:** Sites on this list have underground storage tanks that have released contaminants to the adjacent soil and groundwater and have been reported to Ecology. USTs installed after 1993 are required to meet all of the leak detection requirements as defined under WAC 173-360. The list does not identify which tank on site was leaking, nor if the tank has been removed.

As expected, most of the sites listed in these databases are near or within the Asotin County Public Utility District. It should be pointed out however, that no ground water contamination has been identified in the City's source of supply wells. A summary of the sites identified in these databases is presented in Table 7-8.

Only two sites were identified on the HSL and CSCS lists: (1) Asotin County Landfill in Clarkston; and (2) Western Farm Service in Pomeroy. The UST indicated over 100 USTs in the watershed, but most are located in Clarkston and Pomeroy, those identified as leaking USTs are also located in Clarkston and Pomeroy.

Table 7-14

Summary of Potential Ground Water Contamination Point Sources in WRIA 35

| Database | Sites | Remarks |
|---|---|---|
| HSL/CSCS | ■ Asotin County Landfill in Clarkston<br>■ Western Farm Service in Pomeroy | Specific chemicals not noted; both sites have been ranked and are awaiting remedial action. |
| UST | ■ 185 sites in Asotin Co.<br>■ 13 sites in Columbia Co. (within WRIA 35)<br>■ 87 sites in Garfield Co. | Total sites based on county wide totals; most of the sites are in the Cities of Clarkston, Pomeroy, Starbuck, and Asotin |
| LUST | ■ 28 sites in Asotin Co.<br>■ 0 sites in Columbia Co. (all in Dayton)<br>■ 14 sites in Garfield Co. | Total sites based on county wide totals; all of the sites are in the Cities of Clarkston, Pomeroy, and one in Anatone |

The database does not include non-point sources that could impact ground water quality. As discussed above, the widespread agricultural activities in the basin has the potential for pesticide and nitrate contamination.

### 7.5.4 Ground Water Quality Monitoring

Accurate information about ground water quality is critical to the sensible water resource management. However, there is currently no long-term, systematic state program to monitor and report ambient groundwater quality or water level conditions. Where it is occurring, the monitoring of ambient groundwater quality and water-levels is primarily being conducted at the local level. Local monitoring programs are often designed in response to specific groundwater issues such as known degradation of groundwater quality due to non-point pollution sources or declining water table elevations due to heavy groundwater withdrawals. Based on a survey by the Department of Ecology's Environmental Assessment Program, no monitoring programs are currently active in the WRIA 35 watershed.

As discussed above, DOH is responsible for overseeing water quality monitoring of public drinking water supply wells. DOH requires monitoring of Group A and Group B groundwater-derived public water supplies across the state. Group A systems are required to monitor annually for nitrate, and periodically for bacteria, organic and inorganic chemicals, and other select parameters (refer to data for Asotin PUD in Section 7.4.2). Group B wells are required to monitor once for inorganics, and every three years for nitrate. Group A and Group B monitoring requirements are included in WAC 246-291-300. The WRIA 35 counties have not assembled or and analyzed the data for their areas of concern and the reviewing data for individual public water systems was outside the scope of this Level 1 assessment.

Furthermore, the counties require that newly constructed private wells collect one-time ground water samples. The parameters sampled and the quality of the data varies with nitrate and bacteria being the parameters most frequently monitored. The primary reason for collecting this data is to check for compliance with drinking water standards. This information is typically files as paper copies and not readily accessible in database format. Therefore, reviewing the individual well water quality reports required a level of effort beyond the scope of this Level 1 Assessment.

Ecology's Environmental Assessment Program concluded that despite ground water quality data collected for drinking water supply, the usefulness and applicability of this data for ambient ground water quality monitoring and evaluation has been limited for the following reasons:

- Public water supply wells tend to be installed in deeper, less contaminated portions of aquifer systems (wells found to be above drinking water standards are often deepened or abandoned), biasing the sampling results away from the most vulnerable portions of aquifers.

- The long screen length and high-volume pumping rates of public supply wells don't provide representative samples of aquifer water quality conditions.

- The requirements for monitoring certain parameter groups such as pesticides are waived for many systems due to the assumption that there is a low risk of contamination. Nitrate is the only parameter that is consistently monitored on a state-wide basis.

- The frequency of sampling is often too low and is not designed to evaluate trends or changes over time. There is little or no quality assurance sampling conducted through this program, further limiting the usefulness of the data.

- The test parameters required are focused on a specific list of drinking water contaminants that don't necessarily provide a complete picture of aquifer water quality conditions.

- The DOH program does not provide data for the private domestic wells currently present in the state. Domestic groundwater wells tend to be constructed in the shallower, more vulnerable portions of aquifer systems, where early recognition of changes in water quality is most likely and most needed. The data collected for private domestic wells is not readily available.

Even with these limitations in ground water quality monitoring, ground water contamination is not considered a critical issue in the WRIA 35 watershed because of the limited development and limited potential sources within the basin. However, monitoring is important in terms of identifying non-point source contamination trends (i.e. for nitrates and pesticides).

## 7.6 Summary of Ground Water Resources

The ground water resources in WRIA 35 were formed by geologic and tectonic processes that have created a complex basalt aquifer system. The information contained in region-wide hydrogeologic assessments of ground water availability and quality provide the following conclusions regarding occurrence, quantity, and natural quality of ground water in WRIA 35:

- The Columbia River Basalt Group underlies WRIA 35. The three primary basalt units include from shallowest to deep: Saddle Mountain Unit, Wanapum unit, and Grande Ronde unit. Generally, these geologic formations correspond with the water-bearing units or aquifers. A thin layer of loess sediment covers most of the basalts but does not provide significant water-bearing capacity.

- Ground water in the basalt aquifers generally flows from the higher elevation recharge areas in the Blue Mountains toward the main surface water bodies, discharging toward the Snake River and Grande Ronde River. Primary tributaries such as the Tucannon River and Asotin Creek do not appear to control the regional flow patterns in the deeper basalt aquifers, but baseflows (ground water discharge) to these tributaries are a significant portion of the total stream flows. This indicates that shallow ground water is also affected by the smaller tributaries on a local level.

- Ground water usage in the basin is very small relative to the estimated amount of water stored in the aquifers. Even though the estimated values are cursory, the estimates indicate that generally ground water availability is not a critical issue in the basin when compared with the current and projected future demands.

- Baseflow studies conducted in specific streams in the basin indicate that ground water discharge to streams is a significant portion of total stream flow. However, because the water demand is low for the watershed, the level of effort needed to characterize hydraulic continuity is considered low. The need to conduct detailed characterization will be limited to discrete areas where potential instream needs are a concern. Areas near the Tucannon River and perhaps in tributaries near Clarkston where demands are greatest, may require further characterization.

- Ground water quality information is extremely limited for WRIA 35. However, regional studies for the Columbia basalt aquifers indicate that ground water in the basalt unit is generally of good quality and suitable for most uses. Analyses conducted by the Asotin County Public Utility District also show no water quality issues for their source of water supply.

Information reviewed as part of the Level 1 assessment will ultimately be used in the Planning Phase of the watershed planning process. This information will be used for both water supply and habitat restoration strategies. However as discussed previously, ground water data for both quantity and quality issues are very limited for WRIA 35. Adequacy of existing data and prioritization for addressing data gaps is discussed in Section 10 of this assessment.