Washington State Groundwater Assessment Program

Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer

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Cover photo: A Department of Ecology hydrogeologist measures the hydraulic gradient in an instream piezometer installed in the Chehalis River.

Washington State
Groundwater Assessment Program

Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer

by

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Conversion Factors and Datums

Multiply	By	To Obtain
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
square ft (ft^2)	0.0929	square meter (m^2)
acre	4,047	square meter (m^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per second per mile (ft^3/sec/mi)	0.0176	cubic meter per second per kilometer (m^3/sec/km)
cubic foot (ft^3)	28.32	liter (L)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
gallon (gal/min)	3.785	liter/min (L/min)

Temperature

To convert degrees Celsius (°C) to degrees Fahrenheit (°F), use the following equation: °F= 9/5°C + 32.

To convert degrees Fahrenheit (°F) to degrees Celsius (°C), use the following equation: °C= 5/9(°F-32).

Concentration

Concentrations of chemical constituents in water are presented as milligrams per liter (mg/L) or micrograms per liter (µg/L).

Datums

The vertical coordinates in this report are referenced to the North American Vertical Datum of 1988 (NAVD88). Altitude values represent the distance above or below the vertical datum in feet.

The horizontal coordinates in this report are referenced to the North American Datum of 1927 (NAD27).

Abstract

This report presents the results of a 2003-05 hydrogeologic assessment of the Centralia-Chehalis area surficial aquifer. The study was undertaken by the Washington State Department of Ecology to pilot test a standardized technical approach for a new state groundwater assessment program.

The primary technical objectives of the pilot study were to characterize the hydrogeologic setting of the study area, monitor and describe local groundwater/surface water interactions, and monitor and describe current ambient groundwater quality and water level conditions. Study activities in support of these objectives included developing a well inventory and database, conducting a dry-season seepage evaluation of the Chehalis and Newaukum rivers, and assembling and monitoring area-wide well and instream piezometer networks.

The Centralia-Chehalis area surficial aquifer, which is underlain by Miocene-age continental sediments and bedrock, is comprised of a complex assemblage of unconsolidated Pleistocene-age to Holocene-age glacial and alluvial deposits. Monitoring results indicate that groundwater in the aquifer system is in close hydraulic connection to study area rivers throughout most of the valley. Changes in the aquifer matrix and grain size strongly influence the local groundwater geochemistry, resulting in a marked contrast in reducing/oxidizing (redox) condition between the northern and southern portions of the study area. Current overall groundwater quality is good, with only limited occurrences of nitrate (as nitrogen) above 5 mg/L.

This document serves as an example of the type of technical report that would be generated by a long-term state groundwater assessment program, if the proposed assessment approach were applied to other basins of interest. A separate report evaluating the overall success of this study is in progress. The follow-up report will present lessons learned and will also evaluate the costs and benefits of the proposal for Ecology management consideration.

Acknowledgements

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Introduction

Project Background and Goals

The Washington State Department of Ecology (Ecology) has primary responsibility for managing Washington's water resources. In this role, Ecology relies on a variety of field monitoring programs to inform and improve decision-making and long-range planning by the agency's water management staff. Current monitoring programs focus largely on ambient[1] surface water conditions, including the measurement of streamflows, ambient surface water quality, and aquatic biological health.

Although groundwater serves as the primary drinking water source for state citizens, and groundwater can significantly influence surface water quality and flow, Ecology does not have an equivalent program to systematically monitor ambient groundwater conditions. In response, Pitz (2003a) recommended that Ecology pilot test a standardized technical approach for a new state groundwater assessment program. The assessment approach is intended to provide high quality data about ambient groundwater conditions, focused at the basin or subbasin scale.

To test the recommended technical approach, Ecology's Environmental Assessment Program, with support from the agency's Southwest Region Water Programs Management Team, identified a high-priority study area that would benefit from baseline monitoring and characterization of groundwater conditions (Pitz, 2003b). The area selected for study encompasses the unconsolidated surficial deposits underlying the Chehalis and Newaukum river valleys between Newaukum Prairie and Grand Mound in Lewis and Thurston counties (Figure 1).

This report presents the technical results of the 2003-05 pilot study. A separate report evaluating the overall success of the study is in progress. The follow-on report will present lessons learned and will also evaluate the costs and benefits of the proposal for Ecology management consideration.

[1] The term "ambient" refers to large-scale or area-wide conditions (i.e., conditions not associated with a specific point source, facility, or property).

Technical Objectives

The main technical objectives for the pilot study were to:

- Characterize and describe the hydrogeologic setting of the study area.
- Monitor and describe ambient groundwater level conditions.
- Monitor and describe interactions between the local surficial aquifer system and the mainstem Chehalis and Newaukum rivers.
- Monitor and describe ambient groundwater quality conditions.

Since most environmental or public drinking-water health issues occur or begin near land surface, study efforts were focused toward monitoring and describing the uppermost aquifer. The assessment study did not attempt to assign cause or origin to problems observed, nor did it attempt to provide solutions for specific water-supply or water-quality concerns present in the study area.

Previous Investigations

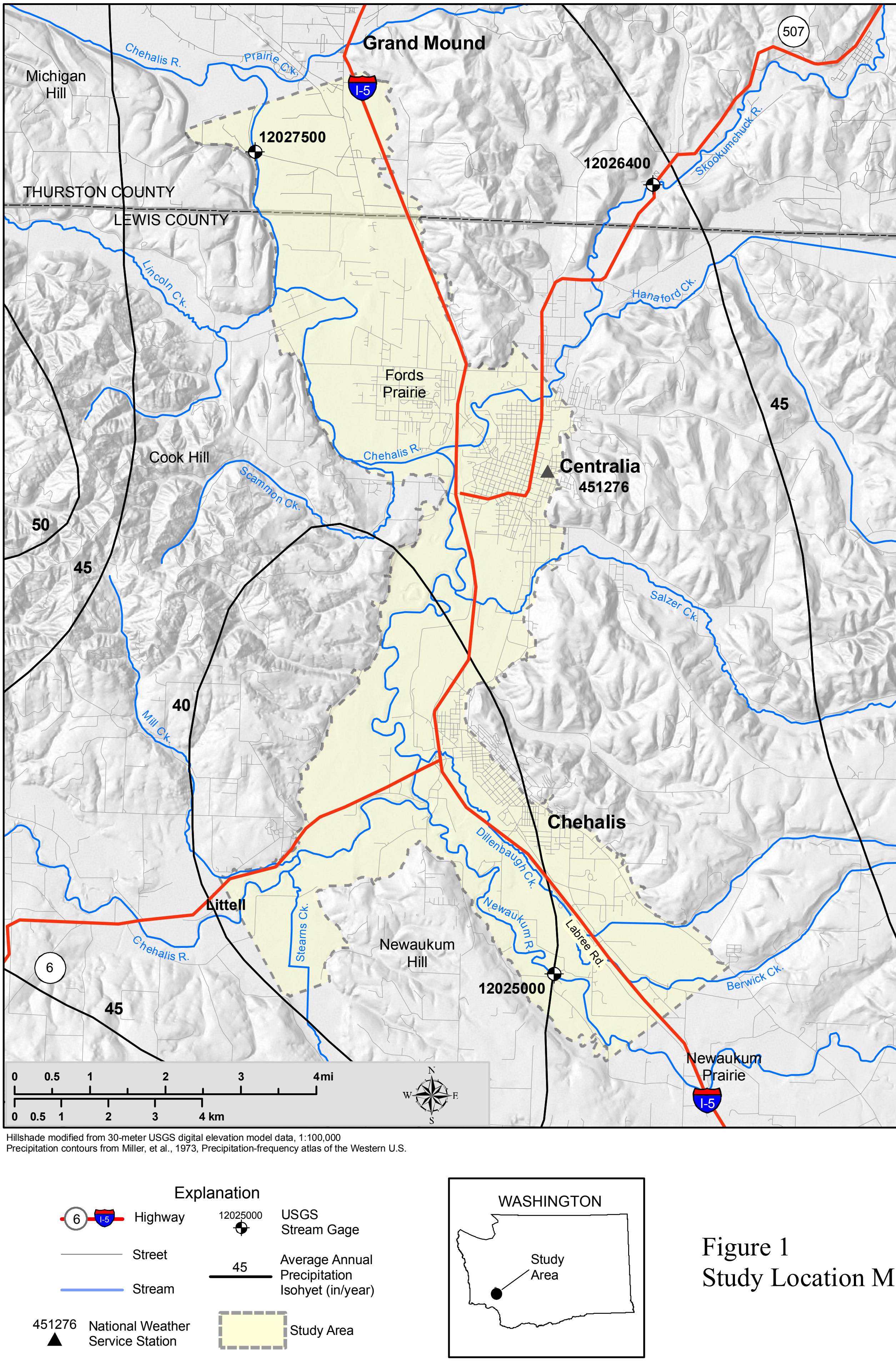
This study drew data and information from a number of previously published geologic or hydrogeologic investigations of the greater Centralia-Chehalis area.

Regional to sub-regional scale studies and geologic mapping by Snavely et al., 1958; Weigle and Foxworthy, 1962; Noble and Wallace, 1966; Lea, 1984; Logan, 1987; Schasse, 1987; and Walsh et al, 1987, provided a framework for the subsurface hydrogeologic interpretations presented here.

Localized remedial investigation studies and aquifer test reports by Dames and Moore, 1994; Robinson and Noble, 1997 and 2002; and Garrigues et al, 1998, provided additional insights regarding area groundwater levels, water quality, and flow directions. These sources were also valuable in helping to refine the study area hydrogeologic conceptual model.

Site Numbering System

The well locations referenced in this report are described using the township, range, section, and quarter-quarter section convention. Range designations include a "W" and township designations include an "N," to indicate the well lies west and north of the Willamette meridian and baseline, respectively. Each 40-acre, quarter-quarter section is represented by a single capital letter (Figure 2).



Hillshade modified from 30-meter USGS digital elevation model data, 1:100,000
Precipitation contours from Miller, et al., 1973, Precipitation-frequency atlas of the Western U.S.

Figure 1
Study Location Map

If a quarter-quarter contains more than one inventoried well, a sequence number is added after the letter designation to assure uniqueness. For example, the first inventoried well in the southwest quarter of the northwest quarter of Section 23, Township 15N, Range 03W, is represented as 15N/03W-23E01, the second well as 23E02, and so forth (Figure 2).

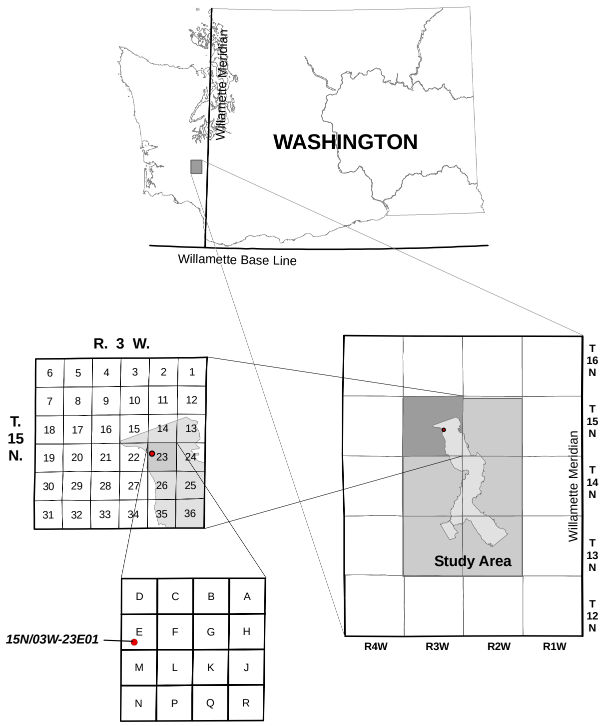


Figure 2 - Well numbering and location system

This site location and numbering convention has been used for many years by the Department of Ecology, the U.S. Geological Survey (USGS), and others, and sometimes results in numbering conflicts between reports or agencies. Numerous wells previously inventoried by the USGS and Ecology are referenced in this report. Where possible, the assigned location numbers for these wells were adopted during this study to facilitate comparisons between this and earlier publications. Readers attempting to cross-reference wells in this report with those in earlier publications should verify well identity via the construction details and descriptions provided in Appendix A.

As an additional aid to future investigators, all wells monitored during this study for water level or water quality were fitted, where possible, with a Department of Ecology well identification tag. The tag contains a six-digit, alpha-numeric identifier, consisting of three letters and three numbers, (e.g., AKB695) that uniquely identifies each well, thereby avoiding the potential cross-study conflicts inherent in the TRS numbering system. The two-by-three inch aluminum identification tag was secured to the well casing, or other permanent fixture of the water system, with stainless steel banding.

Study Area Description

Physical Setting, Land Use, and Environmental Concerns

The study area for this project is centered near the cities of Centralia and Chehalis in northwestern Lewis County. The area encompasses approximately 32 square miles (mi^2) of the broad north-south trending alluvial floodplain and bottomland that surrounds the juncture of the Chehalis, Newaukum, and Skookumchuck rivers (Figure 1).

The Chehalis River is the area's dominant surface drainage. It enters the study area near the community of Littell, at an elevation of approximately 165 feet, and flows north and east through farms and rangeland to its confluence with the Newaukum River near the city of Chehalis. From Chehalis, the river continues northward, meandering through comparatively flat-lying agricultural land to its confluence with the Skookumchuck River at the city of Centralia. Beyond Centralia the river increases in gradient as it flows west and then north through the glacial outwash plain of Fords Prairie. The river finally exits the study area at an approximate elevation of 127 feet, near the community of Grand Mound.

The Chehalis Valley has long been home to groups of Salish-speaking people who maintained year-round villages at several locations, including Grand Mound and the mouths of Lincoln Creek and the Skookumchuck River (Chehalis Tribe, 2005). Rivers and streams were the primary route of travel between villages and were used to access the upland prairies and forests where tribal members gathered edible roots and berries. The rivers also provided an abundance of freshwater clams, crayfish, and anadromous (sea-run) fish species including chinook, coho, chum, and steelhead salmon, as well as sea-run cutthroat trout and pacific lamprey (Wildrick et al., 1995).

Broad-scale European settlement of the region began in the 1850s when the Northern Pacific Railway was extended north through the area presently occupied by the cities of Centralia and Chehalis. These historic railroad and lumber towns are still the area's major commercial, industrial, and residential centers with populations of 14,742 and 7,057 full-time residents, respectively (2000 census). Like many western Washington cities, these communities have experienced steady population growth over the past two decades.

The fertile alluvial floodplain and bottomlands of the area are currently used to grow field crops such as hay, silage, grain, vegetables, and berries as well as to rear poultry, beef, and dairy cattle. The foothills to the east and west of the Chehalis valley, which reach elevations of approximately 700 and 800+ feet respectively, are actively managed for timber production.

Urbanization and agricultural development of the Chehalis Valley have been accompanied by complex environmental problems and water-resource management issues. For example:

- The Chehalis River routinely fails to meet minimum state-required instream flows, raising concerns about the influence of groundwater withdrawals on area streamflows and surface water quality (Wildrick et al., 1995; Langlow Assoc. et al., 1995).
- Area groundwater is known to be locally contaminated with nitrate and industrial solvents (CCWU/LCEHD, 1990; Marti, 2000; Robinson and Noble, 1998; Kennedy/Jenks, 1996).
- Groundwater nutrient loading was identified as one of the probable sources of depressed dissolved oxygen conditions in the Chehalis River during a 1994 Total Maximum Daily Load (TMDL) assessment (Pickett, 1994).

These and other problems could benefit from an improved understanding of the study area groundwater system.

Climate

The study area climate is typical of the Puget Sound Lowland, characterized by mild, wet winters and warm, dry summers. Winter temperatures are generally above freezing due to the low elevation of the study area and the moderating influence of the Pacific Ocean. Annual precipitation varies by location, ranging from less than 40 inches in the southern and central lowlands of the study area, to greater than 50 inches in the western foothills bordering the Chehalis Valley (Figure 1).

Precipitation patterns and trends for the area were evaluated using climate records for the National Weather Service station at Centralia (NWS station 451276). Figure 3 depicts the total annual precipitation at Centralia for water years 1932-2004. The annual precipitation at Centralia during this period averaged 46.1 inches (for years with a complete record), and varied from a minimum of 27.7 to a maximum of 66.8 inches. The annual precipitation totals during 2003 (the year preceding this study's sampling events) and 2004 (the primary monitoring period for the study) were 41.8 and 43.6 inches respectively. The 2004 value, however, is missing data from the wet-season months of February and March.

Figure 4 illustrates average conditions at Centralia for daily temperature and monthly precipitation, and compares these data to values recorded during the 2003-05 study period. Daily mean temperatures are typically lowest in January and highest in July and August. The study period temperatures closely matched this pattern. At Centralia, December is typically the wettest month, while July and August are typically the driest. During the study period, conditions were wetter than normal during winter 2003-2004 and spring 2005. Conditions were drier than normal during winter 2004-2005, and the summers of 2004 and 2005.

Streamflow

At present, there are six continuous and five partial-year (October-May) streamflow gages in the Upper Chehalis River watershed. Streamflow data for three of the continuous stations (the Chehalis River near Grand Mound, the Skookumchuck River near Bucoda, and the Newaukum River near Chehalis) were evaluated during this study. Figure 5 presents average daily discharge conditions for these stations for the 1932-2003 period, and compares these data to values measured during the study period.

The average streamflow patterns for these gages are quite similar and are significantly influenced by both annual and seasonal variations in precipitation. The streamflows at all three gages are generally highest between mid-November and mid-March, when precipitation is most plentiful. Area streamflows are generally lowest in July and August when precipitation is scarce.

For all three gages, stream discharge was notably higher than average from late August to October 2004, and generally lower than average for the remainder of the study period. Streamflows were significantly below average from late February through March 2005. Stream discharge during baseflow conditions for the Newaukum and Chehalis river gages were lower than normal during both summer 2003 and summer 2004. Flows for the Skookumchuck River (12026400) did not vary significantly from the norm, presumably due in part to regulation of flow by a dam upstream of the gage.

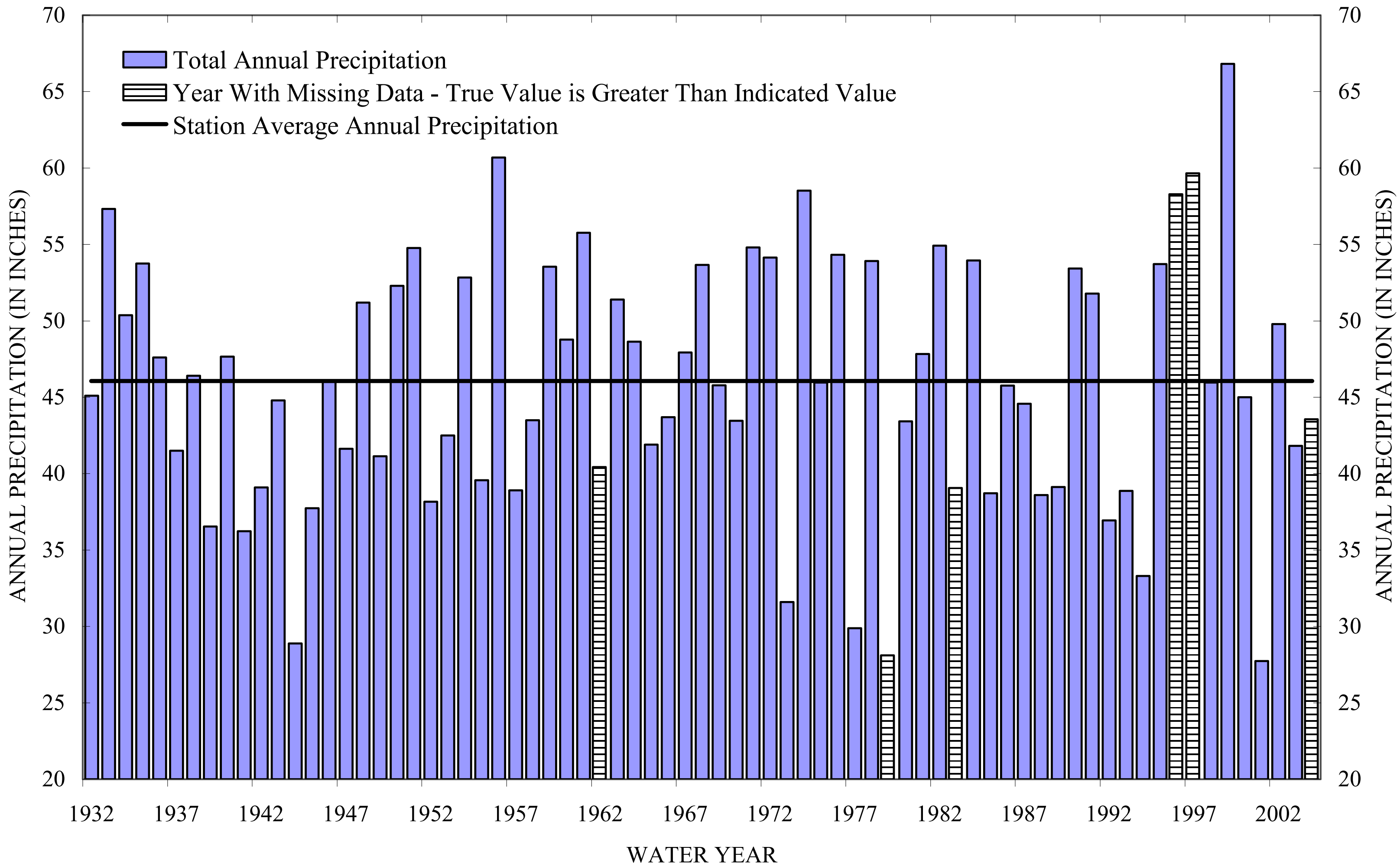


Figure 3 - Total annual precipitation at Centralia, Washington, NWS Station 451276 (Water Year 1932-2004)

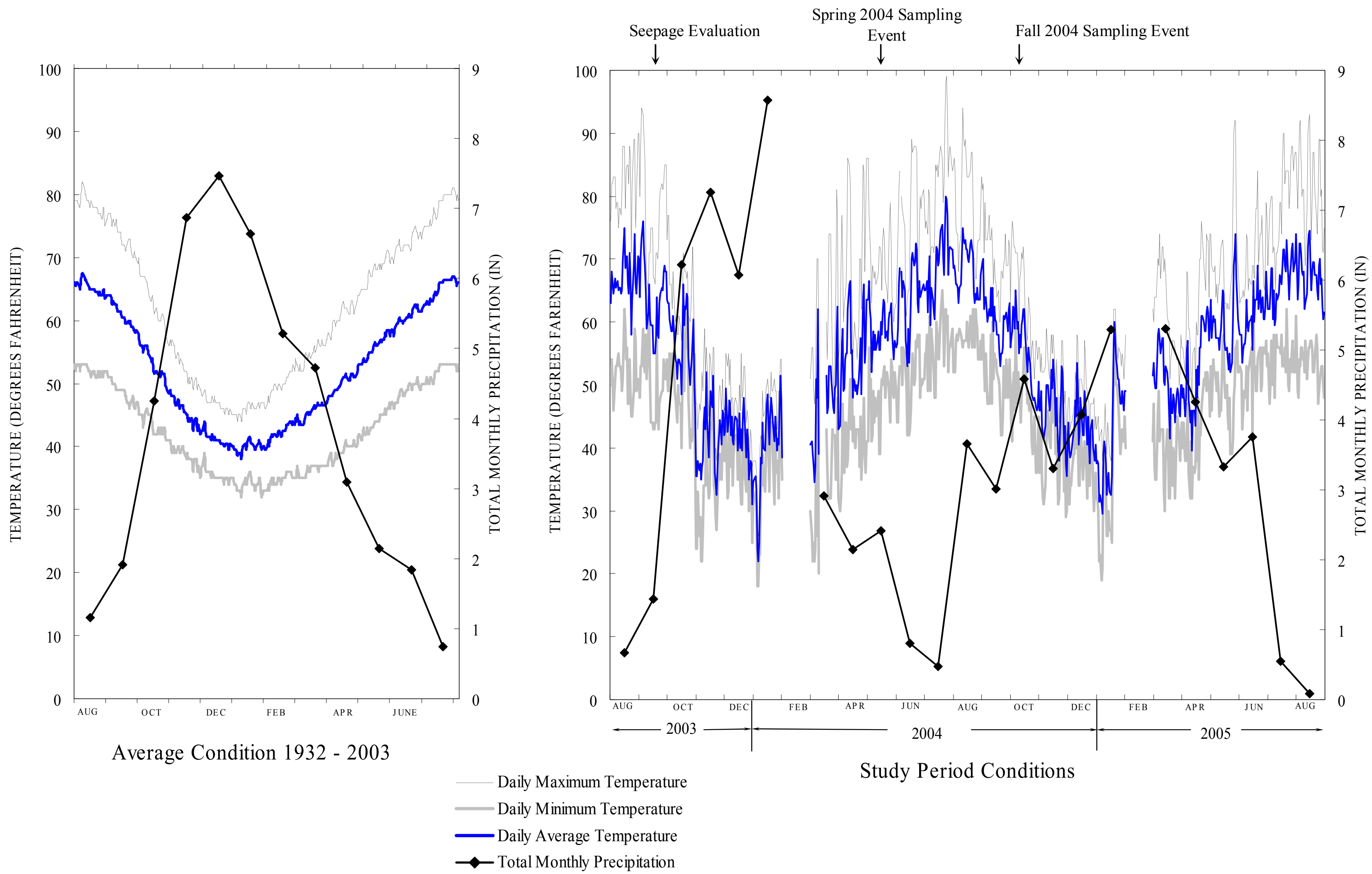


Figure 4 – Daily temperature and monthly precipitation total statistics for National Weather Service Station 451276, Centralia, WA

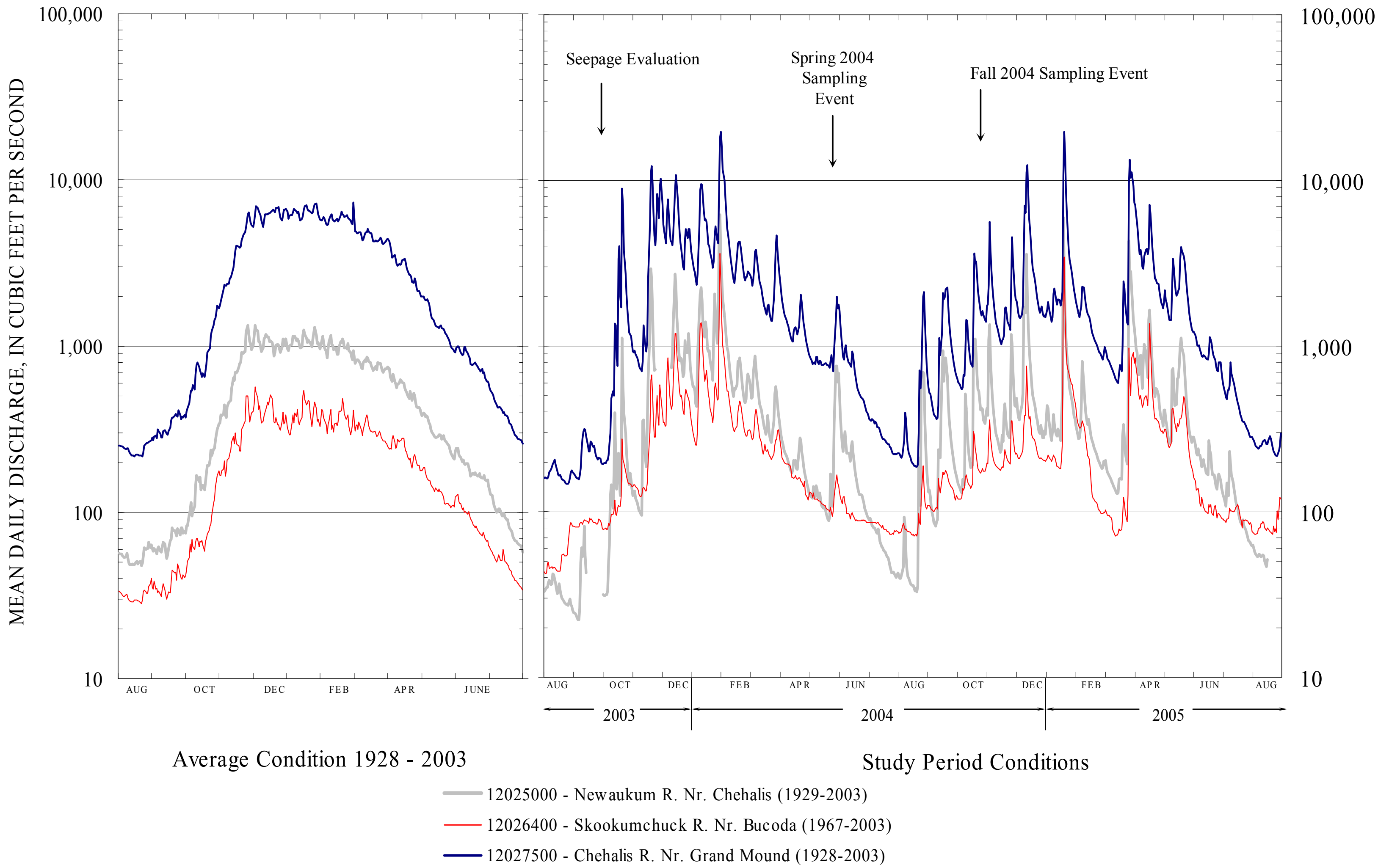


Figure 5 – Daily mean discharge for U.S. Geological Survey streamflow-gaging stations

Geologic Setting

The Chehalis River Valley lies at the southern end of the Puget Sound Lowland; an elongated structural basin that extends from the western drainage divide of the Cascade Range to the eastern drainage divide of the Olympic Mountains and north to the Frasier River in British Columbia (Jones, 1999). The structural origin of the Puget Lowland derives in large part from tectonic processes that began in the Tertiary period, when the North American continental plate converged with and partially over-rode denser oceanic plates of the eastern Pacific Ocean.

During the Eocene-to-Miocene Epochs (approximately 45-5 million years before present [B.P.]), subsidence and volcanism associated with these tectonic processes enabled vast deposits of marine, brackish water, and non-marine sediments and volcanic rocks to accumulate within the area that is now occupied by the Chehalis Valley. During early Miocene time and again in late Pliocene time (approximately 5.3-1.6 million years B.P.) significant compressional-folding and faulting deformed these rocks into the dominant southeast-northwest trending synclines and anticlines which define the present geologic structure of the area and form the foothills that bound the valley to the east and west (Snavely et al., 1958).

Although the structural framework of the Chehalis Valley was essentially complete by late Pliocene time, the area has since experienced considerable modification by continental and alpine glacial activity and erosion. During the Pleistocene Epoch, the Puget Lowland was repeatedly inundated by ice during multiple advances of the Puget lobe of the Cordilleran ice sheet. The most recent glacial incursion to affect the area occurred during the Vashon Stade of the Frasier Glaciation, which began approximately 15,000 years ago. During this period the global climate cooled, and a continental ice mass formed and advanced south from British Columbia.

As the Vashon glacier advanced, it split to form two lobes. The Juan de Fuca lobe moved west and blocked the Strait of Juan de Fuca, while the Puget lobe flowed south into the Puget Sound Lowland. At its maximum extent, the Vashon Puget lobe spanned from the Cascade Range to the Olympic Mountains and extended to just beyond Tenino in southern Thurston County, where it terminated near the southern foothills of the eastern Scatter Creek Valley (Bretz, 1913).

With the advance of the Vashon Puget lobe, once northward-flowing rivers and streams were blocked and diverted south, resulting in the creation of large lakes beside and in front of the advancing ice. Low energy melt-water from the glacier and surrounding mountains deposited thin layers of glaciolacustrine sand, silt, and clay in the progressively deepening lakes. The lakes eventually filled to the point that drainage pathways were opened through the Skookumchuck and Chehalis river valleys via divides at Johnson Creek and Mcintosh Lake to the east of our study area; thereby re-establishing flow to the Pacific Ocean.

At the onset of glacial retreat, approximately 13,500 years ago, high-energy streams (fed by melting ice, diverted streamflow, and periodic outbursts from ice-dammed-glacial lakes) transported large quantities of coarse-grained outwash deposits down the Skookumchuck River gorge and into the lower Skookumchuck and Chehalis river valleys. Although Vashon ice never occupied the Chehalis Valley proper, melt water from the glacier deposited large quantities of outwash deposits on the valley floor as far south as the present Chehalis and Skookumchuck river confluence (Plate A).

As the Vashon glacier spilled meltwater and outwash into the Chehalis Valley, it blocked or partially blocked the northern drainage of the Chehalis River. This temporary blockage created glacial Lake Chehalis, which at its maxima is thought to have extended south from the Chehalis and Skookumchuck river confluence several miles up valley beyond the Chehalis and Newaukum river confluence (Bretz, 1913). During its existence, Lake Chehalis enabled a generally fine-grained assemblage of glacio-lacustrine sand, silt, and clay to accumulate on the Chehalis and Newaukum river valley bottoms of the southern study area.

These Vashon-age deposits are inferred to overlie older (>125K years B.P.) continental glacial deposits, informally named Penultimate Drift by Lea (1984). At its glacial maxima, ice of the Penultimate Puget lobe is inferred to have extended from 2-12 km beyond the ice limit of the Vashon Puget lobe and into the Chehalis Valley nearly as far south as the present city of Centralia (Lea, 1984). Vashon meltwater likely reoccupied and deepened many of the discharge pathways created during the Penultimate glaciation. Accordingly, most topographic features associated with the Penultimate glaciation have since been eroded or are obscured by subsequent Vashon deposits. Nonetheless, thin discontinuous deposits of moderately weathered drift attributed to the Penultimate glaciation are preserved at land surface in the foothills to the north of our study area. Based on a comparison of till descriptions by Lea and those in area well reports, Penultimate till and outwash gravels are inferred to discontinuously underlie younger deposits of Vashon outwash and recent alluvium in the Chehalis Valley at least as far south as the present Skookumchuck River.

The Vashon and Penultimate deposits that dominate the northern study area abruptly give way, south of the Skookumchuck River, to a generally finer-grained assemblage of recent alluvium, Vashon-age glacio-lacustrine deposits, and older alpine drift. Two Cascade alpine drift sequences are represented within the study area: the Logan Hill Formation (approximately 1,200K years B.P.) and the Hayden Creek drift (approximately 140K years B.P.). Both units are more deeply weathered and contain a greater proportion of interstitial silt and clay than the Vashon and Penultimate deposits to the north (Plate A).

The Logan Hill Formation is widely distributed throughout the uplands that border the Chehalis Valley, where it unconformably overlies and caps many of the low-lying bedrock hills. In contrast, surface exposures of Hayden Creek drift are restricted to low-lying terraces that border the Newaukum and central Chehalis river valley. On the basis of area well log descriptions, Hayden Creek deposits are inferred to extend north and west beneath the Chehalis Valley where they unconformably overlie older deposits, and are themselves overlain by younger continental glacio-lacustrine deposits and recent alluvium.

Geologic Units

The Pleistocene-age glaciations, and subsequent Holocene-age alluvial processes that shaped the Chehalis lowlands, left behind significant accumulations of glacial outwash, till, glacio-lacustrine deposits, and alluvium. Arranged youngest to oldest, these deposits comprise six previously named geologic units: recent alluvium, landslide debris, Vashon drift (which includes glacio-lacustrine deposits), Penultimate drift, Hayden Creek drift, and the Logan Hill Formation. These Quaternary deposits rest on older, Tertiary-age rocks and sediments and form the area's major water-supply aquifers.

Alluvium, the youngest geologic unit in the study area, consists of modern river and stream deposits of fine gravel, sand, and silt. These deposits are broadly distributed across the flood plains and valley bottom of the study area where they overlie older deposits. This unit varies in thickness from a thin veneer near the valley edges to several tens of feet in the Chehalis Valley interior, where the river has meandered and reworked underlying sediments.

Vashon outwash gravel and sand occurs at land surface within Fords Prairie, and along the lower Skookumchuck River Valley north and east of Centralia. Vashon outwash also underlies alluvium in the Chehalis Valley north of Salzer Creek and west of Fords Prairie. The Vashon deposits consist of well-rounded, poorly-to-moderately well sorted, stratified to non-stratified, gray to dark-gray brown, coarse gravel and sand with interspersed cobbles and minor amounts of silt or clay. The gravel shows little weathering and is generally of local volcanic rock types, but also contains a significant percentage of metamorphic or granitic rocks of non-local origin.

South of the Chehalis and Skookumchuck river confluence, Vashon-age outwash interfingers with and eventually gives way to glaciolacustrine deposits of glacial Lake Chehalis. These lacustrine deposits do not occur at land surface and are overlain by recent alluvium throughout their range. They are identifiable only through well log descriptions and are often difficult to distinguish from overlying fine-grained alluvial deposits or underlying older fine-grained continental sediments. They abut Vashon outwash in the vicinity of Centralia and extend south into the Chehalis Valley at least as far south as Adna and up the Newaukum Valley to at least Newaukum (Weigle and Foxworthy, 1962).

In the southern Fords Prairie area, Vashon outwash is inferred to overlie older continental glacial deposits, informally named Penultimate Drift (by Lea, 1984). Although no known Penultimate deposits occur at land surface within our study area, surface exposures to the north are characterized by thin, discontinuous till deposits and associated erratics. Penultimate till ranges from 1.5 to 20 feet thick and is interspersed with or overlies poorly sorted, non-stratified outwash sand and gravel which reaches thicknesses of 3 to 20 feet (Lea, 1984). The till is only lightly weathered and consists of rounded to sub-rounded pebbles and cobbles in an oxidized, fine-grained matrix of compact sand, silt, and clay. Locally the matrix consists of un-compacted sand. The outwash gravel is often stained reddish brown to yellowish brown and is predominately of mafic volcanic origin, with lesser amounts of metamorphic, silicic plutonic, sandstone, and siltstone rock types.

Hayden Creek drift is widely distributed within the Newaukum and central Chehalis river valleys south of Salzer Creek. It is composed of poorly sorted, weathered to relatively un-weathered sand, gravel, and occasional cobbles in a matrix of yellow-brown to yellow-green-gray silt or clay. The gravel is generally composed of well-rounded rocks of local volcanic origin and is often iron stained and locally cemented.

The Logan Hill Formation consists of deeply weathered yellow-gray to yellow-brown, poorly sorted sand and gravel deposits that cover large areas of the bedrock uplands bordering the Chehalis and Newaukum river valleys. These deposits are thought to be of early Pleistocene Cascade Valley glacial and glaciofluvial origin (Weigle and Foxworthy, 1962). The upper 20-50 feet of the formation is often weathered to a reddish clay or clay soil. Pebbles in this zone have deep to fully penetrating weathering rinds. When wet, surface exposures exhibit brightly colored shades of red, yellow, orange, blue, and green (Noble and Wallace, 1966). Pebbles within the Logan Hill Formation are predominately of andesitic or basaltic origin with lesser amounts of red volcanic, tuffaceous, and dark sandstone pebbles of local origin.

Within the southern study area, deposits of Hayden Creek Drift, and to a lesser extent those of the Logan Hill Formation, unconformably overlie Miocene-age continental sediments of the Wilkes(?) Formation. These sediments consist of unconsolidated, thinly bedded blue to blue-green clay with interbedded lenses of fine-to-coarse sand or silt. Locally, the clay contains abundant wood or plant fragments, and occasional thin lenses of small gravel.

The contact between the Logan Hill Formation and the underlying fine-grained continental sediments of the Wilkes(?) Formation is often obscured by landside debris. Landslides are particularly common along the foothills of the Newaukum River Valley where Logan Hill deposits have slumped at the contact with the fine-grained continental sediments. The landslide deposits are typically poorly sorted assemblages of clay, silt, sand, and gravel.

In the southwestern foothills of the Chehalis Valley, near the town of Littell, the Logan Hill Formation is underlain by basalts of the Columbia River Basalt group. These rocks apparently extend eastward beneath the Newaukum River Valley at depth before pinching out near the confluence of the South and North forks of the Newaukum River (Weigle and Foxworthy, 1962). In un-weathered exposures this unit is typically black to dark-gray. It is fine-grained to finely-porphyritic and typically massive, but may be locally jointed or vesicular. Where exposed at land surface, the upper portion of this unit may be deeply weathered to a reddish-brown clay soil (Weigle and Foxworthy, 1962).

The Columbia River Basalt group is underlain by Miocene to Eocene-age volcanic rocks, siltstones, sandstones, shales, and conglomerates of the Astoria(?), Lincoln Creek, Skookumchuck, Northcraft, and Mcintosh formations. These older consolidated rocks comprise area bedrock, and have been grouped into a single generalized unit for this study. Readers are referred to the work of Snavely et al. (1958), and Weigle and Foxworthy (1962) for a detailed discussion of origin and geology of these units.

Study Methods

A variety of field methods and analytical techniques were used during this project to characterize the study area hydrogeologic framework, groundwater levels and flow directions, and groundwater/surface water interactions. These methods and techniques are described below. Water quality methods and analytical techniques are discussed separately in the *Groundwater Quality* section of this report.

Well Inventory and Data Compilation

The initial data compilation and well inventory for this study began in winter 2003/2004 when historic well, climate, and streamflow records for the greater Centralia-Chehalis area were queried and downloaded from computerized databases maintained by the USGS, the National Oceanic and Atmospheric Administration (NOAA), and the Washington State Departments of Health and Ecology.

This initial effort (coupled with a review of paper files and published reports) culminated with the development of a database of 814 area wells. A digital coverage of the database wells was prepared using the reported coordinates for each site and ESRI ArcMap® Geographic Information System (GIS) software. A subset of 307 wells was then selected for follow-up evaluation or field inventory (Plate B).

The wells for inventory were selected based on the availability of a drillers log, the availability of historic water level or water quality data, the reported accuracy of the well location, and the desire to obtain a representative distribution of wells within the study area. During follow-up field visits, previously reported well locations were updated using a satellite-based Global Positioning System (GPS) receiver with a reported horizontal accuracy of approximately 10 meters (32.8 feet). The land surface altitude at each well was then estimated using a pixel matching process and digital LIDAR or 10-meter DEM Grids.

Well Monitoring Networks

Two well networks were monitored during this study. The primary network (referred to in this report as *Tier 1*) consisted of a combination of 43 domestic wells, upgradient facility monitoring wells, and inactive municipal supply wells. A second, smaller network (referred to as *Tier 2*) was comprised of two dedicated monitoring wells installed by Ecology subsequent to the inventory. The Tier 2 wells were installed to augment the Tier 1 network, and to establish long-term ambient groundwater monitoring points for the study area. A larger Tier 2 network was originally planned, but failure to reach access agreements with local property owners prevented installation of more wells.

The Tier 2 wells were installed per the requirements of Chapter 173-160 WAC using either hollow-stem auger (well AKB695), or a combination of hollow-stem auger and air rotary (AKB696). Both wells were constructed from 2-inch diameter PVC flush-threaded casing, using a 10-foot long, 20-slot (0.020 inch) well screen. Well head elevations were determined using either LIDAR data (well ABK695) or traditional surveying methods (well AKB696). The wells were developed using a submersible pump and surge block until the discharge water was sediment free. The wells were allowed to equilibrate for approximately one week after installation before water quality samples were collected.

Aquifer Hydraulic Properties

Horizontal hydraulic conductivity values for the study area aquifer deposits were calculated using data from well specific capacity tests. Specific capacity test parameters were, in most cases, derived directly from the driller's log filed with Ecology.

Only wells with a known pumping rate, drawdown value, and construction and lithologic logs were selected for analysis. Wells tested using air lift methods were not included in the analysis.

For wells completed with a screened or perforated open interval (n = 30), test data were evaluated using a software program developed by Bradbury and Rothschild (1985). The program solves a modified version of Theis's equation to estimate aquifer transmissivity (Theis et al., 1963).

As shown in Equation (1) below, Theis's equation is modified in the program to incorporate corrections for well loss and partial penetration effects, using formulas proposed by Csallany and Walton (1963) and Brons and Marting (1961), respectively:

$$T_{CALC} = \frac{Q}{4\pi (s - s_w)} \left[\ln\left(\frac{2.25\ Tet}{r_w^2 S}\right) + 2\ s_p\right] \qquad (1)$$

where: T_{CALC} = calculated transmissivity (L^2/t)
Q = well discharge or pumping rate (L^3/t)
s = drawdown in the well (L)
t = duration of pumping (t)(*value assumed for analysis if otherwise unknown: 2 hours*)
S = formation storage coefficient (dimensionless)(*values assumed for analysis: 0.1 for unconfined conditions; 0.002 for leaky confined conditions)*
r_w = radius of the well (L)
Te = an initial estimate of transmissivity used by the program @ time t = 0 (L^2/t)
s_w = well loss correction factor (L)(*value assumed for all wells: 1.0*)
s_p = a factor to correct for partial penetration
(L = length, t = time)

Using an initial estimate of transmissivity (Te), the program iteratively solves Equation (1), substituting Te with an updated value (T_{CALC}) for each iteration. This process continues until Te and T_{CALC} agree within a set error criterion. The program divides the final calculated transmissivity value by the aquifer thickness input by the user to obtain horizontal hydraulic conductivity (K_h) values in units of feet per day (ft/day).[2]

During model input of the user-defined variables, the assumption was made that the total saturated thickness of the aquifer at each well equaled the length of the open interval for that well. While this assumption may overestimate K_h if the open interval is actually less than the total saturated thickness of the aquifer, the error is likely to be small. Vertical anisotropy in alluvial and glacial sediments often results in preferential horizontal flow to a well, thereby limiting inflow from areas above or below the open interval.

Based on local aquifer test data (Robinson and Noble, 1993a, 1993b, 1994, 1996, 2000) and a review of geologic logs, an unconfined storage coefficient was assumed for all wells north of the Ford's Prairie area; a storage coefficient representing leaky confined conditions was assumed for all wells south of this area.

To determine if the K_h values derived from local single-well specific capacity tests are comparable to values derived from more rigorous multi-well aquifer tests, data from seven such tests (Robinson and Noble, 1993a, 1993b, 1994, 1996, 2000) were input into the Bradbury and Rothschild program. This comparison revealed that on average, the K_h values from specific capacity tests differed by less than a factor of 2 from values derived from multi-well aquifer tests. This difference is comparable to the uncertainty often assigned to aquifer test results (Winter, 1981). This suggests that the specific capacity-derived K_h values are reasonable for the purposes of this study.

Horizontal hydraulic conductivity values for open-ended wells (those without screens or casing perforations, n = 44) were estimated using Bear's (1979) equation for hemispherical flow to an open-ended well just penetrating an aquifer. When modified to describe *spherical* flow to the open end of a well completed *within* an aquifer, the equation becomes:

$$K_h = \frac{Q}{4\pi sr} \qquad (2)$$

where: K_h = horizontal hydraulic conductivity (L/t)
Q = well discharge or pumping rate (L^3/t)
s = drawdown (L)
r = well radius (L)
(L = length, t = time)

Equation (2) assumes that the horizontal (K_h) and vertical (K_v) hydraulic conductivity of the aquifer are equal, and that water flows to the well uniformly from all directions. This assumption is probably incorrect, given the heterogeneous, layered character of the study area deposits. As a result, the equation likely underestimates K_h by an unknown factor.

Groundwater Level Measurements

Static water levels in wells were measured according to procedures detailed in Pitz (2004). Where owner permission was granted and down-hole access was feasible, water level measurements were made and recorded by field personnel (typically with an electric tape) at the beginning of each site

[2] Since the screen openings and filter pack material size selected for monitoring wells are typically designed to optimize the collection of long-term water quality samples (as opposed to water production), the hydraulic conductivity values derived by Equation 1 for the Tier 2 wells probably underestimate the true permeability of the aquifer sediments adjacent to these wells.

visit. Measurements were avoided in active, large-diameter production wells, or when repeated measures indicated a well undergoing dynamic response to pumping. Water level measurements were made in a total of 95 wells throughout the study area.

Measurements were made prior to well purge and sampling, and were recorded to the nearest 0.01 feet. Three mass water level measurement rounds were conducted across the study area during 2004. These efforts included once in April during the initial well inventory, again in May during the first (spring) mass sampling event, and again in October, during the second (fall) mass sampling event. After adjusting for well-casing stickup, water level altitudes were estimated for each well by subtracting the measured depth-to-water from the ground surface elevation at the well head.

In addition to these periodic hand measurements, a subset of wells located along the main axis of the study area were instrumented with absolute (non-vented) pressure transducers for continuous measurement of water levels. Transducers were installed in eight wells (Plate C, Figure C-1) and were programmed to record the static pressure head once per day. Manual water level measurements in these wells were made monthly to calibrate and verify the transducer data.

To compensate for atmospheric pressure effects, two barometric pressure transducers were also deployed: one in the northern and one in the southern portion of the study area. Barometric measurements were made once per day and corresponded with transducer water level measurements. A software program was subsequently used to remove the barometric effect from transducer measured water levels (using the northern barometer for northern wells, the southern barometer for southern wells). Recorded groundwater pressure heads were then converted to altitudes, using the ground surface elevation at the well head.

Groundwater/Surface Water Interactions

Three field techniques were used during this study to assess groundwater/surface water interactions. A baseflow condition seepage evaluation, in September 2003, provided reach-scale estimates of water exchange between groundwater and the study area mainstem rivers. The seepage results were used to guide the placement of instream piezometers and streambed thermistor arrays. These latter tools were used to assess finer scale temporal and spatial exchange processes and dynamics.

Seepage Evaluation

A seepage evaluation (also referred to as a seepage run) was conducted on September 25, 2003 to quantify reach-scale water exchanges that occur between the surficial aquifer system and the mainstem Chehalis and Newaukum rivers. During the evaluation, eight wading discharge measurements (at three mainstem and five tributary sites) were made between RM 59.9 on the Chehalis River, and RM 4.1 on the Newaukum River. Discharge estimates for two additional transects were developed from established stage-discharge relationships for gaging stations operated by the U.S. Geological Survey (USGS): station 12025000 - the Newaukum River at Labree Road, and station 12027500 - the Chehalis River at Prather Road.

The measurement transects for the evaluation were selected and distributed to enable an accurate accounting of surface water discharge volumes within each of three previously defined seepage reaches (Plate C, Figure C-2 and Table C-1). The evaluation was conducted following a period of dry, stable weather (Figure 4).

The discharge measurements were made using a Swoffer Model 2100 horizontal axis current meter in accordance with standard USGS methodology for mid-section method wading measurements; modified to accommodate Ecology's Environmental Assessment Program equipment (Pitz and Erickson, 2003; Rantz et al., 1982).

The field measured velocity and stream cross-section data were input into QWIN (an automated discharge calculation software developed by Ecology's Stream Hydrology Unit; Larson 2004) to derive discharge values for each measurement transect. These discharge values were then combined with estimated water withdrawals and effluent discharges to develop numeric water budgets for each seepage reach (Equation 3):

$$S = Q_d - Q_u - T - E + D \qquad (3)$$

where:

S = the net seepage gain or loss along the reach, in ft^3/sec

Q_d = the discharge measured at the downstream end of the seepage reach, in ft^3/sec

Q_u = the discharge measured at the upstream end of the seepage reach, in ft^3/sec

T = the sum of all tributary inputs to the mainstem river between the upper and lower reach transects, in ft^3/sec

E = the sum of all point effluent discharges[3] to the mainstem river between the upper and lower reach transects, in ft^3/sec

D= the sum of all water diversions[4] from the mainstem river that occur between the upper and lower reach transects, in ft^3/sec

[3] Estimated effluent discharges from permitted facilities were derived for each seepage reach from Ecology maintained databases.

Positive seepage values indicate the river gained water from groundwater discharge across the seepage reach. Negative values indicate the river lost water to the underlying aquifer across the reach. If the input value for effluent discharges to the river (E) underestimates the true field condition, then the seepage rate (S) will be an overestimate. Conversely, if the input value for diversions (D) underestimates the true field condition, then S will also be underestimated.

Seepage evaluations suffer from a number of potentially significant limitations. They provide only a single point-in-time estimate of ground- and surface-water exchanges. Accordingly, numerous assessments may be required to characterize highly dynamic river systems. Seepage assessments are also prone to significant uncertainty due to field measurement errors and difficulties in accurately accounting for real-time, surface-water withdrawals and point discharges. Nonetheless, seepage evaluations can provide a valuable initial understanding of the location, direction, and volume of water exchanges between groundwater systems and surface streams during baseflow conditions. Seepage runs are particularly useful for defining and prioritizing the placement of instream piezometers and thermistor arrays which are commonly used to evaluate finer-scale temporal and spatial seepage conditions.

A number of field quality assurance tests, such as replicate discharge measurements, were conducted the day of the evaluation. These tests are described in detail in Appendix B. Results of the testing indicated excellent data quality and reproducibility.

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Instream Piezometers and Streambed Thermistor Arrays

In spring 2004, a network of instream piezometers was installed along the Chehalis and Newaukum rivers to help characterize temporal patterns of groundwater/surface water exchange at specific locations within the study area. Three piezometer types were installed during this effort. One-inch inside diameter (I.D.) galvanized-steel pipe piezometers were used at sites where very coarse-grained or partially cemented streambed sediments were encountered. These larger diameter casings were perforated with drill holes over the lowermost 4 inches to allow water entry. In loose finer-grained sediments, stainless-steel drive screens (0.75-inch I.D.), or screened polyethylene tubing piezometers (0.25-inch I.D.), were deployed. In all cases, the piezometers were driven into the streambed within wadeable distance of shore using a slide hammer. Installation depths ranged from 3.4 and 8.7 feet below the streambed (Appendix C, Table C-1).

The piezometers were developed using standard surge and pump techniques. Development continued until the purge water was visibly clear and free of sediment, and a good hydraulic connection had been established between the piezometer and surrounding streambed sediments.

The piezometer network was visited monthly between May and October 2004 to make comparative head (water-level) measurements between the piezometers and the river. For the steel-cased piezometers, stream stage was measured by aligning an engineers tape parallel to the outside of the piezometer pipe and measuring the distance from the stream surface to the top of the piezometer. The inside (piezometer) water level was also measured from the top of the piezometer using an electric tape. For severely angled (off-vertical) piezometers, these "raw" field measurements were corrected using simple trigonometric relationships to yield true depth-to-water measurements.

Water levels in the tubing piezometer were measured by first lifting and orienting the tubing until it was perpendicular to the water surface. After allowing the piezometer head to equilibrate, its position relative to that of the stream was measured using a small stilling tube and metric scale which were held adjacent to the piezometer tubing (after Welch and Lee, 1989).

To normalize for differences in piezometer depth between sites, field measured water levels were converted to vertical hydraulic gradients as follows:

$$i_v = dh/dl \qquad (4)$$

where: i_v = the vertical hydraulic gradient (dimensionless)

dh = the difference between the stream stage and the piezometer water level (L)

dl = the distance from the streambed to the midpoint of the piezometer perforations (L)

(L = length)

Negative values of i_v indicate loss of water from the river to groundwater, while positive values indicate groundwater discharge into the river.

Thermistor arrays, comprised of three vertically spaced I-button® recording thermistors (model DS 1921L), were installed within each of the 1-inch steel piezometers. For each array, the thermistors were programmed to simultaneously record water temperatures at half-hour intervals at discrete depths below the

[4] Since it was not practical to survey and measure individual point diversions along the river the day of the evaluation, the Ecology Water Resources Program water rights database was queried to identify *certificated* rights for diversion of surface water along the sections of interest. While there is no evidence that the certificated diversions were necessarily active during the day of measurement, their inclusion in the budget provides insight into the potential impact of anthropogenic (human-caused) surface water withdrawals on the seepage run findings. See Appendix B for additional discussion.

streambed[5]. In a typical installation, one thermistor was located near the piezometer bottom within the perforated interval of the pipe, one approximately 0.5-1 foot below the streambed, and one roughly equidistant between the upper and lower thermistors. An additional thermistor was deployed in the river immediately adjacent to the piezometer to monitor surface water temperatures.

The resultant thermal records provide (1) a qualitative confirmation of the monthly hydraulic gradient measurements, and (2) a continuous temporal record of groundwater/surface water exchange relationships. Sites where streambed water temperature ranges are highly dampened relative to surface water temperatures indicate groundwater discharge into the stream (a gaining stream segment). Conversely, sites where streambed water temperatures closely mimic those in the stream indicate surface water loss through the streambed (a losing stream segment) (Stonestrom and Constantz, 2003).

Groundwater System

For this study, the previously described geologic deposits were grouped into eight hydrogeologic units (Plate A and Appendix D, Table D-l). Unit designations were made using information from surficial geologic maps, horizontal hydraulic conductivity estimates, driller reported lithologic descriptions, and reported or measured groundwater levels.

Four of these units are further grouped to define the principal aquifer systems of the study area. The study area surficial aquifer system encompasses three hydrogeologic units [(Qa, Qgog, and Qapo(h)]. Although these units comprise a single aquifer system, they are described separately to acknowledge and accommodate significant differences in their hydraulic and geo-chemical properties. The second principal aquifer system is contained within the higher permeability zones of hydrogeologic unit Mc(w). These aquifers are separated and/or underlain by lower permeability confining units as described below.

Hydrogeologic Units

Unit Qa occurs at land surface throughout most of the study area valley bottom. It is comprised mostly of recent alluvial deposits of silt, sand, and fine gravel but locally includes fine-grained, glacio-lacustrine deposits of sand, silt, and clay. Based on the wells inventoried for this study, unit Qa is approximately 22 feet thick on average, and varies from a thin veneer to 80 feet in the valley bottom, between Centralia and Chehalis, where the glacio-lacustrine deposits are thickest. Unit Qa may serve as a surficial semi-confining unit to the generally coarser grained aquifers that underlie it in the northern and southern portions of the study area (units Qgo(g) and Qapo(h) respectively). In the central study area, where these coarser units are thin or absent, unit Qa produces small to moderate amounts of water from sand and gravel interbeds contained within it.

Unit Qls consists of older to recent landslide deposits that border the Newaukum Valley and cap portions of the foothills bordering the Chehalis Valley. It is comprised of poorly sorted deposits of clay, silt, sand, and gravel that slumped or were otherwise disturbed by mass-wasting processes. Only two of the wells inventoried for this study penetrated this unit so little is known about its water-bearing characteristics.

Unit Qgo(g) is the primary water-supply aquifer in the northern study area. It is comprised largely of Vashon recessional outwash but also contains discontinuous deposits of Penultimate outwash and till, as well as undifferentiated pre-Frasier glacial deposits. Unit Qgo(g) is composed largely of well-to-poorly-sorted deposits of coarse-to-medium gravel, sand, cobbles, and occasional boulders, with localized accumulations of interstitial silt or clay. This unit also contains thin discontinuous deposits of till or cemented gravel. Based on the wells inventoried during this study, unit Qgo(g) averages approximately 56 feet thick and ranges from approximately 6 feet to 91 feet thick.

Unit Qapo(h) is a major water-supply aquifer in the Chehalis and Newaukum river valleys east and south of the city of Chehalis. This unit is composed of Hayden Creek drift deposits of generally poorly-sorted, well-rounded gravel and sand, in a silt and clay matrix. The gravel is often iron stained and may be locally weathered or cemented. Based on the wells inventoried for this study, unit Qapo(h) is approximately 37 feet thick and ranges from 19 to >134 feet thick.

Unit Qapo(lh) is a significant aquifer regionally, particularly south and east of the study area. Locally, however, it is only of minor importance where it caps portions of the bedrock hills bordering the Chehalis and Newaukum river valleys. This unit is composed of Logan Hill Formation drift. It is characterized by often deeply weathered deposits of sand and gravel with interspersed lenses of silt and clay. When saturated, the less weathered basal gravels and sand can be an important aquifer. Since only one of our inventory wells actually penetrated this unit, its thickness can not be defined from the wells evaluated for this study. However, based on previous work by Weigle and Foxworthy (1962), this unit may be greater than 150 feet thick in some areas.

Unit Mc(w) forms the basal confining unit for the surficial aquifer of the Newaukum Valley and portions of the southern and central Chehalis River Valley south of Salzer Creek. This unit consists mostly of unconsolidated non-marine continental

[5] I-button® thermistors have a recording range of -20°C to +85°C, a resolution of 0.5°C, and a purported accuracy of 1°C.

sediments (blue-gray to blue-green clay with sand interbeds) but also contains fine-grained, glacio-lacustrine deposits in some areas. Despite its generally fine-grained nature, unit Mc(w) does contain appreciable quantities of often poor quality, confined groundwater, particularly within the Newaukum Valley. Based on the wells inventoried for this study, unit Mc(w) ranges from 8 to greater than 364 feet thick and averages 176 feet.

Unit Tb(bslt) is comprised of basalt flows of the Columbia River Basalt group. Surface exposures of this unit are restricted to the southwestern foothills of the study area. It also underlies alluvium in the southern Chehalis and western Newaukum river valleys and, where it occurs, forms the basal confining unit for these sediments. Basalts of the Columbia River group may be as much as 125 feet thick in some areas (Weigle and Foxworthy, 1962). However, based on the wells inventoried for this study, the unit is considerably thinner locally, where it ranges from 4 to 59 feet and averages 25 feet thick.

Unit Tbu consists of consolidated marine, non-marine, and brackish water siltstone, sandstone, shale, and conglomerate deposits. These rocks comprise area bedrock and form the basal confining unit for the study area's unconsolidated deposits. They also underlie and form the foothills that border the study area. Depth-to-bedrock is generally less than 90 feet in the Chehalis Valley proper and increases to more than 300 feet in the Newaukum Valley where unit Mc(w) achieves its maximum thickness. Despite its generally low permeability, this unit does contain secondary fractures that may yield usable quantities of water to wells that intercept them.

Conceptual Model of Groundwater Flow System

Figure 6 presents a generalized conceptual model of the hydrologic cycle and groundwater flow system for the study area.

For regions with little snowfall, such as the Centralia-Chehalis lowlands, some of the rain that falls on land surface quickly flows to nearby streams or rivers as surface runoff. Another portion infiltrates into the ground where it may recharge the groundwater system, or return to the atmosphere via evapotranspiration processes. Some of the recharge follows local (small scale) flow paths and moves quickly (days to months) from points of recharge to points of natural groundwater discharge at nearby seeps, springs, streams, and rivers. Other water moves more deeply into the groundwater system and follows longer (years to decades) regional flow paths through the subsurface. This water eventually returns to the surface as groundwater discharge (baseflow) to major rivers, which serve as regional drains for the surficial aquifer system.

The subsurface path that an individual water particle follows between points of recharge and discharge is controlled, in large part, by the geometry and distribution of higher and lower permeability geologic materials. Variations in the permeability of overlying units can also result in differing degrees of hydraulic confinement of the underlying groundwater. In the Chehalis valley, the low permeability Tertiary-age bedrock and continental sediments form the lower boundary for the surficial aquifer. Groundwater contribution to the surficial aquifer system from bedrock is assumed to be negligible. Groundwater contributions to the surficial aquifer from the unconsolidated Miocene sediments were not quantified during this evaluation.

Groundwater flowing toward a point of natural discharge, such as the Chehalis River, may be intercepted by supply wells prior to reaching the river. In addition, aquifer recharge may be locally increased by injection wells, stormwater dry wells, irrigation seepage, and septic systems. Differences in groundwater residence time and aquifer matrix materials along a flow path can result in significant natural differences in groundwater chemistry from location to location, as well as differences in susceptibility to contamination by non-natural sources.

Hydraulic Properties

Table 1 summarizes the horizontal hydraulic conductivity distribution by hydrogeologic unit. Calculated K_h values for individual wells are presented in Appendix D, Table D-1.

Table 1 – Horizontal Hydraulic Conductivity (K_h) by Hydrogeologic Unit

Hydrogeologic Unit	Number of Wells	K_h (ft/day)	
		Range	Median
Qgo(g)	60	20-16200	310
Qapo(h)	7	18-184	77
Qa	1	85	NA
Mc(w)	10	7-212	71
Tbu	7	<1-143	5

Most of the wells in Table 1 are water-supply wells and are, therefore, likely completed in the coarsest, most permeable portions of the aquifer system. This suggests that, if the hydraulic properties of the finer-grained portions of the system were also accounted for, the *bulk* hydraulic conductivity values for the units presented in the table may be lower than estimated.

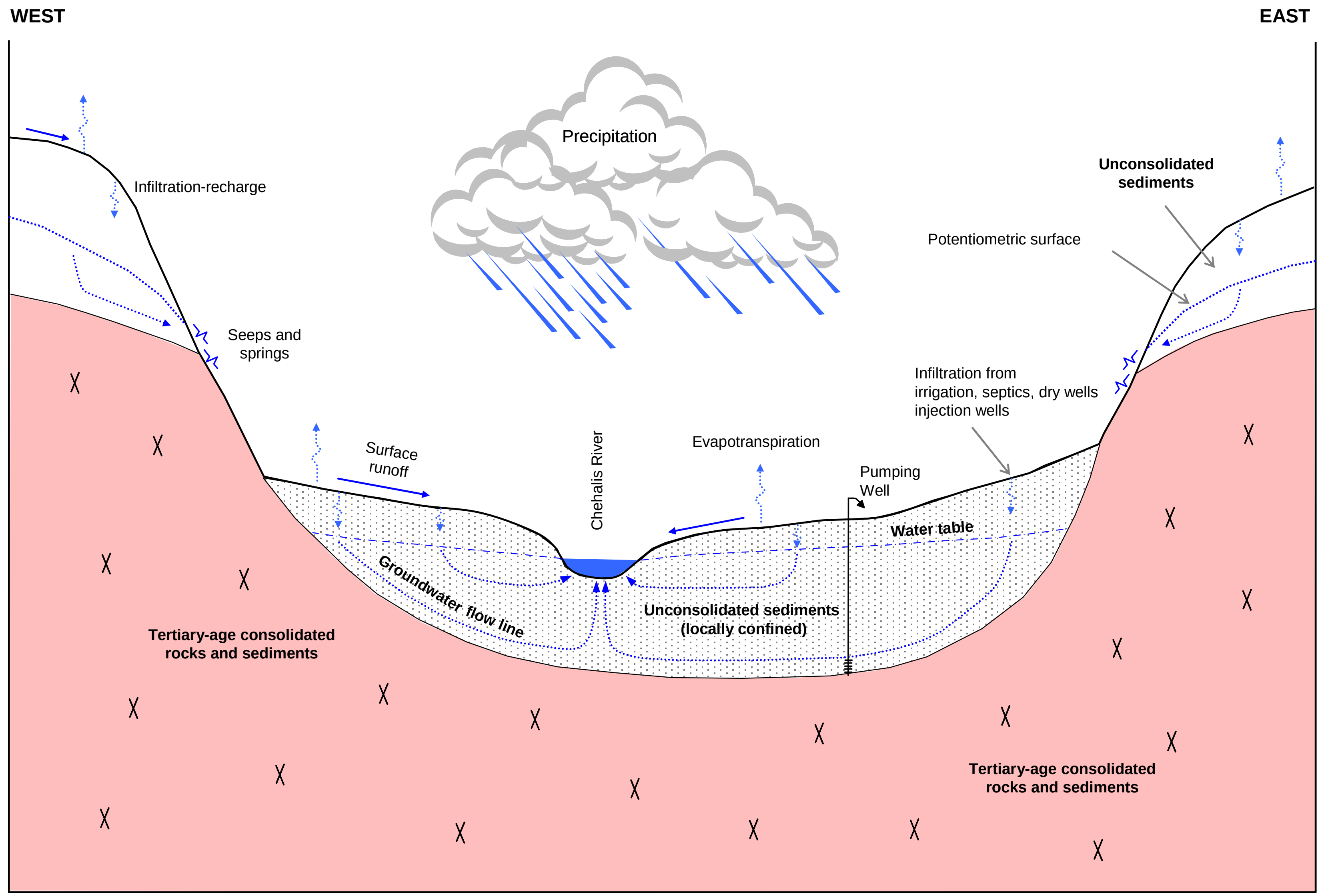

Figure 6 - Generalized conceptual model of groundwater flow in the Centralia-Chehalis lowland

In relative terms, there is an order-of-magnitude permeability contrast between the continental outwash deposits of the northern study area [unit Qgo(g)], and the generally finer-grained units [Qa, Qapo(h) and Mc(w)] in the southern study area (Plate A). In the south, there is a notable similarity between the hydraulic conductivity values estimated for units Qapo(h) and Mc(w). In the north, the area of highest permeability (Fords Prairie) coincides with surface exposures of unit Qgo(g) and unconfined hydraulic conditions, suggesting this area could be highly vulnerable to surface contamination.

Groundwater Levels

Flow Directions, Hydraulic Gradients, and Depth-to-Water

Plate C, Figure C-1 presents a generalized water-level-contour and groundwater-flow-direction map for the study area for 2004. Placement of the contour lines was guided largely by measurements from October 2004; however, additional data from April and May 2004 were used to interpret contour positions in areas of sparse coverage. Contour placement was also guided by land surface topography, surface expressions of the water table, and the results of the seepage and piezometer evaluations. No attempt was made to adjust contour placement to account for localized pumping effects or smaller-scale drainage features. The seasonal variability observed in water levels during the study period (discussed in detail below) did not significantly change contour positions or inferred groundwater flow directions.

Groundwater in the study area generally flows in a north-northwest direction, losing approximately 100 feet of elevation between the southern and northern study area boundaries. The mainstems of the Newaukum and Chehalis rivers regionally serve as sinks for the aquifer system (although the Chehalis River apparently loses water to the underlying glacial deposits for a short reach west of the Chehalis and Skookumchuck river confluence). As a result, groundwater often moves in an oblique direction toward the river and generally perpendicular to the potentiometric contours shown on Plate C, Figure C-1, as it travels down-valley. Some groundwater underflow probably also occurs down the main valley axis, beneath the mainstem channels.

Horizontal hydraulic gradients vary along the main axis of the valley, in response to changes in surface topography and subsurface permeability. In the northern and central study area, gradients average approximately 0.0025 (~13 ft/mi). The hydraulic gradient increases in the Newaukum River Valley to an average of approximately 0.0055 (~29 ft/mi).

No significant differences in water level altitudes were noted between adjacent wells drawing from the different surficial hydrogeologic units. This suggests that vertical hydraulic gradients between these units are quite small and that the units are closely coupled hydraulically. At the scale of this study, vertical gradients were only apparent near rivers and streams.

In the northern study area, depth-to-water ranges from 10-35 feet below ground surface (bgs), with an average depth of approximately 22 feet bgs. In the southern study area, depth-to-water ranges from 1-25 feet bgs, with an approximate average depth of 11 feet bgs.

Daily and Seasonal Variations

The largest seasonal water-level fluctuation observed in a single well during the monitored period was 9.62 feet (well ALB685); the smallest fluctuation was 3.57 feet (ALB684) Plate C, Figure C-1. In general, the range of fluctuation within the coarser-grained continental outwash deposits at the northern end of the study area was greater than observed in the south. This most likely reflects aquifer response to differing rates of recharge in these two areas.

Where a continuous daily record is available, the highest water levels were recorded during January 2005; the lowest levels were noted in August 2004. Periodic hand measurements of water levels indicate that transducers provided reliable data, with little or no long-term drift.

The hydrographs indicate that groundwater levels closely followed the overall annual pattern of local precipitation, with a rising trend in water levels during wet periods (e.g., April 2004 to January 2005; March 2005), and declining trend in water levels during dry periods (e.g., January to March 2005; April to August 2005). The annual-low water level appeared to be delayed by several weeks during 2005 in comparison to the 2004 period.

Rapid water level responses corresponding to stage changes in the Newaukum and Chehalis rivers were noted for many of the measured wells, particularly in the northern study area. Responses in wells were most pronounced during the large storm-event-related stage maximums observed in December 2004, January 2005, and late March 2005 (Plate C, Figure C-1). The speed and magnitude of the response is interpreted to be a function of the time-of-travel of the stage pulse through the aquifer to the well, and to the degree of interconnection between the aquifer and surface water systems.

As expected, the speed of response (both rising and falling head) was most rapid in wells in coarser-grained settings in close proximity to the Chehalis River (e.g., AGJ766 and AKB695). Responses in wells further from the river were normally more subdued, and often showed a multi-day time lag between the river stage-peak and the peak in the groundwater level. Near the southern end of the study area, where overall aquifer permeability and interconnectedness to the river are more restricted, water levels in wells showed only a weak correlation to changes in adjacent river stage (e.g., ACF368).

Groundwater Velocities and Time-of-Travel

Estimates of horizontal hydraulic gradient and hydraulic conductivity were integrated to develop a better understanding of approximate groundwater velocities and exchange rates within the aquifer system. Groundwater velocities were calculated by:

$$V_h = \frac{K_h * i_h}{n_e} \qquad (5)$$

where: V_h = horizontal groundwater velocity (ft/day)
K_h = horizontal hydraulic conductivity (ft/day)
i_h = horizontal hydraulic gradient (dimensionless)
n_e = effective porosity (dimensionless – assumed to be 0.25 for Qgo(g) sediments, and 0.20 for Qapo(h) and Mc(w) sediments)

The groundwater time-of-travel in the aquifer was then estimated using Equation (6):

$$TOT = \frac{D}{v_h} \qquad (6)$$

where: TOT = groundwater time-of-travel (days)
D = maximum lateral length of flowpath (ft)

Approximate flowpath lengths were derived by measuring the lateral distance between the far eastern edge of the unconsolidated deposits (the assumed outermost entry point for recharge to the surficial aquifer system) and the predicted downgradient point of discharge at the bank of the Chehalis (or Newaukum) River. Table 2 presents the input parameters and results of this evaluation for each of three sections of the study area.

Table 2 – Estimated groundwater velocities and time-of-travel

K_h (ft/day)	i_h	V_h (ft/day)	V_h (ft/yr)	L (ft)	TOT (yr)
Northern Study Area (north of the Skookumchuck River)					
310	0.0025	3.1	1132	11,000	10
Central Study Area					
75	0.0024	0.9	329	7000	21
Southern Study Area (Newaukum River Valley)					
75	0.0055	2.1	767	10,500	14

Because a number of simplifying assumptions were necessary to perform the above analysis, the values presented in Table 2 are considered estimates, and are most appropriately used to assess *relative* (vs. absolute) rates of groundwater exchange within the study area. Table 2 suggests that groundwater time-of-travel in the central study area is, in relative terms, approximately twice as long as in the northern and southern study area. The travel time estimates presented in Table 2 are likely biased low, due to the use of hydraulic conductivity values that best represent the most permeable portions of the aquifer. The assumption that the groundwater flow paths lack a vertical component further suggests the values should be considered lower-bound estimates.

Groundwater time-of-travel estimates provide insight into the movement and residence time of an individual water particle within an aquifer. The actual transport rates for a dissolved chemical carried by groundwater is dependent on the compound's physical and chemical properties, and may vary significantly from the above time-of-travel estimates. Additional local scale studies would be required to develop reliable values for transport timeframes for specific chemicals of concern.

Groundwater/Surface Water Interactions

In most physiographic settings of the Puget Sound Lowland, water is freely exchanged between groundwater and surface water systems. The Chehalis Lowland is no exception. Most perennial rivers (and streams) in the watershed are sustained during the dry summer months by groundwater discharge (baseflow condition). The rate and direction of water exchange (into or out of a river) can be highly variable both spatially and temporally, and is dependent on the streambed hydraulic properties, the gradient relationships between the river and groundwater, and the streambed geometry, among other factors. The discussion below presents the results of the monitoring efforts undertaken to characterize this exchange.

To facilitate this discussion, the study reach was divided into three sub-reaches, hereafter called *seepage* reaches. The seepage reach boundaries were chosen to coincide with major river confluences and/or a significant change in the geologic character of the underlying aquifer system.

Seepage Reach 1

Seepage Reach 1 is approximately 6.3 river miles long and extends from the Chehalis River gage near Grand Mound (station 1202750) to just below the boat launch at Borst Park (station SR-06) (Plate C, Figure C-2 and Table C-1). The streambed sediments within this reach consist largely of compact sand, gravel, and cobbles with a thin discontinuous veneer of loose sand and silt. This is consistent with the generally coarse-grained nature of the geologic deposits in this area.

During the September 2003 seepage evaluation, the Chehalis River showed an increased discharge of approximately 31 ft^3/sec along Reach 1; a net gain of 4.9 ft^3/sec/mi of stream length. If potential diversions by certificated surface water users ('D' in Equation 3) are incorporated into the budget calculation, the net gain along Reach 1 increases to approximately 37 ft^3/sec (5.9 ft^3/sec/mi; Plate C, Table C-1 and Figure C-2, and Appendix B, Figure B-1).

This seepage gain is consistent with the vertical hydraulic-gradient and streambed-temperature profiles measured in the instream piezometers installed along Reach 1. Two of the Reach 1 piezometers (wells AHL145 and AHL144) showed consistently positive hydraulic gradients, suggesting that groundwater discharged to the river at these locations throughout the measurement period (May to October 2004). This finding is supported by the continuous temperature data for these sites (Plate C, Figure C-2). The lower and middle thermistors show a gradual rise in temperature over the summer with little or no diurnal temperature variation. Only the upper thermistor registered a consistent diurnal signal similar to that observed in the river. Even so, the upper thermistors in these wells are 7-10 degrees C cooler than the river during peak summer temperatures in July and early August. This pattern is consistent with groundwater discharge conditions.

The two remaining piezometers within Reach 1 (AHL143 and AHL142) showed a gradual transition from positive to negative gradients over the course of the measurement period. This suggests that the river gained (received groundwater discharge) throughout Reach 1 in the early summer when regional groundwater levels are near their annual maximum and then began to recharge the underlying aquifer (lose water) upstream of piezometer AHL143 by mid summer (Plate C, Figure C-3).

Seepage Reach 2

Seepage Reach 2 is approximately 8.9 river miles long and extends from just below the Chehalis River boat ramp at Borst Park (station SR-06) to the former Boy Scouts of America camp below the Chehalis and Newaukum river confluence. Most of the near-surface streambed sediments through this reach consist of loose-to-compacted deposits of fine sand, silt, and occasional clay beds. That portion of the reach below the Chehalis and Skookumchuck river confluence is underlain by compact gravel, sand, and cobbles.

During the seepage evaluation, Reach 2 showed a net loss of 17 ft^3/sec, or approximately 1.9 ft^3/sec/mi of stream length. If one accounts for potential surface water diversions by certificated right holders, the net loss decreases to 8.7 ft^3/sec, or approximately 1.0 ft^3/sec/mi (Plate C, Table C-1 and Figure C-2, and Appendix B, Figure B-1).

Of the four instream piezometers in this reach, only the northernmost (AHL141) showed a loss throughout the measurement period. This is consistent with the continuous temperature data for well AHL141 (Plate C, Figure C-2). The temperatures at all three subsurface thermistors closely followed the diurnal temperature patterns of the river and were markedly warmer than the regional groundwater temperature in July and early August when the river temperature was highest.

The three remaining piezometers in Reach 2 showed slightly positive to strongly positive gradients or groundwater discharge conditions throughout the summer of 2004. This suggests that the bulk of the water lost from the river through Reach 2 occurs within the lower two miles of the reach (below piezometer ABK199) where the streambed transitions from the fine-grained sediments which dominate the area south of the Chehalis and Skookumchuck river confluence to the generally coarse-grained alluvium and outwash lying north of the confluence.

Seepage Reach 3

Seepage Reach 3 is approximately four miles long and extends from the Newaukum River at Shorey Road (station SR-01) to the USGS gaging station on the Newaukum River near Chehalis (station 12025000). The streambed sediments through this reach consist largely of loose-to-cemented sand and gravel with discontinuous overlying deposits of silty sand in some areas.

During the seepage evaluation, Reach 3 showed a net gain of approximately 4 ft^3/sec, or about 1 ft^3/sec/mi of stream length. Accounting for potential diversions by certificated surface water users increased the net gain to 12 ft^3/sec, or approximately 3 ft^3/sec/mi (Plate C, Table C-1 and Figure C-2, and Appendix B, Figure B-1).

The downstream piezometer in this reach (AHL137) showed consistently positive gradients, suggesting the river gained flow at that location throughout the measurement period. The second piezometer showed positive gradients during the spring and early summer before transitioning to negative gradients in late summer (Plate C, Figure C-3). This suggests that Reach 3 gains water from groundwater discharge throughout its length during the spring and early summer when regional groundwater levels are at annual maximums but loses water (recharges groundwater) in its upper portion beginning in late summer as the regional water table drops.

Groundwater Quality

Two key technical objectives guided the water quality sampling program implemented during this study:

- Develop a description of the current general chemistry and water-quality conditions of the local aquifer system.
- Characterize the quality of the water discharging from that system to local streams and rivers.

The focus of this effort was to provide a regional-scale description of ambient conditions and areal water-quality patterns. Accordingly, sampling in the vicinity of known point sources or pre-existing contaminant plumes was avoided whenever possible.

Two mass sampling events were conducted to characterize broad-scale seasonal changes in water quality. The first event was conducted in the spring of 2004 to characterize conditions at the end of the wet season. The sampling network was revisited in October to characterize conditions at the end of the dry season. Piezometers were sampled on a frequent basis between these events to determine if significant changes in water chemistry were occurring in the groundwater discharge zone during the growing season. The Tier 2 monitoring wells were also sampled on a more frequent basis to identify smaller time-scale changes in the chemistry of the aquifer system.

Detailed descriptions of the sample measurement, collection, analysis, and quality assurance methods used during the study were outlined in Pitz and Erickson (2003), and Pitz (2004). Summary descriptions of these procedures are presented below.

Sampling Methods

Instream Piezometers

Instream piezometers were allowed to equilibrate after installation for approximately one week prior to the first water quality sampling event. Only those piezometers that had a positive (upward) vertical hydraulic gradient (indicating groundwater discharge conditions) were sampled for water quality.

Prior to collecting water quality samples, surface water immediately adjacent to the piezometer was pumped through a closed-atmosphere flow cell equipped with calibrated field meters to measure stream temperature, pH, specific conductance, and dissolved oxygen. This step was taken to later determine if annular leakage down the outside of the piezometer (i.e., entry of surface water into the piezometer intake) was occurring due to pumping-induced gradient reversals.

After recording the surface water field-parameter values, dedicated pump tubing was inserted into the piezometer until it was positioned at the middle of the intake (or for well AHL146, the pump was connected directly to the upper end of the piezometer tubing). Piezometers were then purged, and ultimately sampled, using low-flow techniques (<0.5 L/min), as described in Pitz (2004).

Once the field meter readings for the purge parameters had stabilized (indicating the completion of purge) and were recorded, the groundwater dissolved-oxygen concentration was confirmed using a field photometer. All samples were then collected into appropriate containers through a clean, dedicated 0.45 micron (µm) filter, preserved if applicable, and placed immediately on ice for transport to Ecology's Manchester Environmental Laboratory.

The piezometer network was sampled monthly between May and October 2004. Samples were submitted for analysis of total dissolved solids (TDS), chloride, nitrate+nitrite as nitrogen (nitrate+nitrite-N), ammonia as nitrogen (ammonia-N), ortho-phosphate as phosphorus (orthophosphate-P), dissolved organic carbon (DOC), and iron. During the October 2004 sampling round, field alkalinity was measured at the end of the purge period, and additional samples were collected and submitted for analysis of major ions. Surface water samples were also collected at three of the piezometer locations at this time for analysis of field alkalinity and major ions.

Wells

The off-stream wells sampled during this study were selected to provide a representative areal coverage of the study area. The density of sampled wells was, however, higher in the area north of the Skookumchuck River, due to the very low density of water-supply wells to the south. Approximately two-thirds of the wells sampled are completed in the Qgo(g) outwash deposits, the principal water-supply unit in the northern study area. The remainder of the wells are evenly distributed between the Qa, Qapo(h), Mc(w), and Tbu units.

Water quality measurement and sample collection methods in off-stream wells varied with the well type being tested. Thirty-four existing water-supply wells equipped with a dedicated pump were sampled directly from an outside tap as close to the well head as possible. No samples were collected downstream of any treatment or storage systems that could modify the water chemistry of the sample (e.g., filters, water softening units, hot water tanks).[6]

[6] Due to their long screen intervals and high volume of discharge, active, large-diameter production wells were avoided during the sampling program. Wells located within the boundaries of a known contaminant plume were similarly rejected for use in the sampling network.

Water-supply wells were purged at flow rates averaging 2.5 gallons per minute (gal/min) or less. During well purge, temperature, pH, specific conductance, and dissolved oxygen were measured in a closed-atmosphere flow cell instrumented with field meters. Field parameters were recorded at five-minute intervals until consecutive measurements met stabilization criteria. Upon stabilization (indicating completion of purge), flow was redirected from the flow cell to a sampling port, and further field verification of the groundwater dissolved oxygen concentration was conducted with a field photometer for stations showing less than 2.0 mg/L on the field meter. All samples were subsequently collected through a new, dedicated 0.45 µm filter, after discard of the initial filtrate. Samples were preserved as appropriate, and immediately placed on ice for transport to Manchester Laboratory.

In addition to the water-supply wells, 10 monitoring wells[7] were also purged and sampled in a manner similar to the description above using a clean, stainless-steel submersible sampling pump. All monitoring wells were sampled using standard low-flow (<1 L/min) techniques, after stabilization of field parameters. Unless otherwise specified, all samples were filtered through a dedicated field filter. Raw water samples were collected directly from the dedicated pump line after the completion of the purge period.

Tier 1 wells were sampled twice, once in May 2004 and again in October 2004. During each event, samples were collected and submitted for analysis for TDS, chloride, nitrate+nitrite-N, orthophosphate-P, and iron. In October, additional samples were collected from all wells and analyzed for manganese, major ions, silica, DOC, and arsenic. A subset of Tier 1 wells was also sampled in October for lead (8 wells) and volatile organic compounds (VOCs) (9 wells).

Tier 2 wells were sampled approximately every two months between August 2004 and April 2005. Tier 2 wells were sampled for a short list of indicator parameters during each sampling round (TDS, chloride, nitrate+nitrite-N, orthophosphate-P, iron), and additional analytes during October 2004 (field alkalinity, manganese, major ions, silica, DOC, lead, arsenic, and VOCs).

[7] Only confirmed upgradient facility monitoring wells were included in the Tier 1 well network.

Quality Assurance

A variety of steps were taken during this study to verify the water quality data presented in this report. These steps included:

- Use of standardized, well-accepted measurement and data collection techniques
- Application of the sample collection methods in a consistent manner throughout the study period
- Accurate record-keeping in the field, and accurate documentation and tracking of samples between the field and the laboratory
- Use of field-based quality assurance tests of data reproducibility
- Collection and analysis of a wide variety of quality assurance samples to evaluate data acceptability
- Review and qualification of all laboratory data by both a Manchester Laboratory quality assurance officer, and the authors of this report.

Detailed descriptions of the quality assurance program and procedures used for this study were presented in two Quality Assurance Project Plans (Pitz and Erickson, 2003; Pitz, 2004). Detailed descriptions of the results of quality assurance testing conducted during the study are presented in Appendix B.

The results of the quality assurance testing and review indicate the majority of the water quality data generated during the study are of overall excellent quality and can be used without condition. In a small number of cases, the quality assurance review justified the addition of data qualifiers; these occasions are noted where applicable.

Groundwater Chemistry

Summary descriptive statistics of the groundwater quality results for instream piezometers and off-stream wells are presented in Table 3. Tables of the individual results for each station for each sampling round are presented in Appendix E, Tables E-1 through E-4.

Figures D-1 and D-2 (Plate D), and Table E-1 (Appendix E) present the hydrochemistry results reported from the October 2004 sampling round. The figures graphically represent the relative percentage of major ions in each water sample collected, allowing comparison of the basic hydrochemistry of the water from station to station. Groundwater sampled during the study was predominantly of mixed calcium-magnesium-bicarbonate water type, consistent with the earlier findings of Ebbert and Payne (1985).

Table 3 - Summary descriptive statistics for water quality constituents

		May 2004												State Groundwater Quality Criteria[b]		State Drinking Water Quality Standards[c]	
		Instream piezometers						Wells						Primary Criteria	Secondary Criteria	Primary MCL[d]	Secondary MCL[e]
Constituent	UOM	n	Minimum	Maximum	Mean	Median	Geomean	n	Minimum	Maximum	Mean	Median	Geomean				
pH	SU	10	6.43	8.21	6.82	6.65	6.80	37	6.11	7.84	6.81	6.74	6.80	NA	6.5-8.5	NA	NA
Specific Conductance	umhos/cm	10	140	563	320	259	238	37	82	473	233	199	213	NA	NA	NA	700
Dissolved Oxygen[a]	mg/L	10	<0.01	7.56	3.13	1.97	1.05	37	<0.01	10.50	3.26	2.61	0.94	NA	NA	NA	NA
Chloride (dissolved)	mg/L	9	2.9	59.6	14.1	6.5	9.1	38	3.4	45.6	10.6	6.8	8.3	NA	250	NA	250.0
Total Dissolved Solids	mg/L	9	87	395	206	162	185	38	57	314	160	146	148	NA	500	NA	500
Ammonia-N (dissolved)	mg/L	9	<0.01	4.55	x	x	x	-	NS	NS	NS	NS	NS	NA	NA	NA	NA
Nitrate+Nitrite-N (dissolved)	mg/L	9	<0.01	39.9	x	x	x	38	<0.01	6.9	x	x	x	10	NA	10.0[f]	NA
Orthophosphate-P (dissolved)	mg/L	9	0.017	1.11	0.183	0.038	0.069	38	0.013	1.72	0.149	0.034	0.052	NA	NA	NA	NA
Dissolved Organic Carbon	mg/L	9	<1.0	9.2	x	x	x	-	NS	NS	NS	NS	NS	NA	NA	NA	NA
Iron (dissolved)	mg/L	9	<0.05	39.6	x	x	x	38	<0.05	6.7	x	x	x	NA	0.3[g]	NA	0.3[g]

		October 2004												State Groundwater Quality Criteria[b]		State Drinking Water Quality Standards[c]	
		Instream piezometers						Wells						Primary Criteria	Secondary Criteria	Primary MCL[d]	Secondary MCL[e]
Constituent	UOM	n	Minimum	Maximum	Mean	Median	Geomean	n	Minimum	Maximum	Mean	Median	Geomean				
pH	SU	9	6.25	7.53	6.57	6.43	6.56	43	5.93	7.51	6.57	6.44	6.56	NA	6.5-8.5	NA	NA
Specific Conductance	umhos/cm	9	106	556	286	247	247	43	89	526	240	230	219	NA	NA	NA	700
Dissolved Oxygen[a]	mg/L	9	0.15	1.70	0.61	0.21	0.39	43	<0.01	7.83	2.66	2.19	0.72	NA	NA	NA	NA
Field Alkalinity	mg/L	8	40	260	118	100	97	42	16	175	72	57	61	NA	NA	NA	NA
Chloride (dissolved)	mg/L	9	5.0	61.2	13.3	6.4	8.9	43	2.2	62.3	12.1	7.4	9.1	NA	250	NA	250.0
Total Dissolved Solids	mg/L	9	81	290	184	165	168	43	71	308	163	159	153	NA	500	NA	500
Ammonia-N (dissolved)	mg/L	9	<0.01	5.4	x	x	x	-	NS	NS	NS	NS	NS	NA	NA	NA	NA
Nitrate+Nitrite-N (dissolved)	mg/L	9	<0.01	2.48	x	x	x	42	<0.01	6.84	x	x	x	10[f]	NA	10.0[f]	NA
Orthophosphate-P (dissolved)	mg/L	9	0.03	1.39	0.203	0.040	0.065	42	0.0069	2.43	0.188	0.032	0.046	NA	NA	NA	NA
Dissolved Organic Carbon	mg/L	9	<1.0	8	x	x	x	42	<1.0	4.1	x	x	x	NA	NA	NA	NA
Iron (dissolved)	mg/L	9	<0.05	40.2	x	x	x	43	<0.05	9.95	x	x	x	NA	0.3[g]	NA	0.3[g]
Manganese (dissolved)	mg/L	-	NS	NS	NS	NS	NS	43	<0.01	1.41	x	x	x	NA	0.05[g]	NA	0.05[g]
Magnesium (dissolved)	mg/L	8	3.37	14.60	8.75	8.21	7.71	43	1.96	17.20	7.30	6.08	6.45	NA	NA	NA	NA
Calcium (dissolved)	mg/L	8	8.88	45.80	25.56	23.90	22.33	43	7.27	42.20	18.59	16.30	17.17	NA	NA	NA	NA
Potassium (dissolved)[a]	mg/L	8	<0.50	7.04	1.91	1.35	1.15	43	<0.50	3.50	1.35	1.30	1.22	NA	NA	NA	NA
Sodium (dissolved)	mg/L	8	6.20	30.20	12.39	9.42	10.68	43	5.42	75.00	16.38	10.60	13.16	NA	NA	NA	20[h]
Fluoride (dissolved)	mg/L	7	<0.1	0.19	x	x	x	43	<0.1	0.51	x	x	x	4	NA	4.0	NA
Sulfate (dissolved)[a]	mg/L	9	<0.3	8.47	x	x	x	43	<0.3	65.20	8.51	5.86	3.89	NA	250	NA	250.0
Silica (dissolved)	mg/L	8	22.6	68.4	43.3	38.0	40.3	43	21.5	72.4	38.8	34.4	37.0	NA	NA	NA	NA
Lead (dissolved)	µg/L	-	NS	NS	NS	NS	NS	10	<0.02	0.04	x	x	x	50[g]	NA	15[g]	NA
Arsenic (dissolved)	µg/L	-	NS	NS	NS	NS	NS	42	<0.1	12.7	0.77	0.22	0.28	0.05[g]	NA	10-50[g][j]	NA
Volatile Organic Compounds	µg/L	-	NS	NS	NS	NS	NS	11	No Detections[i]					NA	NA	variable[j]	NA

UOM - unit of measure
Geomean - geometric mean
n - number of samples
MCL - Maximum Contaminant Level

[a] Summary statistics calculated assuming a concentration of 1/2 the lab or field reporting limit for non-detects.

[b] State groundwater quality numerical criteria legally apply only to discharges to state groundwaters and are included in the table for purposes of comparison only.

[c] State Drinking Water Quality Standards apply only to public water supply systems and are included in the table for purposes of comparison only.

[d] Primary drinking water standards are based on chronic, non-acute, or acute human health effects and represent the maximum contaminant level (MCL) allowable.

[e] Secondary drinking water standards are based on factors other than health effects (for example, taste or odor).

[f] The listed primary criteria and MCL concentrations are for Nitrate as N.

[g] Numerical criteria or MCLs for iron, manganese, lead, and arsenic are for total metals.

[h] The secondary MCL for sodium is the recommended level of concern for consumers that may be restricted for daily sodium intake in their diets.

[i] A total of 71 unique volatile organic analytes were evaluated by the laboratory for each sample. With the exception of the tentative identification of chloroform in well ALB684 (3.6 µg/L), no detections were reported by the lab for any of the compounds tested.

[j] Constituent considered is a carcinogen.

x - Percentage of data set as non-detects was too high to calculate accurate summary statistic.

NA - No state drinking water standard has been issued for the constituent
NS - Not sampled

Distinct differences in groundwater geochemistry were noted between the northern and southern study area. A comparatively sharp east-west boundary, lying approximately coincident with the confluence of the Skookumchuck and Chehalis rivers, separates these two zones. This boundary is defined primarily by a difference in oxidizing/reducing (redox) conditions, and the resulting presence or absence of dissolved phase redox-sensitive parameters.

Table 4 presents a summary of the median constituent concentrations for wells completed in unit Qgo(g) versus wells completed in the remaining units (Qa, Qapo(h), Mc(w), and Tbu). Due to the geographic distribution of hydrogeologic units, this division reasonably approximates changes in the redox condition between the northern and southern study area.

Table 4 - Median constituent concentration by hydrogeologic unit

Constituent	Unit of Measure	Hydrogeologic Unit			
		Qgo(g)	n	Qa, Qapo(h), Mc(w), and Tbu (combined)	n
pH	SU	6.51	54	7.08	27
Specific Conductance	µmhos/cm	190	54	270	27
Dissolved Oxygen	mg//L	2.68	54	0.13	27
Field Alkalinity	mg//L	46	28	92	15
Chloride	mg//L	6.87	53	9.59	28
TDS	mg//L	139	53	182	28
Nitrate+Nitrite-N	mg//L	1.6	53	<0.01	28
Orthophosphate-P	mg//L	0.028	53	0.090	27
DOC	mg//L	<1.0	26	<1.0	14
Iron	mg//L	<0.05	53	1.97	28
Manganese	mg//L	<0.01	28	0.21	15
Magnesium	mg//L	5.32	28	8.55	15
Calcium	mg//L	16.3	28	20.4	15
Potassium	mg//L	1.3	28	1.2	15
Sodium	mg//L	10.5	28	18.0	15
Fluoride	mg//L	<0.1	28	0.12	15
Sulfate	mg//L	6.71	28	2.47	15
Silica	mg//L	31.3	28	48.5	15
Lead	µg/L	<0.02	5	<0.02	4
Arsenic	µg/L	0.19	28	0.32	13
VOCs	µg/L	ND	7	ND	4

n – number of samples
TDS – total dissolved solids
DOC – dissolved organic carbon
VOCs – volatile organic compounds
mg/L – milligram/liter
µg/L – microgram/liter
ND – not detected (see text)

In the northern study area, dissolved oxygen concentrations are typically greater than 1 mg/L, and nitrogen, when present, occurs as nitrate. Concentrations of orthophosphate-P and iron are typically very low or undetectable, further indicating oxidizing conditions for this area.

In contrast, dissolved oxygen concentrations in the southern study area are routinely below 1 mg/L. Nitrogen as nitrate+nitrite is generally absent, while orthophosphate-P and iron are routinely present at elevated concentrations. Taken together, this suggests the southern study area is dominated by reducing conditions.

In addition to differences in redox condition, notable differences in pH, specific conductance, TDS, alkalinity, sodium, and ionic strength are also apparent between the northern and southern portions of the study area (Plate D). The geochemical zonation of the aquifer system is interpreted to result from differences in the character of the host aquifer material, groundwater contact times, and the rate and type of solution reactions resulting from these conditions.

Although there are notable spatial differences in the general chemistry of the aquifer, there were no recognizable trends in the distribution of either arsenic or lead. In most cases, dissolved concentrations for these constituents were very low (Plate D, Figures D-13 and D-14). The dissolved arsenic concentration at well ALB686 (12.7 µg/L) was, however, significantly higher than that noted in other wells. The high arsenic level in this well was coincident with a high organic content and reducing conditions (Tables E-1 and E-3) that can allow the natural dissolution of arsenic from common aquifer matrix sources such as iron oxyhydroxides (Kelly et al., 2005). Since these conditions may also arise as a result of localized aquifer contamination, the origin of the higher arsenic in this well is difficult to determine without additional study.

Despite a history of local contamination by industrial solvents (Marti, 2000; Robinson and Noble, 1998; Kennedy/Jenks, 1996), virtually no detectable concentrations of VOCs were identified in wells sampled during this study (Plate D, Figure D-15). The only exception is a tentative identification of chloroform in well ALB684, at an estimated concentration of 3.6 µg/L[8].

Groundwater quality results were generally consistent from wet season (May) to dry season (October) (Table 3 and Plate D). Those changes that were observed (e.g., pH, dissolved oxygen, chloride) were primarily in wells and piezometers located at the northern end of the study area. The changes identified in this area are assumed to be related to the higher velocity (i.e., exchange rate) of groundwater, and higher recharge rate, in comparison to the south. The observed changes in dissolved oxygen were not great enough to alter the redox condition of the aquifer. Water quality results for wells and piezometers that were sampled on a

[8] Chloroform is a member of the trihalomethane chemical group, which are byproducts of water disinfection by chlorine. The maximum total trihalomethane concentration allowed in a public water supply is 80 µg/L.

more frequent basis exhibited only minor variation in concentration with time (Appendix E, Tables E-2 and E-4).

Water quality conditions observed in piezometers generally mimic the conditions observed in the upgradient aquifer, particularly in the north. Those differences that were noted (e.g., DOC, iron, dissolved oxygen) are potentially associated with biogeochemical processes unique to the groundwater flow path through the riparian zone. The general hydrochemical character of surface water, piezometer, and well samples were similar in the north, but were often distinct from one another in the south (Plate D, Figure D-1). These differences in chemistry may be additional evidence of a slower rate of exchange of water between the aquifer and the river in the south, in comparison to the north.

Comparison to Water Quality Criteria

The overall quality of the groundwater sampled during this project was good, particularly within unit Qgo(g) in the northern portion of the study area. Water quality results were compared to two standards: the state quality criteria for water distributed from a public drinking water supply (Washington Administrative Code 246-290-310), and the state criteria for groundwater quality (WAC 173-200-040). In a strict regulatory sense, these criteria do not apply to the wells and piezometers sampled during this study; they are presented only as a useful point of reference for judging the ambient groundwater condition (both as a source of community drinking water, and as a potential discharge to area rivers and streams[9]). Where available, these criteria are presented with the summary water quality statistics in Table 3.

None of the water-supply wells tested exceeded the primary maximum contaminant level (MCL) allowable in a public water supply for nitrate (10 mg/L), although several wells in the northern study area exhibited nitrate+nitrite-N concentrations between 5-10 mg/L (nitrite is infrequently detected in groundwater due to its rapid conversion to nitrate). One of these wells is directly downgradient of Ford's Prairie, a region that has historically shown elevated nitrate concentrations (CCWU/LCEHD, 1990). While the sampling density for this study was not sufficient to accommodate a detailed assessment of current water quality conditions for Ford's Prairie specifically, no widespread nitrate contamination was observed within the surrounding (and comparatively vulnerable) outwash gravels that dominate the northern third of the study area.

No exceedances were noted for chloride, TDS, sulfate, or lead, and VOCs were essentially absent at the tested locations. The reducing conditions observed in portions of the aquifer system resulted in approximately 1/3 of tested wells exceeding (not meeting) the secondary (aesthetic) drinking water criteria for iron and manganese. Elevated iron or manganese concentrations are a common non-health-related water quality condition in western Washington. Sodium was also found in approximately 20 percent of sampled wells at concentrations exceeding the 20 mg/L health advisory level for sodium-sensitive consumers (Plate D, Figures D-9 and D-12).

Only one well (ALB686) exceeded the 10 µg/L public drinking water MCL for arsenic. The primary state groundwater quality criterion for arsenic is significantly lower than the drinking water criterion (0.05 µg/L as total vs. 10 µg/L). A majority of the wells tested during this study exceeded the groundwater standard; in fact, the detection limit reported for arsenic during the study was twice the criterion concentration. The data collected during this study suggests, however, that arsenic concentrations up to at least 1 µg/L likely represent natural conditions.

Summary

This report presents the results of a hydrogeologic assessment of the Centralia-Chehalis lowlands of Lewis and Thurston counties conducted during 2003-05. The study was undertaken to pilot test a basin-to-subbasin-scale groundwater assessment process that could be adopted as the standard technical approach of a proposed state groundwater monitoring program.

The technical objectives for the pilot study were focused toward description of current ambient groundwater conditions. These objectives can be summarized as follows:

- Characterize the hydrogeologic setting of the study area
- Monitor and describe ambient groundwater, water-level conditions
- Monitor and describe local groundwater/surface water interactions
- Monitor and describe ambient groundwater quality conditions

This study began with an initial well inventory and literature search, which led to the development of a project database of well construction information, historic water level and water quality data, and well location records. A subset of 307

[9] Significant changes to water quality (in many cases *reduction* of dissolved concentrations – particularly of redox sensitive species) can occur in the final centimeters of the groundwater flow path when approaching the point of discharge to a surface waterbody. The potential for such changes occurring between the piezometer screen and the surface water/groundwater interface indicates caution should be followed when using the study results to evaluate the impact of groundwater discharges on local surface water quality conditions (Jones and Mulholland, 2000; Ford, 2005).

wells was selected from the larger database for follow-up evaluation and/or field inventory. This well subset supported the development of a conceptual model and hydrogeologic framework of the study area, and provided wells for area-wide, water-level and water-quality sampling networks.

To support the study area characterization, hydrogeologic maps and cross sections were constructed, aquifer hydraulic properties were evaluated, and approximate groundwater flow directions, velocities, and travel times for the study area were estimated.

The Centralia-Chehalis area lies at the southern end of the continental glaciated portion of the Puget Sound Lowland, straddling both continental and alpine dominated glacial regimes. Bedrock in the northern third of the study area is overlain by as much as 90+ feet of generally un-weathered water-bearing, continental-glacial deposits and recent alluvium comprised of coarse sand, gravel, and cobbles with variable amounts of interstitial silt and clay. Discontinuous till, cemented zones, and silty clay beds occur locally. Bedrock in the southern two-thirds of the study area is overlain by a generally finer-grained assemblage of water-bearing alluvium and glacio-lacustrine deposits, alpine glacial drift, and older Tertiary-age continental sediments.

Groundwater in the study area flows in a generally north-northwest direction, losing approximately 100 feet of elevation between the southern and northern study area boundaries. Horizontal hydraulic gradients vary along the main axis of the Chehalis Valley, in response to changes in surface topography and subsurface permeability. In the northern and central portions of the valley, the horizontal hydraulic gradient averages approximately 0.0025 (13 ft/mi). The average gradient increases to approximately 0.0055 (29 ft/mi) in the Newaukum Valley where aquifer deposits are generally finer-grained and less well-sorted.

In the northern study area, depth-to-water ranges from 10-35 feet below ground surface (bgs), and averages approximately 21 feet bgs. In the southern study area, water levels range from 1-25 feet bgs, and average approximately 11 feet bgs. Regardless of location, water elevations were generally highest during the wet, winter months and lowest during late summer. No significant differences in water-level altitude were noted between wells drawing from the different surficial hydrogeologic units. Accordingly, vertical hydraulic gradients within the surficial aquifer system are inferred to be relatively small.

The Newaukum and Chehalis rivers are hydraulically coupled with the local surficial aquifer system. Groundwater levels in many of the continuously monitored wells responded rapidly to river stage changes. Such responses were most pronounced in wells in the northern half of the study area. Both rivers receive water from or contribute water to the groundwater system locally. A dry-season seepage evaluation and instream piezometer surveys showed that both rivers generally gained flow from groundwater throughout most of their lengths during the dry summer months. A short segment of the Chehalis River below its confluence with the Skookumchuck River consistently lost flow. This loss reach overlies the transition zone between the upgradient fine-grained deposits of the southern study area and the downgradient coarse-grained deposits of the northern study area.

The contrast in aquifer matrix between the northern and southern study area strongly influences local groundwater chemistry. A comparatively sharp geochemical boundary, defined primarily by differences in redox condition, lies coincident with the transition between the coarser northern deposits, and the finer-grained deposits to the south. South of this boundary, reducing conditions prevail, and constituents mobilized in the absence of oxygen (iron, orthophosphate) occur at elevated concentrations in the dissolved phase. North of the boundary, these parameters are largely absent in groundwater. The geochemical zonation of the aquifer system is interpreted to be the result of differences in the character of the host aquifer material, groundwater contact times, and the rate and type of solution reactions that result from these conditions.

Overall, groundwater quality in the study area was good. All of the water-supply wells tested were below the public drinking water standard for nitrate (10 mg/L); however, several wells had elevated values between 5 and 10 mg/L. Approximately one-third of the tested wells exceeded the secondary (aesthetic) drinking water standards for iron or manganese, while approximately 20 percent exceeded the secondary standard for sodium (20 mg/L). No significant concentrations of volatile organic compounds or dissolved lead were identified in any of the wells tested. Natural background concentrations of dissolved arsenic appear to occur up to at least 1 µg/L.

Water quality results were generally consistent between the end of the wet season in May, and the end of the dry season in October. The water quality measured in instream piezometers frequently mirrored the conditions observed in upgradient wells, providing further evidence of the close hydraulic and geochemical connections between area rivers and the surficial aquifer system.

Recommendations

As a result of this study, the following recommendations are presented:

- Continued long-term monitoring of groundwater quality is recommended, particularly in the new monitoring well located at the northern end of Borst Park (well AKB696). This well is located upgradient of a major water-supply well field operated by the City of Centralia. This well could serve as a valuable "early warning" station for the city well field. Care should be taken to protect this well from activities that could corrupt it as a monitoring station.

- The highly transmissive nature of the aquifer sediments in the northern portion of the study area, and the absence of an overlying finer-grained surface unit like that present to the south, suggests land-use planning activities should protect the vulnerability of this portion of the aquifer system. The close hydraulic connection demonstrated during this study between the aquifer system and the Chehalis River also suggests that contamination of the aquifer would not only jeopardize local drinking water quality, but could also adversely impact river water quality.

- Increasing demand for additional groundwater from the local aquifer system, coupled with potentially significant future changes in climate (and therefore recharge) patterns, suggest that long-term monitoring of local water levels should continue in representative wells within the study area. At a minimum, the monitoring wells installed during this study should be considered (with cooperation from the City of Centralia) for incorporation into the Department of Ecology's Water Resources Program Southwest Regional Office water level monitoring network. Preferably these wells could be instrumented with recording transducers for continuous measurement.

- This report provides much of the information required to develop or refine a numerical, three-dimensional groundwater flow model of the Centralia-Chehalis lowland. Development of such a model should be considered in light of growing demand for additional water supply from the aquifer system. A numerical model would enable planning agencies to predict the impact of additional groundwater withdrawals on surface water flows and aquifer storage conditions.

Besides providing an evaluation of the Centralia-Chehalis area groundwater system, this pilot study was also an important test of a proposed technical approach for a state groundwater monitoring and assessment program. To assist Ecology management in evaluating the practicality of this approach, a follow-on report will be prepared. This second report will summarize project costs and benefits, lessons learned, and recommended modifications to the study methodology.

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Appendices

A. Physical Description of Inventoried Wells

B. Project Quality Assurance

C. Location and Physical Description of Instream Piezometers

D. Distribution and Thickness of Hydrogeologic Units

E. Water Quality Results

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Appendix A

Physical Description of Inventoried Wells
Centralia-Chehalis Area, Lewis and Thurston Counties

Following is an explanation of data listed in Table A-1.

Map identifier:	A shorthand identification number used on all tables and Plates A, B, and C of this report to uniquely identify wells and instream piezometers. See Plate B for a graphical depiction of well locations by Map ID and a cross-walk table linking map identifier, project well identifier, and well location.
Site latitude:	The latitude of the well site in decimal degrees.
Site longitude:	The longitude of the well site in decimal degrees.
Land surface altitude:	The land surface altitude, at the well head, in feet above mean sea level. Land surface altitudes for wells with map identifiers between 1 and 52 were derived from LIDAR data and are considered accurate to ± 1 meter (± 3.28 feet). Altitudes for wells with map identifiers between 53 and 307 were derived from a 10-meter DEM and are considered accurate to ± 5 meters (± 16.4 feet).
Casing diameter:	The diameter of the well casing, at land surface, in inches. For wells with multiple casing strings, only the largest casing diameter is referenced here.
Completed well depth:	The maximum depth to which the well can be sounded, in feet below land surface. In some cases, the completed depth may be less than the drilled depth reported on the well log.
Well completion type and open interval:	O - open bottom casing; P - perforated casing; S - well screen; OH - open hole; the reported numeric ranges indicate the perforated or screened interval(s), in feet below land surface, through which water enters the well; nr - completion type not reported.
Groundwater level:	The driller-reported depth-to-groundwater in the well, in feet below land surface. Driller-reported water levels are considered accurate to ± one foot.
Water level date:	The date the groundwater level was measured; "–" - measurement date unknown.
Remarks:	USGS - well originally inventoried by the U.S. Geological Survey; Weigle - well originally inventoried by Weigle and Foxworthy (1962).

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Table A-1 - Physical Description of Inventoried Wells, Centralia Chehalis Area, Lewis and Thurston Counties

Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
13N/02W-03F	261	13-2-3E11	46.643588	122.918953	417	6	362	P 355-361	2/2/1981	90	2/2/1981	
13N/02W-03N	265	11505	46.637530	122.925407	230	6	131	O	3/22/1995	60	3/22/1995	
13N/02W-04C	250	18536	46.647962	122.942575	208	6	36	O	5/16/1988	12	5/16/1988	
13N/02W-04D	252	ACC817	46.645746	122.944702	204	6	44	O	-	16	10/4/1995	
13N/02W-04D	254	AFC083	46.645306	122.945252	204	6	52	O	-	18	3/12/1993	
13N/02W-04L	263	11378	46.639374	122.941169	202	6	86	O	9/15/1989	4	9/15/1989	
13N/02W-04P	266	13-2-4P1	46.636270	122.941693	189	4	50	O	-	-	-	Weigle
13N/02W-05A	253	13-2-5H2	46.645418	122.950825	182	4	408	OH 50-408	-	-	-	Weigle
13N/02W-05B	251	463849122572301	46.646944	122.956389	182	4	110	O	1/1/1952	-	-	Weigle
13N/02W-05C	249	ALB684	46.648261	122.961449	181	1	24	S 17-24	-	-	-	
13N/02W-05H	255	13-2-5H1	46.644809	122.950313	183	12	322	P 23-39, 96-106, 295-315	5/5/1905	< 0	-	Weigle, well flows
13N/02W-05J	262	13-2-5J1	46.639386	122.949792	185	4	409	O	-	-	-	Weigle
13N/02W-08A	270	463757122570501	46.632500	122.951389	184	6	35	O	6/2/1975	5	6/4/1975	USGS
13N/02W-08A	272	463755122570602	46.631944	122.951667	185	6	39	O	7/6/1974	7	7/3/1974	USGS
13N/02W-08B	271	13007	46.632319	122.954357	187	6	34	O	-	11	8/17/1991	
13N/02W-08C	269	13857	46.633037	122.961399	184	6	65	S 59-65	-	15	10/18/1992	
13N/02W-08L	282	ACC843	46.625684	122.962354	244	6	40	O	8/16/1996	< 0	8/16/1996	Well flows
13N/02W-08Q	298	13-2-8	46.620307	122.954662	230	6	170	O	-	55	5/23/1978	
13N/02W-08R	291	ABK192	46.622326	122.952596	198	6	56	S 51-56	-	6	5/11/1992	
13N/02W-09A	267	271990	46.633764	122.930922	222	0.75	13	S 8-13	11/13/1995	2	11/13/1995	
13N/02W-09A	268	AHG689	46.633778	122.929128	221	2	35	S 20-35	4/21/2003	14	4/2/2003	
13N/02W-09B	273	AFC720	46.631235	122.936017	202	6	45	P 30-44	-	6	4/18/1997	
13N/02W-09E	276	463745122565201	46.629167	122.947778	192	36	25	O	1/1/1946	-	-	Weigle
13N/02W-09E	277	463745122565202	46.629167	122.947778	192	72	25	Open pit, no casing	5/1/1945	3	5/1/1945	USGS
13N/02W-09F	278	CT1-67	46.628254	122.940972	197	2	44	S 33-44	7/29/2002	-	-	
13N/02W-09J	283	18571	46.626203	122.931943	208	1	19	S 18-19	-	-	-	
13N/02W-09J	285	CT1-70	46.624849	122.932238	203	2	44.8	S 34-44	5/2/1997	30	5/15/1997	
13N/02W-09J	287	CT1-66	46.623733	122.932941	205	2	46	S 35-45	7/22/2002	-	-	
13N/02W-09P	288	AGJ760	46.623018	122.940661	202	6	31	O	-	10	1/24/1985	
13N/02W-09P	292	13-2-9P1	46.622318	122.941418	200	6	35	O	-	20	7/1952	Weigle
13N/02W-09P	297	17315	46.620780	122.941509	202	6	40	O	4/28/1994	10	4/28/1994	
13N/02W-09R	289	CT1-69	46.622887	122.932481	205	2	48	S 35-45	2/28/1997	2	2/28/1997	
13N/02W-09R	290	CT1-68	46.622820	122.929599	209	2	48.4	S 35-46	2/26/1997	4	2/26/1997	
13N/02W-09R	293	CT1-71	46.622568	122.928640	208	6	49	S 19-49	-	-	-	
13N/02W-09R	295	CT1-72	46.622322	122.928749	208	6	49	S 19-49	-	-	-	
13N/02W-10E	279	CT1-61	46.627446	122.923713	228	2	17.5	S 7-17	10/4/1993	12	10/4/1993	
13N/02W-10E	280	AAB874	46.627261	122.924232	228	4	198.5	S 183-193	4/26/1994	36	4/26/1994	
13N/02W-10L	284	CT1-58	46.625950	122.920650	233	4	42	O	5/5/1905	9	10/15/1952	
13N/02W-10L	286	CT1-63	46.624322	122.921742	227	8	358	S 338-358	10/15/1993	14	11/2/1993	
13N/02W-10N	294	ACF368	46.622486	122.926467	211	2	48.6	S 28-48	2/2/2001	-	-	

Table A-1 - Physical Description of Inventoried Wells, Centralia Chehalis Area, Lewis and Thurston Counties

Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
13N/02W-10Q	296	AAB873	46.621866	122.914675	243	4	306.5	S 291-301	4/20/1994	26	4/20/1994	
13N/02W-15A	301	AFC082	46.617845	122.908092	247	6	50	O	-	18	7/7/1975	
13N/02W-15A	303	ABK186	46.616282	122.909201	244	6	52	O	8/29/1992	31	8/29/1992	
13N/02W-15D	300	ACC839	46.619418	122.925816	217	6	235	O	7/16/1996	< 0	7/16/1996	Well flows
13N/02W-15J	307	AGJ772	46.611230	122.907194	250	6	94	P 71-77	2/15/1983	14	2/15/1983	
13N/02W-15L	305	17833	46.612438	122.922093	222	6	70	P 26-66	8/4/1992	6	8/4/1992	
13N/02W-15L	306	17832	46.612438	122.922093	222	8	21	P 16-21	9/24/1992	6	9/24/1992	
13N/02W-16D	302	15134	46.617039	122.944167	211	6	77.7	S 67-77	-	12	6/18/1992	
13N/02W-16H	304	13-2-16H1	46.613031	122.930594	212	8	210	S 208-210	9/4/1951	< 0	9/4/1951	Well flows
13N/03W-01D	247	AFP914	46.647484	123.011180	182	6	48	O	-	13	3/1/2001	
13N/03W-01Q	264	AFN910	46.636075	122.999218	245	6	54	P 46-54	-	10	1/3/2001	
13N/03W-02H	256	AFT849	46.643175	123.016257	195	6	87	O	4/16/2001	45	4/16/2001	
13N/03W-02H	257	ALB682	46.643081	123.015032	186	6	90	P 39-98	8/15/1989	41	8/16/1989	
13N/03W-02H	258	CT1-64	46.643046	123.015257	185	nr	nr	nr	-	-	-	
13N/03W-02H	259	AFC711	46.642909	123.016078	190	6	89	O	4/16/2001	45	4/16/2001	
13N/03W-02M	260	ALB683	46.641368	123.032634	253	6	108	O	9/30/1996	60	9/30/1996	
13N/03W-11E	275	AFC084	46.627642	123.029023	182	6	54	O	12/3/1992	19	12/3/1992	
13N/03W-11F	274	11554	46.628116	123.027066	181	6	41	O	10/20/1992	22	10/20/1992	
13N/03W-11M	281	EC11M1	46.624282	123.032224	181	6	49	O	5/14/1974	9	5/14/1974	
14N/02W-04E	145	464352122564701	46.731111	122.946389	187	26	57	P 38-53	1/1/1934	-	-	Weigle
14N/02W-05B	139	AGN061	46.732952	122.958928	181	6	58	O	-	17	9/11/2002	
14N/02W-05C	135	ABA853	46.734561	122.964364	186	8	92	P 55-70, 86-90	-	15	6/3/1994	
14N/02W-05D	132	13731	46.735529	122.967931	190	6	38	O	6/18/1990	15	6/18/1990	
14N/02W-05F	146	AFC587	46.730349	122.959928	183	6	83	O	3/9/2001	17	3/29/2001	USGS
14N/02W-05F	151	ABK180	46.729483	122.961668	184	6	68	O	-	30	9/8/1993	
14N/02W-05F	154	AFC723	46.728685	122.962944	184	26	93	P 40-87	6/1/1935	-	-	
14N/02W-05G	147	464351122573101	46.730233	122.959130	186	26	88	P 41-85	1/1/1935	15	1/1/1935	Weigle
14N/02W-05G	148	464304122571901	46.730229	122.959124	185	26	84	P 42-82	-	-	-	Weigle
14N/02W-05G	149	AFC722	46.730185	122.958751	185	20	88	S 48-79	3/29/1994	19	3/28/1994	
14N/02W-05H	150	AFC731	46.729822	122.951254	183	26	68	P 43-66	2/27/1934	11	2/27/1934	
14N/02W-06C	134	ALB685	46.734440	122.983080	180	8	68.3	nr	-	-	-	
14N/02W-06D	130	AFM242	46.735717	122.988225	175	2	20	S 10-20	7/2/2001	-	-	
14N/02W-06E	142	ACD333	46.731307	122.986747	174	4	36	S 21-36	10/16/1995	27	10/16/1995	
14N/02W-06F	141	ACD334	46.732077	122.985154	175	4	36	S 21-36	10/17/1995	26	10/17/1995	
14N/02W-06F	143	ACD332	46.731181	122.984359	174	4	36	S 21-36	10/16/1995	26	10/16/1995	
14N/02W-06F	144	18315	46.730949	122.982868	180	6	50	O	-	26	11/1/1989	
14N/02W-06G	152	18309	46.728779	122.978668	181	2	30	S 10-30	11/5/1998	-	-	
14N/02W-06K	153	215861	46.728481	122.978023	181	2	23.5	S 4-24	7/19/1989	-	-	
14N/02W-06K	155	19471	46.727303	122.978049	181	2	28	S 10-28	2/6/1997	14	2/6/1997	
14N/02W-06K	156	AKB696	46.727250	122.977209	181	2	53	S 43-53	8/10/2004	25	8/9/2004	

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Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
14N/02W-06N	159	AGJ762	46.725175	122.987798	173	6	58	O	-	19	4/4/1965	USGS
14N/02W-06N	164	464322122591101	46.722778	122.986389	171	6	56	P 36-56	5/1/1951	-	-	Weigle
14N/02W-06P	162	ACJ574	46.724043	122.983046	174	24	68.4	S 51-64	9/19/1996	26	9/11/1996	
14N/02W-06P	163	ABA865	46.724043	122.983046	174	8	87	P 55-75	3/29/1994	24	6/21/1994	
14N/02W-07B	173	AGJ766	46.718157	122.980567	165	8	65	P 51-59	-	16	11/25/1992	
14N/02W-07C	166	AAF345	46.720692	122.980962	172	16	66.9	S 38-53	-	18	6/23/1993	
14N/02W-07C	167	ABF586	46.720320	122.986115	172	8	56	P 30-50	-	23	6/14/1994	
14N/02W-07C	168	AAF344	46.720196	122.980940	171	16	62.8	S 40-55	-	19	6/9/1993	
14N/02W-07C	169	ALB680	46.720162	122.980998	171	8	67.8	S 40-60	-	19	11/2/1992	
14N/02W-07G	174	AFB618	46.715512	122.980223	177	6	55	P 40-55	-	20	4/11/2000	
14N/02W-07G	175	AKP544	46.715385	122.978211	174	6	39	O	8/17/2003	21	8/17/2003	
14N/02W-07J	185	AHE362	46.711615	122.971333	166	2	22	S 12-22	6/5/2002	-	-	
14N/02W-07J	186	19124	46.711545	122.971009	166	4	25	S 10-25	4/7/1995	14	4/7/1995	
14N/02W-07K	181	AFM243	46.712024	122.977834	182	2	20	S 10-20	7/2/2001	-	-	
14N/02W-07K	183	361264	46.711790	122.975354	166	12	59	S 39-59	4/18/2003	17	4/21/2003	
14N/02W-07Q	189	464235122584701	46.709722	122.979722	181	6	67	O	1/1/1950	-	-	Weigle
14N/02W-08C	171	ACD298	46.719293	122.962221	181	2	30	S 10-30	1/3/1996	12	1/3/1996	
14N/02W-08D	172	AHR647	46.718971	122.965924	181	4	28	S 6-28	2/3/2003	14	2/3/2003	
14N/02W-08F	179	20740	46.713906	122.960411	183	2	26	S 24-26	4/20/1995	-	-	
14N/02W-08G	176	215680	46.715412	122.958353	183	2	20	S 5-20	12/15/1993	12	12/15/1993	
14N/02W-08K	187	215695	46.711659	122.954797	183	2	19	S 9-19	2/3/1993	14	2/3/1993	
14N/02W-08L	180	AGH916	46.713571	122.960868	183	2	25	S 2-17	5/3/2001	-	-	
14N/02W-08M	188	ABK181	46.710318	122.967267	175	6	53	O	-	15	9/29/1989	
14N/02W-08N	190	AFB872	46.707789	122.964683	178	6	64	O	-	9	7/10/2000	
14N/02W-16D	192	344544	46.704775	122.948679	178	6	45	O (?)	2/4/1959	13	1/1/1950	
14N/02W-16E	195	464207122565101	46.701944	122.947500	173	6	102	OH 82-102	9/1/1951	-	-	Weigle
14N/02W-16M	203	AGC799	46.696437	122.944064	268	6	200	P 190-200	10/26/2001	165	10/26/2001	
14N/02W-17E	193	464208122580901	46.702222	122.969167	170	6	50	O	6/1/1946	-	-	Weigle
14N/02W-17F	198	CT1-57	46.699469	122.964038	168	2	65.5	S 53-63	-	55	8/1/1996	
14N/02W-17G	199	ALB686	46.699653	122.954273	176	2	75	S 59-69	-	-	-	
14N/02W-17N	204	CT1-55	46.695527	122.966554	165	2	65	S 52-62	5/17/1996	50	8/1/1996	
14N/02W-17N	208	CT1-56	46.692404	122.964662	166	2	60	S 47-57	5/20/1996	8	5/18/1996	
14N/02W-18A	191	13097	46.704687	122.970002	167	6	67	O	-	17	11/9/1989	
14N/02W-18E	194	AFC580	46.701776	122.988172	218	6	60	P 40-59	12/16/1999	15	12/16/1999	
14N/02W-18J	200	003LEW	46.697500	122.969997	169	4 (?)	40	S nr	-	-	-	
14N/02W-18K	202	CT1-77	46.695978	122.977332	170	2	25	S 10-25	7/1/1996	15	7/1/1996	
14N/02W-18Q	206	CT1-79	46.692872	122.975466	165	2	25	S 15-25	4/20/2003	-	-	
14N/02W-18Q	207	CT1-76	46.692675	122.975399	163	2	25	S 10-25	7/1/1996	15	7/1/1996	
14N/02W-19A	212	AHG691	46.688923	122.971141	170	2	35	S 25-35	4/20/2003	-	-	
14N/02W-19B	209	CT1-78	46.691640	122.979281	172	2	30	S 19-29	4/20/2003	-	-	

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Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
14N/02W-19H	214	CT1-75	46.687970	122.975145	171	2	25	S 10-25	7/1/1996	20	7/1/1996	
14N/02W-19H	216	AGC751	46.687403	122.975038	171	2	39	S 34-39	7/30/2001	16	7/30/2001	
14N/02W-19H	217	464114122582805	46.687222	122.974444	171	2 (?)	300	OH 150-300	4/23/1905	-	-	Weigle
14N/02W-20D	210	CT1-74	46.690580	122.966592	171	2	15	S 5-15	7/1/1996	14	7/1/1996	
14N/02W-20D	211	CT1-73	46.689700	122.964651	171	2	15	S 5-15	7/1/1996	13	7/1/1996	
14N/02W-20G	215	215873	46.687842	122.958760	172	2	12	S 5-12	7/11/1997	21	7/11/1997	
14N/02W-30H	221	ABN974	46.673536	122.972567	181	4	39.5	S 15-40	11/2/1994	20	11/2/1994	
14N/02W-31A	222	AEE616	46.662474	122.971401	192	2	25	S 10-25	6/22/1998	13	6/22/1998	
14N/02W-31A	224	ABY772	46.661277	122.971438	189	6	30	S 5-30	6/8/1995	11	6/8/1995	
14N/02W-31B	223	463940122585101	46.661111	122.980833	173	8	127	OH 65-127	4/1/1953	-	-	Weigle
14N/02W-31H	231	CT1-48	46.657325	122.971238	180	2	45.8	S 35-45	5/13/1991	10	5/9/1991	
14N/02W-31K	237	AGJ765	46.653931	122.976450	174	2	15	S 3-15	10/27/1995	7	10/27/1995	
14N/02W-31K	238	19889	46.653312	122.977774	171	2	15	S 3-15	10/27/1995	7	10/27/1995	
14N/02W-31L	240	14-2-31P1	46.652416	122.981992	170	8	1031	OH 40-1031	5/6/1905	14	5/1/1953	Weigle
14N/02W-31M	234	AKP238	46.655678	122.991539	182	2	17.5	S 8-18	5/2/2003	-	-	
14N/02W-31M	236	AHL008	46.655599	122.991535	182	2	30	S 20-30	9/16/2002	-	-	
14N/02W-31Q	244	463905122584401	46.651389	122.978889	177	24	34	O (?)	9/1/1953	-	-	Weigle
14N/02W-32E	230	CT1-46	46.657995	122.966594	180	2	45	S 40-45	7/12/1990	-	-	
14N/02W-32E	235	CT1-47	46.656099	122.968911	184	2	45	S 40-45	7/13/1990	-	-	
14N/02W-32P	241	AHL335	46.652271	122.960793	183	6	57	O	-	9	6/2/2003	
14N/02W-33P	248	ACG018	46.648841	122.940754	232	2	20	S 10-20	2/26/1996	13	2/26/1996	
14N/02W-33R	245	AFC712	46.650843	122.929905	184	6	57	O	9/17/1996	13	9/17/1996	
14N/03W-01A	138	ABK182	46.732800	122.994049	172	6	40	O	-	17	6/6/1997	
14N/03W-01B	129	14-3-1B1	46.735497	122.998765	165	6	46	O	5/1/1905	14	5/1/1954	Weigle
14N/03W-01B	136	AEC914	46.733667	123.000720	167	20	70	S 41-62	-	28	8/17/2000	
14N/03W-01B	137	AEC935	46.733501	123.001814	164	24	66.5	S 38-61	3/2/2001	24	2/28/2001	
14N/03W-01H	140	AGN034	46.732193	122.992547	172	6	57	O	7/7/2002	24	7/7/2002	
14N/03W-01J	158	464333122593701	46.725833	122.993611	169	6	55	O	1/1/1948	-	-	Weigle
14N/03W-01K	157	464333122595606	46.725833	122.998889	166	6	50	O	6/5/1963	17	6/5/1963	USGS
14N/03W-01R	160	ABK193	46.724926	122.994828	167	8	56	O	-	25	8/10/1946	
14N/03W-01R	161	625601	46.724925	122.994875	167	8	56	O	-	25	8/10/1946	
14N/03W-12A	165	464316122593401	46.721111	122.992778	168	8	43	P 30-43	5/20/1950	15	5/20/1950	USGS
14N/03W-12H	177	464252122594101	46.714445	122.994722	170	48	20	O	1/1/1901	-	-	Weigle
14N/03W-12K	178	18986	46.714004	123.000117	172	6	260	O	9/23/1993	-	-	
14N/03W-12K	182	18985	46.711551	122.997734	181	6	100	O	-	32	9/27/1993	
14N/03W-13H	196	AFC574	46.700144	122.992041	221	6	163	P 143-162	10/5/1999	45	10/5/1999	
14N/03W-13H	197	AFC572	46.700053	122.993476	264	6	86	O	9/22/1999	1	9/22/1999	
14N/03W-13J	201	AFN676	46.695920	122.992892	197	6	140	P 120-140	-	15	6/7/2001	
14N/03W-24G	213	ACQ918	46.687452	123.001405	371	6	199	O	7/23/1997	67	7/23/1997	
14N/03W-24J	218	17907	46.684082	122.995286	204	6	150	P 57-140	-	75	4/28/1995	

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14N/03W-24K	219	11514	46.681757	122.997212	242	6	300	P 100-120, 160-295	10/23/1991	63	10/25/1991	
14N/03W-24Q	220	AFC081	46.680562	122.998169	264	6	70	P 35-75	6/12/1992	17	6/12/1992	
14N/03W-35B	225	AFB896	46.659771	123.019020	243	6	60	O	8/10/2000	28	8/10/2000	
14N/03W-35J	233	17906	46.655151	123.016264	184	6	117	P 57-117	3/30/1995	75	3/30/1995	
14N/03W-36F	226	AKR867	46.659198	123.002839	168	2	28	S 15-25	11/26/2003	-	-	
14N/03W-36H	227	ABK187	46.659370	122.993054	172	6	64	O	1/1/1955	-	-	
14N/03W-36H	228	463933122593801	46.659167	122.993889	173	6	138	OH 64-138	1/1/1955	-	-	Weigle
14N/03W-36M	232	AKR866	46.655630	123.009009	167	2	25	S 15-25	11/28/2003	-	-	
14N/03W-36P	242	CT1-49	46.651227	123.003804	179	2	17	S 7-17	2/27/2002	2	2/27/2002	
14N/03W-36Q	239	463908122595301	46.652222	122.998055	158	6	93	P 48-58	5/1/1949	20	4/5/1949	Weigle
14N/03W-36Q	243	14-3-36Q1	46.651141	122.999744	180	8	220	O	4/27/1905	-	-	Weigle
15N/02W-18M	10	AGN036	46.784316	122.990941	227	6	280	P 240-280	7/19/2002	51	7/21/2002	
15N/02W-19E	27	12661	46.772014	122.990076	189	6	80	P 60-80	10/10/1989	23	10/11/1989	
15N/02W-30N	66	464508122592001	46.752222	122.988889	166	5	30	P nr	5/3/1972	20	12/3/1973	USGS
15N/02W-30Q	70	16771	46.751415	122.977559	233	6	280	P 240-280	7/14/1995	100	7/14/1995	
15N/02W-31A	74	AGE891	46.749924	122.970898	482	6	200	O	7/22/2002	-	-	
15N/02W-31A	76	AGP813	46.749214	122.972909	390	6	160	P 150-160	8/26/2002	135	8/26/2002	
15N/02W-31C	75	13099	46.749144	122.980980	190	6	118	P 98-118	8/7/1976	55	8/4/1976	
15N/02W-31D	77	ABK194	46.748781	122.990885	169	6	70	O	-	24	11/22/1996	
15N/02W-31E	81	AGP809	46.746921	122.991652	171	6	69	O	8/2/2002	26	8/2/2002	
15N/02W-31E	82	AGP838	46.746714	122.991420	171	6	68	O	-	29	9/19/2002	
15N/02W-31E	83	AGP873	46.746491	122.991474	171	6	58	O	-	27	11/19/2002	
15N/02W-31E	85	AGP837	46.746318	122.991466	171	6	55	O	-	27	9/18/2002	
15N/02W-31E	86	AGP874	46.746022	122.991361	171	6	58	O	-	34	11/18/2002	
15N/02W-31E	88	464444122592501	46.745556	122.990278	172	6	57	O	3/24/1954	17	3/27/1954	USGS
15N/02W-31E	95	464440122591201	46.744444	122.986667	175	6	60	O	5/7/1979	-	-	USGS
15N/02W-31F	99	12579	46.743320	122.986152	176	6	77	O	-	20	10/5/1990	
15N/02W-31F	101	464436122585401	46.743333	122.981667	181	12	112	P 45-58, 68-76, 78-88	8/22/1946	32	8/22/1946	Weigle
15N/02W-31H	89	ABK185	46.745532	122.973942	319	6	77	O	8/31/1994	52	8/31/1994	
15N/02W-31L	105	AFB647	46.742501	122.985217	177	6	58	O	-	25	6/30/2000	
15N/02W-31L	112	13621	46.740733	122.984234	180	6	58	O	-	28	8/18/1995	
15N/02W-31L	115	464426122590301	46.740555	122.984167	180	6	57	O	12/16/1952	-	-	Weigle
15N/02W-31L	116	AHB160	46.739949	122.983951	181	6	68	P 62-68	12/4/1993	32	12/4/1993	
15N/02W-31L	118	AEK438	46.739700	122.985084	179	6	58	O	-	21	12/8/1998	
15N/02W-31M	102	AGN077	46.743101	122.990684	172	6	57	O	-	27	11/12/2002	
15N/02W-31M	111	ABK195	46.740756	122.990536	172	6	58	O	8/8/1997	21	8/8/1997	
15N/02W-31M	114	14971	46.740513	122.989455	173	6	55	P 40-55	-	28	10/1/1992	
15N/02W-31M	117	14754	46.739683	122.991672	172	6	58	O	-	35	6/12/1996	
15N/02W-31N	123	15-2-31N1	46.737405	122.988966	174	6	53	P 35-48	5/28/1950	18	5/28/1950	Weigle
15N/02W-31P	126	464412122590601	46.736667	122.985000	178	8	77	P 44-73	12/24/1959	8	12/24/1959	USGS

Table A-1 - Physical Description of Inventoried Wells, Centralia Chehalis Area, Lewis and Thurston Counties

Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
15N/02W-31P	127	14269	46.736304	122.984716	179	6	77	O	7/23/1996	40	7/23/1996	
15N/02W-31P	128	14037	46.736304	122.984716	179	6	55	O	5/6/1984	21	5/6/1984	
15N/02W-31Q	121	464419122584501	46.738611	122.979167	183	6	60	O	9/10/1946	25	9/10/1946	USGS
15N/02W-32K	119	16198	46.740354	122.954715	193	6	49	O	6/4/1992	15	6/4/1992	
15N/02W-32P	122	14604	46.738504	122.963079	295	6	70	P 58-68	-	55	9/20/1995	
15N/02W-32P	133	AGE852	46.735562	122.960058	189	6	60	O	4/12/2002	8	4/12/2002	
15N/02W-32Q	125	ABK190	46.737512	122.958409	192	6	62	O	-	28	9/16/1992	
15N/02W-32Q	131	464410122571801	46.736111	122.955000	192	6	41	O	1/1/1952	-	-	Weigle
15N/03W-13E	5	AGC858	46.787373	123.010417	163	6	79	O	10/11/2001	28	10/11/2001	
15N/03W-13E	6	ABK189	46.787272	123.011407	163	6	49	O	10/31/1989	26	10/31/1989	
15N/03W-13M	7	ABK184	46.785217	123.011279	161	8	44	S 34-44	-	19	12/30/1990	
15N/03W-13N	11	AGT286	46.782768	123.007943	162	6	80	O	-	36	11/21/2001	
15N/03W-13N	12	AFC141	46.782565	123.008984	159	6	51.5	O	-	24	8/25/1999	
15N/03W-13N	14	AGE834	46.781080	123.008112	159	6	76	O	-	16	2/26/2002	
15N/03W-14A	2	ALB681	46.793058	123.014036	170	6	58	O	2/26/1997	20	2/26/1997	
15N/03W-14A	3	ABK183	46.791447	123.013541	169	6	78	S 73-78	3/17/1995	37	3/17/1995	
15N/03W-14B	4	AGN013	46.790671	123.017544	172	6	59	O	5/15/2002	24	5/15/2002	
15N/03W-14C	1	ABZ630	46.793308	123.022771	166	6	59.6	O	7/14/1995	25	7/14/1995	
15N/03W-14K	8	AGE924	46.783909	123.020105	160	6	38	P 35-38	-	18	2/15/2002	
15N/03W-14K	9	ABK176	46.783770	123.018329	162	6	46	O	-	22	4/22/1979	
15N/03W-14R	13	464655123010001	46.781945	123.016667	151	6	62	O	7/27/1965	22	7/27/1965	USGS
15N/03W-23A	18	AGJ773	46.775984	123.012932	152	6	56	O	10/10/1992	16	10/23/1992	USGS
15N/03W-23C	16	464638123013001	46.777222	123.025278	148	6	55	O	8/24/1951	20	8/24/1951	USGS
15N/03W-23G	22	AAF309	46.774552	123.023088	153	6	38	O	11/21/1994	18	11/21/1994	USGS
15N/03W-23H	26	12199	46.772446	123.012915	164	6	39	O	-	23	2/24/1998	
15N/03W-23P	31	AKB695	46.768312	123.023294	146	2	36	S 26-36	7/7/2004	-	-	
15N/03W-23Q	36	464558123011701	46.766945	123.018889	142	6	30	P 20-30	7/1/1949	10	7/1/1949	USGS
15N/03W-24A	15	18099	46.779148	122.992133	201	6	60	P 40-55	-	20	9/18/1997	
15N/03W-24D	19	ACB121	46.775657	123.007375	162	6	60	P 55-60	3/8/1983	25	3/8/1983	
15N/03W-24E	23	464628123004201	46.774444	123.011667	157	6	61	O	10/21/1977	25	10/21/1977	USGS
15N/03W-24E	24	ACQ237	46.774198	123.011807	159	6	53	O	-	16	11/25/1997	
15N/03W-24E	25	464626123003401	46.773520	123.008940	165	6	63	O	2/3/1995	24	2/3/1995	USGS
15N/03W-24F	20	AAG500	46.775308	123.004239	162	4	70	S 50-70	-	20	3/13/1994	
15N/03W-24G	21	ACY539	46.775054	123.001664	178	6	73	O	-	39	8/19/1998	
15N/03W-24L	29	464612123001601	46.770988	123.003046	163	6	58	O	3/4/1991	20	3/7/1991	USGS
15N/03W-24L	30	AFP482	46.769891	123.006409	164	6	52	O	-	26	11/21/2000	
15N/03W-24L	32	296901	46.768644	123.004661	164	6	45	O	12/13/1950	13	12/13/1950	
15N/03W-24M	28	AGN069	46.771450	123.008286	161	6	59	O	-	18	2/19/2003	
15N/03W-24N	35	CT1-81	46.767293	123.012461	152	2	20	S 10-20	4/18/2003	-	-	
15N/03W-24P	34	AGP877	46.767766	123.004366	163	6	58	O	-	24	11/27/2002	

Table A-1 - Physical Description of Inventoried Wells, Centralia Chehalis Area, Lewis and Thurston Counties

Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
15N/03W-24P	39	464612123001501	46.765892	123.002591	165	6	60	O	10/19/1989	25	10/19/1988	USGS
15N/03W-24Q	38	464559122594201	46.766254	122.997082	166	12	51	P nr	-	13	1/24/1975	USGS
15N/03W-24R	33	464606122594001	46.768333	122.994445	164	6	40	O	1/1/1947	15	5/14/1947	USGS
15N/03W-24R	37	ABK196	46.767017	122.995552	168	6	50	O	-	25	5/27/1987	
15N/03W-25B	41	ABK177	46.762173	123.001313	165	6	56	O	8/25/1967	18	8/25/1997	
15N/03W-25C	43	AFS017	46.761587	123.004532	166	6	80	P 74-78	8/9/1989	22	8/9/1989	
15N/03W-25C	44	AFS018	46.761556	123.004534	166	6	69	O	12/19/1991	21	12/19/1991	
15N/03W-25D	42	CT1-82	46.761606	123.012433	155	2	20	S 9-19	4/18/2003	-	-	
15N/03W-25E	46	AGJ763	46.759925	123.011904	154	6	58	O	11/1/1989	10	11/1/1989	
15N/03W-25E	47	15637	46.759001	123.012384	153	6	50	O	-	13	5/1/1989	
15N/03W-25F	50	AHS234	46.758466	123.002275	168	2	30	S 20-30	4/17/2003	-	-	
15N/03W-25G	52	AFC708	46.758322	122.999531	170	6	75	P 71-75	9/30/1970	23	7/1/1971	
15N/03W-25G	53	363130	46.757936	123.001507	168	12	45	S 25-45	5/9/2003	7	4/23/2003	
15N/03W-25G	54	14687	46.757936	123.001507	168	6	48	O	12/20/1993	20	11/20/1983	
15N/03W-25K	61	AFM238	46.755698	123.001430	164	2	20	S 10-20	7/2/2001	-	-	
15N/03W-25K	62	AGC809	46.755575	123.001536	163	6	58	O	6/21/2001	25	6/21/2001	
15N/03W-25K	63	15577	46.755517	123.002064	162	6	57	O	-	20	5/15/1995	
15N/03W-25K	65	AFC702	46.754878	122.997033	168	8	78	P 60-70	-	14	4/1/1989	
15N/03W-25L	57	AFC710	46.757424	123.006468	149	10	78	S 58-78	5/8/1985	-	-	
15N/03W-25L	59	28301	46.756969	123.003675	158	6	56	O	-	24	7/1/1990	
15N/03W-25L	60	AGC898	46.755791	123.002471	160	6	59	O	-	20	4/16/2002	
15N/03W-25M	64	AFN526	46.755167	123.008917	160	6	78	P 50-78	-	24	3/13/2001	
15N/03W-25P	68	12246	46.751624	123.003429	159	6	53	O	-	22	11/3/1995	
15N/03W-25P	69	ABK179	46.750850	123.004834	157	6	66	O	-	18	12/30/1989	
15N/03W-25Q	67	AGP827	46.751842	123.000745	165	6	57.5	O	9/11/2002	25	9/11/2002	
15N/03W-26A	40	16552	46.762851	123.013217	153	6	55	O	-	10	3/14/1995	
15N/03W-26F	49	CT1-84	46.758023	123.026813	153	2	20	S 10-20	4/17/2003	-	-	
15N/03W-26G	48	AFT316	46.758618	123.019583	151	8	53	O	-	14	6/16/2003	
15N/03W-26H	51	AFT317	46.758150	123.016017	151	8	60	S 45-55	-	12	7/8/2003	
15N/03W-26H	55	342095	46.757588	123.017364	141	10	40	S 10-40	8/19/2002	10	7/15/2002	
15N/03W-26J	56	CT1-83	46.757392	123.016928	153	2	20	S 10-20	4/17/2003	-	-	
15N/03W-26J	58	15-3-26J2	46.757014	123.014602	150	8	35	O	5/5/1905	15	1/5/1952	Weigle
15N/03W-35H	80	ABK188	46.746486	123.013707	144	6	53	O	7/21/1987	26	7/21/1987	
15N/03W-35L	96	18342	46.742901	123.025066	161	6	37	O	-	25	9/10/1997	
15N/03W-35L	100	18737	46.742397	123.026934	161	6	105	O	9/8/1993	16	9/8/1993	
15N/03W-35L	103	16952	46.742251	123.025766	161	6	36	O	-	22	10/2/1989	
15N/03W-35L	106	15-3-35L4	46.741372	123.025980	155	6 (?)	68	O	4/11/1905	18	6/1/1940	Weigle
15N/03W-35L	107	ABK178	46.741132	123.024784	161	6	25	O	-	15	8/30/1994	
15N/03W-35L	108	ABH693	46.741049	123.025168	161	6	38	O	-	12	5/29/1998	
15N/03W-35L	109	18978	46.740550	123.026401	161	6	36	O	-	17	10/2/1989	

Table A-1 - Physical Description of Inventoried Wells, Centralia Chehalis Area, Lewis and Thurston Counties

Well Location	Map Identifier	Project Well Identifier	Site Latitude (decimal degree)	Site Longitude (decimal degree)	Land surface altitude at well head (feet)	Casing diameter (inches)	Completed well depth (feet)	Well completion type and open interval (feet)	Well construction date	Groundwater level, below land surface (feet)	Water level date	Remarks
15N/03W-35M	110	AFB881	46.739976	123.028834	158	6	26	O	7/18/2000	8	7/18/2000	
15N/03W-36B	71	14973	46.750599	123.000021	167	6	55	P 50-55	-	15	5/1/1988	
15N/03W-36B	73	464458122595601	46.749444	122.998889	164	6	51	O	9/3/1975	25	9/3/1975	USGS
15N/03W-36B	78	AFC701	46.748345	123.000443	172	6	60	O	-	25	6/16/1993	
15N/03W-36D	72	CT1-80	46.749729	123.012345	157	2	20	S 10-20	4/17/2003	-	-	
15N/03W-36F	94	15-3-36F2	46.744234	123.004816	165	7	54	O	4/24/1905	25	7/9/1954	Weigle
15N/03W-36G	92	659301	46.744707	122.998304	165	6	53	O	-	21	6/7/1971	
15N/03W-36H	84	AGP871	46.746454	122.992298	171	6	57	O	-	28	12/10/2002	
15N/03W-36H	87	652101	46.745599	122.996553	166	6	40	O	-	19	10/8/1997	
15N/03W-36H	90	15546	46.744887	122.995347	168	6	54	O	-	22	7/1/1990	
15N/03W-36H	93	ABG032	46.744678	122.996507	167	6	59	O	-	20	5/11/1999	
15N/03W-36H	97	ABK191	46.743522	122.992391	171	6	50	O	4/1/1977	22	4/1/1977	
15N/03W-36K	98	11462	46.743056	122.999924	165	6	50	O	7/12/1981	20	7/16/1981	
15N/03W-36K	104	11450	46.742729	122.997674	166	6	63	O	12/8/1979	23	12/8/1979	
15N/03W-36K	113	464425123000501	46.740278	123.001389	179	8	54	P 48-54	1/1/1942	20	7/1/1943	Weigle
15N/03W-36P	120	ABK200	46.738894	123.007753	165	8	58	P 45-55	4/16/1980	12	4/16/1980	
15N/03W-53C	79	AEK406	46.747033	123.023798	161	6	38	O	-	18	8/12/1998	

Appendix B

Project Quality Assurance

Detailed descriptions of the quality assurance (QA) program and procedures used for this study were presented in two Quality Assurance Project Plans (Pitz and Erickson, 2003; Pitz, 2004). This appendix describes the results of QA testing conducted as part of this program.

Seepage Evaluation

Precision

Two replicate discharge measurements were made during the September 25, 2003 seepage evaluation to help assess the quality of the stream discharge measurements made during this study (Table B-1).

Table B-1. Results of replicate tests of discharge measurement, September 25, 2003 (estimated discharge in ft^3/sec)

Station	SR-05 Skookumchuck R. (between team test)	SR-02 Chehalis R. (within team test)
1st Measurement	93 (Team 1)	97 (Team 1)
2nd Measurement	94 (Team 2)	98 (Team 1)
Replicate Error RPD	1.6 %	1.4 %

The first replicate measurement was made at Station SR-05 (Skookumchuck River at Riverside Park) at the beginning of the field day, and was overseen by a member of Ecology's Environmental Assessment Program, Stream Hydrology Unit (SHU). Two field teams participated in this test which was conducted to evaluate the potential variability introduced into the discharge estimates, by the use of multiple field teams. The test consisted of back-to-back discharge measurements, one by each team, at a common stream cross-section. This test provided confirmation that correct and consistent procedures were used by each team.

A second replicate test was conducted at the end of the day by a single field team. This event occurred at Station SR-02 (Chehalis River at the former Boy Scouts of America Camp). For this test the field team made two back-to-back discharge measurements at the same cross-section.

The test data indicate excellent reproducibility (as relative percent difference - RPD) in discharge estimates for both the *between* and *within* team replicate measurements.

In addition to the replicate tests described above, a current velocity comparison test was conducted, at various depths, at three locations on the SR-06 stream section. The test compared the average stream velocity recorded from a Swoffer meter (the meter type used during the synoptic survey) against the flow velocity recorded by a factory-calibrated SHU reference meter.

Table B-2 presents the measurements recorded by the two devices. The data indicate good reproducibility between the Swoffer meter and the SHU reference meter.

Table B-2. Stream velocity measurements recorded by the Swoffer meter and the SHU reference meter (ft/sec)

	Location 1 (water depth = 0.9 feet)	Location 2 (water depth = 1.83 feet)	Location 3 (water depth = 2.49 feet)
0.2 Depth			
Swoffer	-	2.02	1.9
Reference meter	-	1.85	1.79
RPD	-	8.8 %	6.0 %
0.6 Depth			
Swoffer	0.87	-	-
Reference meter	0.87	-	-
RPD	0.0 %	-	-
0.8 Depth			
Swoffer	-	1.03	1.32
Reference meter	-	1.05	1.5
RPD	-	1.9 %	12.8 %

Uncertainty

To evaluate uncertainty introduced into the seepage budget results by measurement error, an assumed error range (as % of flow) was assigned to each of the discharge measurements (Plate C, Table C-1, Column F). The assumed range was based on the physical characteristics and error rating of the stream cross-section used for measurement, as judged by field personnel, following recommendations by Rantz et al. (1982). Measurement error for pipe discharge was assumed as 2%; measurement error for gaging stations was based on the precision assigned to the appropriate portion of the discharge rating curve, as provided by the USGS (Laird, 2003). Error-adjusted potential discharge minimums and maximums were then calculated and included in the water budget (Columns G and H).

To determine the uncertainty range for the net seepage due to measurement error, the budget was recalculated under two scenarios.

1. *Upper-bound case:* the estimated potential minimum discharge values along a reach (including the starting station) were summed and then compared to the estimated potential maximum discharge value at the station at the end of the reach.
2. *Lower-bound case:* the sum of the estimated potential maximum discharge values along a reach (including the starting station) was compared to the estimated potential minimum discharge value at the final station.

The resulting uncertainty boundaries are plotted on the seepage chart on Figure B-1 below, and Plate C, Table C-1, Column I. While the results indicate a range of uncertainty on the absolute amount of seepage, particularly along Reaches 2 and 3, the direction of *net* seepage (losing or gaining) remains the same for each reach. This analysis does not, however, address additional uncertainty introduced into the seepage estimate resulting from unmeasured diversions or effluent discharges.

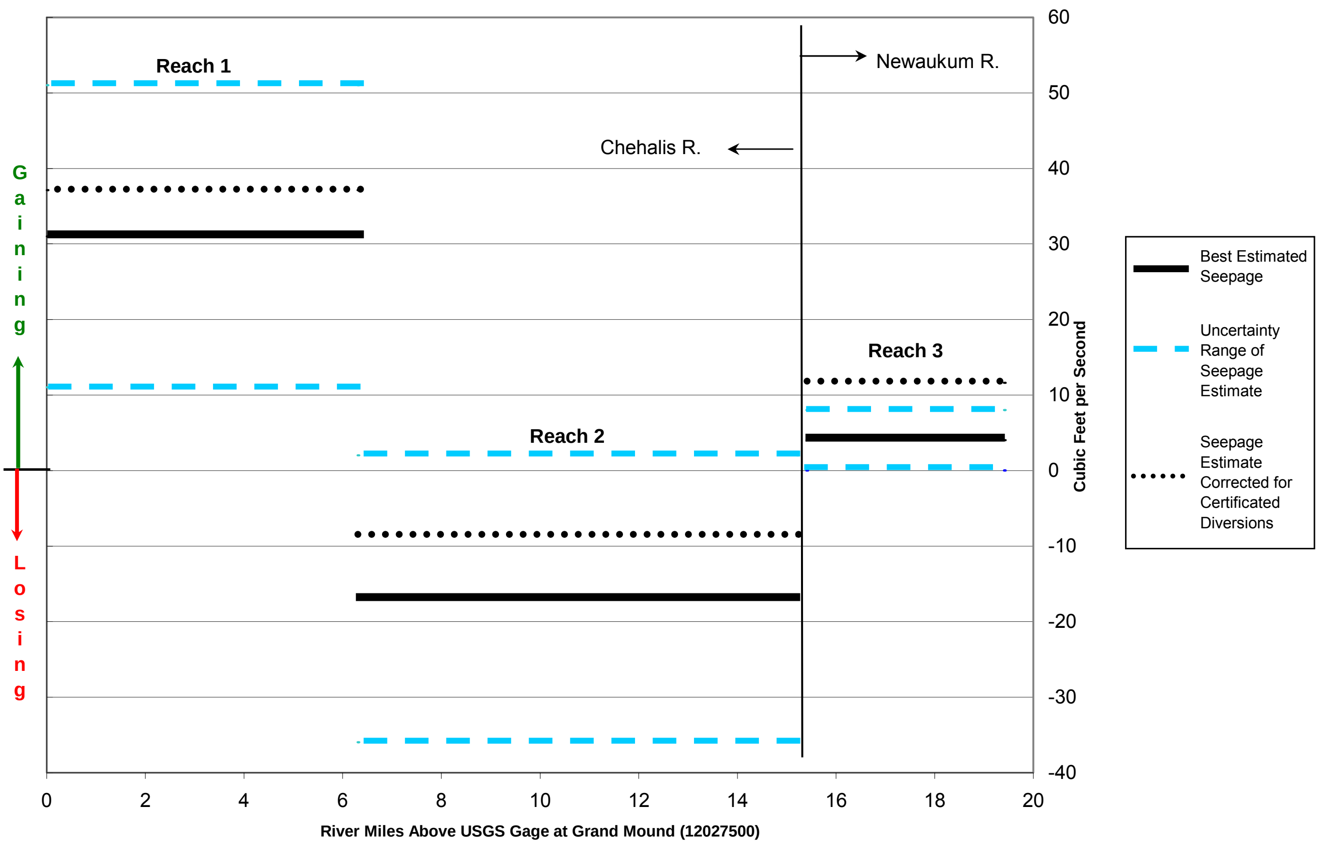

Figure B-1 - Seepage Evaluation - Estimated Gains and Losses

Water Quality Analyses

All project analytical results were subject to a two-step quality assurance (QA) review process before acceptance for use in this report. Analytical results were initially reviewed by a laboratory QA officer. The data were then further reviewed by the authors to account for QA testing conducted separately from the laboratory. This review process is described in detail below.

Laboratory

The precision and accuracy of results for samples submitted to Manchester Environmental Laboratory (MEL) were estimated using the laboratory quality control tests performed for each batch of 20 or fewer samples. Laboratory quality control testing consisted of method blanks, duplicate lab samples, spiked samples, and lab control standards. Manchester Laboratory's quality control program procedures are discussed in detail in MEL (2001).

Quality assurance reviews were completed by a Manchester QA officer for each case-narrative report delivered to the project manager for each sample batch. The laboratory reviews indicated that the data produced during this project were of generally excellent quality, meeting or exceeding the data quality objectives established in the project plan. In limited cases, data qualifiers were added by the Manchester QA officer to the data results; these data qualifiers are reflected in the data tables presented elsewhere in this report. None of the data qualifiers added by the Manchester QA officers were judged to disqualify the data from use for this project.

Samples submitted for analysis of volatile organic compounds (VOCs) were forwarded to a contract laboratory: Analytical Resources, Inc. (ARI), Tukwila, WA. The contract laboratory is accredited by the Department of Ecology's Laboratory Accreditation Program; therefore the routine laboratory quality control procedures described above were also implemented during the VOC analysis. After review and qualification by an ARI QA officer, the data were further reviewed and qualified by a Manchester QA officer. None of the lab data qualifiers added were judged to disqualify the data from use for this project.

Field

A variety of field-based QA tests were conducted by the authors to determine the influence of sample collection and handling procedures on the final analytical results. Additional tests were also conducted to independently verify the laboratory's performance for key project analytes. All QA samples were submitted to the laboratory blind (i.e., samples were labeled in a manner to hide their origin and purpose from laboratory personnel). The results of these tests, described in detail below, were used by the authors to further qualify the laboratory data prior to use in the report.

Equipment Blanks

To determine if any component of the sampling equipment used during this project was contributing a positive bias to the analytical results, clean, laboratory-supplied, reagent-grade, de-ionized (DI) water was pumped through the sample collection and filtering system once per sampling round. The filtrate collected from this process was submitted as a blind sample to the laboratory for analysis of all the same parameters true field samples were tested for.

The procedures used for the collection of an equipment blank were customized to the various sampling systems used during this project (piezometer sampling, supply well sampling, monitoring well sampling). Initially, blank samples were collected using all new components of the sampling systems. Later in the project, blanks were collected in a manner to examine the potential for cross-contamination between sampling stations. This testing was conducted by collecting blank samples using permanent sampling equipment parts that had been previously used and cleaned (e.g., tubing fittings, pump tubing).

Equipment blank results for piezometer and well sampling events are presented in Tables B-3, B-4, and B-5. Results indicate no significant bias was introduced into the sampling results by the equipment or handling procedures used, with the following exceptions:

- October piezometer and surface water results for sodium were flagged as potentially biased high due to blank interference
- October Tier 2 monitoring well results for sodium and lead were flagged as potentially biased high due to blank interference
- February Tier 2 monitoring well results for chloride were rejected by the authors due to high levels of blank interference
- February Tier 2 monitoring well results for orthophosphate-P were flagged as potentially biased high due to blank interference.

Transport Blanks

Sample bottles filled with reagent-grade, de-ionized water were supplied to the authors by Manchester Laboratory for use in evaluating the potential positive bias in VOC concentrations introduced into project samples during transport from the field to the lab. No VOC detections were reported in the October transport blank sample.

Split Duplicates

To help determine data precision, blind split duplicate samples were collected and submitted for analysis for every ten field samples. Split duplicates were collected by splitting the pump discharge between two sets of sample bottles, and then labeling the second bottle set as an additional field station under a false station name.

First-round duplicate sample stations were selected randomly; duplicate locations selected for subsequent rounds were chosen on the basis of previous results. Over the course of the study, duplicate stations were chosen to represent the entire concentration range of interest.

Precision estimates are influenced not only by random error introduced by collection and measurement procedures, but also by the natural variability in the media being sampled. Estimates of precision are less representative of random error as the measured values approach the practical quantitation limit of an analytical procedure.

Tables B-6 and B-7 present the reported concentration data for each of the duplicate pairs, grouped by constituent. The tables additionally show the relative standard deviation (RSD) calculated for each pair, and the mean RSD for each constituent.

The duplicate results indicate that in the large majority of cases, the data precision is well within the measurement quality objectives established in the Quality Assurance Project Plans (Pitz and Erickson, 2003; Pitz, 2004). Exceptions include:

- September piezometer results for orthophosphate-P and dissolved organic carbon were qualified as estimates for all samples collected on 9/1/2004 due to a duplicate precision on that date greater than the established quality objective.
- September Tier 2 monitoring well results for orthophosphate-P were qualified as estimates due to a duplicate precision greater than the established quality objective.

Blind Reference Solution Samples

To independently test the accuracy performance of the laboratory, blind reference solution samples were submitted every applicable sample round for analysis of chloride, nitrate-N, and orthophosphate-P. Reference solution standards were provided by an Ecology Laboratory Accreditation Section QA officer.

Reference solutions were prepared by the authors prior to each sample round, and were submitted with the remainder of the project samples under a false sample station name. Upon receipt of the laboratory results, the reported lab concentration was compared to the known reference solution concentration.

Tables B-8 and B-9 present the results for the comparison between lab-reported and known concentration for the reference solutions submitted during the project. In all cases, the differences between the two values were within acceptable limits, indicating excellent data quality.

Material Comparison Samples

To test alternative piezometer designs for future applications, several different piezometer material types were deployed in the field during this study: 3/4" I.D. galvanized steel riser-pipe attached to a stainless steel screen point, 1" I.D. galvanized steel pipe perforated near the point, and ¼" I.D. high-density polyethylene tubing with a filter fabric screen near the point.

In order to determine the comparability of water quality results between differing piezometer types, samples were collected from co-located piezometers. Co-located piezometers AHL145 (stainless screen) and ALB687 (perforated galvanized steel screen) were sampled together on five occasions. Co-located piezometers ABK198 and AHL146 were sampled together on one occasion. Table B-10 presents the results for these comparison studies.

While differences in water quality concentrations between co-located piezometers may be the result of a variety of factors (e.g., heterogeneity in water quality conditions between stations; influence of material type on tested constituents; laboratory error), the comparison results indicate good reproducibility between material types. The notable exceptions were:

- Poor reproducibility between the stainless screen and the filter fabric wrapped poly-tube for dissolved organic carbon. The cause for this difference is unknown.
- Poor reproducibility between the stainless screen and the filter fabric wrapped poly-tube for iron. The cause for this difference is unknown, but may be a result of aquifer heterogeneity, or the influence of the black steel driver pipe used to install the poly-tubing piezometer.

Ionic Balance

Samples for analysis of ionic hydrochemistry were submitted for a total of 54 stations during October 2004. The charge balance error was calculated for each station as a check on the accuracy and completeness of the analyses. The mean charge balance error for all stations was +6.2%. Charge balance errors were frequently >+10% for stations with a field measured alkalinity value of <75 mg/L.

The high balance error for these samples is directly attributed by the authors to the poor accuracy of the field test procedure for alkalinity at concentrations less than 75 mg/L (typically under-reporting the true value). Accounting for this bias, the data indicate that the laboratory analytical measurements were of otherwise good quality.

Table B-3 - Equipment Blank Data (Piezometers)

	May '04		June '04		July '04		Aug. '04		Sept. '04		Oct. '04	
Analyte	**Conc.**	**Qual.**	**Conc.**	**Qual.**	**Conc.**	**Qual.**	**Conc.**	**Qual.**	**Conc.**	**Qual.**	**Conc.**	**Qual.**
Chloride (dissolved) - mg/L	0.10	U	0.10	U	0.10	U	0.0030	U	0.0030	U	0.0030	U
Total Dissolved Solids - mg/L	10	U	10	U	10	U	10	U	10	U	10	U
Ammonia (dissolved) - mg/L	0.010	U	0.010	U	0.010	U	0.10	U	0.2	U	0.10	U
Nitrate+Nitrite-N (dissolved) - mg/L	0.010	U	0.010	U	0.010	U	0.010	U	0.010	U	0.010	U
Orthophosphate-P (dissolved) - mg/L	0.0030	U	0.0030	U	0.0030	U	0.010	U	0.010	U	0.010	U
Dissolved Organic Carbon - mg/L	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Iron (dissolved) - µg/L	50	U	50	U	50	U	50	U	50	U	50	U
Fluoride (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.10	U
Sulfate (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.3	U
Silica (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	110	U
Calcium (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	50	U
Magnesium (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	50	U
Sodium (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**140**	
Potassium (dissolved) - mg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	500	U
Comments	New tubing, new filter, new filter connection		New tubing, fresh filter (old), used filter connection		Used tubing (3 prior stations) followed by a lab DI H_2O purge, new filter, new filter connection		ABK199 dedicated tubing purged for 20 minutes w/ DI H_2O, new filter, used filter connection		AHL140 dedicated tubing purged for 6 mins. w/ DI H_2O, used silastic on peristaltic pump, new filter, used filter connection		Used silastic tubing on peristaltic pump purged w/ 1 gal. DI H_2O, used 3 new filters during blank, used filter connection	

U - Not detected at or above the reporting limit
NS - Not sampled
Shaded values denote a detection.

Table B-4 - Equipment Blank Data (Tier 1 Wells)

Analyte	May '04			October '04		
	Conc.	UOM	Qual.	Conc.	UOM	Qual.
Chloride (dissolved)	0.10	mg/L	U	0.10	mg/L	U
Total Dissolved Solids	10	mg/L	U	10	mg/L	U
Nitrate+Nitrite-N (dissolved)	0.010	mg/L	U	0.010	mg/L	U
Orthophosphate-P (dissolved)	0.0030	mg/L	U	0.0030	mg/L	U
Iron (dissolved)	50	ug/L	U	50	ug/L	U
Dissolved Organic Carbon	NS	NS	NS	1.0	mg/L	U
Fluoride (dissolved)	NS	NS	NS	0.10	mg/L	U
Sulfate (dissolved)	NS	NS	NS	0.30	mg/L	U
Manganese (dissolved)	NS	NS	NS	10	ug/L	U
Silica (dissolved)	NS	NS	NS	110	ug/L	U
Calcium (dissolved)	NS	NS	NS	50	ug/L	U
Magnesium (dissolved)	NS	NS	NS	50	ug/L	U
Sodium (dissolved)	NS	NS	NS	50	ug/L	U
Potassium (dissolved)	NS	NS	NS	500	ug/L	U
Lead (dissolved)	NS	NS	NS	0.020	ug/L	U
Arsenic (dissolved)	NS	NS	NS	0.10	ug/L	U
Volatile Organic Compounds (VOCs)	NS	NS	NS	ND	ND	ND
Comments	Fresh tubing, fresh filter, fresh filter connection			Fresh silastic tubing to filter, fresh 1/2" to 1/4" barb fitting, fresh filter, fresh filter connector, dedicated tubing for AHG691, lab DI H2O after 15 min purge, fresh silastic tubing through pump		

UOM - Unit of measurement
NS - Not sampled
U - Not detected at or above reporting limit
ND - Of the 71 unique VOAs analyzed, no detections were reported in either the equipment or transport blanks.

Table B-5 - Equipment Blank Data (Tier 2 Wells)

Analyte	August '04		October '04		December '04		February '05		April '05	
	Conc.	Qual.	Conc.	Qual.	Conc.	Qual.	Conc.	Qual.	Conc.	Qual.
Chloride (dissolved) - mg/L	0.10	U	0.10	U	0.10	U	21.4		0.10	U
Total Dissolved Solids - mg/L	10	U	10	U	10	U	10	U	10	U
Nitrate-Nitrite-N (dissolved) - mg/L	0.010	U	0.010	U	0.010	U	0.010	U	0.010	U
Orthophosphate-P (dissolved) - mg/L	0.0030	U	0.0030	U	0.0030	U	0.0042		0.0030	U
Iron (dissolved) - mg/L	50	U	50	U	50	U	50	U	50.0	U
Fluoride (dissolved) - mg/L	NS	NS	0.10	U	NS	NS	NS	NS	NS	NS
Sulfate (dissolved) - mg/L	NS	NS	0.30	U	NS	NS	NS	NS	NS	NS
Manganese (dissolved) - µg/L	NS	NS	10	U	NS	NS	NS	NS	NS	NS
Silica (dissolved) - µg/L	NS	NS	110	U	NS	NS	NS	NS	NS	NS
Calcium (dissolved) - µg/L	NS	NS	50	U	NS	NS	NS	NS	NS	NS
Magnesium (dissolved) - µg/L	NS	NS	50	U	NS	NS	NS	NS	NS	NS
Sodium (dissolved) - µg/L	NS	NS	130		NS	NS	NS	NS	NS	NS
Potassium (dissolved) - µg/L	NS	NS	500	U	NS	NS	NS	NS	NS	NS
Lead (dissolved) - µg/L	NS	NS	0.014		NS	NS	NS	NS	NS	NS
Arsenic (dissolved) - µg/L	NS	NS	0.10	U	NS	NS	NS	NS	NS	NS
Dissolved Organic Carbon - mg/L	NS	NS	1.0		NS	NS	NS	NS	NS	NS
Volatile Organic Compounds (VOCs) - µg/L	NS	NS	ND	ND	NS	NS	NS	NS	NS	NS
Comments	Used silastic tubing, new filter connector, new filter, dedicated downhole tubing, lab DI H_2O purge for 15 minutes		New silastic tubing, new filter, used filter connector, dedicated downhole tubing, lab DI H_2O purge for 15 minutes		New high capacity filter, used filter connector, new silastic tubing, lab DI H_2O purge, first 200ml filtrate discarded		New high capacity filter, used connectors, new silastic tubing, lab DI H_2O purge, first 200ml filtrate discarded		New high capacity filter, used connectors, new silastic tubing, lab DI H_2O purge, first 200ml filtrate discarded	

NS - Not sampled
U - Not detected at or above reporting limit
ND - Of the 71 unique VOCs analyzed, no detections were reported in either the equipment or transport blanks
Shaded cell indicates detection

Table B-6 - Blind Field Duplicate Performance Data (Piezometers)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
Chloride (dissolved) - mg/L (Mean RSD = 1.6)							
1	AHL142 AHL142 Dup	19.7 19.6		0.10	0.1	19.65	0.4
2	AHL146 AHL146 Dup	11.9 12.0		0.10	0.1	11.95	0.6
3	ABK199 ABK199 Dup	6.33 6.53		0.20	0.14	6.43	2.2
4	AHL137 AHL137 Dup	61.1 61.6		0.50	0.4	61.35	0.6
5	AHL145 AHL145 Dup	6.43 6.40		0.03	0.02	6.42	0.3
5	ABK197 ABK197 Dup	4.95 4.60		0.35	0.25	4.60	5.4
6	AHL144 AHL144 Dup	9.53 9.34		0.19	0.13	9.44	1.4
Total Dissolved Solids - mg/L (Mean RSD = 2.0)							
1	AHL142 AHL142 Dup	395 367		28	20	381	5.2
2	AHL146 AHL146 Dup	271 268		3	2	270	0.8
3	ABK199 ABK199 Dup	274 278		4	3	276	1.0
4	AHL137 AHL137 Dup	281 278		3	2	280	0.8
5	AHL145 AHL145 Dup	126 122		4	3	124	2.3
5	ABK197 ABK197 Dup	159 152		7	5	156	3.2
6	AHL144 AHL144 Dup	176 174		2	1	175	0.8
Ammonia-N (dissolved) - mg/L (Mean RSD = 0.3)							
1	AHL142 AHL142 Dup	0.010 0.010	U U	0.000	0.000	0.010	0.0
2	AHL146 AHL146 Dup	0.619 0.612		0.007	0.005	0.616	0.8
3	ABK199 ABK199 Dup	4.94 4.96		0.02	0.01	4.95	0.3
4	AHL137 AHL137 Dup	0.589 0.586		0.003	0.002	0.588	0.4
5	AHL145 AHL145 Dup	0.010 0.010	U U	0.000	0.000	0.010	0.0
5	ABK197 ABK197 Dup	0.155 0.154		0.001	0.001	0.155	0.5
6	AHL144 AHL144 Dup	0.010 0.010	U U	0.000	0.000	0.010	0.0

U - Not detected at or above the reporting limit

Table B-6 - Blind Field Duplicate Performance Data (Piezometers) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Abs. Mean (x)	RSD (s/x*100)
Nitrate+Nitrite-N (dissolved) - mg/L (Mean RSD = 0.1)							
1	AHL142 AHL142 Dup	39.9 40.1		0.2	0.1	40.0	0.4
2	AHL146 AHL146 Dup	0.010 0.010	U U	0.000	0.000	0.010	0.0
3	ABK199 ABK199 Dup	0.010 0.010	UJ U	0.000	0.000	0.010	0.0
4	AHL137 AHL137 Dup	0.010 0.010	U U	0.000	0.000	0.010	0.0
5	AHL145 AHL145 Dup	1.48 1.48		0.00	0.00	1.48	0.0
5	ABK197 ABK197 Dup	0.010 0.010	U U	0.000	0.000	0.010	0.0
6	AHL144 AHL144 Dup	2.48 2.50		0.02	0.01	2.49	0.6
Orthophosphate-P (dissolved) - mg/L (Mean RSD = 3.9)							
1	AHL142 AHL142 Dup	0.024 0.024		0.000	0.000	0.024	0.0
2	AHL146 AHL146 Dup	1.30 1.35		0.05	0.04	1.33	2.7
3	ABK199 ABK199 Dup	0.120 0.126		0.006	0.004	0.123	3.4
4	AHL137 AHL137 Dup	0.0329 0.0337		0.0008	0.0006	0.0333	1.7
5	AHL145 AHL145 Dup	0.0400 0.0403		0.0003	0.0002	0.0402	0.5
5	ABK197 ABK197 Dup	0.0344 0.0447	J J	0.0103	0.0073	0.0396	18.4
6	AHL144 AHL144 Dup	0.0327 0.0325		0.0002	0.0001	0.0326	0.4
Dissolved Organic Carbon - mg/L (Mean RSD = 6.4)							
1	AHL142 AHL142 Dup	1.0 1.0	U U	0.0	0.0	1.0	0.0
2	AHL146 AHL146 Dup	1.6 1.5		0.1	0.1	1.6	4.6
3	ABK199 ABK199 Dup	7.7 7.8		0.1	0.1	7.8	0.9
4	AHL137 AHL137 Dup	1.8 1.9		0.1	0.1	1.9	3.8
5	AHL145 AHL145 Dup	1.0 1.0	U U	0.0	0.0	1.0	0.0
5	ABK197 ABK197 Dup	1.0 1.5	UJ J	0.5	0.4	1.0	35.4
6	AHL144 AHL144 Dup	1.0 1.0	U U	0.0	0.0	1.0	0.0

U - Not detected at or above the reporting limit

J - Reported result is an estimate

Shaded cells indicate value above target established in project QA Project Plan

Table B-6 - Blind Field Duplicate Performance Data (Piezometers) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Abs. Mean (x)	RSD (s/x*100)
Iron (dissolved) - µg/L (Mean RSD = 0.2)							
1	AHL142 AHL142 Dup	50 50	U U	0	0	50	0.0
2	AHL146 AHL146 Dup	1290 1290		0	0	1290	0.0
3	ABK199 ABK199 Dup	37900 37900		0	0	37900	0.0
4	AHL137 AHL137 Dup	19600 19600		0	0	19600	0.0
5	AHL145 AHL145 Dup	50 50	U U	0	0	50	0.0
5	ABK197 ABK197 Dup	15100 15400		300	212	15250	1.4
6	AHL144 AHL144 Dup	50 50	U U	0	0	50	0.0
Silica (dissolved) - µg/L							
6	AHL144 AHL144 Dup	33000 32900		100	71	32950	0.2
Calcium (dissolved) - µg/L							
6	AHL144 AHL144 Dup	27000 27200		200	141	27100	0.5
Magnesium (dissolved) - µg/L							
6	AHL144 AHL144 Dup	9030 9100		70	49	9065	0.5
Sodium (dissolved) - µg/L							
6	AHL144 AHL144 Dup	10500 10500		0	0	10500	0.0
Potassium (dissolved) - µg/L							
6	AHL144 AHL144 Dup	1700 1700		0	0	1700	0.0
Fluoride (dissolved) - mg/L							
6	AHL144 AHL144 Dup	0.10 0.10	U U	0	0	0.1	0.0
Sulfate (dissolved) - mg/L							
6	AHL144 AHL144 Dup	6.86 7.02		0.16	0.11	6.94	1.6

U - Not detected at or above the reporting limit

Table B-7 - Blind Field Duplicate Performance Data (Wells)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
Chloride (dissolved) - mg/L (Mean RSD = 0.7)							
1	ABK176 ABK176 Dup	4.31 4.27		0.0	0.0	4.3	0.7
1	ABK195 ABK195 Dup	12.9 12.7		0.2	0.1	12.8	1.1
1	AGN061 AGN061 Dup	20.3 20.3		0.0	0.0	20.3	0.0
1	AHS234 AHS234 Dup	3.52 3.54		0.0	0.0	3.5	0.4
2	ABK200 ABK200 Dup	4.73 4.93		0.2	0.1	4.8	2.9
2	AHL335 AHL335 Dup	62.3 62.1		0.2	0.1	62.2	0.2
2	ABK192 ABK192 Dup	11.9 11.9		0.0	0.0	11.9	0.0
2	AHG691 AHG691 Dup	19.1 19.0		0.1	0.1	19.1	0.4
2	AKB696 AKB696 dup	6.8 6.8		0.0	0.0	6.8	0.4
3	AKB696 AKB696 dup	7.1 7.0		0.0	0.0	7.1	0.4
4	AKB695 AKB695 dup	8.7 8.6		0.1	0.1	8.6	1.0
6	AKB695 AKB695 dup	8.7 8.6		0.0	0.0	8.7	0.3
Total Dissolved Solids - mg/L (Mean RSD = 1.8)							
1	ABK176 ABK176 Dup	104 105		1	1	105	0.7
1	ABK195 ABK195 Dup	113 114		1	1	114	0.6
1	AGN061 AGN061 Dup	142 145		3	2	144	1.5
1	AHS234 AHS234 Dup	57 62		5	4	60	5.9
2	ABK200 ABK200 Dup	141 144		3	2	143	1.5
2	AHL335 AHL335 Dup	292 282		10	7	287	2.5
2	ABK192 ABK192 Dup	202 196		6	4	199	2.1
2	AHG691 AHG691 Dup	308 307		1	1	308	0.2
2	AKB696 AKB696 dup	135 132		3	2	134	1.6
3	AKB696 AKB696 dup	128 133		5	4	131	2.7
4	AKB695 AKB695 dup	153 150		3	2	152	1.4
5	AKB695 AKB695 dup	137 140		3	2	139	1.5
6	AKB695 AKB695 dup	137 139		2	1	138	1.0

Table B-7 - Blind Field Duplicate Performance Data (Wells) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
Nitrate+Nitrite-N (dissolved) - mg/L (Mean RSD = 1.6)							
1	ABK176 ABK176 Dup	1.87 1.88		0.01	0.01	1.88	0.4
1	ABK195 ABK195 Dup	2.21 2.33		0.12	0.08	2.27	3.7
1	AGN061 AGN061 Dup	1.61 1.60		0.01	0.01	1.61	0.4
1	AHS234 AHS234 Dup	2.55 2.82		0.27	0.19	2.69	7.1
2	ABK200 ABK200 Dup	6.84 6.73		0.11	0.08	6.79	1.1
2	AHL335 AHL335 Dup	0.011 0.010		0.00	0.00	0.011	6.7
2	ABK192 ABK192 Dup	0.010 0.010	U U	0.00	0.00	0.010	0.0
2	AHG691 AHG691 Dup	0.010 0.010	U U	0.00	0.00	0.010	0.0
2	AKB696 AKB696 dup	1.04 1.04		0.00	0.00	1.040	0.0
3	AKB696 AKB696 dup	1.09 1.09		0.00	0.00	1.090	0.0
4	AKB695 AKB695 dup	1.49 1.50		0.01	0.01	1.495	0.5
5	AKB695 AKB695 dup	1.40 1.41		0.01	0.01	1.405	0.5
6	AKB695 AKB695 dup	1.31 1.31		0.00	0.00	1.310	0.0
Dissolved Organic Carbon - mg/L (Mean RSD = 2.9)							
2	ABK200 ABK200 Dup	1.0 1.0	U U	0.0	0.0	1.0	0.0
2	AHL335 AHL335 Dup	1.0 1.0	U U	0.0	0.0	1.0	0.0
2	ABK192 ABK192 Dup	1.0 1.0	U U	0.0	0.0	1.0	0.0
2	AHG691 AHG691 Dup	1.6 1.3		0.3	0.2	1.5	14.6
3	AKB696 AKB696 dup	1.0 1.0	U U	0.0	0.0	1.0	0.0

U - Not detected at or above the reporting limit

Shaded cells indicate value above target established in project QA Project Plan

Table B-7 - Blind Field Duplicate Performance Data (Wells) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
	Orthophosphate-P (dissolved) - mg/L (Mean RSD = 4.3)						
1	ABK176 ABK176 Dup	0.025 0.025	J J	0.000	0.000	0.025	0.0
1	ABK195 ABK195 Dup	0.019 0.019	J J	0.000	0.000	0.019	0.0
1	AGN061 AGN061 Dup	0.030 0.029	J J	0.001	0.001	0.030	2.4
1	AHS234 AHS234 Dup	0.024 0.024		0.000	0.000	0.024	0.0
2	ABK200 ABK200 Dup	0.018 0.017		0.001	0.001	0.018	4.0
2	AHL335 AHL335 Dup	0.028 0.034		0.006	0.004	0.031	13.9
2	ABK192 ABK192 Dup	0.029 0.027		0.002	0.001	0.028	5.1
2	AHG691 AHG691 Dup	0.0369 0.0337		0.003	0.002	0.035	6.4
2	AKB696 AKB696 dup	0.0280 0.0270		0.001	0.001	0.028	2.6
3	AKB696 AKB696 dup	0.0332 0.0328		0.000	0.000	0.033	0.9
4	AKB695 AKB695 dup	0.0308 0.0308		0.000	0.000	0.031	0.0
5	AKB695 AKB695 dup	0.0441 0.0331	JF JF	0.011	0.008	0.039	20.2
6	AKB695 AKB695 dup	0.0323 0.0319		0.000	0.000	0.032	0.9
	Manganese (dissolved) - µg/L (Mean RSD = 0.2)						
2	ABK200 ABK200 Dup	10 10	U U	0	0	10	0.0
2	AHL335 AHL335 Dup	262 263		1	1	263	0.3
2	ABK192 ABK192 Dup	235 236		1	1	236	0.3
2	AHG691 AHG691 Dup	1410 1420		10	7	1415	0.5
3	AKB696 AKB696 dup	10 10	U U	0	0	10	0.0

U - Not detected at or above the reporting limit
J - Reported result is an estimate
F - Equipment blank results suggest reported result may be biased high
Shaded cells indicate value above target established in project QA Project Plan

Table B-7 - Blind Field Duplicate Performance Data (Wells) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
			Iron (dissolved) - µg/L (Mean RSD = 0.1)				
1	ABK176 ABK176 Dup	50 50	U U	0	0	50	0.0
1	ABK195 ABK195 Dup	50 50	U U	0	0	50	0.0
1	AGN061 AGN061 Dup	50 50	U U	0	0	50	0.0
1	AHS234 AHS234 Dup	50 50	U U	0	0	50	0.0
2	ABK200 ABK200 Dup	50 50	U U	0	0	50	0.0
2	AHL335 AHL335 Dup	9950 9960		10	7	9955	0.1
2	ABK192 ABK192 Dup	7510 7520		10	7	7515	0.1
2	AHG691 AHG691 Dup	5580 5620		40	28	5600	0.5
2	AKB696 AKB696 dup	50 50	U U	0	0	50	0.0
3	AKB696 AKB696 dup	50 50	U U	0	0	50	0.0
4	AKB695 AKB695 dup	50 50	U U	0	0	50	0.0
5	AKB695 AKB695 dup	50 50	U U	0	0	50	0.0
6	AKB695 AKB695 dup	50 50	U U	0	0	50	0.0
			Silica (dissolved) - µg/L (Mean RSD = 0.3)				
2	ABK200 ABK200 Dup	29900 30100		200	141	30000	0.5
2	AHL335 AHL335 Dup	40400 40400		0	0	40400	0.0
2	ABK192 ABK192 Dup	48500 48300		200	141	48400	0.3
2	AHG691 AHG691 Dup	72400 72500		100	71	72450	0.1
3	AKB696 AKB696 dup	34000 34200		200	141	34100	0.4
			Calcium (dissolved) - µg/L (Mean RSD = 0.5)				
2	ABK200 ABK200 Dup	17300 17500		200	141	17400	0.8
2	AHL335 AHL335 Dup	20800 21000		200	141	20900	0.7
2	ABK192 ABK192 Dup	13900 14000		100	71	13950	0.5
2	AHG691 AHG691 Dup	42200 42600		400	283	42400	0.7
3	AKB696 AKB696 dup	16300 16300		0	0	16300	0.0

U - Not detected at or above the reporting limit

Table B-7 - Blind Field Duplicate Performance Data (Wells) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
Magnesium (dissolved) - µg/L (Mean RSD = 0.6)							
2	ABK200 ABK200 Dup	5110 5170		60	42	5140	0.8
2	AHL335 AHL335 Dup	11200 11400		200	141	11300	1.3
2	ABK192 ABK192 Dup	8550 8550		0	0	8550	0.0
2	AHG691 AHG691 Dup	17200 17400		200	141	17300	0.8
3	AKB696 AKB696 dup	4600 4600		0	0	4600	0.0
Sodium (dissolved) - µg/L (Mean RSD = 0.5)							
2	ABK200 ABK200 Dup	9150 9330		180	127	9240	1.4
2	AHL335 AHL335 Dup	53000 53700		700	495	53350	0.9
2	ABK192 ABK192 Dup	30300 30300		0	0	30300	0.0
2	AHG691 AHG691 Dup	23100 23100		0	0	23100	0.0
3	AKB696 AKB696 dup	8400 8450	F F	50	35	8425	0.4
Potassium (dissolved) - µg/L (Mean RSD = 1.6)							
2	ABK200 ABK200 Dup	1200 1200		0	0	1200	0.0
2	AHL335 AHL335 Dup	3500 3600		100	71	3550	2.0
2	ABK192 ABK192 Dup	1200 1200		0	0	1200	0.0
2	AHG691 AHG691 Dup	2600 2700		100	71	2650	2.7
3	AKB696 AKB696 dup	860 900		40	28	880	3.2
Lead (dissolved) - µg/L (Mean RSD = 6.6)							
2	AHG691 AHG691 Dup	0.020 0.022	U	0.00	0.00	0.021	6.7
3	AKB696 AKB696 dup	0.031 0.034	F F	0.00	0.00	0.0325	6.5
Arsenic (dissolved) - µg/L (Mean RSD = 3.8)							
2	ABK200 ABK200 Dup	0.15 0.16		0.01	0.01	0.16	4.6
2	AHL335 AHL335 Dup	0.97 0.94		0.03	0.02	0.96	2.2
2	ABK192 ABK192 Dup	0.84 0.84		0.00	0.00	0.84	0.0
2	AHG691 AHG691 Dup	0.32 0.34		0.02	0.01	0.33	4.3
3	AKB696 AKB696 dup	0.19 0.17		0.02	0.01	0.18	7.9

U - Not detected at or above the reporting limit
F - Equipment blank results suggest reported result may be biased high

Table B-7 - Blind Field Duplicate Performance Data (Wells) (cont.)

Round	Station	Conc.	Qual.	Abs. Diff. [D]	Std. Dev. (s)	Dup. Mean (x)	RSD (s/x*100)
Fluoride (dissolved) - mg/L (Mean RSD = 4.4)							
2	ABK200 ABK200 Dup	0.10 0.10	U U	0.00	0.00	0.10	0.0
2	AHL335 AHL335 Dup	0.20 0.21		0.01	0.01	0.21	3.4
2	ABK192 ABK192 Dup	0.12 0.10	 U	0.02	0.01	0.11	12.9
2	AHG691 AHG691 Dup	0.24 0.26		0.02	0.01	0.25	5.7
3	AKB696 AKB696 dup	0.10 0.10	U U	0.00	0.00	0.10	0.0
Sulfate (dissolved) - mg/L (Mean RSD = 6.1)							
2	ABK200 ABK200 Dup	6.2 6.03		0.1	0.09	6.1	1.5
2	AHL335 AHL335 Dup	17.4 17.4		0.0	0.00	17.4	0.0
2	ABK192 ABK192 Dup	0.4 0.6		0.2	0.14	0.5	28.3
2	AHG691 AHG691 Dup	10.6 10.6		0.0	0.00	10.6	0.0
3	AKB696 AKB696 dup	13.0 13.1		0.1	0.07	13.1	0.5

U - Not detected at or above the reporting limit

Shaded cells indicate value above target established in project QA Project Plan

Table B-8 - Blind Reference Sample Performance Data (Piezometers)

Round	Reported Sample Conc. (mg/L)	Qual.	Ref. Solution Conc. (mg/L)	Reported vs. Expected RSD	Lower Acceptance Limit (mg/L)	Upper Acceptance Limit (mg/L)	Lower Warning Limit (mg/L)	Upper Warning Limit (mg/L)
Chloride (Mean RSD - 0.9)								
1	14.7		14.9	1.0	12.40	17.30	13.00	16.70
2	14.7		14.9	1.0	12.40	17.30	13.00	16.70
3	14.8		14.9	0.5	12.40	17.30	13.00	16.70
4	15.0		14.9	0.5	12.40	17.30	13.00	16.70
5	15.1		14.9	0.9	12.40	17.30	13.00	16.70
6	15.3		14.9	1.9	12.40	17.30	13.00	16.70
Nitrate-N 1 (Mean RSD = 4.0)								
1	7.65		8.34	6.4	6.76	9.69	7.11	9.34
3	7.98		8.34	3.2	6.76	9.69	7.11	9.34
5	8.64		8.34	2.5	6.76	9.69	7.11	9.34
Nitrate-N 2 (Mean RSD = 0.8)								
2	0.384		0.39	1.1	0.28	0.50	0.31	0.47
4	0.387		0.39	0.5	0.28	0.50	0.31	0.47
6	0.386		0.39	0.7	0.28	0.50	0.31	0.47
Orthophosphate-P 1 (Mean RSD = 8.5)								
1	0.048		0.056	11.8	0.03	0.08	0.04	0.07
3	0.051		0.056	7.4	0.03	0.08	0.04	0.07
5	0.051		0.056	6.3	0.03	0.08	0.04	0.07
Orthophosphate-P 2 (Mean RSD = 2.7)								
2	2.70		2.8	2.6	2.43	3.19	2.52	3.10
4	2.67		2.8	3.4	2.43	3.19	2.52	3.10
6	2.72		2.8	2.0	2.43	3.19	2.52	3.10

Table B-9 - Blind Reference Sample Performance Data (Wells)

Round[1]	Reported Sample Conc. (mg/L)	Qual.	Reference Solution Conc. (mg/L)	Lower Acceptance Limit (mg/L)	Upper Acceptance Limit (mg/L)	Lower Warning Limit (mg/L)	Upper Warning Limit (mg/L)
Chloride (dissolved) - mg/L							
1-1	14.7		14.9	12.4	17.3	13.0	16.7
1-2	15.2		14.9	12.4	17.3	13.0	16.7
2-1	14.7		14.9	12.4	17.3	13.0	16.7
2-2	14.7		14.9	12.4	17.3	13.0	16.7
2-3	15.3		14.9	12.4	17.3	13.0	16.7
2-4	14.7		14.9	12.4	17.3	13.0	16.7
2-5	14.4		14.9	12.4	17.3	13.0	16.7
2-6	15.3		14.9	12.4	17.3	13.0	16.7
Nitrate-N High Conc. (dissolved) - mg/L							
1-2	8.15		8.34	6.76	9.69	7.11	9.34
2-1	7.91		8.34	6.76	9.69	7.11	9.34
2-4	7.78		8.34	6.76	9.69	7.11	9.34
Nitrate-N Low Conc. (dissolved) - mg/L							
1-1	0.385		0.39	0.28	0.50	0.31	0.47
2-2	0.385		0.39	0.28	0.50	0.31	0.47
2-3	0.385		0.39	0.28	0.50	0.31	0.47
2-5	0.389		0.39	0.28	0.50	0.31	0.47
2-6	0.377		0.39	0.28	0.50	0.31	0.47
Orthophosphate-P - High Conc. (dissolved) - mg/L							
1-1	2.62		2.8	2.43	3.19	2.52	3.10
2-2	2.68		2.8	2.43	3.19	2.52	3.10
2-3	2.79		2.8	2.43	3.19	2.52	3.10
2-5	2.72		2.8	2.43	3.19	2.52	3.10
2-6	2.73		2.8	2.43	3.19	2.52	3.10
Orthophosphate-P - Low Conc. (dissolved) - mg/L							
1-2	0.0497		0.056	0.03	0.08	0.04	0.07
2-1	0.0511		0.056	0.03	0.08	0.04	0.07
2-4	0.0492		0.056	0.03	0.08	0.04	0.07

[1]Round identifier - first number represents Tier 1 or 2 well, second number designates sampling event for that well type

Table B-10 - Comparison of Water Quality Data for Piezometers Constructed of Different Casing Material

Stainless Steel Screen vs. Perforated Galvanized Steel								
Date	**Piezo Screen Type**	**Station**	**Conc.**	**Qual.**	**Abs. Diff. [D]**	**Dup. Mean (x)**	**Std. Dev. (s)**	**RSD (s/x*100)**
Chloride (dissolved) - mg/L (Mean RSD = 2.6)								
6/7/2004	SSSDP PGS	AHL145 ALB687	5.41 5.03		0.38	5.22	0.27	5.1
7/6/2004	SSSDP PGS	AHL145 ALB687	5.41 5.17		0.24	5.29	0.17	3.2
8/4/2004	SSSDP PGS	AHL145 ALB687	5.71 5.77		0.06	5.74	0.04	0.7
8/31/2004	SSSDP PGS	AHL145 ALB687	6.43 6.16		0.27	6.30	0.19	3.0
10/4/2004	SSSDP PGS	AHL145 ALB687	6.44 6.35		0.09	6.40	0.06	1.0
Total Dissolved Solids - mg/L (Mean RSD = 1.5)								
6/7/2004	SSSDP PGS	AHL145 ALB687	130 125		5	128	4	2.8
7/6/2004	SSSDP PGS	AHL145 ALB687	130 132		2	131	1	1.1
8/4/2004	SSSDP PGS	AHL145 ALB687	132 139		7	136	5	3.7
8/31/2004	SSSDP PGS	AHL145 ALB687	126 126		0	126	0	0.0
10/4/2004	SSSDP PGS	AHL145 ALB687	143 143		0	143	0	0.0
Ammonia-N (dissolved) - mg/L (Mean RSD = 0.0)								
6/7/2004	SSSDP PGS	AHL145 ALB687	0.010 0.010	U U	0.000	0.010	0.000	0.0
7/6/2004	SSSDP PGS	AHL145 ALB687	0.010 0.010	U U	0.000	0.010	0.000	0.0
8/4/2004	SSSDP PGS	AHL145 ALB687	0.010 0.010	U U	0.000	0.010	0.000	0.0
8/31/2004	SSSDP PGS	AHL145 ALB687	0.010 0.010	U U	0.000	0.010	0.000	0.0
10/4/2004	SSSDP PGS	AHL145 ALB687	0.010 0.010	U U	0.000	0.010	0.000	0.0
Nitrate+Nitrite-N (dissolved) - mg/L (Mean RSD = 0.6)								
6/7/2004	SSSDP PGS	AHL145 ALB687	1.83 1.83		0.00	1.83	0.00	0.0
7/6/2004	SSSDP PGS	AHL145 ALB687	1.84 1.87		0.03	1.86	0.02	1.1
8/4/2004	SSSDP PGS	AHL145 ALB687	1.79 1.82		0.03	1.81	0.02	1.2
8/31/2004	SSSDP PGS	AHL145 ALB687	1.48 1.49		0.01	1.49	0.01	0.5
10/4/2004	SSSDP PGS	AHL145 ALB687	2.18 2.17		0.01	2.18	0.01	0.3

U - Not detected at or above the reporting limit
SSSDP - Screened Stainless Steel Drive Point
PGS - Perforated Galvanized Steel

Table B-10 - Comparison of Water Quality Data for Piezometers Constructed of Different Casing Material (cont.)

Stainless Steel Screen vs. Perforated Galvanized Steel								
Date	**Piezo Screen Type**	**Station**	**Conc.**	**Qual.**	**Abs. Diff. [D]**	**Dup. Mean (x)**	**Std. Dev. (s)**	**RSD (s/x*100)**
Orthophosphate-P (dissolved) - mg/L (Mean RSD =1.0)								
6/7/2004	SSSDP	AHL145	0.0385		0.0004	0.0383	0.0003	0.7
	PGS	ALB687	0.0381					
7/6/2004	SSSDP	AHL145	0.0395		0.0003	0.0397	0.0002	0.5
	PGS	ALB687	0.0398					
8/4/2004	SSSDP	AHL145	0.0425		0.0003	0.0424	0.0002	0.5
	PGS	ALB687	0.0422					
8/31/2004	SSSDP	AHL145	0.0400		0.0008	0.0396	0.0006	1.4
	PGS	ALB687	0.0392					
10/4/2004	SSSDP	AHL145	0.0401		0.0010	0.0396	0.0007	1.8
	PGS	ALB687	0.0391					
Dissolved Organic Carbon - mg/L (Mean RSD = 0.0)								
6/7/2004	SSSDP	AHL145	1.0	U	0.0	1.0	0.0	0.0
	PGS	ALB687	1.0	U				
7/6/2004	SSSDP	AHL145	1.0	U	0.0	1.0	0.0	0.0
	PGS	ALB687	1.0	U				
8/4/2004	SSSDP	AHL145	1.0	U	0.0	1.0	0.0	0.0
	PGS	ALB687	1.0	U				
8/31/2004	SSSDP	AHL145	1.0	U	0.0	1.0	0.0	0.0
	PGS	ALB687	1.0	U				
10/4/2004	SSSDP	AHL145	1.0	U	0.0	1.0	0.0	0.0
	PGS	ALB687	1.0	U				
Iron (dissolved) - µg/L (Mean RSD = 0.0)								
6/7/2004	SSSDP	AHL145	50	U	0	50	0	0.0
	PGS	ALB687	50	U				
7/6/2004	SSSDP	AHL145	50	U	0	50	0	0.0
	PGS	ALB687	50	U				
8/4/2004	SSSDP	AHL145	50	U	0	50	0	0.0
	PGS	ALB687	50	U				
8/31/2004	SSSDP	AHL145	50	U	0	50	0	0.0
	PGS	ALB687	50	U				
10/4/2004	SSSDP	AHL145	50	U	0	50	0	0.0
	PGS	ALB687	50	U				
Sulfate (dissolved) - mg/L								
10/4/2004	SSSDP	AHL145	8.47		0.94	8.00	0.66	8.3
	PGS	ALB687	7.53					

U - Not detected at or above the reporting limit
SSSDP - Screened Stainless Steel Drive Point
PGS - Perforated Galvanized Steel

Table B-10 - Comparison of Water Quality Data for Piezometers Constructed of Different Casing Material (cont.)

Stainless Steel Screen vs. Filter-Wrapped Polyethylene tubing								
Date	**Piezo Screen Type**	**Station**	**Conc.**	**Qual.**	**Abs. Diff. [D]**	**Dup. Mean (x)**	**Std. Dev. (s)**	**RSD (s/x*100)**
Chloride (dissolved)								
6/9/2004	SSSDP	ABK198	12.0		0.1	11.9	0.1	0.6
	PFWPET	AHL146	11.9					
Total Dissolved Solids								
6/9/2004	SSSDP	ABK198	261		10	271	7	2.6
	PFWPET	AHL146	271					
Nitrate+Nitrite-N (dissolved)								
6/9/2004	SSSDP	ABK198	0.010	U	0.000	0.010	0.000	0.0
	PFWPET	AHL146	0.010	U				
Ammonia-N (dissolved)								
6/9/2004	SSSDP	ABK198	0.702		0.090	0.657	0.064	9.7
	PFWPET	AHL146 Dup	0.612					
Orthophosphate-P (dissolved)								
6/9/2004	SSSDP	ABK198	1.18		0.17	1.27	0.12	9.5
	PFWPET	AHL146 Dup	1.35					
Dissolved Organic Carbon								
6/9/2004	SSSDP	ABK198	2.6		1.1	2.1	0.8	37.9
	PFWPET	AHL146 Dup	1.5					
Iron (dissolved)								
6/9/2004	SSSDP	ABK198	130		1160	710	820	115.5
	PFWPET	AHL146	1290					

U - Not detected at or above the reporting limit

Shaded cells indicate value above target established in project QA Project Plan

SSSDP - Screened Stainless Steel Drive Point

PFWPET - Perforated, filter-wrapped 1/4" polyethylene tubing

Appendix C

Location and Physical Description of Instream Piezometers

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Table C-1 - Location and Physical Description of Instream Piezometers

Map ID[1]	Well tag ID	Site description	Site location	River mile[2] (miles)	Site latitude (decimal deg)	Site longitude (decimal deg)	Site altitude[3] (feet AMSL)	Casing type[4]	Opening type[5]	Casing diameter (inches)	Casing length (feet)	Piezometer stickup (feet above streambed)	Piezometer depth (feet below streambed)	Depth to midpoint of screen or perforations (feet below) streambed)	Screen or perforation length (feet)	Thermistor depths (feet below streambed)
17	AHL145	Chehalis R. at Prather Rd.	15N/03W-22A	59.9	46.77561	123.03393	135	G	S	0.75	8.7	3.8	4.9	4.5	0.3	-
17	ALB687	Chehalis R. at Prather Rd.	15N/03W-22A	59.9	46.77563	123.03394	135	G	P	1.00	7.1	3.7	3.4	3.0	0.5	0.37; 1.37; 3.09
45	AHL144	Chehalis R. above WWTP outfall	15N/03W-26F	61.6	46.76097	123.02808	137	G	P	1.00	7.0	2.7	4.3	4.0	0.5	0.93; 2.32; 4.15
91	AHL143	Chehalis R.	15N/03W-36F	63.1	46.74459	123.00666	146	G	S	0.75	11.8	6.2	5.6	5.2	0.3	-
124	AHL142	Chehalis R. at Galvin Rd.	15N/03W-35Q	64.2	46.73622	123.01886	154	G	S	0.75	8.7	3.3	5.4	5.0	0.3	-
170	AHL141	Chehalis R. at Borst Park	14N/02W-07C	66.7	46.71943	122.98303	153	G	P	1.00	7.1	3.2	3.9	3.5	0.5	1.3; 2.49; 3.61
184	ABK199	Chehalis R. at Mellen St.	14N/02W-07K	67.5	46.71167	122.97710	153	G	S	0.75	11.0	3.1	7.9	7.5	0.3	-
205	ABK198	Chehalis R. nr. Airport Rd.	14N/02W-18R	69	46.69472	122.97184	154	G	S	0.75	11.5	5.0	6.5	6.1	0.3	-
205	AHL146	Chehalis R. nr. Airport Rd.	14N/02W-18R	69	46.69472	122.97184	154	T	S	0.25	12.0	4.8	7.2	6.7	1	-
229	ABK197	Chehalis R. at State Rte. 6	14N/02W-31F	74.6	46.65812	122.98442	157	G	S	0.75	10.7	2.0	8.7	8.2	0.3	-
246	AHL137	Newaukum R. at Shorey Rd.	14N/02W-31Q	0.2	46.64969	122.97966	159	G	S	0.75	10.7	3.2	7.5	7.1	0.3	-
299	AHL140	Newaukum R. at LaBree Rd.	13N/02W-09N	4.1	46.62035	122.94406	195	G	S	0.75	8.7	4.8	3.9	3.5	0.3	-

AMSL - Above mean sea level
WWTP - Wastewater Treatment Plant

[1] The listed Map ID corresponds to the site number shown on Plate B
[2] River mile location refers to the approximate distance, in river miles, from the indicated stream mouth
[3] Site altitudes were determined from a 10-meter DEM and are considered accurate to +-16 feet
[4] Casing type: G - galvanized steel; T - polyethylene tubing
[5] Opening type: P - casing perforations; S - well screen

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Appendix D

Distribution and Thickness of Hydrogeologic Units

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Table D-1 - Distribution and thickness of hydrogeologic units encountered at selected well sites within the Centralia Chehalis area, Lewis and Thurston counties

Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
13N/02W-03F	261	-	13-2-3E11	0	98	Qls	417	319	98		
				98	204	Mc(w)	319	213	106		
				204	362	Tbu	213	55	>158	Tbu	-
13N/02W-03N	265	-	11505	0	134	Qapo(h)	230	96	>134	Qapo(h)	-
13N/02W-04C	250	-	18536	0	37	Qapo(h)	208	171	>37	Qapo(h)	21
13N/02W-04D	252	ACC817	ACC817	0	33	Qapo(h)	204	171	33		
				33	44	Mc(w)	171	160	>11	Mc(w)	212
13N/02W-04D	254	AFC083	AFC083	0	52	Qapo(h)	204	152	>52	Qapo(h)	-
13N/02W-04L	263	-	11378	0	3	Qa	201	198	3		
				3	42	Qapo(h)	198	159	39		
				42	86	Mc(w)	159	115	>44	Mc(w)	11.1
13N/02W-04P	266	-	13-2-4P1	0	8	Qa	189	181	8		
				8	42	Qapo(h)	181	147	34		
				42	262	Mc(w)	147	-73	>220	Mc(w)	-
13N/02W-05A	253	-	13-2-5H2	0	44	Qapo(h)	182	138	44		
				44	408	Mc(w)	138	-226	>364	Qapo(h)/Mc(w)	-
13N/02W-05B	251	-	463849122572301	0	8	Qa	182	174	8		
				8	39	Qapo(h)	174	143	31		
				39	248	Mc(w)	143	-66	209	Mc(w)	-
				248	396	Tbu	-66	-214	>148		
13N/02W-05C	249	ALB684	ALB684	0	10	Qa	181	171	10		
				10	24	Qapo(h)	171	157	>14	Qapo(h)	-
13N/02W-05H	255	-	13-2-5H1	0	39	Qapo(h)	183	144	39		
				39	322	Mc(w)	144	-139	>283	Qapo(h)/Mc(w)	-
13N/02W-05J	262	-	13-2-5J1	0	11	Qa	185	174	11		
				11	30	Qapo(h)	174	155	19		
				30	382	Mc(w)	155	-197	352	Mc(w)	-
				382	409	Tbu	-197	-224	>27		
13N/02W-08A	270	-	463757122570501	0	8	Qa	184	176	8		
				8	35	Qapo(h)	176	149	27	Qapo(h)	184
				35	35	Mc(w)	149	149	>1		
13N/02W-08A	272	-	463755122570602	0	5	Qa	185	180	5		
				5	39	Qapo(h)	180	146	>34	Qapo(h)	74
13N/02W-08B	271	-	13007	0	2	Qa	187	185	2		
				2	34	Qapo(h)	185	153	>32	Qapo(h)	136
13N/02W-08C	269	-	13857	0	28	Qa	184	156	28		
				28	65	Mc(w)	156	119	>37	Mc(w)	18.9
13N/02W-08L	282	ACC843	ACC843	0	26	Qa	244	218	26		
				26	40	Mc(w)	218	204	>14	Mc(w)	
13N/02W-08Q	298	-	13-2-8	0	52	Qls	230	178	52		
				52	170	Mc(w)	178	60	>118	Mc(w)	20
13N/02W-08R	291	ABK192	ABK192	0	18	Qa	198	180	18		
				18	60	Mc(w)	180	138	>42	Mc(w)	-

Table D-1 - Distribution and thickness of hydrogeologic units encountered at selected well sites within the Centralia Chehalis area, Lewis and Thurston counties

Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
13N/02W-09A	267	-	271990	0	13	Qapo(h)	222	209	>13	Qapo(h)	-
13N/02W-09A	268	AHG689	AHG689	0	35	Qapo(h)	221	186	>35	Qapo(h)	-
13N/02W-09B	273	AFC720	AFC720	0	45	Qapo(h)	202	157	45	Qapo(h)	-
				45	50	Mc(w)	157	152	>5		
13N/02W-09E	276	-	463745122565201	0	25	Qa	192	167	>25	Qa	85
13N/02W-09E	277	-	463745122565202	0	25	Qa	192	167	>25	Qa	-
13N/02W-09F	278	-	CT1-67	0	12	Qa	197	185	12		
				12	42	Qapo(h)	185	155	30		
				42	44	Mc(w)	155	153	>2	Qapo(h)/Mc(w)	-
13N/02W-09J	283	-	18571	0	6	Qa	208	202	6		
				6	19	Qapo(h)	202	189	>13	Qapo(h)	-
13N/02W-09J	285	-	CT1-70	0	12	Qa	203	191	12		
				12	47	Qapo(h)	191	156	>35	Qapo(h)	-
13N/02W-09J	287	-	CT1-66	0	10	Qa	205	195	10		
				10	43	Qapo(h)	195	162	33	Qapo(h)	-
				43	46	Mc(w)	162	159	>3		
13N/02W-09P	288	AGJ760	AGJ760	0	16	Qa	201	185	16		
				16	31	Mc(w)	185	170	>15	Mc(w)	153
13N/02W-09P	292	-	13-2-9P1	0	37	Qa	200	163	>37	Qa	-
13N/02W-09P	297	-	17315	0	40	Qa	201	161	>40	Qa	-
13N/02W-09R	289	-	CT1-69	0	7	Qa	205	198	7		
				7	44	Qapo(h)	198	161	37	Qapo(h)	-
				44	46	Mc(w)	161	159	>2		
13N/02W-09R	290	-	CT1-68	0	5	Qa	209	204	5		
				5	47	Qapo(h)	204	162	42	Qapo(h)	-
				47	48	Mc(w)	162	161	>1		
13N/02W-09R	293	-	CT1-71	0	14	Qa	208	194	14		
				14	49	Qapo(h)	194	159	35	Qapo(h)	-
				49	52	Mc(w)	159	156	>3		
13N/02W-09R	295	-	CT1-72	0	10	Qa	208	198	10		
				10	50	Qapo(h)	198	158	40	Qapo(h)	-
				50	51.5	Mc(w)	158	156.5	>1.5		
13N/02W-10E	279	-	CT1-61	0	44	Qapo(h)	228	184	44	Qapo(h)	-
				44	54	Mc(w)	184	174	>10		
13N/02W-10E	280	AAB874	AAB874	0	30	Qapo(h)	228	198	30		
				30	216	Mc(w)	198	12	>186	Mc(w)	-
13N/02W-10L	284	-	CT1-58	0	42	Qapo(h)	233	191	42	Qapo(h)	-
				42	355	Mc(w)	191	-122	>313		
13N/02W-10L	286	-	CT1-63	0	44	Qapo(h)	227	183	44		
				44	390	Mc(w)	183	-163	>346	Mc(w)	92
13N/02W-10N	294	ACF368	ACF368	0	12	Qa	211	199	12		
				12	51	Qapo(h)	199	160	>39	Qapo(h)	-

Table D-1 - Distribution and thickness of hydrogeologic units encountered at selected well sites within the Centralia Chehalis area, Lewis and Thurston counties

Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface		Hydro-geologic unit	Altitude, in feet, above NGVD 29		Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
				To unit top	To unit bottom		Unit top	Unit bottom			
13N/02W-10Q	296	AAB873	AAB873	0	47	Qapo(h)	243	196	47		
				47	400	Mc(w)	196	-157	>353	Mc(w)	-
13N/02W-15A	301	AFC082	AFC082	0	55	Qapo(h)	247	192	>55	Qapo(h)	77
13N/02W-15A	303	ABK186	ABK186	0	52	Qapo(h)	244	192	>52	Qapo(h)	92
13N/02W-15D	300	ACC839	ACC839	0	25	Qa	217	192	25		
				25	47	Qapo(h)	192	170	22		
				47	237	Mc(w)	170	-20	>190	Mc(w)	6.7
13N/02W-15J	307	AGJ772	AGJ772	0	83	Qapo(h)	250	167	83	Qapo(h)	61
				83	94	Mc(w)	167	156	>11		
13N/02W-15L	305	-	17833	0	4	Qa	222	218	4		
				4	34	Qapo(h)	218	188	30		
				34	70	Mc(w)	188	152	>36	Qapo(h)/Mc(w)	-
13N/02W-15L	306	-	17832	0	8	Qa	222	214	8		
				8	21	Qapo(h)	214	201	>13	Qapo(h)	18.2
13N/02W-16D	302	-	15134	0	28	Qa	211	183	28		
				28	80	Mc(w)	183	131	>52	Mc(w)	-
13N/02W-16H	304	-	13-2-16H1	0	30	Qa	212	182	30		
				30	210	Mc(w)	182	2	>180	Mc(w)	-
13N/03W-01D	247	AFP914	AFP914	0	25	Qa	182	157	25		
				25	62	Tbu	157	120	>37	Tbu	81
13N/03W-01Q	264	AFN910	AFN910	0	58	Qapo(h)	245	187	>58	Qapo(h)	-
13N/03W-02H	256	AFT849	AFT849	0	41	Qa	195	154	41		
				41	45	Tb(bslt)	154	150	4		
				45	89	Tbu	150	106	>44	Tbu	-
13N/03W-02H	257	ALB682	ALB682	0	39	Qa	186	147	39		
				39	71	Tb(bslt)	147	115	32		
				71	100	Tbu	115	86	>29	Tb(bslt)/Tbu	-
13N/03W-02H	259	AFC711	AFC711	0	41	Qa	190	149	41		
				41	45	Tb(bslt)	149	145	4		
				45	89	Tbu	145	101	>44	Tbu	143
13N/03W-02M	260	ALB683	ALB683	0	19	Qapo(lh)	253	234	19		
				19	78	Tb(bslt)	234	175	59		
				78	123	Tbu	175	130	>45	Tbu	-
13N/03W-11E	275	AFC084	AFC084	0	29	Qa	182	153	29		
				29	57	Tbu	153	125	>28	Tbu	-
13N/03W-11F	274	-	11554	0	30	Qa	181	151	30		
				30	41	Tbu	151	140	>11	Tbu	123
13N/03W-11M	281	-	EC11M1	0	16	Qa	181	165	16		
				16	49	Tbu	165	132	>33	Tbu	
14N/02W-04E	145	-	464352122564701	0	56	Qgo(g)	187	131	56	Qgo(g)	
				56	63	Mc(w)	131	124	>7		
14N/02W-05B	139	AGN061	AGN061	0	19	Qa	181	162	19		
				19	58	Qgo(g)	162	123	>39	Qgo(g)	-

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Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
14N/02W-05C	135	ABA853	ABA853	0	91	Qgo(g)	186	95	91	Qgo(g)	-
				91	94	Tbu	95	92	>3		
14N/02W-05D	132	-	13731	0	38	Qgo(g)	190	152	>38	Qgo(g)	29
14N/02W-05F	146	AFC587	AFC587	0	20	Qa	183	163	20		
				20	83	Qgo(g)	163	100	>63	Qgo(g)	525
14N/02W-05F	151	ABK180	ABK180	0	14	Qa	184	170	14		
				14	70	Qgo(g)	170	114	>56	Qgo(g)	37
14N/02W-05F	154	AFC723	AFC723	0	90	Qgo(g)	184	94	90	Qgo(g)	148
				90	93	Tbu	94	91	>3		
14N/02W-05G	147	-	464351122573101	0	10	Qa	186	176	10		
				10	88	Qgo(g)	176	98	78	Qgo(g)	364
				88	90	Tbu	98	96	>2		
14N/02W-05G	148	-	464304122571901	0	84	Qgo(g)	185	101	84	Qgo(g)	77
				84	95	Tbu	101	90	>11		
14N/02W-05G	149	AFC722	AFC722	0	16	Qa	185	169	16		
				16	89	Qgo(g)	169	96	73	Qgo(g)	-
				89	90	Tbu	96	95	>1		
14N/02W-05H	150	AFC731	AFC731	0	68	Qgo(g)	183	115	68	Qgo(g)	175
				68	72	Tbu	115	111	>4		
14N/02W-06D	130	AFM242	AFM242	0	20	Qgo(g)	175	155	>20	Qgo(g)	-
14N/02W-06E	142	ACD333	ACD333	0	36	Qgo(g)	174	138	>36	Qgo(g)	-
14N/02W-06F	141	ACD334	ACD334	0	36	Qgo(g)	175	139	>36	Qgo(g)	-
14N/02W-06F	143	ACD332	ACD332	0	36	Qgo(g)	174	138	>36	Qgo(g)	-
14N/02W-06F	144	-	18315	0	60	Qgo(g)	180	120	>60	Qgo(g)	-
14N/02W-06G	152	-	18309	0	30	Qgo(g)	181	151	>30	Qgo(g)	-
14N/02W-06K	153	-	215861	0	24	Qgo(g)	181	157	>24	Qgo(g)	-
14N/02W-06K	155	-	19471	0	28	Qgo(g)	181	153	>28	Qgo(g)	-
14N/02W-06K	156	AKB696	AKB696	0	54	Qgo(g)	181	127	>54	Qgo(g)	276
14N/02W-06N	159	AGJ762	AGJ762	0	58	Qgo(g)	173	115	>58	Qgo(g)	334
14N/02W-06N	164	-	464322122591101	0	10	Qa	171	161	10		
				10	56	Qgo(g)	161	115	>46	Qgo(g)	187
14N/02W-06P	162	ACJ574	ACJ574	0	65	Qgo(g)	174	109	65	Qgo(g)	2720
				65	69	Tbu	109	105	>4		
14N/02W-06P	163	ABA865	ABA865	0	78	Qgo(g)	174	96	78	Qgo(g)	-
				78	87	Tbu	96	87	>9		
14N/02W-07B	173	AGJ766	AGJ766	0	49	Qa	165	116	49		
				49	58	Qgo(g)	116	107	9	Qgo(g)	-
				58	65	Tbu	107	100	>7		

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14N/02W-07C	166	AAF345	AAF345	0	27	Qa	172	145	27		
				27	63	Qgo(g)	145	109	36	Qgo(g)	-
				63	72	Tbu	109	100	>9		
14N/02W-07C	167	ABF586	ABF586	0	5	Qa	172	167	5		
				5	57	Qgo(g)	167	115	52	Qgo(g)	57
				57	58	Tbu	115	114	>1		
14N/02W-07C	168	AAF344	AAF344	0	25	Qa	171	146	25		
				25	58	Qgo(g)	146	113	33	Qgo(g)	-
				58	65	Tbu	113	106	>7		
14N/02W-07C	169	ALB680	ALB680	0	40	Qa	171	131	40		
				40	62	Qgo(g)	131	109	22	Qgo(g)	-
				62	70	Tbu	109	101	>8		
14N/02W-07G	174	AFB618	AFB618	0	25	Qa	177	152	25		
				25	55	Qgo(g)	152	122	>30	Qgo(g)	58
14N/02W-07G	175	AKP544	AKP544	0	19	Qa	174	155	19		
				19	39	Qgo(g)	155	135	>20	Qgo(g)	-
14N/02W-07J	185	AHE362	AHE362	0	22	Qa	166	144	>22	Qa	-
14N/02W-07J	186		19124	0	25	Qa	166	141	>25	Qa	-
14N/02W-07K	181	AFM243	AFM243	0	20	Qa	182	162	>20	Qa	-
14N/02W-07K	183	-	361264	0	18	Qa	166	148	18		
				18	59	Qgo(g)	148	107	>41	Qgo(g)	-
14N/02W-07Q	189	-	464235122584701	0	10	Qa	181	171	10		
				10	67	Qapo(h)	171	114	57	Qapo(h)	-
				67	69	Mc(w)	114	112	>2		
14N/02W-08C	171	ACD298	ACD298	0	30	Qgo(g)	181	151	>30	Qgo(g)	-
14N/02W-08D	172	AHR647	AHR647	0	28	Qgo(g)	181	153	>28	Qgo(g)	-
14N/02W-08F	179	-	20740	0	26	Qgo(g)	183	157	>26	Qgo(g)	-
14N/02W-08G	176	-	215680	0	20	Qgo(g)	183	163	>20	Qgo(g)	-
14N/02W-08K	187	-	215695	0	19	Qa	183	164	>19	Qa	-
14N/02W-08L	180	AGH916	AGH916	0	25	Qgo(g)	183	158	>25	Qgo(g)	-
14N/02W-08M	188	ABK181	ABK181	0	49	Qa	175	126	49		
				49	54	Qgo(g)	126	121	>5	Qgo(g)	-
14N/02W-08N	190	AFB872	AFB872	0	55	Qa	178	123	55		
				55	71	Qgo(g)	123	107	16	Qgo(g)	-
				71	73	Tbu	107	105	>2		
14N/02W-16D	192	-	344544	0	19	Qa	178	159	19		
				19	45	Qgo(g)	159	133	>26	Qgo(g)	-
14N/02W-16E	195	-	464207122565101	0	44	Qa	173	129	44		
				44	102	Tbu	129	71	>58	Tbu	-
14N/02W-16M	203	AGC799	AGC799	0	200	Tbu	268	68	>200	Tbu	-

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14N/02W-17E	193	-	464208122580901	0	25	Qa	170	145	25		
				25	53	Qgo(g)	145	117	>28	Qgo(g)	953
14N/02W-17F	198	-	CT1-57	0	54	Qa	168	114	54		
				54	64	Qgo(g)	114	104	10	Qgo(g)	-
				64	67	Tbu	104	101	>3		
14N/02W-17G	199	ALB686	ALB686	0	64	Qa	176	112	64		
				64	70	Qgo(g)	112	106	6	Qa/Qgo(g)	-
				70	75	Tbu	106	101	>5		
14N/02W-17N	204	-	CT1-55	0	48	Qa	165	117	48		
				48	68	Qapo(h)	117	97	20	Qapo(h)	-
				68	73	Tbu	97	92	>5		
14N/02W-17N	208	-	CT1-56	0	44	Qa	166	122	44		
				44	64	Qapo(h)	122	102	20	Qapo(h)	-
				64	73	Tbu	102	93	>9		
14N/02W-18A	191	-	13097	0	55	Qa	167	112	55		
				55	69	Qgo(g)	112	98	>14	Qgo(g)	-
14N/02W-18E	194	AFC580	AFC580	0	60	Tbu	218	158	>60	Tbu	2
14N/02W-18K	202	-	CT1-77	0	25	Qa	170	145	>25	Qa	-
14N/02W-18Q	206	-	CT1-79	0	25	Qa	165	140	>25	Qa	-
14N/02W-18Q	207	-	CT1-76	0	25	Qa	163	138	>25	Qa	-
14N/02W-19A	212	AHG691	AHG691	0	35	Qa	170	135	>35	Qa	-
14N/02W-19B	209	-	CT1-78	0	30	Qa	172	142	>30	Qa	-
14N/02W-19H	214	-	CT1-75	0	25	Qa	171	146	>25	Qa	-
14N/02W-19H	216	AGC751	AGC751	0	39	Qa	171	132	39	Qa	-
14N/02W-19H	217	-	464114122582805	0	75	Qa	171	96	75		
				75	300	Tbu	96	-129	>225		Tbu
14N/02W-20D	210	-	CT1-74	0	15	Qa	171	156	>15	Qa	-
14N/02W-20D	211	-	CT1-73	0	15	Qa	171	156	>15	Qa	-
14N/02W-20G	215	-	215873	0	12	Qa	172	160	>12	Qa	-
14N/02W-30H	221	ABN974	ABN974	0	40	Qa	181	141	>40	Qa	-
14N/02W-31A	222	AEE616	AEE616	0	25	Qapo(h)	192	167	>25	Qapo(h)	-
14N/02W-31A	224	ABY772	ABY772	0	6	Qa	189	183	6		
				6	30	Qapo(h)	183	159	>24	Qapo(h)	-
14N/02W-31B	223	-	463940122585101	0	65	Qa	173	108	65		
				65	127	Mc(w)	108	46	>62	Mc(w)	-
14N/02W-31H	231	-	CT1-48	0	11	Qa	180	169	11		
				11	41	Qapo(h)	169	139	30	Qapo(h)	-
				41	47	Tbu	139	133	>6		
14N/02W-31K	237	AGJ765	AGJ765	0	15	Qa	174	159	>15	Qa	-

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14N/02W-31K	238	-	19889	0	15	Qa	171	156	>15	Qa	-
14N/02W-31L	240	-	14-2-31P1	0	25	Qa	170	145	25		
				25	50	Qapo(h)	145	120	25		
				50	215	Mc(w)	120	-45	165		
				215	1031	Tbu	-45	-861	>816	Qapo(h)/Mc(w)/Tbu	-
14N/02W-31M	234	AKP238	AKP238	0	18	Qa	182	164	>18	Qa	-
14N/02W-31M	236	AHL008	AHL008	0	32	Qa	182	150	>32	Qa	-
14N/02W-31Q	244	-	463905122584401	0	31	Qa	177	146	31		
				31	34	Mc(w)	146	143	>3	Mc(w)	-
14N/02W-32E	230	-	CT1-46	0	46	Qapo(h)	180	134	46	Qapo(h)	-
				46	65	Tbu	134	115	>19		
14N/02W-32E	235	-	CT1-47	0	15	Qa	184	169	15		
				15	47	Qapo(h)	169	137	32	Qapo(h)	-
				47	70	Tbu	137	114	>23		
14N/02W-32P	241	AHL335	AHL335	0	41	Qapo(h)	183	142	41		
				41	76	Mc(w)	142	107	>35	Mc(w)	-
14N/02W-33P	248	ACG018	ACG018	0	20	Tbu	232	212	>20	Tbu	-
14N/02W-33R	245	AFC712	AFC712	0	55	Qapo(lh)	184	129	55	Qapo(lh)	-
				55	57	Tbu	129	127	>2		
14N/03W-01A	138	ABK182	ABK182	0	40	Qgo(g)	172	132	>40	Qgo(g)	-
14N/03W-01B	129	-	14-3-1B1	0	46	Qgo(g)	165	119	>46	Qgo(g)	525
14N/03W-01B	136	AEC914	AEC914	0	70	Qgo(g)	167	97	70	Qgo(g)	-
				70	71	Tbu	97	96	>1		
14N/03W-01B	137	AEC935	AEC935	0	61	Qgo(g)	164	103	61	Qgo(g)	2440
				61	66	Tbu	103	98	>5		
14N/03W-01H	140	AGN034	AGN034	0	57	Qgo(g)	172	115	>57	Qgo(g)	-
14N/03W-01J	158	-	464333122593701	0	55	Qgo(g)	169	114	>55	Qgo(g)	490
14N/03W-01K	157	-	464333122595606	0	50	Qgo(g)	166	116	>50	Qgo(g)	2042
14N/03W-01R	160	ABK193	ABK193	0	56	Qgo(g)	167	111	>56	Qgo(g)	-
14N/03W-01R	161	-	625601	0	56	Qgo(g)	167	111	>56	Qgo(g)	-
14N/03W-12A	165	-	464316122593401	0	20	Qa	168	148	20		
				20	43	Qgo(g)	148	125	>23	Qgo(g)	463
14N/03W-12H	177	-	464252122594101	0	8	Qa	170	162	8		
				8	22	Tbu	162	148	>14	Tbu	-
14N/03W-12K	178	-	18986	0	30	Qapo(h)	172	142	30		
				30	260	Tbu	142	-88	>230	Tbu	-
14N/03W-12K	182	-	18985	0	60	Qapo(h)	181	121	60		
				60	100	Tbu	121	81	>40	Tbu	-
14N/03W-13H	196	AFC574	AFC574	0	163	Tbu	221	58	>163	Tbu	1

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Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
14N/03W-13H	197	AFC572	AFC572	0	87	Tbu	264	177	>87	Tbu	8
14N/03W-13J	201	AFN676	AFN676	0	142	Tbu	197	55	>142	Tbu	-
14N/03W-24G	213	ACQ918	ACQ918	0	199	Tbu	371	172	>199	Tbu	5
14N/03W-24J	218	-	17907	0	16	Qa	204	188	16		
				16	150	Tbu	188	54	>134	Tbu	-
14N/03W-24K	219	-	11514	0	295	Tbu	242	-53	>295	Tbu	-
14N/03W-24Q	220	AFC081	AFC081	0	75	Tbu	264	189	>75	Tbu	-
14N/03W-35B	225	AFB896	AFB896	0	60	Tbu	243	183	>60	Tbu	-
14N/03W-35J	233	-	17906	0	16	Qa	184	168	16		
				16	117	Tbu	168	67	>101	Tbu	-
14N/03W-36F	226	AKR867	AKR867	0	25	Qa	168	143	>25	Qa	-
14N/03W-36H	228	-	463933122593801	0	40	Qa	173	133	40		
				40	138	Mc(w)	133	35	>98	Mc(w)	-
14N/03W-36M	232	AKR866	AKR866	0	25	Qa	167	142	>25	Qa	-
14N/03W-36P	242	-	CT1-49	0	19	Qa	179	160	>19	Qa	-
14N/03W-36Q	239	-	463908122595301	0	58	Qa	158	100	58		
				58	93	Tbu	100	65	>35	Tbu	43
14N/03W-36Q	243	-	14-3-36Q1	0	80	Qa	180	100	80		
				80	220	Tbu	100	-40	>140	Tbu	-
15N/02W-18M	10	AGN036	AGN036	0	280	Tbu	227	-53	>280	Tbu	-
15N/02W-19E	27	-	12661	0	80	Tbu	189	109	>80	Tbu	-
15N/02W-30N	66	-	464508122592001	0	30	Qgo(g)	166	136	>30	Qgo(g)	-
15N/02W-30Q	70	-	16771	0	65	Qapo(lh)	233	168	65		
				65	280	Tbu	168	-47	>215	Tbu	-
15N/02W-31A	74	AGE891	AGE891	0	76	Qapo(lh)	482	406	76		
				76	200	Tbu	406	282	>124	Tbu	-
15N/02W-31A	76	AGP813	AGP813	0	71	Qapo(lh)	390	319	71		
				71	160	Tbu	319	230	>89	Tbu	-
15N/02W-31C	75	-	13099	0	118	Tbu	190	72	>118	Tbu	1
15N/02W-31D	77	ABK194	ABK194	0	70	Qgo(g)	169	99	>70	Qgo(g)	-
15N/02W-31E	81	AGP809	AGP809	0	69	Qgo(g)	171	102	>69	Qgo(g)	-
15N/02W-31E	82	AGP838	AGP838	0	68	Qgo(g)	171	103	>68	Qgo(g)	-
15N/02W-31E	83	AGP873	AGP873	0	58	Qgo(g)	171	113	>58	Qgo(g)	-
15N/02W-31E	85	AGP837	AGP837	0	58	Qgo(g)	171	113	>58	Qgo(g)	-
15N/02W-31E	86	AGP874	AGP874	0	58	Qgo(g)	171	113	>58	Qgo(g)	-

Table D-1 - Distribution and thickness of hydrogeologic units encountered at selected well sites within the Centralia Chehalis area, Lewis and Thurston counties

Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
15N/02W-31E	88	-	464444122592501	0	57	Qgo(g)	172	115	>57	Qgo(g)	715
15N/02W-31E	95	-	464440122591201	0	60	Qgo(g)	175	115	>60	Qgo(g)	-
15N/02W-31F	99	-	12579	0	80	Qgo(g)	176	96	>80	Qgo(g)	-
15N/02W-31F	101	-	464436122585401	0	83	Qgo(g)	181	98	83	Qgo(g)	126
				83	112	Tbu	98	69	>29		
15N/02W-31H	89	ABK185	ABK185	0	77	Tbu	319	242	>77	Tbu	-
15N/02W-31L	105	AFB647	AFB647	0	58	Qgo(g)	177	119	>58	Qgo(g)	-
15N/02W-31L	112	-	13621	0	58	Qgo(g)	180	122	>58	Qgo(g)	-
15N/02W-31L	115	-	464426122590301	0	57	Qgo(g)	180	123	>57	Qgo(g)	438
15N/02W-31L	116	AHB160	AHB160	0	68	Qgo(g)	181	113	>68	Qgo(g)	30
15N/02W-31L	118	AEK438	AEK438	0	58	Qgo(g)	179	121	>58	Qgo(g)	-
15N/02W-31M	102	AGN077	AGN077	0	60	Qgo(g)	172	112	>60	Qgo(g)	-
15N/02W-31M	111	ABK195	ABK195	0	58	Qgo(g)	172	114	>58	Qgo(g)	-
15N/02W-31M	114	-	14971	0	54	Qgo(g)	173	119	54	Qgo(g)	-
				54	60	Tbu	119	113	>6		
15N/02W-31M	117	-	14754	0	58	Qgo(g)	172	114	>58	Qgo(g)	-
15N/02W-31N	123	-	15-2-31N1	0	53	Qgo(g)	174	121	>53	Qgo(g)	187
15N/02W-31P	126	-	464412122590601	0	78	Qgo(g)	178	100	>78	Qgo(g)	-
15N/02W-31P	127	-	14269	0	77	Qgo(g)	179	102	>77	Qgo(g)	-
15N/02W-31P	128	-	14037	0	55	Qgo(g)	179	124	>55	Qgo(g)	31
15N/02W-31Q	121	-	464419122584501	0	60	Qgo(g)	183	123	>60	Qgo(g)	460
15N/02W-32K	119	-	16198	0	50	Qgo(g)	193	143	>50	Qgo(g)	1430
15N/02W-32P	122	-	14604	0	17	Qa	295	278	>17	Qgo(g)	-
15N/02W-32P	133	AGE852	AGE852	0	60	Qgo(g)	189	129	>60	Qgo(g)	-
15N/02W-32P	122	-	14604	17	69	Qgo(g)	278	226	52	Qgo(g)	-
				69	70	Tbu	226	225	>1		
15N/02W-32Q	125	ABK190	ABK190	0	62	Qgo(g)	192	130	>62	Qgo(g)	-
15N/02W-32Q	131	-	464410122571801	0	41	Qgo(g)	192	151	>41	Qgo(g)	-
15N/03W-13E	5	AGC858	AGC858	0	80	Qgo(g)	163	83	>80	Qgo(g)	-
15N/03W-13E	6	ABK189	ABK189	0	48	Qgo(g)	163	115	>48	Qgo(g)	123
15N/03W-13M	7	ABK184	ABK184	0	57	Qgo(g)	161	104	>57	Qgo(g)	59
15N/03W-13N	11	AGT286	AGT286	0	80	Qgo(g)	162	82	>80	Qgo(g)	-
15N/03W-13N	12	AFC141	AFC141	0	52	Qgo(g)	159	107	>52	Qgo(g)	-

Table D-1 - Distribution and thickness of hydrogeologic units encountered at selected well sites within the Centralia Chehalis area, Lewis and Thurston counties

Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
15N/03W-13N	14	AGE834	AGE834	0	1	Qa	159	158	1		
				1	78	Qgo(g)	158	81	>77	Qgo(g)	-
15N/03W-14A	2	ALB681	ALB681	0	58	Qgo(g)	170	112	>58	Qgo(g)	-
15N/03W-14A	3	ABK183	ABK183	0	78	Qgo(g)	169	91	>78	Qgo(g)	241
15N/03W-14B	4	AGN013	AGN013	0	60	Qgo(g)	172	112	>60	Qgo(g)	-
15N/03W-14C	1	ABZ630	ABZ630	0	60	Qgo(g)	166	106	>60	Qgo(g)	184
15N/03W-14K	8	AGE924	AGE924	0	38	Qgo(g)	160	122	>38	Qgo(g)	553
15N/03W-14K	9	ABK176	ABK176	0	47	Qgo(g)	162	115	>47	Qgo(g)	2206
15N/03W-14R	13	-	464655123010001	0	62	Qgo(g)	151	89	>62	Qgo(g)	-
15N/03W-23A	18	AGJ773	AGJ773	0	28	Qa	152	124	28		
				28	56	Qgo(g)	124	96	>28	Qgo(g)	664
15N/03W-23C	16	-	464638123013001	0	55	Qa	148	93	>55	Qa	-
15N/03W-23G	22	AAF309	AAF309	0	38	Qa	153	115	>38	Qa	-
15N/03W-23H	26	-	12199	0	16	Qa	164	148	16		
				16	39	Qgo(g)	148	125	>23	Qgo(g)	-
15N/03W-23P	31	AKB695	AKB695	0	20	Qa	146	126	20		
				20	35	Qgo(g)	126	111	>15	Qgo(g)	79
15N/03W-23Q	36	-	464558123011701	0	6	Qa	142	136	6		
				6	30	Qgo(g)	136	112	>24	Qgo(g)	16200
15N/03W-24A	15	-	18099	0	62	Tbu	201	139	>62	Tbu	-
15N/03W-24D	19	ACB121	ACB121	0	20	Qa	162	142	20		
				20	60	Qgo(g)	142	102	>40	Qgo(g)	-
15N/03W-24E	23	-	464628123004201	0	15	Qa	157	142	>15	Qgo(g)	-
15N/03W-24E	24	ACQ237	ACQ237	0	40	Qa	159	119	40		
				40	59	Qgo(g)	119	100	>19	Qgo(g)	368
15N/03W-24E	25	-	464626123003401	0	14	Qa	165	151	14		
				14	64	Qgo(g)	151	101	>50	Qgo(g)	-
15N/03W-24E	23	-	464628123004201	15	61	Qgo(g)	142	96	>46	Qgo(g)	-
15N/03W-24F	20	AAG500	AAG500	0	15	Qa	162	147	15		
				15	71	Qgo(g)	147	91	>56	Qgo(g)	29
15N/03W-24G	21	ACY539	ACY539	0	75	Tbu	178	103	>75	Tbu	-
15N/03W-24L	29	-	464612123001601	0	2	Qa	163	161	2		
				2	60	Qgo(g)	161	103	>58	Qgo(g)	613
15N/03W-24L	30	AFP482	AFP482	0	18	Qa	164	146	18		
				18	60	Qgo(g)	146	104	>42	Qgo(g)	-
15N/03W-24L	32	-	296901	0	19	Qa	164	145	19		
				19	45	Qgo(g)	145	119	>26	Qgo(g)	189

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15N/03W-24M	28	AGN069	AGN069	0	15	Qa	161	146	15		
				15	59	Qgo(g)	146	102	>44	Qgo(g)	-
15N/03W-24N	35	-	CT1-81	0	20	Qa	152	132	>20	Qa	-
15N/03W-24P	34	AGP877	AGP877	0	36	Qa	163	127	36		
				36	58	Qgo(g)	127	105	>22	Qgo(g)	-
15N/03W-24P	39	-	464612123001501	0	30	Qa	165	135	30		
				30	60	Qgo(g)	135	105	>30	Qgo(g)	-
15N/03W-24Q	38	-	464559122594201	0	51	Qgo(g)	166	115	>51	Qgo(g)	20
15N/03W-24R	33	-	464606122594001	0	40	Qgo(g)	164	124	>40	Qgo(g)	-
15N/03W-24R	37	ABK196	ABK196	0	50	Qgo(g)	168	118	>50	Qgo(g)	204
15N/03W-25B	41	ABK177	ABK177	0	60	Qgo(g)	165	105	>60	Qgo(g)	-
15N/03W-25C	43	AFS017	AFS017	0	78	Qgo(g)	166	88	78	Qgo(g)	96
				78	87	Tbu	88	79	>9		
15N/03W-25C	44	AFS018	AFS018	0	70	Qgo(g)	166	96	>70	Qgo(g)	919
15N/03W-25D	42	-	CT1-82	0	20	Qa	155	135	>20	Qa	-
15N/03W-25E	46	AGJ763	AGJ763	0	14	Qa	154	140	14		
				14	60	Qgo(g)	140	94	>46	Qgo(g)	-
15N/03W-25E	47	-	15637	0	13	Qa	153	140	13		
				13	50	Qgo(g)	140	103	>37	Qgo(g)	-
15N/03W-25F	50	AHS234	AHS234	0	30	Qgo(g)	168	138	>30	Qgo(g)	-
15N/03W-25G	52	AFC708	AFC708	0	76	Qgo(g)	170	94	>76	Qgo(g)	598
15N/03W-25G	53	-	363130	0	45	Qgo(g)	168	123	>45	Qgo(g)	-
15N/03W-25G	54	-	14687	0	48	Qgo(g)	168	120	>48	Qgo(g)	-
15N/03W-25K	61	AFM238	AFM238	0	20	Qgo(g)	164	144	>20	Qgo(g)	-
15N/03W-25K	62	AGC809	AGC809	0	58	Qgo(g)	163	105	>58	Qgo(g)	-
15N/03W-25K	63	-	15577	0	60	Qgo(g)	162	102	>60	Qgo(g)	-
15N/03W-25K	65	AFC702	AFC702	0	77	Qgo(g)	168	91	77	Qgo(g)	-
				77	82	Tbu	91	86	>5		
15N/03W-25L	57	AFC710	AFC710	0	78	Qgo(g)	149	71	78	Qgo(g)	-
				78	78	Tbu	71	71	>1		
15N/03W-25L	59	-	28301	0	56	Qgo(g)	158	102	>56	Qgo(g)	-
15N/03W-25L	60	AGC898	AGC898	0	59	Qgo(g)	160	101	>59	Qgo(g)	-
15N/03W-25M	64	AFN526	AFN526	0	78	Qgo(g)	160	82	>78	Qgo(g)	-
15N/03W-25P	68	-	12246	0	53	Qgo(g)	159	106	>53	Qgo(g)	245
15N/03W-25P	69	ABK179	ABK179	0	66	Qgo(g)	157	91	>66	Qgo(g)	613

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15N/03W-25Q	67	AGP827	AGP827	0	58	Qgo(g)	165	107	>58	Qgo(g)	-
15N/03W-26A	40	-	16552	0	10	Qa	153	143	10		
				10	55	Qgo(g)	143	98	>45	Qgo(g)	-
15N/03W-26F	49	-	CT1-84	0	20	Qa	153	133	>20	Qa	-
15N/03W-26G	48	AFT316	AFT316	0	10	Qa	151	141	10		
				10	54	Qgo(g)	141	97	>44	Qgo(g)	276
15N/03W-26H	51	AFT317	AFT317	0	16	Qa	151	135	16		
				16	67	Qgo(g)	135	84	51	Qgo(g)	633
				67	70	Tbu	84	81	>3		
15N/03W-26H	55	-	342095	0	8	Qa	141	133	8		
				8	40	Qgo(g)	133	101	>32	Qgo(g)	-
15N/03W-26J	56	-	CT1-83	0	20	Qa	153	133	>20	Qa	-
15N/03W-26J	58	-	15-3-26J2	0	7	Qa	150	143	7		
				7	35	Qgo(g)	143	115	>28	Qgo(g)	804
15N/03W-35H	80	ABK188	ABK188	0	1	Qa	144	143	1		
				1	53	Qgo(g)	143	91	>52	Qgo(g)	-
15N/03W-35L	96	-	18342	0	37	Qgo(g)	161	124	>37	Qgo(g)	-
15N/03W-35L	100	-	18737	0	53	Qgo(g)	161	108	53		
				53	105	Tbu	108	56	>52	Tbu	-
15N/03W-35L	103	-	16952	0	36	Qgo(g)	161	125	>36	Qgo(g)	-
15N/03W-35L	106	-	15-3-35L4	0	68	Qgo(g)	155	87	>68	Qgo(g)	56
15N/03W-35L	107	ABK178	ABK178	0	25	Qgo(g)	161	136	>25	Qgo(g)	61
15N/03W-35L	108	ABH693	ABH693	0	38	Qgo(g)	161	123	>38	Qgo(g)	-
15N/03W-35L	109	-	18978	0	36	Qgo(g)	161	125	>36	Qgo(g)	-
15N/03W-35M	110	AFB881	251162	0	8	Qa	158	150	8		
				8	29	Qgo(g)	150	129	35	Qgo(g)	-
				29	50	Tbu	129	108	>21		
15N/03W-36B	71	-	14973	0	55	Qgo(g)	167	112	>55	Qgo(g)	-
15N/03W-36B	73	-	464458122595601	0	51	Qgo(g)	164	113	>51	Qgo(g)	1838
15N/03W-36B	78	AFC701	AFC701	0	60	Qgo(g)	172	112	>60	Qgo(g)	-
15N/03W-36D	72	-	CT1-80	0	11	Qa	157	146	11		
				11	20	Qgo(g)	146	137	>9	Qgo(g)	-
15N/03W-36F	94	-	15-3-36F2	0	54	Qgo(g)	165	111	>54	Qgo(g)	248
15N/03W-36G	92	-	659301	0	53	Qgo(g)	165	112	>53	Qgo(g)	110
15N/03W-36H	84	AGP871	AGP871	0	58	Qgo(g)	171	113	>58	Qgo(g)	-
15N/03W-36H	87	-	652101	0	40	Qgo(g)	166	126	>40	Qgo(g)	-
15N/03W-36H	90	-	15546	0	34	Qgo(g)	168	134	>34	Qgo(g)	-

Table D-1 - Distribution and thickness of hydrogeologic units encountered at selected well sites within the Centralia Chehalis area, Lewis and Thurston counties

Well Location	Map ID	Well Tag ID	Project ID	Depth, in feet, below land surface: To unit top	Depth, in feet, below land surface: To unit bottom	Hydro-geologic unit	Altitude, in feet, above NGVD 29: Unit top	Altitude, in feet, above NGVD 29: Unit bottom	Unit Thickness (feet)	Source Aquifer	Horizontal Hydraulic Conductivity (feet/day)
15N/03W-36H	93	ABG032	ABG032	0	60	Qgo(g)	167	107	>60	Qgo(g)	-
15N/03W-36H	97	ABK191	ABK191	0	50	Qgo(g)	171	121	>50	Qgo(g)	306
15N/03W-36K	98	-	11462	0	63	Qgo(g)	165	102	>63	Qgo(g)	919
15N/03W-36K	104	-	11450	0	63	Qgo(g)	166	103	>63	Qgo(g)	3064
15N/03W-36K	113	-	464425123000501	0	54	Qgo(g)	179	125	>54	Qgo(g)	1340
15N/03W-36P	120	ABK200	ABK200	0	59	Qgo(g)	165	106	>59	Qgo(g)	313
15N/03W-53C	79	AEK406	AEK406	0	17	Qa	161	144	17		
				17	38	Qgo(g)	144	123	>21	Qgo(g)	-

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Appendix E

Water Quality Results

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Table E-1 - October 2004 Hydrochemistry Results - Piezometers, Surface Water, and Wells

Station	Map ID	Station Type[1]	Hydro Unit	Date	TDS mg/L	Chloride (dissolved) mg/L	Iron (dissolved) µg/L	Manganese (dissolved) µg/L	Magnesium (dissolved) µg/L	Calcium (dissolved) µg/L	Sodium (dissolved) µg/L	Potassium (dissolved) µg/L	Fluoride (dissolved) mg/L	Sulfate (dissolved) mg/L	Silica (dissolved) µg/L	Field Alkalinity mg/L
ABK189	6	W	Qgo(g)	10/20/04	71	3.85	50 U	10 U	2280	7370	5420	870	0.10 U	3.81	24500	21 J
ABK176	9	W	Qgo(g)	10/20/04	102	4.39	50 U	10 U	4310	13600	6880	1000	0.10 U	4.65	28900	42 J
AGE834	14	W	Qgo(g)	10/20/04	268	12.9	3090	222	12300	20100	51700	870	0.34	0.30 U	54500	175 J
AHL145	17	P	Qa	10/4/04	143	6.44 U	50 U	NA	7080	17800	8340 F	1500	0.10 U	8.47	36000	70 J
ACY539	21	W	Tbu	10/20/04	306	5.66	1890	229	8310	13800	75000	810	0.23	0.30 U	56200	J
AAF309	22	W	Qa	10/20/04	121	6.65	50 U	10 U	5730	16300	8670	1100	0.10 U	7.00	33900	43 J
ACQ237	24	W	Qgo(g)	10/20/04	146	6.43	50 U	10 U	5520	16900	10600	1600	0.10 U	22.9	41800	34 J
AFP482	30	W	Qgo(g)	10/19/04	166	3.78	50 U	10 U	6940	21300	10300	1700	0.10 U	43.3	39300	40 J
AKB695	31	W	Qgo(g)	10/7/04	161	8.91	50 U	10 U	8180	24800	9170 F	1400	0.10 U	5.86	31200	78 J
ABK196	37	W	Qgo(g)	10/18/04	196	5.02	5500	123	9700	25600	10500	1600	0.14	65.2	34400	50 J
AHL144	45	P	Qa	10/4/04	176	9.53	50 U	NA	9030	27000	10500 F	1700	0.10 U	6.86	33000	90 J
SW-01	45	S	-	10/4/04	79	5.08	NA	NA	2740	9680	7500 F	650	0.10 U	10.1	NA	32 J
AGJ763	46	W	Qgo(g)	10/19/04	110	6.87	50 U	10 U	4120	13300	9210	1300	0.10 U	6.75	33400	39 J
AFT316	48	W	Qgo(g)	10/19/04	203	11.8	3370	76	13700	41100	13500	2000	0.10 U	5.50	32900	152 J
AHS234	50	W	Qgo(g)	10/28/04	83	4.02	50 U	10 U	1960	7270	6820	600	0.10 U	4.61	24200	15.5 J
AFN526	64	W	Qgo(g)	10/19/04	106	9.54	50 U	10 U	4620	15300	9910	1300	0.10 U	7.08	32700	43 J
ABK179	69	W	Qgo(g)	10/19/04	120	10.4	120	15	4640	15900	9800	1300	0.10 U	6.67	31200	49 J
ABK194	77	W	Qgo(g)	10/18/04	97	4.60	50 U	10 U	3730	10600	8030	1100	0.10 U	9.35	30000	35 J
AFC701	78	W	Qgo(g)	10/18/04	123	11.9	50 U	10 U	4510	15900	10000	1200	0.10 U	7.18	31400	41 J
AEK406	79	W	Qgo(g)	10/14/04	90	5.60	50 U	10 U	3920	10400	6150	550	0.10 U	5.69	25900	40 J
ABK188	80	W	Qgo(g)	10/14/04	87	5.33	71	10 U	3610	9810	5670	730	0.10 U	7.53	23900	33 J
AHL143	91	P	Qa	10/4/04	97	5.88	50 U	NA	3370	12000	7660 F	1000	0.10 U	7.63	26400	40 J
ABK195	111	W	Qgo(g)	10/13/04	122	15.3	50 U	10 U	4590	15000	10500	1100	0.10 U	7.55	23200	31 J
AEK438	118	W	Qgo(g)	10/18/04	274	49.1	50 U	1370	13200	39300	23600	2300	0.10 U	4.74	42700	102 J
ABK200	120	W	Qgo(g)	10/14/04	141	4.73	50 U	10 U	5110	17300	9150	1200	0.10 U	6.16	29900	44 J
ABK190	125	W	Qgo(g)	10/13/04	139	25.2	77	10 U	6080	17000	14000	1600	0.10 U	7.49	21500	49 J
ABA853	135	W	Qgo(g)	10/27/04	163	27.2	7120	470	5760	15700	19300	1300	0.10 U	9.71	26400	70 J
AGN061	139	W	Qgo(g)	10/13/04	146	20.4	50 U	10 U	5600	18600	15500	1300	0.10 U	5.30	26600	60 J
ABK180	151	W	Qgo(g)	10/13/04	167	17.8	270	10 U	7840	20100	15300	1600	0.10 U	6.87	37700	70 J
AKB696	156	W	Qgo(g)	10/7/04	128	7.08	50 U	10 U	4600	16300	8400 F	860	0.10 U	13.0	34000	48 J
AGJ762	159	W	Qgo(g)	10/18/04	112	6.09	50 U	10 U	4070	13200	7630	970	0.10 U	5.80	29500	40 J
ABK193	160	W	Qgo(g)	10/13/04	143	7.39	50 U	10 U	5790	16300	12900	1400	0.10 U	7.98	36800	69 J
AGJ766	173	W	Qgo(g)	10/28/04	165	6.53	1690	305	8320	17600	17200	1600	0.10 U	2.8	38400	69 J

TDS - Total dissolved solids
[1]Station Type: P = piezometer, S = surface water, W = well
U - Not detected at or above the reporting limit
J - Reported result is considered an estimate
F - Equipment Blank Results suggest reported result may be biased high
NA - Not analyzed

Table E-1 - October 2004 Hydrochemistry Results - Piezometers, Surface Water, and Wells (cont.)

Station	Map ID	Station Type[1]	Hydro Unit	Date	TDS mg/L	Chloride (dissolved) mg/L	Iron (dissolved) µg/L	Manganese (dissolved) µg/L	Magnesium (dissolved) µg/L	Calcium (dissolved) µg/L	Sodium (dissolved) µg/L	Potassium (dissolved) µg/L	Fluoride (dissolved) mg/L	Sulfate (dissolved) mg/L	Silica (dissolved) µg/L	Field Alkalinity mg/L
ABK199	184	P	Qa	10/6/04	283	6.98	40200	NA	14600	45800	11000 F	1200	0.10 U	0.30 U	68400	260 J
SW-02	184	S	-	10/6/04	72	6.04	NA	NA	2470	8460	6290 F	640	0.10 U	2.1	NA	32 J
AFB872	190	W	Qgo(g)	10/25/04	228	7.73	1210	864	11300	29800	25700	3400	0.20	3.20	53600	153 J
ALB686	199	W	Qa/Qgo(g)	10/26/04	213	5.91	2870	688	8480	25000	29600	1900	0.51	0.30 U	46300	150 J
AFN676	201	W	Tbu	10/12/04	161	4.30	8250	207	5340	15300	18000	1400	0.23	4.88	41800	100 J
AHL146	205	P	Qa	10/6/04	275	12.7	1260	NA	13200	42300	18700 F	7040	0.19	0.47	60700	190 J
AHG691	212	W	Qa	10/27/04	308	19.1	5580	1410	17200	42200	23100	2600	0.24	10.6	72400	171 J
ABK187	227	W	Mc(w)	10/12/04	185	17.3	4320	452	9760	20400	7330	1300	0.12	0.30 U	62900	92 J
ABK197	229	P	Qa	10/5/04	165	5.63	16200	NA	7380	20800	6540 F	500 U	0.10 U	2.7	40000	110 J
AGJ765	237	W	Qa	10/25/04	84	2.21	50 U	10 U	2210	7650	9020	500 U	0.10 U	4.52	32800	29 J
AHL335	241	W	Mc(w)	10/12/04	292	62.3	9950	262	11200	20800	53000	3500	0.20	17.4	40400	150 J
AHL137	246	P	Qa	10/5/04	290	61.2	18700	NA	11900	29900	30200 F	2300	0.10 U	0.30 U	59100	140 J
SW-03	246	S	-	10/5/04	63	5.75	NA	NA	2040	8440	5360 F	500 U	0.10 U	1.0	NA	27 J
ALB684	249	W	Qapo(h)	10/26/04	206	17.9	50 U	17	9600	21200	19300	1300	0.10 U	22.5	54800	60 J
AFC083	254	W	Qapo(h)	10/11/04	220	12.5	2390	274	14100	21500	25500	1600	0.20	7.85	42500	150 J
AFC084	275	W	Tbu	10/11/04	192	6.90	1950	154	13400	25000	9230	1200	0.18	0.30 U	52900	95 J
AGJ760	288	W	Mc(w)	10/12/04	178	22.3	170	17	10100	21400	11400	790	0.12	0.30 U	45500	80 J
ABK192	291	W	Mc(w)	10/11/04	202	11.9	7510	235	8550	13900	30300	1200	0.12	0.4	48500	130 J
ACF368	294	W	Qapo(h)	10/21/04	138	5.44	50 U	10 U	6080	14400	11500	680	0.10 U	0.87	53300	60 J
AHL140	299	P	Qa	10/5/04	81	4.97	220	NA	3430	8880	6200 F	500 U	0.10 U	1.6	22600	40 J
AFC082	301	W	Qapo(h)	10/14/04	159	8.27	50 U	10 U	7490	15000	10700	770	0.10 U	2.47	62500	54 J

TDS - Total dissolved solids
[1]Station Type: P = piezometer, S = surface water, W = well
U - Not detected at or above the reporting limit
J - Reported result is considered an estimate
F - Equipment Blank Results suggest reported result may be biased high
NA - Not analyzed

Table E-2 - Water Quality Data – Piezometers

pH - standard units (field)

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	6.46		6/7/2004	6.58		7/6/2004	6.62		8/4/2004	6.39		8/31/2004	6.28		10/4/2004	6.35	
AHL144	45	5/10/2004	6.57		6/7/2004	6.58		7/6/2004	6.65		8/4/2004	6.43		8/31/2004	6.36		10/4/2004	6.43	
AHL143	91	5/10/2004	6.73		6/7/2004	6.68		7/6/2004	6.75		8/4/2004	6.47		—	—	—	10/4/2004	6.51	
AHL142	124	5/11/2004	6.48		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	6.75		6/15/2004	6.66		7/8/2004	6.67		8/3/2004	6.64		9/2/2004	6.63		10/6/2004	6.56	
ABK198	205	5/12/2004	8.21		6/9/2004	8.65		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	7.81		7/8/2004	7.47		8/3/2004	7.54		9/2/2004	7.53		10/6/2004	7.53	
ABK197	229	5/12/2004	6.55		6/9/2004	7.19		7/7/2004			8/3/2004	6.45		9/1/2004	6.35		10/5/2004	6.38	
AHL137	246	5/13/2004	7.08		6/8/2004	6.94		7/7/2004	6.77		8/2/2004	6.78		9/1/2004	6.77		10/5/2004	6.69	
AHL140	299	5/13/2004	6.95		6/8/2004	6.62		7/7/2004	6.37		8/2/2004	6.39		9/1/2004	6.54		10/5/2004	6.43	

Specific Conductance - µS/cm (field)

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	184		6/7/2004	184		7/6/2004	181		8/4/2004	185		8/31/2004	184		10/4/2004	190	
AHL144	45	5/10/2004	258		6/7/2004	257		7/6/2004	257		8/4/2004	261		8/31/2004	263		10/4/2004	260	
AHL143	91	5/10/2004	178		6/7/2004	176		7/6/2004	178		8/4/2004	153	—	—	—	—	10/4/2004	130	
AHL142	124	5/11/2004	563		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	536		6/15/2004	520		7/8/2004	528		8/3/2004	525		9/2/2004	551		10/6/2004	556	
ABK198	205	5/12/2004	407		6/9/2004	401		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	404		7/8/2004	257		8/3/2004	408		9/2/2004	414		10/6/2004	413	
ABK197	229	5/12/2004	259		6/9/2004	262		7/7/2004	493		8/3/2004	244		9/1/2004	243		10/5/2004	247	
AHL137	246	5/13/2004	490		6/8/2004	485		7/7/2004	132		8/2/2004	488		9/1/2004	444		10/5/2004	480	
AHL140	299	5/13/2004	140		6/8/2004	94		7/7/2004	399		8/2/2004	153		9/1/2004	113		10/5/2004	106	

Dissolved Oxygen - mg/L (field)

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	2.05		6/7/2004	1.65		7/6/2004	1.43		8/4/2004	1.72		8/31/2004	1.16		10/4/2004	0.94	
AHL144	45	5/10/2004	R		6/7/2004	0.87		7/6/2004	0.98		8/4/2004	0.75		8/31/2004	0.79		10/4/2004	0.72	
AHL143	91	5/10/2004	6.08		6/7/2004	6.10		7/6/2004	5.72		8/4/2004	4.68		—	—	—	10/4/2004	1.70	
AHL142	124	5/11/2004	0.48		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	1.88		6/15/2004	0.055		7/8/2004	0.125		8/3/2004	0.075		9/2/2004	0.09		10/6/2004	0.17	
ABK198	205	5/12/2004	R		6/9/2004	1.76		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	0.285		7/8/2004	0.285		8/3/2004	0.225		9/2/2004	0.26		10/6/2004	0.205	
ABK197	229	5/12/2004	0.01		6/9/2004	0.045		7/7/2004	0.12		8/3/2004	0.15		9/1/2004	0.14		10/5/2004	0.16	
AHL137	246	5/13/2004	0.33		6/8/2004	0.015		7/7/2004	0.17		8/2/2004	0.14		9/1/2004	0.27		10/5/2004	0.15	
AHL140	299	5/13/2004	0.30		6/8/2004	0.26		7/7/2004	0.09		8/2/2004	0.20		9/1/2004	0.235		10/5/2004	0.185	

(—) - Not Sampled

R - Result rejected

Table E-2 - Water Quality Data - Piezometers (cont.)

Chloride (dissolved) - mg/L

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	5.02		6/7/2004	5.41		7/6/2004	5.41		8/4/2004	5.71		8/31/2004	6.43		10/4/2004	6.44	
AHL144	45	5/10/2004	8.31		6/7/2004	8.53		7/6/2004	8.72		8/4/2004	9.31		8/31/2004	9.24		10/4/2004	9.53	
AHL143	91	5/10/2004	6.16		6/7/2004	6.16		7/6/2004	6.45		—	—	—	—	—	—	10/4/2004	5.88	
AHL142	124	5/11/2004	19.7		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	6.46		6/15/2004	6.35		7/8/2004	6.33		8/3/2004	6.77		9/2/2004	6.78		10/6/2004	6.98	
ABK198	205	5/12/2004	12.9		6/9/2004	12.0		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	11.9		7/8/2004	12.2		8/3/2004	12.4		9/2/2004	12.5		10/6/2004	12.7	
ABK197	229	5/12/2004	5.85		6/9/2004	5.53		7/7/2004	5.40		8/3/2004	4.70		9/1/2004	4.95		10/5/2004	5.63	
AHL137	246	5/13/2004	59.6		6/8/2004	58.7		7/7/2004	59.6		8/2/2004	61.1		9/1/2004	54.7		10/5/2004	61.2	
AHL140	299	5/13/2004	2.90		6/8/2004	3.51		7/7/2004	4.31		8/2/2004	5.12		9/1/2004	5.78		10/5/2004	4.97	

Total Dissolved Solids - mg/L

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	124		6/7/2004	130		7/6/2004	131		8/4/2004	132		8/31/2004	126		10/4/2004	143	
AHL144	45	5/10/2004	162		6/7/2004	160		7/6/2004	168		8/4/2004	170		8/31/2004	162		10/4/2004	176	
AHL143	91	5/10/2004	122		6/7/2004	125	J	7/6/2004	126		—	—	—	—	—	—	10/4/2004	97	
AHL142	124	5/11/2004	395		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	276		6/15/2004	270		7/8/2004	276		8/3/2004	274		9/2/2004	286		10/6/2004	283	
ABK198	205	5/12/2004	255		6/9/2004	261		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	271		7/8/2004	269		8/3/2004	266		9/2/2004	276		10/6/2004	275	
ABK197	229	5/12/2004	153		6/9/2004	163		7/7/2004	165		8/3/2004	165		9/1/2004	159		10/5/2004	165	
AHL137	246	5/13/2004	279		6/8/2004	265		7/7/2004	288		8/2/2004	281		9/1/2004	263		10/5/2004	290	
AHL140	299	5/13/2004	86.5		6/8/2004	70		7/7/2004	87	J	8/2/2004	103		9/1/2004	85		10/5/2004	81	

Ammonia-N (dissolved) - mg/L as N

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	0.010	U	6/7/2004	0.010	U	7/6/2004	0.010	U	8/4/2004	0.010	U	8/31/2004	0.010	U	10/4/2004	0.010	U
AHL144	45	5/10/2004	0.010	U	6/7/2004	0.010	U	7/6/2004	0.010	U	8/4/2004	0.010	U	8/31/2004	0.010	U	10/4/2004	0.010	U
AHL143	91	5/10/2004	0.027		6/7/2004	0.010	U	7/6/2004	0.010	U	—	—	—	—	—	—	10/4/2004	0.010	U
AHL142	124	5/11/2004	0.010	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	4.55		6/15/2004	4.96		7/8/2004	4.94		8/3/2004	5.19		9/2/2004	5.31		10/6/2004	5.40	
ABK198	205	5/12/2004	0.638		6/9/2004	0.702		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	0.619		7/8/2004	0.611		8/3/2004	0.671		9/2/2004	0.665		10/6/2004	0.690	
ABK197	229	5/12/2004	0.133		6/9/2004	0.142		7/7/2004	0.137		8/3/2004	0.148		9/1/2004	0.155		10/5/2004	0.156	
AHL137	246	5/13/2004	0.552		6/8/2004	0.544		7/7/2004	0.551		8/2/2004	0.589		9/1/2004	0.579		10/5/2004	0.622	
AHL140	299	5/13/2004	0.010	U	6/8/2004	0.010	U	7/7/2004	0.010	U	8/2/2004	0.010	U	9/1/2004	0.010	U	10/5/2004	0.010	U

U - not detected above the laboratory reporting limit

J - Reported result is considered an estimate

(—) - Not Sampled

Table E-2 - Water Quality Data - Piezometers (cont.)

Nitrate+Nitrite-N (dissolved) - mg/L as N

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	1.80		6/7/2004	1.83		7/6/2004	1.84		8/4/2004	1.79		8/31/2004	1.48		10/4/2004	2.18	
AHL144	45	5/10/2004	1.88		6/7/2004	1.87		7/6/2004	1.76		8/4/2004	1.71		8/31/2004	1.79		10/4/2004	2.48	
AHL143	91	5/10/2004	3.22		6/7/2004	3.41		7/6/2004	3.22		—	—	—	—	—	—	10/4/2004	1.08	
AHL142	124	5/11/2004	39.9		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	0.010	U	6/15/2004	0.010	U	7/8/2004	0.010	UJ	8/3/2004	0.010	U	9/2/2004	0.010	UJ	10/6/2004	0.010	U
ABK198	205	5/12/2004	0.010	U	6/9/2004	0.010	U	—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	0.010	U	7/8/2004	0.010	U	8/3/2004	0.010	U	9/2/2004	0.010	U	10/6/2004	0.010	U
ABK197	229	5/12/2004	0.010	U	6/9/2004	0.010	U	7/7/2004	0.010	U	8/3/2004	0.010	U	9/1/2004	0.010	U	10/5/2004	0.011	
AHL137	246	5/13/2004	0.010	U	6/8/2004	0.010	U	7/7/2004	0.010	U	8/2/2004	0.010	U	9/1/2004	0.010	U	10/5/2004	0.010	U
AHL140	299	5/13/2004	0.031		6/8/2004	0.010	U	7/7/2004	0.118		8/2/2004	0.010	U	9/1/2004	0.010	U	10/5/2004	0.010	U

Orthophosphate-P (dissolved) - mg/L as P

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	0.0377		6/7/2004	0.0385		7/6/2004	0.0395		8/4/2004	0.0425		8/31/2004	0.0400		10/4/2004	0.0401	
AHL144	45	5/10/2004	0.0314		6/7/2004	0.0324		7/6/2004	0.0321		8/4/2004	0.0350		8/31/2004	0.0325		10/4/2004	0.0327	
AHL143	91	5/10/2004	0.017		6/7/2004	0.022		7/6/2004	0.023		—	—	—	—	—	—	10/4/2004	0.030	
AHL142	124	5/11/2004	0.024		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	0.182		6/15/2004	0.133		7/8/2004	0.120		8/3/2004	0.189		9/2/2004	0.177		10/6/2004	0.175	
ABK198	205	5/12/2004	1.11		6/9/2004	1.18		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	1.30		7/8/2004	1.35		8/3/2004	1.38		9/2/2004	1.31		10/6/2004	1.39	
ABK197	229	5/12/2004	0.127		6/9/2004	0.128		7/7/2004	0.124		8/3/2004	0.0419		9/1/2004	0.0344	J	10/5/2004	0.030	J
AHL137	246	5/13/2004	0.0862		6/8/2004	0.0319		7/7/2004	0.0349		8/2/2004	0.0329		9/1/2004	0.030	J	10/5/2004	0.0428	
AHL140	299	5/13/2004	0.0354		6/8/2004	0.0369		7/7/2004	0.0455		8/2/2004	0.0323		9/1/2004	0.0440	J	10/5/2004	0.0461	

Dissolved Organic Carbon - mg/L

Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	1.0	U	6/7/2004	1.0	U	7/6/2004	1.0	U	8/4/2004	1.0	U	8/31/2004	1.0	U	10/4/2004	1.0	U
AHL144	45	5/10/2004	1.0	U	6/7/2004	1.0	U	7/6/2004	1.0	U	8/4/2004	1.0	U	8/31/2004	1.0	U	10/4/2004	1.0	U
AHL143	91	5/10/2004	1.0	U	6/7/2004	1.0	U	7/6/2004	1.0	U	—	—	—	—	—	—	10/4/2004	1.0	U
AHL142	124	5/11/2004	1.0	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	9.2		6/15/2004	8.5		7/8/2004	7.7		8/3/2004	8.4		9/2/2004	9.1		10/6/2004	8.0	
ABK198	205	5/12/2004	2.5		6/9/2004	2.6		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	1.6		7/8/2004	1.6		8/3/2004	2.0		9/2/2004	1.6		10/6/2004	1.0	
ABK197	229	5/12/2004	1.0	U	6/9/2004	1.0	U	7/7/2004	1.0	U	8/3/2004	1.0	U	9/1/2004	1.0	UJ	10/5/2004	1.0	U
AHL137	246	5/13/2004	1.4		6/8/2004	1.2		7/7/2004	1.2		8/2/2004	1.8		9/1/2004	1.5	J	10/5/2004	1.1	
AHL140	299	5/13/2004	1.0	U	6/8/2004	1.2		7/7/2004	1.0	U	8/2/2004	1.2		9/1/2004	1.3	J	10/5/2004	1.2	

U - Not detected at or above the reporting limit

J - Reported result is considered an estimate

(—) - Not Sampled

Table E-2 - Water Quality Data - Piezometers (cont.)

Iron (dissolved) - µg/L																			
Station ID	Map ID	May			June			July			August			September			October		
		Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AHL145	17	5/10/2004	50	U	6/7/2004	50	U	7/6/2004	50	U	8/4/2004	50	U	8/31/2004	50	U	10/4/2004	50	U
AHL144	45	5/10/2004	50	U	6/7/2004	50	U	7/6/2004	50	U	8/4/2004	50	U	8/31/2004	50	U	10/4/2004	50	U
AHL143	91	5/10/2004	65		6/7/2004	50	U	7/6/2004	50	U	—	—	—	—	—	—	10/4/2004	50	U
AHL142	124	5/11/2004	50	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ABK199	184	5/11/2004	39600		6/15/2004	35500		7/8/2004	37900		8/3/2004	36300		9/2/2004	36700		10/6/2004	40200	
ABK198	205	5/12/2004	480		6/9/2004	130		—	—	—	—	—	—	—	—	—	—	—	—
AHL146	205	—	—	—	6/9/2004	1290		7/8/2004	1240		8/3/2004	1270		9/2/2004	1210		10/6/2004	1260	
ABK197	229	5/12/2004	18100		6/9/2004	17700		7/7/2004	17100		8/3/2004	16000		9/1/2004	15100		10/5/2004	16200	
AHL137	246	5/13/2004	20800		6/8/2004	21100		7/7/2004	20700		8/2/2004	19600		9/1/2004	14700		10/5/2004	18700	
AHL140	299	5/13/2004	130		6/8/2004	95		7/7/2004	150		8/2/2004	190		9/1/2004	190		10/5/2004	220	

U - Not detected at or above the reporting limit

(—) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells

Station ID	Map ID	Hydro Unit	pH - S.U. (field)						Specific Conductance - uS/cm (field)						Dissolved Oxygen - mg/L (field)					
			May			October			May			October			May			October		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
ABK189	6	Qgo(g)	5/26/04	6.77		10/20/04	6.41		5/26/04	87		10/20/04	89		5/26/04	8.55		10/20/04	7.83	
ABK176	9	Qgo(g)	5/25/04	6.82		10/20/04	6.52		5/25/04	142		10/20/04	143		5/25/04	7.21		10/20/04	7.14	
AGE834	14	Qgo(g)	5/25/04	7.62		10/20/04	7.12		5/25/04	449		10/20/04	439		5/25/04	0.04		10/20/04	0.00	
ACY539	21	Tbu	—	—	—	10/20/04	7.42		—	—	—	10/20/04	460		—	—	—	10/20/04	4.20	
AAF309	22	Qa	5/26/04	6.33		10/20/04	6.08		5/26/04	159		10/20/04	179		5/26/04	3.58		10/20/04	1.33	
ACQ237	24	Qgo(g)	5/25/04	6.42		10/20/04	6.18		5/25/04	187		10/20/04	193		5/25/04	6.18		10/20/04	5.73	
AFP482	30	Qgo(g)	5/20/04	6.36		10/19/04	6.11		5/20/04	220		10/19/04	224		5/20/04	5.99		10/19/04	4.57	
ABK196	37	Qgo(g)	5/25/04	6.18		10/18/04	5.93		5/25/04	192		10/18/04	230		5/25/04	6.16		10/18/04	5.14	
AGJ763	46	Qgo(g)	5/24/04	6.67		10/19/04	6.27		5/24/04	149		10/19/04	147		5/24/04	2.67		10/19/04	2.63	
AFT316	48	Qgo(g)	5/24/04	6.62		10/19/04	6.38		5/24/04	394		10/19/04	376		5/24/04	0.09		10/19/04	0.02	
AHS234	50	Qgo(g)	6/2/04	6.60		10/28/04	6.12		6/2/04	82		10/28/04	97		6/2/04	7.26		10/28/04	7.29	
AFN526	64	Qgo(g)	5/25/04	7.04		10/19/04	6.13		5/25/04	168		10/19/04	169		5/25/04	2.52		10/19/04	1.74	
ABK179	69	Qgo(g)	5/20/04	6.51		10/19/04	6.14		5/20/04	169		10/19/04	174		5/20/04	2.61		10/19/04	1.68	
ABK194	77	Qgo(g)	5/19/04	6.81		10/18/04	6.65		5/19/04	129		10/18/04	125		5/19/04	1.09		10/18/04	2.69	
AFC701	78	Qgo(g)	5/19/04	6.45		10/18/04	6.33		5/19/04	170		10/18/04	176		5/19/04	2.73		10/18/04	3.78	
AEK406	79	Qgo(g)	5/25/04	6.50		10/14/04	6.30		5/25/04	132		10/14/04	125		5/25/04	3.43		10/14/04	2.68	
ABK188	80	Qgo(g)	5/24/04	6.63		10/14/04	6.53		5/24/04	147		10/14/04	117		5/24/04	0.68		10/14/04	1.25	
ABK195	111	Qgo(g)	5/20/04	6.11		10/13/04	5.97		5/20/04	181		10/13/04	185		5/20/04	4.30		10/13/04	1.97	
AEK438	118	Qgo(g)	5/24/04	6.89		10/18/04	6.83		5/24/04	375		10/18/04	395		5/24/04	1.3		10/18/04	4.83	
ABK200	120	Qgo(g)	5/20/04	6.51		10/14/04	6.32		5/20/04	199		10/14/04	195		5/20/04	9.38		10/14/04	5.21	
ABK190	125	Qgo(g)	5/19/04	6.31		10/13/04	6.16		5/19/04	171		10/13/04	230		5/19/04	4.39		10/13/04	2.57	
ABA853	135	Qgo(g)	—	—	—	10/27/04	6.58		—	—	—	10/27/04	265		—	—	—	10/27/04	<0.01	
AGN061	139	Qgo(g)	5/19/04	6.53		10/13/04	6.40		5/19/04	233		10/13/04	232		5/19/04	1.02		10/13/04	3.02	
ABK180	151	Qgo(g)	5/19/04	6.56		10/13/04	6.44		5/19/04	254		10/13/04	254		5/19/04	0.67		10/13/04	0.84	
AGJ762	159	Qgo(g)	5/24/04	6.74		10/18/04	6.61		5/24/04	139		10/18/04	144		5/24/04	9.82		10/18/04	7.12	
ABK193	160	Qgo(g)	5/19/04	6.72		10/13/04	6.62		5/19/04	200		10/13/04	202		5/19/04	4.75		10/13/04	3.36	

(—) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	pH - S.U. (field)						Specific Conductance - uS/cm (field)						Dissolved Oxygen - mg/L (field)					
			May			October			May			October			May			October		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AGJ766	173	Qgo(g)	—	—	—	10/28/04	7.51		—	—	—	10/28/04	243		—	—	—	10/28/04	0.02	
ABK181	188	Qgo(g)	5/24/04	6.88		—	—	—	5/24/04	286		—	—	—	5/24/04	0.08		—	—	—
AFB872	190	Qgo(g)	5/20/04	7.27		10/25/04	7.16		5/20/04	372		10/25/04	358		5/20/04	0.030		10/25/04	0.025	
ALB686	199	Qa/Qgo(g)	5/27/04	7.50		10/26/04	7.49		5/27/04	326		10/26/04	338		5/27/04	0.13		10/26/04	0.08	
AFN676	201	Tbu	5/18/04	7.84		10/12/04	6.59		5/18/04	220		10/12/04	239		5/18/04	10.5		10/12/04	0.04	
AHG691	212	Qa	5/27/04	7.09		10/27/04	7.06		5/27/04	473		10/27/04	464		5/27/04	0.015		10/27/04	0.06	
ABK187	227	Mc(w)	5/18/04	7.26		10/12/04	7.08		5/18/04	247		10/12/04	240		5/18/04	0.02		10/12/04	0.065	
AGJ765	237	Qa	—	—	—	10/25/04	6.00		—	—	—	10/25/04	101		—	—	—	10/25/04	6.59	
AHL335	241	Mc(w)	5/18/04	7.19		10/12/04	7.12		5/18/04	468		10/12/04	526		5/18/04	0.24		10/12/04	0.010	
ALB684	249	Qapo(h)	—	—	—	10/26/04	6.43		—	—	—	10/26/04	291		—	—	—	10/26/04	2.51	
AFC083	254	Qapo(h)	5/17/04	7.48		10/11/04	7.30		5/17/04	342		10/11/04	343		5/17/04	0.005		10/11/04	0.02	
AFC084	275	Tbu	5/17/04	7.38		10/11/04	7.25		5/17/04	270		10/11/04	275		5/17/04	0.02		10/11/04	0.03	
AGJ760	288	Mc(w)	5/18/04	7.11		10/12/04	6.96		5/18/04	243		10/12/04	255		5/18/04	1.19		10/12/04	1.07	
ABK192	291	Mc(w)	5/18/04	6.97		10/11/04	6.86		5/18/04	295		10/11/04	300		5/18/04	0.08		10/11/04	0.01	
ACF368	294	Qapo(h)	6/2/04	6.85		10/21/04	6.68		6/2/04	172		10/21/04	175		6/2/04	5.60		10/21/04	6.43	
AFC082	301	Qapo(h)	5/17/04	6.45		10/14/04	6.26		5/17/04	186		10/14/04	192		5/17/04	6.41		10/14/04	5.71	

U - Not detected at or above the reporting limit

(—) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	Chloride (dissolved) - mg/L						Total Dissolved Solids - mg/L						Nitrate+Nitrite (dissolved) - mg/L as N					
			May			October			May			October			May			October		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
ABK189	6	Qgo(g)	5/26/04	3.84		10/20/04	3.85		5/26/04	70.4		10/20/04	71		5/26/04	1.40		10/20/04	1.47	
ABK176	9	Qgo(g)	5/25/04	4.31		10/20/04	4.39		5/25/04	104		10/20/04	102		5/25/04	1.87		10/20/04	2.91	
AGE834	14	Qgo(g)	5/25/04	13.1		10/20/04	12.9		5/25/04	275		10/20/04	268		5/25/04	0.010	U	10/20/04	0.010	U
ACY539	21	Tbu	5/25/04	5.17		10/20/04	5.66		5/25/04	305		10/20/04	306		5/25/04	0.010	U	10/20/04	0.010	U
AAF309	22	Qa	5/26/04	4.44		10/20/04	6.65		5/26/04	121		10/20/04	121		5/26/04	5.07		10/20/04	3.26	
ACQ237	24	Qgo(g)	5/25/04	5.15		10/20/04	6.43		5/25/04	142		10/20/04	146		5/25/04	1.60		10/20/04	2.03	
AFP482	30	Qgo(g)	5/20/04	3.37		10/19/04	3.78		5/20/04	165		10/19/04	166		5/20/04	1.14		10/19/04	1.31	
ABK196	37	Qgo(g)	5/25/04	4.45		10/18/04	5.02		5/25/04	147		10/18/04	196		5/25/04	0.303		10/18/04	0.197	
AGJ763	46	Qgo(g)	5/24/04	6.17		10/19/04	6.87		5/24/04	108		10/19/04	110		5/24/04	1.76		10/19/04	1.84	
AFT316	48	Qgo(g)	5/24/04	10.3		10/19/04	11.8		5/24/04	240		10/19/04	203		5/24/04	0.350		10/19/04	0.361	
AHS234	50	Qgo(g)	6/2/04	3.52		10/28/04	4.02		6/2/04	57		10/28/04	83		6/2/04	2.55		10/28/04	3.32	
AFN526	64	Qgo(g)	5/25/04	9.03		10/19/04	9.54		5/25/04	124		10/19/04	106		5/25/04	1.82		10/19/04	2.78	
ABK179	69	Qgo(g)	5/20/04	8.69		10/19/04	10.4		5/20/04	117		10/19/04	120		5/20/04	1.70		10/19/04	2.57	
ABK194	77	Qgo(g)	5/19/04	4.25		10/18/04	4.60		5/19/04	93.8		10/18/04	97		5/19/04	0.405		10/18/04	0.394	
AFC701	78	Qgo(g)	5/19/04	9.81		10/18/04	11.9		5/19/04	119		10/18/04	123		5/19/04	1.95		10/18/04	2.43	
AEK406	79	Qgo(g)	5/25/04	4.63		10/14/04	5.60		5/25/04	95.0		10/14/04	90		5/25/04	1.07		10/14/04	0.677	
ABK188	80	Qgo(g)	5/24/04	5.25		10/14/04	5.33		5/24/04	93.8		10/14/04	87		5/24/04	0.612		10/14/04	0.329	
ABK195	111	Qgo(g)	5/20/04	12.9		10/13/04	15.3		5/20/04	113		10/13/04	122		5/20/04	2.21		10/13/04	3.13	
AEK438	118	Qgo(g)	5/24/04	45.6		10/18/04	49.1		5/24/04	224		10/18/04	274		5/24/04	0.043		10/18/04	0.061	
ABK200	120	Qgo(g)	5/20/04	4.61		10/14/04	4.73		5/20/04	149		10/14/04	141		5/20/04	6.90		10/14/04	6.84	
ABK190	125	Qgo(g)	5/19/04	13.3		10/13/04	25.2		5/19/04	108		10/13/04	139		5/19/04	2.50		10/13/04	2.63	
ABA853	135	Qgo(g)	—	—	—	10/27/04	27.2		—	—	—	10/27/04	163		—	—	—	10/27/04	0.254	
AGN061	139	Qgo(g)	5/19/04	20.3		10/13/04	20.4		5/19/04	142		10/13/04	146		5/19/04	1.61		10/13/04	2.48	
ABK180	151	Qgo(g)	5/19/04	17.3		10/13/04	17.8		5/19/04	166		10/13/04	167		5/19/04	1.39		10/13/04	1.60	
AGJ762	159	Qgo(g)	5/24/04	4.36		10/18/04	6.09		5/24/04	95.8		10/18/04	112		5/24/04	2.00		10/18/04	2.64	
ABK193	160	Qgo(g)	5/19/04	6.63		10/13/04	7.39		5/19/04	144		10/13/04	143		5/19/04	3.03		10/13/04	2.78	

U - Not detected at or above the reporting limit

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	Chloride (dissolved) - mg/L						Total Dissolved Solids - mg/L						Nitrate+Nitrite (dissolved) - mg/L as N					
			May			October			May			October			May			October		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
AGJ766	173	Qgo(g)	—	—	—	10/28/04	6.53		—	—	—	10/28/04	165		—	—	—	10/28/04	0.010	U
ABK181	188	Qgo(g)	5/24/04	6.64		—	—	—	5/24/04	184		—	—	—	5/24/04	0.010	U	—	—	—
AFB872	190	Qgo(g)	5/20/04	9.20		10/25/04	7.73		5/20/04	237		10/25/04	228		5/20/04	0.010	U	10/25/04	0.010	U
ALB686	199	Qa	5/27/04	5.47		10/26/04	5.91		5/27/04	214		10/26/04	213		5/27/04	0.010	U	10/26/04	0.010	U
AFN676	201	Tbu	5/18/04	12.3		10/12/04	4.30		5/18/04	143		10/12/04	161		5/18/04	1.10		10/12/04	0.010	U
AHG691	212	Qa	5/27/04	19.4		10/27/04	19.1		5/27/04	314		10/27/04	308		5/27/04	0.010	U	10/27/04	0.010	U
ABK187	227	Mc(w)	5/18/04	16.5		10/12/04	17.3		5/18/04	174		10/12/04	185		5/18/04	0.010	U	10/12/04	0.010	U
AGJ765	237	Qa	—	—	—	10/25/04	2.21		—	—	—	10/25/04	84		—	—	—	—	—	—
AHL335	241	Mc(w)	5/18/04	42.2		10/12/04	62.3		5/18/04	270		10/12/04	292		5/18/04	0.498		10/12/04	0.011	
ALB684	249	Qapo(h)	—	—	—	10/26/04	17.9		—	—	—	10/26/04	206		—	—	—	10/26/04	3.74	
AFC083	254	Qapo(h)	5/17/04	12.0		10/11/04	12.5		5/17/04	201		10/11/04	220		5/17/04	0.010	U	10/11/04	0.010	U
AFC084	275	Tbu	5/17/04	6.20		10/11/04	6.90		5/17/04	179		10/11/04	192		5/17/04	0.010	U	10/11/04	0.010	U
AGJ760	288	Mc(w)	5/18/04	18.5		10/12/04	22.3		5/18/04	160		10/12/04	178		5/18/04	0.689		10/12/04	0.635	
ABK192	291	Mc(w)	5/18/04	10.9		10/11/04	11.9		5/18/04	179		10/11/04	202		5/18/04	0.010	U	10/11/04	0.010	U
ACF368	294	Qapo(h)	6/2/04	5.30		10/21/04	5.44		6/2/04	136		10/21/04	138		6/2/04	1.40		10/21/04	1.40	
AFC082	301	Qapo(h)	5/17/04	7.02		10/14/04	8.27		5/17/04	155		10/14/04	159		5/17/04	1.75		10/14/04	2.40	

U - Not detected at or above the reporting limit

(—) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	Orthophosphate-P (dissolved) - mg/L as P						Iron (dissolved) - µg/L						Dissolved Organic Carbon - mg/L					
			May			October			May			October			May			October		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
ABK193	160	Qgo(g)	5/19/04	0.0490	J	10/13/04	0.0440		5/19/04	50	U	10/13/04	50	U	—	—	—	10/13/04	1.0	U
AGJ766	173	Qgo(g)	—	—	—	10/28/04	0.0442		—	—	—	10/28/04	1690		—	—	—	10/28/04	1.0	U
ABK181	188	Qgo(g)	5/24/04	0.014	J	—	—	—	5/24/04	853		—	—	—	—	—	—	—	—	—
AFB872	190	Qgo(g)	5/20/04	0.567	J	10/25/04	0.713		5/20/04	1040		10/25/04	1210		—	—	—	10/25/04	1.0	U
ALB686	199	Qa	5/27/04	1.72	J	10/26/04	2.43		5/27/04	2890		10/26/04	2870		—	—	—	10/26/04	4.1	
AFN676	201	Tbu	5/18/04	0.0518		10/12/04	0.0407		5/18/04	50	U	10/12/04	8250		—	—	—	10/12/04	1.0	U
AHG691	212	Qa	5/27/04	0.018	J	10/27/04	0.0369		5/27/04	4500		10/27/04	5580		—	—	—	10/27/04	1.6	
ABK187	227	Mc(w)	5/18/04	0.113	J	10/12/04	0.0685		5/18/04	5430		10/12/04	4320		—	—	—	10/12/04	1.0	U
AGJ765	237	Qa	—	—	—	—	—	—	—	—	—	10/25/04	50	U	—	—	—	—	—	—
AHL335	241	Mc(w)	5/18/04	0.0722		10/12/04	0.028		5/18/04	2570		10/12/04	9950		—	—	—	10/12/04	1.0	U
ALB684	249	Qapo(h)	—	—	—	10/26/04	0.134		—	—	—	10/26/04	50	U	—	—	—	10/26/04	1.0	
AFC083	254	Qapo(h)	5/17/04	0.0898		10/11/04	0.0731		5/17/04	1740		10/11/04	2390		—	—	—	10/11/04	1.0	U
AFC084	275	Tbu	5/17/04	0.249		10/11/04	0.209		5/17/04	2000		10/11/04	1950		—	—	—	10/11/04	1.1	
AGJ760	288	Mc(w)	5/18/04	0.0726		10/12/04	0.0678		5/18/04	50	U	10/12/04	170		—	—	—	10/12/04	1.0	U
ABK192	291	Mc(w)	5/18/04	0.157	J	10/11/04	0.029		5/18/04	6720		10/11/04	7510		—	—	—	10/11/04	1.0	U
ACF368	294	Qapo(h)	6/2/04	0.114		10/21/04	0.112		6/2/04	50	U	10/21/04	50	U	—	—	—	10/21/04	1.0	U
AFC082	301	Qapo(h)	5/17/04	0.120		10/14/04	0.117		5/17/04	50	U	10/14/04	50	U	—	—	—	10/14/04	1.0	U

U - Not detected at or above the reporting limit
J - Reported result is considered an estimate
(—) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	Orthophosphate-P (dissolved) - mg/L as P						Iron (dissolved) - µg/L						Dissolved Organic Carbon - mg/L					
			May			October			May			October			May			October		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
ABK189	6	Qgo(g)	5/26/04	0.016	J	10/20/04	0.014		5/26/04	50	U	10/20/04	50	U	—	—	—	10/20/04	1.0	U
ABK176	9	Qgo(g)	5/25/04	0.025	J	10/20/04	0.020		5/25/04	50	U	10/20/04	50	U	—	—	—	10/20/04	1.0	U
AGE834	14	Qgo(g)	5/25/04	0.939	J	10/20/04	1.49		5/25/04	3020		10/20/04	3090		—	—	—	10/20/04	3.0	
ACY539	21	Tbu	5/25/04	0.692	J	10/20/04	1.65		5/25/04	2710		10/20/04	1890		—	—	—	10/20/04	3.4	
AAF309	22	Qa	5/26/04	0.0368	J	10/20/04	0.0386		5/26/04	50	U	10/20/04	50	U	—	—	—	10/20/04	1.0	U
ACQ237	24	Qgo(g)	5/25/04	0.0475	J	10/20/04	0.0393		5/25/04	50	U	10/20/04	50	U	—	—	—	10/20/04	1.0	U
AFP482	30	Qgo(g)	5/20/04	0.0370	J	10/19/04	0.0307		5/20/04	50	U	10/19/04	50	U	—	—	—	10/19/04	1.0	U
ABK196	37	Qgo(g)	5/25/04	0.018	J	10/18/04	0.018		5/25/04	140		10/18/04	5500		—	—	—	10/18/04	1.0	U
AGJ763	46	Qgo(g)	5/24/04	0.0328	J	10/19/04	0.029		5/24/04	50	U	10/19/04	50	U	—	—	—	10/19/04	1.0	U
AFT316	48	Qgo(g)	5/24/04	0.013	J	10/19/04	0.011		5/24/04	1110		10/19/04	3370		—	—	—	10/19/04	1.0	U
AHS234	50	Qgo(g)	6/2/04	0.024		10/28/04	0.025		6/2/04	50	U	10/28/04	50	U	—	—	—	10/28/04	1.0	U
AFN526	64	Qgo(g)	5/25/04	0.0333	J	10/19/04	0.030		5/25/04	50	U	10/19/04	50	U	—	—	—	10/19/04	1.0	U
ABK179	69	Qgo(g)	5/20/04	0.0307	J	10/19/04	0.020		5/20/04	50	U	10/19/04	120		—	—	—	10/19/04	1.0	U
ABK194	77	Qgo(g)	5/19/04	0.0344	J	10/18/04	0.0348		5/19/04	50	U	10/18/04	50	U	—	—	—	10/18/04	1.0	U
AFC701	78	Qgo(g)	5/19/04	0.028	J	10/18/04	0.024		5/19/04	50	U	10/18/04	50	U	—	—	—	10/18/04	1.0	U
AEK406	79	Qgo(g)	5/25/04	0.028	J	10/14/04	0.028		5/25/04	50	U	10/14/04	50	U	—	—	—	10/14/04	1.0	U
ABK188	80	Qgo(g)	5/24/04	0.021	J	10/14/04	0.0358		5/24/04	160		10/14/04	71		—	—	—	10/14/04	1.0	U
ABK195	111	Qgo(g)	5/20/04	0.019	J	10/13/04	0.016		5/20/04	50	U	10/13/04	50	U	—	—	—	10/13/04	1.0	U
AEK438	118	Qgo(g)	5/24/04	0.015	J	10/18/04	0.012		5/24/04	50	U	10/18/04	50	U	—	—	—	10/18/04	1.0	U
ABK200	120	Qgo(g)	5/20/04	0.024	J	10/14/04	0.018		5/20/04	50	U	10/14/04	50	U	—	—	—	10/14/04	1.0	U
ABK190	125	Qgo(g)	5/19/04	0.017	J	10/13/04	0.013		5/19/04	50	U	10/13/04	77		—	—	—	10/13/04	1.0	U
ABA853	135	Qgo(g)	—	—	—	10/27/04	0.0069		—	—	—	10/27/04	7120		—	—	—	10/27/04	1.0	U
AGN061	139	Qgo(g)	5/19/04	0.030	J	10/13/04	0.023		5/19/04	50	U	10/13/04	50	U	—	—	—	10/13/04	1.0	U
ABK180	151	Qgo(g)	5/19/04	0.0572	J	10/13/04	0.0432		5/19/04	50	U	10/13/04	270		—	—	—	10/13/04	1.0	U
AGJ762	159	Qgo(g)	5/24/04	0.018	J	10/18/04	0.015		5/24/04	180		10/18/04	50	U	—	—	—	10/18/04	1.0	U

U - Not detected at or above the reporting limit

J - Reported result is considered an estimate

(—) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	Lead (dissolved) - µg/L October 2004 Date	Conc.	Qual.	Arsenic (dissolved) - µg/L October 2004 Date	Conc.	Qual.	VOCs - µg/L October 2004 Date	Conc.	Qual.
ABK189	6	Qgo(g)	–	–	–	10/20/04	0.13		–	–	–
ABK176	9	Qgo(g)	–	–	–	10/20/04	0.18		–	–	–
AGE834	14	Qgo(g)	–	–	–	10/20/04	2.21		–	–	–
ACY539	21	Tbu	–	–	–	10/20/04	0.48		–	–	–
AAF309	22	Qa	–	–	–	10/20/04	0.28		–	–	–
ACQ237	24	Qgo(g)	–	–	–	10/20/04	0.28		–	–	–
AFP482	30	Qgo(g)	–	–	–	10/19/04	0.19		–	–	–
ABK196	37	Qgo(g)	–	–	–	10/18/04	0.10	U	–	–	–
AGJ763	46	Qgo(g)	–	–	–	10/19/04	0.20		–	–	–
AFT316	48	Qgo(g)	–	–	–	10/19/04	0.18		–	–	–
AHS234	50	Qgo(g)	10/28/04	0.020	U	10/28/04	0.13		10/28/04	ND(1)	U
AFN526	64	Qgo(g)	–	–	–	10/19/04	0.18		–	–	–
ABK179	69	Qgo(g)	–	–	–	10/19/04	0.15		–	–	–
ABK194	77	Qgo(g)	–	–	–	10/18/04	0.28		–	–	–
AFC701	78	Qgo(g)	–	–	–	10/18/04	0.15		–	–	–
AEK406	79	Qgo(g)	–	–	–	10/14/04	0.13		–	–	–
ABK188	80	Qgo(g)	–	–	–	10/14/04	0.23		–	–	–
ABK195	111	Qgo(g)	–	–	–	10/13/04	0.10	U	10/13/04	ND(1)	U
AEK438	118	Qgo(g)	–	–	–	10/18/04	0.32		–	–	–
ABK200	120	Qgo(g)	–	–	–	10/14/04	0.15		–	–	–
ABK190	125	Qgo(g)	–	–	–	10/13/04	0.10	U	–	–	–

(1) - A total of 71 unique volatile organic compounds were evaluated by the laboratory. No detections were reported by the lab for any of the compounds tested.

U - Not detected at or above the reporting limit

(–) - Not Sampled

Table E-3 - Water Quality Data - Tier 1 Wells (cont.)

Station ID	Map ID	Hydro Unit	Lead (dissolved) - µg/L			Arsenic (dissolved) - µg/L			VOCs - µg/L		
			October 2004			October 2004			October 2004		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
ABA853	135	Qgo(g)	10/27/04	0.020	U	10/27/04	0.19		10/27/04	ND(1)	U
AGN061	139	Qgo(g)	—	—	—	10/13/04	0.18		—	—	—
ABK180	151	Qgo(g)	—	—	—	10/13/04	0.42		—	—	—
AGJ762	159	Qgo(g)	—	—	—	10/18/04	0.11		—	—	—
ABK193	160	Qgo(g)	—	—	—	10/13/04	0.38		—	—	—
AGJ766	173	Qgo(g)	10/28/04	0.020	U	10/28/04	0.98		10/28/04	ND(1)	U
ABK181	188	Qgo(g)	—	—	—	—	—	—	—	—	—
AFB872	190	Qgo(g)	10/25/04	0.03		10/25/04	3.47		—	—	—
ALB686	199	Qa\Qgo(g)	10/26/04	0.024		10/26/04	12.7		10/26/04	ND(1)	U
AFN676	201	Tbu	—	—	—	10/12/04	0.10	U	—	—	—
AHG691	212	Qa	10/27/04	0.020	U	10/27/04	0.32		10/27/04	ND(1)	U
ABK187	227	Mc(w)	—	—	—	10/12/04	2.83		10/12/04	ND[1]	U
AGJ765	237	Qa	—	—	—	—	—	—	—	—	—
AHL335	241	Mc(w)	—	—	—	10/12/04	0.97		—	—	—
ALB684	249	Qapo(h)	10/28/04	0.020	U	—	—	—	10/28/04	ND[2]	
AFC083	254	Qapo(h)	—	—	—	10/11/04	1.56		—	—	—
AFC084	275	Tbu	—	—	—	10/11/04	0.10	U	—	—	—
AGJ760	288	Mc(w)	—	—	—	10/12/04	0.19		—	—	—
ABK192	291	Mc(w)	—	—	—	10/11/04	0.84		—	—	—
ACF368	294	Qapo(h)	10/21/04	0.020	U	10/21/04	0.23		10/21/04	ND(1)	U
AFC082	301	Qapo(h)	—	—	—	10/14/04	0.23		—	—	—

(1) - A total of 71 unique volatile organic compounds were evaluated by the laboratory. No detections were reported by the lab for any of the compounds tested.

(2) - A total of 71 unique volatile organic compounds were evaluated by the laboratory. Only chloroform was detected, at a concentration of 3.6 ug/L.

U - Not detected at or above the reporting limit

(—) - Not Sampled

Table E-4 - Water Quality Data - Tier 2 Wells

Station ID	Map ID	Hydro Unit	July 2004			August 2004			October 2004			December 2004			February 2005			April 2005		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
pH - S.U. (field)																				
AKB695	31	Qgo(g)	7/14/2004	6.43		8/16/2004	6.41		10/7/2004	6.36		12/6/2004	6.43		2/7/2005	6.34		4/4/2005	6.38	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	6.21		10/7/2004	6.05		12/6/2004	6.09		2/7/2005	6.02		4/4/2005	6.00	
Specific Conductance - uS/cm (field)																				
AKB695	31	Qgo(g)	7/14/2004	230		8/16/2004	251		10/7/2004	234		12/6/2004	226		2/7/2005	213		4/4/2005	215.00	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	170		10/7/2004	168		12/6/2004	172		2/7/2005	168		4/4/2005	174.00	
Dissolved Oxygen - mg/L (field)																				
AKB695	31	Qgo(g)	7/14/2004	1.32		8/16/2004	1.43		10/7/2004	0.90		12/6/2004	0.78		2/7/2005	0.72		4/4/2005	0.62	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	1.09		10/7/2004	2.19		12/6/2004	1.87		2/7/2005	2.06		4/4/2005	3.20	
Chloride (dissolved) - mg/L																				
AKB695	31	Qgo(g)	7/14/2004	8.39		8/16/2004	8.60		10/7/2004	8.91		12/6/2004	8.67		2/7/2005	-	R	4/4/2005	8.68	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	6.75		10/7/2004	7.08		12/6/2004	6.90		2/7/2005	-	R	4/4/2005	7.27	
Total Dissolved Solids - mg/L																				
AKB695	31	Qgo(g)	7/14/2004	153		8/16/2004	168		10/7/2004	161		12/6/2004	153		2/7/2005	137		4/4/2005	137	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	135		10/7/2004	128		12/6/2004	130		2/7/2005	127		4/4/2005	128	
Nitrate+Nitrite-N (dissolved) - mg/L as N																				
AKB695	31	Qgo(g)	7/14/2004	1.56		8/16/2004	1.32		10/7/2004	1.45		12/6/2004	1.49		2/7/2005	1.40		4/4/2005	1.31	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	1.04		10/7/2004	1.09		12/6/2004	1.10		2/7/2005	1.15		4/4/2005	1.25	
Ortho-Phosphate-P (dissolved) - mg/L as P																				
AKB695	31	Qgo(g)	7/14/2004	0.025		8/16/2004	0.03		10/7/2004	0.0302		12/6/2004	0.0308		2/7/2005	0.0441	JF	4/4/2005	0.0323	
AKB696	156	Qgo(g)	—	—	—	8/16/2004	0.03		10/7/2004	0.0332		12/6/2004	0.0331		2/7/2005	0.0382	JF	4/4/2005	0.0346	
Iron (dissolved) - mg/L																				
AKB695	31	Qgo(g)	7/14/2004	50	U	8/16/2004	50	U	10/7/2004	50	U	12/6/2004	50	U	2/7/2005	50	U	4/4/2005	50.0	U
AKB696	156	Qgo(g)	—	—	—	8/16/2004	50	U	10/7/2004	50	U	12/6/2004	50	U	2/7/2005	50	U	4/4/2005	50.0	U

U - Not detected at or above the reporting limit

J - Reported result is considered an estimate

F - Equipment Blank Results suggest reported result may be biased high

R - Reported value rejected due to failure to meet quality assurance targets

(—) - Not sampled

Table E-4 - Water Quality Data - Tier 2 Wells (cont.)

Station ID	Map ID	Hydro Unit	July 2004			August 2004			October 2004			December 2004			February 2005			April 2005		
			Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.	Date	Conc.	Qual.
Dissolved Organic Carbon - mg/L																				
AKB695	31	Qgo(g)	–	–	–	–	–	–	10/7/2004	1.0	U	–	–	–	–	–	–	–	–	–
AKB696	156	Qgo(g)	–	–	–	–	–	–	10/7/2004	1.0	U	–	–	–	–	–	–	–	–	–
Lead (dissolved) - µg/L																				
AKB695	31	Qgo(g)	–	–	–	–	–	–	10/7/2004	0.040	F	–	–	–	–	–	–	–	–	–
AKB696	156	Qgo(g)	–	–	–	–	–	–	10/7/2004	0.031	F	–	–	–	–	–	–	–	–	–
Arsenic (dissolved) - µg/L																				
AKB695	31	Qgo(g)	–	–	–	–	–	–	10/7/2004	0.25		–	–	–	–	–	–	–	–	–
AKB696	156	Qgo(g)	–	–	–	–	–	–	10/7/2004	0.19		–	–	–	–	–	–	–	–	–
Volatile Organic Compounds - µg/L (specific detection limit unique to compound)																				
AKB695	31	Qgo(g)	–	–	–	–	–	–	10/7/2004	ND(1)		–	–	–	–	–	–	–	–	–
AKB696	156	Qgo(g)	–	–	–	–	–	–	10/7/2004	ND(1)		–	–	–	–	–	–	–	–	–

(1) - A total of 71 unique volatile organic compounds were evaluated by the laboratory. No detections were reported by the lab for any of the compounds tested.

U - Not detected at or above the reporting limit

F - Equipment Blank Results suggest reported result may be biased high