Aquifer Storage and Recovery - Hydrogeologic Feasibility Study for The City of Pendleton, Oregon

Prepared for
City of Pendleton

Prepared by
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March 2002

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Contents

Acknowledgments

City of Pendleton staff assisted greatly in the data collection necessary to support this Feasibility Study. Bob Patterson and Ralph Baumgartner provided site access and assisted with system operations. Various City staff employees also collected the majority of the water-level data used for this report. Sue Lawrence measured field water-quality parameters and obtained samples for laboratory analysis, managed the laboratory analytical program, and conducted analyses at the City's laboratory. In addition, Kate Ely of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) shared water-level data and hydrostratigraphic information. CH2M HILL employees Phil Brown and Dennis Orlowski of the Portland, Oregon office participated in preparing this study.

Executive Summary

CH2M HILL has completed a study to assess the hydrogeologic feasibility of implementing an Aquifer Storage and Recovery (ASR) program for the City of Pendleton, Oregon. This report presents the results of that study, and serves as technical documentation to support an Oregon Water Resources Department (OWRD) application for a Limited License to conduct an ASR pilot program at Pendleton. Specifically, the purpose of this study was to satisfy the following Supplemental Reports requirements of OAR 690-350-0020 (ASR Testing Under Limited License): Groundwater Information, Quality of Source Water, Comments on Source Water/Standards, Quality of Receiving Aquifer Water, and Comments on Compatibility. The ASR Pilot Test Program will be provided as a companion document prepared by CH2M HILL and the City of Pendleton.

The results of this investigation lead to the following broad conclusions:

- The City has surface water rights, groundwater rights, and infrastructure to support the ASR program.
- Groundwater flow directions appear to converge on Pendleton from nearly all directions as a result of a structural and hydraulic depression centered near the City. Although these flow patterns may change over time as water levels rise in response to ASR operations, they will serve to ensure that little migration of stored water will occur during the first several years of ASR operations.
- The aquifer system beneath the City is a highly-transmissive, broadly-connected, confined aquifer system comprised of basalts of the Columbia River Basalt Group. The aquifer is relatively unbounded and does not appear to be compartmentalized in the vicinity of the Stillman well.
- Aquifer transmissivity values are quite high in the vicinity of the Stillman well, ranging from 264,000 gpd/ft (early-time pumping) to 960,000 gpd/ft (late-time recovery). Transmissivity values this high will easily support the efficient recharge and recovery of stored water. The aquifer system exhibits no water quality or hydraulic response that suggests a direct hydraulic connection with any nearby surface water feature. No hydraulic conditions that could limit the feasibility of developing an ASR program at the City of Pendleton were observed.
- Estimates of storage area, water-level rise in the wells during recharge, static head changes during the storage period, migration during the storage period, and the potential for recovery of stored water indicate ASR is feasible in the Pendleton area.
- Based on the available water chemistry data and thermodynamic equilibrium modeling (EQ3NR), the projected recharge water, current drinking water, and native groundwater appear to be chemically compatible, and mixtures of the different waters do not appear to present any limitations for ASR at the Pendleton site.

1 Introduction & Purpose

Pendleton, Oregon has historically relied on a combination of spring water and groundwater sources to provide drinking water to residents. Quality concerns with the spring water led to an increased reliance on groundwater sources, which in turn has resulted in declining groundwater levels. The City is constructing a membrane-filtration water treatment plant (WTP) to provide its residents with a long-term, reliable source of high-quality drinking water. The WTP will filter water obtained from the Umatilla River via an intake structure to be located near the new facility.

Pendleton's new WTP will have capacity that exceeds demand during most of the winter months. Therefore, the City is moving forward with a plan to implement Aquifer Storage and Recovery (ASR) as a means to fully realize the capacity of the new WTP. ASR will consist of injecting and storing surplus treated drinking water from the WTP into the deep basalt aquifer beneath Pendleton, and recovering the stored water during the higher-demand summer months. The long-term goal for ASR in Pendleton is to halt, or even reverse, declining groundwater levels in the area, and eventually deliver high quality water from the new WTP year round with an expanded ASR program. The City has selected Well No. 1 (Byers Avenue) and Well No. 5 (Stillman), two existing municipal production wells, as the first wells to be evaluated for ASR feasibility.

This report presents the results of CH2M HILL's ASR hydrogeologic feasibility study of the basalt aquifer in Pendleton, Oregon. It was prepared as technical documentation to support an Oregon Water Resources Department (OWRD) application for a Limited License to conduct an ASR pilot program at Pendleton. Specifically, the purpose of this study was to satisfy the following Supplemental Reports requirements of OAR 690-350-0020 (ASR Testing Under Limited License): Groundwater Information, Quality of Source Water, Comments on Source Water/Standards, Quality of Receiving Aquifer Water, and Comments on Compatibility. Other application requirements are provided in companion documents prepared by CH2M HILL and the City of Pendleton. The approaches used to meet this study's objective included the following:

- Determination of Existing Water Rights and Source Water Availability – includes a brief description of the City's water supply system and current demands, the water rights structure currently in place, the timing of source water availability, and total volumes required to meet target demands.
- Hydrogeologic Characterization – includes descriptions of the regional and local basalt aquifer system, groundwater gradients and flow directions, estimates of aquifer storage capacity, Stillman well performance, and potential target storage zones.
- Groundwater Quality Assessment – includes a geochemical evaluation of mixing treated water from the Umatilla River with native groundwater. This assessment was conducted to determine if chemical reactions could occur which might adversely affect ASR well performance, flow properties of the basalt aquifer, or recovered water quality.

- ASR Evaluation and Pilot Study Recommendations – Includes a brief description of the recommended pilot test approach, timing, duration, and monitoring goals. A detailed Pilot Test Workplan will be developed separately.

2 Physical Setting

This section summarizes the geography and hydrogeologic framework of the basalt aquifer in the Pendleton area. Information presented here was obtained from available literature and interpretations made from drilling' logs of water wells in the project area. The hydrogeology was characterized to identify target storage zones, estimate recharge and recovery rates, and to identify locations (such as springs or nearby wells) that could affect the movement or recoverability of stored water.

2.1 Geography

The City of Pendleton is located in northeastern Oregon within the Umatilla River basin at the junction of US Highway 395 and Interstate 84 (see Figure 2-1). Pendleton is the seat of Umatilla County, and is the most populous city in Eastern Oregon with a 1999 population of 17,175. The economy of the county is based primarily on agriculture, cattle, timber and related industries, and tourism. Several state and federal government offices, a municipal airport, Eastern Oregon Correctional Institution and Blue Mountain Community College are also located in Pendleton. Most land use throughout the area is for agriculture (primarily wheat) and livestock. Groundwater is used for most of the irrigation throughout the region. (Davies-Smith and others, 1983; City of Pendleton web page).

The climate of the Umatilla River basin is temperate and ranges from mild and semiarid in the Umatilla lowland to cool and more humid in the Blue Mountain upland. Pendleton, which lies in the Pendleton plains at an elevation of about 1,100 feet msl, has an average annual precipitation of about 13 inches(Whiteman and others, 1994). The Pendleton plains is a region of gently rolling hills that lies between the Blue Mountain slope to the southeast and the Umatilla lowlands to the northwest. In the higher parts of the Blue Mountains, average annual precipitation increases to about 35 inches. Most of the precipitation falls in the winter months, mostly as rain in the lowlands and rain and snow in the uplands. In most years, snow accumulations in the Blue Mountains of several feet do not melt entirely until June (Hogenson, 1964).

The Umatilla River basin lies completely within the Columbia Plateau physiographic province (see Figure 2-2). This region is characterized as a dissected lava plateau, marked by gently rolling hills with several deep canyons carved by the Deschutes, John Day, and Umatilla Rivers, all of which are tributaries to the Columbia River (Gonthier, 1985). The Umatilla River basin consists of a broad topographic and structural trough oriented east to west, lying between the foothills of the Blue Mountains to the south and the lower-lying Horse Heaven Hills to the north. For most of its course the Umatilla River is a consequent stream, its path directed by pre-existing geologic features. However, just west of Pendleton where it crosses Rieth Ridge, the river is believed to be antecedent, which means that the stream path existed before uplift of the land occurred, and thus the stream incised its channel at the same rate the land was rising. The following streams, all of which are consequent, are tributaries to the Umatilla River : Ryan Creek, Meacham Creek, and Squaw Creek, which join the river in the uplands; Wildhorse Creek, McKay Creek, and Birch

Creek, which join the Umatilla in the Pendleton plains; and Butter Creek, which joins the river in the Umatilla lowlands west of Pendleton (Hogenson, 1964).

2.2 City of Pendleton Potable Water Supply System

This section provides a brief history and the current status of water resources utilized by the City of Pendleton. Most of the information is summarized from the "Water System Master Plan for the City of Pendleton, Oregon," dated May 1995 and prepared by Wallulis and Associates, Inc. More recent groundwater-level data was obtained as part of this feasibility study. Information regarding existing water rights, presented in Section 2.2.2, is also summarized from the Water System Master Plan.

2.2.1 Potable Water Sources

From 1913 until 1948, a series of springs (or "infiltration galleries") provided all of the water for Pendleton's supply system. The springs (North and South Wenix; North, Middle, and South Simon; North, Middle, and South Chaplish; and Longhair) are located approximately 16 to 21 miles east of Pendleton within the Umatilla River valley. Water from the springs is conveyed via a 22-mile long gravity-supply system to seven reservoirs within the City. The reservoirs provide a maximum total storage capacity of 5.45 million gallons. The spring water is chlorinated at a station located at City Well No. 7 (Mission Well), which is approximately 7 miles east of Pendleton. The springs also service the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), which is also east of Pendleton.

In 1948, Well No. 1 (Byers Avenue) and Well No. 2 (Round-Up) were drilled to augment the water provided by the spring gravity supply system. Since 1948, an additional five deep basalt aquifer wells were added to Pendleton's supply system: Well No. 3 (SW 21st Street) in 1952; Well No. 4 (Hospital) in 1955; Well No. 5 (Stillman) in 1960; Well No. 7 (Mission) in 1968; and Well No. 8 (Prison) via a transfer from the State of Oregon in 1984. (It was determined that Well No. 6 did not provide sufficient yield, and thus it was never fully developed and has only been used as an observation well by the City. Well No. 11 is a relatively shallow well that provides water only to the City of Pendleton's Wastewater Treatment Plant (WWTP)) (see Figure 2-1).

In 1978, the Environmental Protection Agency (EPA) classified the springs as surface water sources. A revised monitoring program identified occasional turbidity and coliform bacteria violations. Because of these water-quality concerns, the City began to decrease its reliance on the springs and increase its use of the production wells. In 1989, the EPA implemented the Surface Water Treatment Rule. This policy eventually led to the Oregon Health Division's classification in January 1996 of the springs as "groundwater under the direct influence of surface water." Federal and state regulations mandate that such water be treated by filtration prior to public distribution (the Health Division determined that natural filtration of the spring water was not an alternative available to the City). In September 1999, the Health Division issued a Notice of Determination that required replacement or treatment of the spring source. These latter rulings have further increased Pendleton's reliance on the production wells for its water supply needs.

The increased use of production wells by the City, coupled with additional demands placed on the deep basalt aquifer for irrigation and other large volume uses, has resulted in declining groundwater levels in the Pendleton area. From 1958 until early 2001, the static water level (SWL) in the Stillman well dropped approximately 95 feet. This decline has been occurring at a mostly increasing rate. From 1958 to 1972, the Stillman SWL dropped approximately 10 feet (average about 0.7 ft/yr). However, from 1972 to 1977, the decline was about 12 feet (average about 2.5 ft/yr), and since 1977 until early 2001, it has declined an additional 73 feet (average 3 ft/yr).

To mitigate the declining groundwater levels and avoid water quality (turbidity) violations, the City of Pendleton strategically uses both the production wells and springs to supply its water needs. The production wells now provide the majority of the City's water, and Well Nos. 1, 2, 3, 4, 5, 7, and 8 are pumped as needed throughout the year. Most of the City's groundwater is provided by Well Nos. 1 (Byers Avenue), 8 (Prison), and 5 (Stillman). Because of the water-quality restrictions, the volume of spring water contributing to Pendleton is far less than the volume actually produced by the springs. The City's practice is to turn off and/or bypass the most turbid spring collector lines during the lower demand winter months. In the summer months, when turbidity levels tend to be lower, most or all of the spring water is transmitted to the City's supply system. Pendleton is also obligated to provide a small volume of spring water and/or groundwater from the Mission Well to the CTUIR on an as-needed basis.

2.2.2 Existing Water Rights

The City of Pendleton possesses certificated, permitted, and statutory water rights of record which are summarized in Tables 2-1 and 2-2. The developed sources of supply include a series of springs located 16 to 21 miles east of Pendleton and several deep basalt wells.

The Springs (Wenix/Simon/Chaplish/Longhair) are certificated for 11.7 cfs (7.55 mgd) of flow. However, the gravity transmission line from the Springs to the City is hydraulically limited to about 8.4 cfs (5.4 mgd), which is about 69% of the certificated water right. Under the Safe Drinking Water Act, the City's ability to use water from the Springs has become more difficult due to turbidity issues. Prior to 1986, the City received 62% of its annual water supply from the Springs and 38% from its wells. Today, those percentages have switched.

The City's basalt wells have combined certificated water rights of 18.2 cfs (11.7 mgd) and permitted water rights of 40.1 cfs (25.9 mgd) for a total of 58.3 cfs (37.6 mgd). The certificated wells (Well 1, 2, 3, 4, & 5) have a combined yield of 13.2 cfs (5,900 gpm) to 15.4 cfs (6,900 gpm). The permitted wells in use (Well 7 & 8) have a combined yield of 3.3 cfs (1,500 gpm) to 4.0 cfs (1,800 gpm). The City will be adding Well 14 for production in 2002. This well is being constructed to deliver 3.3 cfs (1,500 gpm) for production flow and 4.5 cfs (2,000 gpm) for fire flow to an industrially zoned area of the water system. By 2002, the City will have a well pumping capacity of 19.8 cfs (8,900 gpm) to 23.9 cfs (10,700 gpm).

Well No. 6, which now serves only as an observation well although it was originally intended to be a production well, was permitted with three other wells (Nos. 9, 10 and 12) which were never drilled. Well No. 11 is only used as a potable water supply for the City's Waste Water Treatment Plant. Well No. 11 has a permitted yield of 4.33 mgd.

The City also has several unused certificated water rights, undeveloped permitted water rights, and an unused statutory water right to the Umatilla River, or portion thereof. The oldest certificated water rights are an 1885 – 2.0 cfs (1.3 mgd) water right and an 1890 – 0.5 cfs (0.3 mgd) water right located below the City's new Umatilla River intake site located just upriver from the Hwy 11 bridge crossing. The City is in the process of transferring these rights upriver to the new intake site. Recent legislation (SB870, enacted June 4, 2001) provides for the transfer of water rights upstream based on an affidavit process through OWRD. The transfer legislation provides a means for affected water rights holders to concur that injury to their water rights is not an issue. In addition, SB869 (also enacted June 4, 2001) allows the City of Pendleton to exercise their 1941 statutory water right (ORS 538.450) to all waters of the North Fork Umatilla River at the new intake site. As part of the legislation, a Memorandum of Agreement was signed by the City and the CTUIR addressing the withdrawal of water from the Umatilla River and other issues. The City is also in the process of amending its 1910 – 8.0 cfs (5.2 mgd) permitted water right to the North Fork Umatilla River and transferring the Springs water rights to a secondary point of diversion at the new intake location.

In summary, the City of Pendleton has a total of 22.2 cfs (14.3 mgd) in certificated and permitted surface water rights. The City also has a statutory surface water right for "all waters" of the North Fork Umatilla River. The City has a total of 58.3 cfs (37.6 mgd) in certificated and permitted groundwater rights. These water rights equate to a 80.5 cfs (51.9 mgd) in certificated and permitted water rights to surface and ground water, excluding the 1941 statutory water right to "all waters" from the North Fork Umatilla River.

2.3 Regional Geology and Hydrogeology

2.3.1 Columbia Plateau

The study area is located in the south-central portion of the Columbia Plateau physiographic province, which encompasses approximately 50,600 square miles of Washington, Oregon, and Idaho (Figure 2-3). The Columbia Plateau consists of a series of basaltic lavas extruded during the Miocene (17 to 6 million years ago (mya)) from north- and northwest-trending fissures located in northeast Oregon and southeast Washington. The layered basalt formations are collectively known as the Columbia River Basalt Group (CRBG). The flood basalt flows were bounded to the north by the Okanogan Highlands, to the east by the Rocky Mountains, and to the west by the Cascade Mountains. In the south the flow boundary is not as well defined, and total basalt thickness tends to diminish with increasing distance from the source fissures. The average total thickness of all basalt flows is about 3300 feet, with a maximum thickness exceeding 14,000 feet in the central part of the Plateau near Pasco, Washington. Individual flows ranged from several inches to several hundred feet thick, averaging about 30-50 feet. Basalt accumulations are thickest where topographic depressions existed prior to emplacement, and become thinner where the basalt flows lapped up against higher elevations. (Gonthier, 1985; Drost & others, 1990).

Sedimentary interbeds exist between some individual basalt flows, and are thickest and most extensive in upper (younger) units of the CRBG. The interbeds consist mostly of clay and silt, but sand and gravel deposits have also been encountered. The interbeds were deposited on lava flows, apparently within local depressions and larger structural basins, between periods of active lava extrusion. Where present, major sedimentary interbeds are used to differentiate CRBG basalt formations; collectively these interbeds are part of the Miocene Ellensburg Formation. Within the Columbia Plateau aquifer system, the basalt and surficial sediment formations are considered aquifers, and the major sedimentary interbeds are usually considered confining units (Gonthier, 1990).

The Columbia Plateau is actually a structural and a topographic basin drained by the Columbia River and its major tributaries: the Snake, Yakima, John Day, Umatilla, Spokane, Klickitat, and Deschutes Rivers. The pre-basalt topography of the Columbia Plateau exhibited considerable relief. However, the initial succession of basalt flows transformed the area into a relatively smooth and flat landscape. Later in the eruptive cycle, warping and folding (especially in the western and southern part of the Plateau) resulted in a moderately-rolling landscape that exists today. Sedimentary deposits exist over much of the basalt, and are thickest in the Yakima River Valley (> 1200 ft) and the Grande Ronde Valley in northeast Oregon (>2000 ft) (Whiteman and others, 1994).

The formations of the Columbia River Basalt Group are, from oldest to youngest:

1. The Imnaha Basalt
2. The Picture Gorge Basalt
3. The Prineville Basalt
4. The Grande Ronde Basalt
5. The Wanapum Basalt
6. The Saddle Mountains Basalt

The Grande Ronde, Wanapum, and Saddle Mountains formations comprise the Yakima Basalt Subgroup, and are also the significant parts of the Columbia Plateau aquifer system.

The Grande Ronde Basalt underlies most of the Columbia Plateau, and comprises about 85% of the total volume of the CRBG (see Figure 2-3). It is made up of at least 131 individual flows of varying thickness. The total thickness of the Grande Ronde Basalt is unknown, but over large areas it is the only CRBG unit present. Sedimentary interbeds are rare in the Grande Ronde, and when present usually consist of clay- to gravel-size deposits only a few feet thick. These interbeds also tend to be relatively thin and limited in areal extent due to brief erosion/deposition periods that existed between the comparatively rapid succession of individual Grande Ronde flows. The top of the Grande Ronde Basalt is typically marked by a weathering zone and/or the Wanapum-Grande Ronde interbed. However, the top is extremely difficult to define in drillers' logs where either the weathering zone or the interbed is not present (Gonthier, 1990; Drost and others, 1990).

The Wanapum-Grande Ronde interbed consists primarily of claystone and siltstone, and if present can be used as a marker bed to differentiate the two basalt formations. (This interbed is probably equivalent to the Vantage Member of the Ellensberg Formation, a unit which has been mapped in Washington in the western part of the Plateau, and to the Latah Formation, which occurs in the northeastern part of the Plateau. To avoid confusion, this study uses the recent USGS convention of naming major interbeds on the basis of their typical stratigraphic position relative to CRBG formations (Whiteman and others, 1994). The Wanapum-Grande Ronde interbed averages 25 feet thick, and is thickest (up to 100 feet) and most extensive in the northern part of the Columbia Plateau. If the interbed is not present, the contact between the Wanapum and the Grande Ronde Basalts is very difficult to identify (Drost and others, 1990).

The Wanapum Basalt overlies portions of the Grande Ronde Basalt, and comprises about 6% of the total volume of the CRBG (see Figure 2-3). It consists of approximately 33 separate flow events. Sedimentary interbeds are more abundant in the Wanapum than in the Grande Ronde, but are usually very thin and localized. The thickness of the Wanapum Basalt, including sedimentary interbeds where present, is variable and ranges from 0 to 1300 feet.

The top of the Wanapum is marked by a weathering zone and/or the Saddle Mountains-Wanapum interbed. The Saddle Mountains-Wanapum interbed is comprised of fine-grained sedimentary rocks and some deposits of unconsolidated sediments. It is much less extensive than the Wanapum-Grande Ronde Interbed, present only in a small area in the west-central part of the Plateau, and is probably equivalent to the Mabton Unit of the Ellensberg Formation of Washington (Gonthier, 1990).

The Saddle Mountains Basalt is the youngest formation of the CRBG. Depending on location, it overlies either the Saddle Mountains-Wanapum interbed, the Wanapum Basalt, or the Grande Ronde Basalt (see Figure 2-3). The thickness of the Saddle Mountains Basalt is variable and ranges from 0 to 800 feet, and it is comprised of approximately 19 separate flows.

Miocene through Holocene age sediment overlies much of the Columbia Plateau basalt. These sediments are up to 2000 feet thick along the west edge of the Plateau where the Cascade Mountains provide much of the sediment supply. The overburden sediments consist of consolidated to unconsolidated fluvial, lacustrine, and volcanic deposits ranging from clay- to gravel-sized particles. Loess, which is a blanket deposit of windblown silt, is common throughout the Plateau, especially between 2700 and 3200 feet elevation. Loess deposits are present up to 250 feet thick, but most occurrences are much thinner. Unconsolidated alluvial deposits of Quaternary age, ranging from clay to gravel, are present along most major streams within the Plateau (Gonthier, 1990; Hogenson, 1964).

2.3.2 Columbia Plateau Aquifer System

The Columbia Plateau aquifer system is a major source of groundwater for municipal, industrial, domestic, and irrigation uses. It consists of Miocene basalt of the Columbia River Basalt Group (CRBG), Miocene sedimentary rocks interlayered with the basalt, and Miocene to Holocene sediments overlying the basalt (Whiteman and others, 1994). Figure 2.4 shows the correlation of these general geologic divisions with the hydrogeologic framework of the region.

The hydrogeology of the Plateau is strongly influenced by geologic structures (such as folds and faults) and by permeability differences between stratigraphic units. In the Pendleton area, the regional groundwater flow direction is to the northwest, from the major recharge zone in the Blue Mountain Anticline to the principal discharge area at the Columbia River (see Figure 2-2). Precipitation enters the aquifer system primarily within the northwestward-dipping basalt of the Blue Mountain slope. Groundwater then flows mostly to the northwest through the Agency syncline to Pendleton, ultimately discharging to the Columbia River.

However, on a more local scale, groundwater flow direction can be governed by the presence of secondary geologic structures (folds, faults, fracture zones) or anthropogenic influences (e.g., major pumping centers). Locally, groundwater tends to flow downward from anticlinal axes towards streams in either intervening synclines or incised canyons. Depending on orientation, these local flow directions can be quite different from the general regional flow direction. Faults and fractures in the basalt aquifer can also significantly alter regional groundwater flow patterns. Faults can effectively compartmentalize a basalt aquifer by offsetting horizontal water-bearing units within the basalt, or they can retard groundwater flow if the fault zone is comprised of less-permeable material. Conversely, groundwater can travel preferentially along fault planes if permeability is sufficient. Concentrated, high-volume pumping of the basalt aquifer can also lead to localized flow patterns that are significantly different from the regional groundwater direction and gradient.

Depths to groundwater are typically hundreds of feet within the Plateau aquifer system, although shallower perched levels and artesian conditions upgradient of faults are not uncommon. Typically, unconfined conditions exist in the uppermost basalt flows, whereas the deeper basalt units tend to be confined. Fine-grained sedimentary interbeds (if present) or dense basalt flow interiors act as confining units. In the south-central part of the Plateau near Pendleton, groundwater levels in deeply buried parts of the Wanapum and Grande Ronde formations appear less influenced by surface water features and thus the potentiometric surface is relatively smooth (Gonthier, 1990).

Recharge of the aquifer system is primarily through precipitation and applied irrigation water (approximately 85-90% of groundwater pumped from the system is used for irrigation (Gonthier, 1990)). Annual precipitation throughout the Plateau is spatially and temporally variable, ranging from over 100 inches in the Cascade Mountains to 10 inches or less in the lowlands. Secondary recharge sources include surface water bodies such as canals, rivers, and reservoirs. Most discharge (excluding pumping) is to major rivers, particularly the Columbia, Snake, and John Day Rivers. Minor volumes of groundwater are also discharged to springs and seeps (Gonthier, 1985).

2.3.3 Deschutes-Umatilla Plateau

The Oregon part of the Columbia Plateau is referred to as the Deschutes-Umatilla Plateau, or sometimes as the Columbia-Deschutes Plateau. It is a lava plateau that slopes gently north-northwestward, from approximately 3000 feet elevation at the base of the Blue Mountains to less than 300 feet near the Columbia River. The Deschutes-Umatilla Plateau is characterized by deep canyons carved by the Deschutes, John Day, and Umatilla Rivers (Gonthier,1990; Orr & Orr, 1999).

Major geologic structures of the Deschutes-Umatilla Plateau include the Dalles-Umatilla Syncline and the Blue Mountains Anticline (see Figure 2-2). The axis of the Dalles-Umatilla Syncline assumes primarily an east-west trend, bordering the south bank of the Columbia River. The deepest part of the syncline is located at or near Boardman, Oregon, which is also probably where the thickest basalt deposits are located. The Blue Mountain Anticline marks approximately the southern edge of the regional aquifer system. North and west of the anticline the basalt slopes gently and thickens toward the synclinal axis. Other structures in the Deschutes-Umatilla Plateau include secondary folds and faults that trend mostly east and northeast, approximately parallel to the axis of the Blue Mountains Anticline. North- and northwest-trending folds, faults, and lineaments are also present, but are less prominent than the easterly-trending features (Gonthier, 1990).

2.3.4 Groundwater Movement in Basalt Aquifers

The bedrock of the Columbia Plateau consists of individual layers (flows) of basalt, ranging from a few to several hundred feet thick, stacked on top of one another. Each flow is typically characterized by a massive flow interior and a thin interflow (see Figure 2-5). The massive flow interiors (entablature and colonnade) are usually comprised of dense basalt, with perhaps columnar jointing resulting from contraction during solidification of the basalt. Permeability of the flow interiors is usually very low. Interflow zones, which tend to separate the dense flow interiors and are typically 5-10 percent of the thickness of an individual basalt flow, are often scoriaceous, rubbly, and possess much higher permeability than the flow interiors. However, not all individual basalt flows possess a corresponding interflow; the flow top might have been eroded between flow events, or perhaps it was poorly developed to begin with. Where they exist, though, interflow zones are the primary water-bearing portions of a basalt aquifer, accounting for most of the storage and transmission of groundwater.

An interflow zone consists of the top of an older flow and/or the bottom of a more recent flow. A flow top is typically vesicular, which is a rock texture marked by small cavities that form by the expansion of gas bubbles during solidification (cooling) of the basalt. Vesicles can also be present at the bottom of a flow. Cooling of the lava flow can cause fractures concentrated primarily near the flow top. Interflows are also often rubbly, a texture caused by churning of semi-solid basalt that results in relatively large void spaces. Later weathering of the basalt surface (flow top) may cause further breakdown of rock and deposition of sediment; both processes can provide additional water storage capacity in the basalt aquifer. If lava is extruded under water (e.g., within an existing lake or stream), a rock texture known as "pillow lava" can form. Pillow lava is characterized by discontinuous pillow-shaped masses commonly 1-2 feet long in the greatest dimension. Vesicles, fractures, sediment formation or deposition, rubbly and pillowy textures are all features that contribute to the storage and transmissive qualities of interflow zones.

Because of the orientation of interflow zones, horizontal permeability is usually much greater than vertical permeability in basalt aquifers. Consequently, most groundwater movement in basalt aquifers is lateral through the interflows. However, if the basalt layers are folded, groundwater flow direction can be primarily controlled by the dip slope of the layers (interflows) (Whiteman and others, 1994). Vertical groundwater movement between interflow zones is restricted by the relatively impermeable massive flow interiors. However, vertical flow can occur within the flow interiors (i.e., between interflows) along columnar jointing, fault zones and fracture zones if any of these features are present. Groundwater can also be conveyed horizontally within a flow interior, especially along fault or fracture zones, but these volumes are typically insignificant compared to those observed in interflows.

Basalt flows that pinch out, faults, or other geologic structures can limit the lateral extent of interflows. Since the static water level in a deep basalt well is the composite of the heads contributed by each interflow intersected by that well, significant hydraulic differences can sometimes exist between two wells that are very close to each other.

2.4 ASR Study Area Geology and Hydrogeology

Pendleton is situated in the Umatilla River Basin approximately midway between the axes of the Rieth anticline and the Agency syncline (Figure 2-2). The axes of both folds trend northeast-southwest, which is roughly perpendicular to the orientation of the Umatilla River Basin. The northwestward-trending Horse Heaven anticline exists farther north of Pendleton, and continues to south-central Washington where it is a prominent topographic feature. These structures are minor folds superimposed on the Dalles-Umatilla Syncline to the north and the Blue Mountains Anticline to the south and east.

Pendleton lies at the base of the southeast limb of the Rieth anticline (Figure 2-2). The elevation at the Rieth anticline axis is approximately 600 to 700 feet greater than the average elevation in Pendleton. This results in a dip of about 1.3 degrees east-southeast for the basalt layers comprising the southeast limb of the anticline. The Agency syncline is a shallow trough-like fold, topographically less distinct than the Rieth Anticline. The syncline lies at the foot of the Blue Mountains slope southeast of Pendleton and forms the gentle depression between the Blue Mountains and the Rieth and Horse Heaven anticlines. Basalt of the Agency syncline nearest the Blue Mountains is overlain by fanglomerate of the Pliocene McKay Beds Formation. In some areas the fanglomerate has been eroded and re-deposited, along with loess, into alluvial beds that are relatively impermeable. This alluvium is a limited source of shallow groundwater for domestic use at ranches and dwellings adjacent to streams (Hogenson, 1964).

The Pendleton area is underlain by the Grande Ronde and the Wanapum Basalts (Figure 2-3). According to recent mapping performed by the USGS, the Saddle Mountains Basalt is not present in the vicinity. The elevation of the top of the Grande Ronde Basalt averages approximately 1000 feet msl within Pendleton, ranging from about 1200 feet six miles east to about 800 feet due north and northwest of the City. In Pendleton, the Grande Ronde Basalt is at or very near ground surface within lower portions of the incised valleys of the Umatilla River and McKay Creek. The valleys are areas where the overlying Wanapum Basalt has been eroded, exposing the underlying Grande Ronde Basalt. Above approximately elevation 1000 feet, the Wanapum Basalt is at or very near the ground surface (Gonthier, 1990).

Within the study area, the Wanapum-Grande Ronde interbed is sporadically present, and is up to 15 feet . The interbed is absent in areas where the Wanapum Basalt is also absent, presumably eroded at the same time that the Wanapum was removed by stream erosion. The interbed does exist where the Wanapum is present, and is more extensive north of the Umatilla River (Gonthier 1990).

Recharge of the basalt aquifer in Pendleton is principally from the Blue Mountains east and south of the City. The presence of major water-supply springs located several miles east of the City within the Umatilla River valley confirms the likelihood of some groundwater discharge to the river at higher elevations, and is perhaps fault-controlled. However, deeper basalt units probably discharge (ultimately) to the Columbia River as part of the regional flow system. Because of the moderately high relief of the area (approximately 700-800 feet), groundwater characteristics (e.g., water-level elevations, flow directions and gradients) are expected to be variable.

2.4.1 Observation Well Network and Local Groundwater Elevations

A water well survey was performed to identify wells that currently exist in the deep basalt aquifer near the Stillman well and at strategic locations throughout the ASR study area. Water Well Reports were obtained from the Oregon Water Resources Department (OWRD), and additional well information was acquired from a literature review (Hogenson, 1964). Information from the survey was used to identify wells that could be used as observation wells, provide stratigraphic control, and assist in developing a hydrogeologic description of the study area.

Of several hundred well logs identified and reviewed for the study area, twelve wells (including the Stillman well) were selected to establish an observation well network for the ASR study area. Five of those wells are City of Pendleton production wells, one is an undeveloped City well used only for groundwater monitoring, and six are private wells. Approximate well locations are depicted on Figure 2-1 (the Dallas well exists approximately 4 miles due north of the Stillman well, and is therefore not depicted on Figure 2-1). Table 2-3 summarizes general information for each observation well.

Selection criteria for the observation wells included the following: location relative to the Stillman well, depths/elevations of penetration similar to the Stillman well, and suitable access including the owner's permission at private well locations. All of the observation wells penetrate the basalt aquifer at least several hundred feet. Well logs for the observation wells and for other wells used to characterize the area hydrogeology are included in Appendix A.

In October 2000, City of Pendleton staff began obtaining weekly depth-to-groundwater measurements from the observation network wells. This periodic monitoring is intended to provide data from which groundwater flow directions and gradients can be determined within the ASR study area. Once groundwater trends are established, the effects of ASR operations (recharge and recovery) to the aquifer can more readily be determined.

A plot of water-level elevations (WLE) for most of the observation wells is provided on Figure 2-6. Four distinct groupings of water level elevations are apparent. The Dallas well WLE is consistently around 1405 feet msl, and is not depicted on Figure 2-6. The WLEs for the BMCC and Rosenberg wells range from about 990 to 1000 feet msl, and the SW 21st Street well SWLE is typically around 760 feet msl. The WLEs for the remaining observation wells, including the Stillman well, range from approximately 815-820 feet msl.

The bottom elevation of the Dallas well (1037 ft msl) is above the WLEs for all the other observation wells. This well likely represents hydraulic conditions in interflows separate than those of the lower City wells, and thus there is probably limited (if any) hydraulic connection between the Dallas and other wells. The WLEs in the Rosenberg and BMCC wells are also significantly higher than the WLEs in most of the other wells. However, those two wells do intersect the approximate WLE (815-820 ft msl) for nine of the wells, suggesting the potential for hydraulic connection. The remaining eight wells, by virtue of very similar WLEs, are most likely in some degree of hydraulic connection with each other.

The current WLE in the SW 21st Street well is significantly lower (i.e., 55-60 feet) than WLEs in observation wells of comparable depth and elevation. Research conducted for this characterization did not reveal any hydrogeologic feature, such as a fault near the well, which could account for the disparity in the SW21st water-level elevation. Also, a review of historic WLEs indicated that as recently as 1989, the WLE in the SW21st well was approximately the same as that in the Stillman well (about 850 ft msl). Therefore, two possible explanations exist for the apparent discrepancy in the WLE at the SW 21st Street well. First, it is possible that a leak has developed in the airline that is used to establish depth-to-water measurements at the well. A leaky airline would result in calculated water level elevations that are erroneously low, which appears to be the case at the SW21st well. Or, it is possible that at some time the depth to the airline was changed, and the change was not compensated for in subsequent water level calculations. Because of these uncertainties, water-level data from the SW21st Street well was not used to determine groundwater flow directions and gradients for this study.

2.4.2 Groundwater Flow Directions and Gradients

Regular production pumping from City of Pendleton wells ended on November 16, 2000, and resumed again on December 12 (at the Stillman well) for an aquifer test conducted for this study. Although exceptions are sure to exist, large-scale irrigation pumping from the basalt aquifer typically ceases by October of each year. To minimize the effects of pumping, water level data obtained from observation wells early on December 12 (prior to the start of the aquifer test) were used to estimate groundwater flow directions. Figure 2-7 is a groundwater map of the ASR study area depicting potentiometric lines derived from December 12, 2000 water-level measurements. Barometric pressure corrections have been made to all water level data used in this study (additional details regarding barometric correction method are provided in Section 3).

The east-west bias in water-level data evident on the map exists because most wells in the study area, from which the observation well network was developed, are concentrated within the floor of the Umatilla River valley. As discussed in Section 2.5.1, observation wells located to the north are either not in hydraulic connection with the Stillman well (Dallas) and/or are influenced by hydrogeologic conditions markedly different than those that exist at Stillman (BMCC and Rosenberg). Water-level data obtained from those wells (and the SW 21st Street well) were not used to derive the potentiometric lines depicted on Figure 2-7. Approximate depth-to-groundwater measurements were obtained from Well No. 14 during its construction in October and November 2000. A WLE for Well No. 14 was extrapolated for December, and this value was used to generate the groundwater map.

The water-level elevations indicate that groundwater is moving toward the central portion of the City from multiple directions (Figure 2-7). West of the Byers Avenue well, the groundwater gradient slopes mostly to the east at approximately 0.0003 ft/ft. From the Byers well eastward, the groundwater gradient slopes to the west-northwest at approximately the same gradient (0.0003 ft/ft).

This groundwater flow pattern varies markedly from the regional southeast-to-northwest pattern inferred from the regional recharge-discharge relationships. However, local structural features and pumping conditions help explain the observed flow patterns. As mentioned in Section 2.4, the southeast limb of the Agency Syncline dips to the northwest, which is approximately the direction of regional groundwater flow. However, the southeast limb of the Rieth Anticline (which abuts the northwest limb of the Agency Syncline) dips to the east-southeast. The 600-800 feet of relief caused by the Rieth anticline essentially "cuts off" the regional flow system, causing a gradient increase as heads rise at the base of the anticline. The situation is roughly analogous to water in a stream rising at the upgradient side of a gravel bar or rock, as the upgradient pressure forces the water over or around the obstruction. The rising head at the base of the anticline creates a localized reverse flow field along the southeastern flank of the anticline.

In addition, although the December 12 data used to generate the groundwater map was believed to be free of recent large-scale pumping influences, it is likely that a residual depression resulting from long-term intensive pumping is present beneath the City. West of the Pendleton, the depression would cause water backing up against the anticline to move to the east toward the center of pumping. East of the City, water will move west toward the center of town, likely under a steeper than expected gradient. Summer flow conditions are likely to be slightly different and variable due to increased large-scale pumping. Drawdown within the City will also be greater with increased pumping, with increasingly steeper groundwater gradients expected towards the center of pumping. However, it is likely that these general flow directions will remain the same throughout the year, with flow moving largely towards Pendleton.

In summary, the groundwater flow directions in the Pendleton area during the winter months of 2000/2001 were observed to vary substantially from the regional-scale flow field. Local variability caused by structural features (Reith anticline and Agency syncline) and large-scale groundwater withdrawals create the appearance of a groundwater depression centered near downtown Pendleton, with water moving toward the City from nearly all directions. Because groundwater elevations at distant observation well locations may vary slightly with completion depth and surface topography, and because the wells east of town (Hyatt and Wood) have not been surveyed for surface elevation, the exact location of the center of the depression is somewhat uncertain. The flow field derived from these observations does not limit the feasibility of ASR in the Pendleton area.

2.4.3 Hydrogeologic Cross-Section

A detailed hydrogeologic cross-section was prepared using driller's logs for deep basalt wells completed in the Pendleton area on file at OWRD. The cross-section location line depicted on Figure 2-1 trends east-west along the floor of the Umatilla River valley. Because data are concentrated in an east-west trend through the City in the Umatilla River valley, a hydrogeologic cross-section perpendicular to the one shown could not be produced. The primary information used to create the cross-section were lithologic interpretations made from the drilling logs included in OWRD Water Well Reports, and a review of available geologic literature (Hogenson, 1964; Gonthier, 1990). The log interpretations in the vicinity of the Stillman well were confirmed by video surveys conducted at the Stillman and Byers Avenue wells. The cross-section depicts only inferred water-bearing interflow zones within the basalt aquifer (see Section 2.3.4 for additional discussion of basalt aquifer properties).

The cross-sections were created to provide a better understanding of the hydrogeologic conditions in the ASR study area.

The hydrogeologic cross-section is presented in Figure 2-8. The section shows that on a broad scale (study area) individual interflows or other features do not appear to be uniform or continuous. Although this may be the result of the interpretation of drilling logs, it is more likely that the depicted variability is actually present. Because the basalt flows in this area were moving into the southern boundary of a structural depression, it is likely that the individual members are more variable than in the central portion of the Columbia Basin or closer to the source of the basalt. Between adjacent wells there is usually strong correlation between most (though not all) of the interpreted features. This implies, and is substantiated by water-level elevation data, that despite the variability, there are enough common interflows connecting wells that there is broad hydraulic connection across the study area.

Although the correlation is interpretive and was not verified with geochemical or isotopic age dating, the slope of the interflow contacts agrees with the inferred structural slope from the Blue Mountains to the west. No faults or other structural features were identified by this interpretation. Although the log interpretations were verified by video surveys at Byers Avenue and Stillman, individual interflows remain interpretive and not all are consistent and identifiable from well-to-well or across the study area. This precludes the precise comparison of individual features necessary to interpret faulting. However, the relatively uniform water-level elevation and the hydraulic response to pumping (discussed in Section 3.0) indicate that large-scale faulting (that usually results in aquifer compartmentalization) is not present in the study area.

3 Hydrogeology of the Stillman Well

This section describes the characterization of the deep basalt aquifer near the Stillman well. An aquifer test and video survey were performed within the Stillman well to refine the current knowledge of existing hydrogeologic conditions, such as transmissivity and storativity, and degree of hydraulic connection with nearby wells.

3.1 Stillman Aquifer Test

3.1.1 Aquifer Test Methods

A 48-hour aquifer test was conducted at the Stillman well between December 12 and 14, 2000. The purpose of the test was to evaluate aquifer characteristics at the Stillman well and in the surrounding basalt aquifer, specifically to assess the feasibility of using the Stillman well for ASR operations.

Regular production pumping from the Stillman well was halted on October 6, 2000 to allow for sufficient stabilization of the aquifer prior to the test (approximately 67 days). Moderate volumes (20,000 to 302,000 gallons each day) were pumped on October 10 and 13 and on November 7 and 10, but all pumping from Stillman was halted after November 10, 2000. The last occurrence of pumping from other city wells prior to the aquifer test occurred on November 16, 2000, when approximately 90,000 gallons total were pumped from City Well No. 3 (SW 21st Street) and City Well No. 8 (Prison). Although exceptions are sure to exist, such as non-irrigation wells with year-round usage within the study area, large-scale irrigation pumping from the basalt aquifer typically ceases by October each year. Consequently, possible interference effects from high-yield pumping wells in the area were minimal during the Stillman aquifer test period.

Beginning at 10:36 AM on December 12, 2000, the Stillman well was pumped for approximately 49 hours at an average rate of 2000 gallons per minute (gpm). In addition to performing periodic depth-to-groundwater measurements in the Stillman well, the following observation wells were also monitored to determine response to pumping: Byers Avenue, Round-Up, SW 21st Street, Hospital, WWTP, Sherwood (No. 6), Wood, Hyatt, BMCC, and Rosenberg (see Figure 2-1).

Pumping was halted at 11:30 AM on December 14, 2000. Recovering groundwater levels were monitored in observation wells that exhibited hydraulic response (i.e., drawdown) during the pumping period. It was anticipated that recovery monitoring would continue until water levels had nearly returned to pre-pumping levels. However, approximately 8 hours into the recovery period a brief but intense windstorm occurred which caused a power outage throughout most of the city. This power outage triggered the activation of the Stillman well (and possibly other high-yield wells within the study area) for a period of at least 45 minutes. The inadvertent pumping disrupted the recovering water levels, so monitoring was halted approximately 24 hours into the recovery period.

Baseline Water Level Monitoring

A hydrograph of the baseline (pre-test) water levels measured at select observation wells is presented on Figure 3-1. Observation well locations are shown on Figure 2-1. Several water level measurements were obtained at observation wells in the two days before the start of the aquifer test. For presentation purposes, only wells that possess water-level elevations close to that of the Stillman well are included on Figure 3-1.

Barometric Pressure Corrections to Water-Level Data

Fluctuations in barometric pressure can cause corresponding changes in water levels in tightly-cased wells penetrating deep, confined aquifers (Landmeyer, 1996). In such aquifers, a rise in barometric pressure can result in a decrease in water level in the well relative to the "actual" water level in the adjacent aquifer because the water in the well can respond to atmospheric pressure changes. Conversely, a reduction in barometric pressure can result in an increase in the water level in the well relative to the groundwater level in the aquifer. In unconfined or poorly-confined aquifers, wells show limited (or no) response to barometric changes because the pressure change is distributed evenly over the water table surface. Consequently, the greater the degree of aquifer confinement, the more that water levels in a well will respond to barometric changes. In Pendleton, the deep basalt aquifer system is largely confined, and thus it is necessary to measure barometric pressure and use it to correct the water level to evaluate the hydraulic response that results from pumping or background recharge trends.

Hourly barometric pressure data recorded at the Pendleton Regional Airport for November and December 2000 are provided on Figure 3-2. Changes in barometric pressure were compared to water-level trends observed during the pumping and recovery stages of the Stillman well aquifer test. The results revealed a very good correlation between barometric pressure fluctuations and water level changes in most responding observation wells. Therefore, barometric corrections were made to all water-level data obtained during the aquifer test, and subsequent analyses were performed using the corrected data.

The average barometric pressure for the two month period was 32.46 ft H2O, which was selected as the "baseline" pressure for corrections made to water levels measured during the Stillman aquifer test. This baseline barometric pressure was present approximately one day prior to and one day after the Stillman pumping period. Since the water-level trends for most wells showed very good correlation with barometric pressure fluctuations, a 100 percent barometric efficiency was assumed for each well. Therefore, deviations from the baseline pressure of 32.46 ft H2O were used to correct to each water level measurement. For example, if the barometric pressure at the time of a water level measurement was 32.50 ft H2O, 0.04 feet was subtracted from the depth-to-groundwater measurement to remove the barometric effect. Hydrographs (Figures 3-3 through 3-11) for the Stillman well and select observation wells include both uncorrected and corrected data.

Antecedent Trend Corrections to Water-Level Data

Baseline data collected prior to the pumping test (Figure 3-1) show that water levels were rising prior to the pumping period. This response is likely due to a combination of the cessation of large-scale pumping and the beginning of the seasonal recharge cycle. However, in the days prior to the test, different hydraulic responses were observed at several locations. Some wells exhibited rising water level trends, some declined, and some were variable and difficult to assess. The long-term consistency and short-term variability emphasize the conceptual hydrogeologic model for the aquifer system in the Pendleton area: there is broad hydrogeologic connection resulting in similar hydraulic response to large-scale/long-term seasonal recharge trends. However, from well to well, short-term responses differ because of the variable nature of individual permeable zones, well depth, and well construction. These variations lead to slightly different degrees of hydraulic connection between individual wells, and as a result slightly different responses to pumping/recovery events.

In general, water-level data was not corrected for antecedent water-level trends where:

a) The antecedent trend immediately prior to the test was insignificant or uncertain.

b) Water levels corrected for barometric pressure trends were declining prior to the test.

The rationale for the second condition is twofold. First, because of precipitation patterns at that time of year and the long-term antecedent recharge trend, it is unlikely that any declining trend continued for the duration of the test period. Secondly, correcting for a declining trend is probably not conservative, as doing so will tend to underestimate interference and overestimate transmissivity. Aquifer test data corrections are described below for each well:

Stillman Well: Water levels were stable for approximately 2 days prior to the test, so the data set was corrected for barometric pressure changes only.

Byers Avenue Well: Water levels were relatively stable, showing a slight decline of only 0.04 ft in the two days prior to the test. Therefore, the data were corrected for barometric pressure changes only.

Round-Up Well: Water levels at the Round-Up well were increasing immediately prior to the test at a rate consistent with the longer-term recharge trend. Round-Up water levels were therefore corrected for this antecedent trend (0.11 ft/day) in addition to barometric pressure changes.

SW 21st St. Well: Water levels at the SW 21st Street well were variable prior to and during the test. The water levels at this location appear to be affected by nearby pumping, and no antecedent trend was apparent. The data presented are corrected for barometric pressure changes only.

Hospital Well: Water levels were relatively stable (showing a slight decline of 0.03 ft) in the two days prior to the test. Thus, the data were corrected for barometric pressure changes only.

Sherwood Well: Water levels were stable for approximately 2 days prior to the test, so the data set was corrected for barometric pressure changes only.

WWTP Well: In the 12 days prior to the test, water levels at the WWTP well rose approximately 2.35 feet, or 0.2 ft/day. When this trend is removed from the data set, water levels appear to decline steadily throughout the pumping and recovery periods (Figure 3-9). This indicates that the antecedent trend may have continued throughout the test, and there is no obvious or significant response to pumping apparent in either the corrected or uncorrected data set.

Wood Well: Water levels at the Wood well rose at a rate of 0.05 ft/day in the 24 hours prior to the test. However, the Wood well is an active domestic well, and this trend is likely the result of recent pumping. Because the trend is slight, and its value uncertain, these data were corrected for barometric pressure changes only.

Hyatt Well: Water levels at the Hyatt well appeared to be relatively stable, showing a slight decline of 0.02 ft in the day prior to the test. Therefore the data were corrected for barometric pressure changes only.

Water Quality Monitoring

In addition to water-level measurements, several groundwater-quality parameters were measured by City of Pendleton staff at various periods during the Stillman aquifer test: pH, temperature, electrical conductivity, oxidation-reduction potential (ORP), turbidity, and dissolved oxygen. For these measurements, groundwater was sampled from an outlet port located within the Stillman wellhouse. Discussion and interpretation of the groundwater quality parameters is provided in Sections 3.1.5 and 5.0 of this report.

3.1.2 Aquifer Response to Pumping

The hydrogeologic cross-section presented in Section 2.4.3 depicts interflow zones (interpreted as zones of increased hydraulic conductivity or permeability) generalized from drilling logs of varying ages and quality. The data set used to develop the cross-section is best characterized as highly variable and difficult to correlate between well locations. This is as likely to be an actual condition in the subsurface as it is to result from variable logging styles and approaches. As a result, the cross-section reflects an understanding of the subsurface that is consistent with previous experience with CRBG basalt aquifer systems: individual interflows are more variable than usually thought, and are difficult to correlate between individual wells without performing geochemical analysis of aquifer materials.

Basalt flows (and interflows) appear to be irregular in this portion of the Columbia Plateau; this region was the southern extent of several of the CRBG members. As a result of the variability, two wells of equal elevation and depth may not penetrate the same number of permeable zones, or the zones penetrated may exhibit dramatically different hydraulic conductivity. The differing thickness of permeable section penetrated can lead to variable hydraulic response to pumping and transmissivity estimates. Because transmissivity (T) is the product of the hydraulic conductivity (K) and aquifer thickness (b), two similar responses (and transmissivity estimates) can result from dissimilar conditions. A very thick sequence of lower permeability material may result in a transmissivity estimate (and hydraulic response) identical to a thin highly permeable sequence, assuming equal degree of connection.

A review of Figure 2-8 shows that the Round-Up, Byers Avenue, Sherwood, Hospital, Wood, and SW 21st Street wells are completed to different depths, with different open intervals, different cased depths, and no strong correlation of inferred permeable intervals. The relatively uniform response to pumping at these locations suggests that they exhibit roughly similar transmissivity values as a result of different combinations of permeable thickness and hydraulic conductivity. This behavior demonstrates that on this scale there is broad hydraulic interconnectivity between zones and a relatively small degree of aquifer compartmentalization resulting from faults or other large-scale boundaries. This broad connectivity and high transmissivity results in a relatively uniform groundwater flow field (elevation, gradient, and flow direction). Individual responses will be discussed in more detail below.

Stillman Well

Maximum drawdown observed in the Stillman well during the aquifer test was 42.5 feet. Figure 3-3 is a hydrograph of the Stillman well for both the pumping and recovery periods. Figure 3-3b shows the water level elevation during the pumping period only. As depicted in both figures, near-maximum drawdown was achieved very rapidly in the Stillman well, with only minor additional drawdown occurring throughout the remainder of the pumping period. From 70 minutes after pumping began until the pump was turned off 2 days later, the water level in the Stillman well dropped only an additional 0.5 feet.

At least a portion of the hydraulic response observed at the Stillman well results from discharge rate variations that occurred during the test. In the Stillman well, a hydraulic response (i.e., change in the rate of drawdown) was assumed to be related to discharge rate variability rather than aquifer hydraulics or interference when:

- A similar response was not observed in nearby observation wells
- A response observed during the pumping period was not observed during the recovery period

The "flattened" intermediate response to pumping at the Stillman well (see Figure 3-12, Drawdown vs.t, elapsed time) could suggest a hydraulic connection to permeable zones below the interval penetrated by the well, or a source of water contributing to the aquifer. The upward inflection very late in the test is either an artifact caused by limitations in the barometric efficiency calculation or a change in the discharge rate. However, the inverse of the response is not observed in the recovery data (Figure 3-13), and is also not apparent in the hydraulic response at either the Byers Avenue or Round-Up wells (Figures 3-14 and 3-15). Therefore, the "flattened" intermediate response at Stillman is likely a well-specific effect caused by discharge rate variations. Although test data can be corrected for these variations, the frequency and resolution of the discharge rate data (discussed in 3.1.4) collected for this test does not allow a numerical correction. Quantification of transmissivity and other hydraulic parameters based on aquifer test data is provided in Section 3.1.3 of this report.

Observation Wells

Measurable drawdown in response to pumping at the Stillman well was observed in five observation wells: Round-Up, Byers Avenue, Wood, Hospital, and Well No. 6 (Sherwood). No response was observed in the WWTP well (see Figures 3-4 through 3-9). In the SW21st Street and BMCC wells, pressurized airlines are utilized to determine depths to groundwater. It was concluded that for the BMCC well, the degree of sensitivity afforded by the airline method was not sufficient to detect response to pumping. For the SW 21st Street well, the airline measurements were very erratic (see Figure 3-10). However, a probable net drawdown in the SW 21st Street well is evident from the water level data. No discernible hydraulic response to pumping occurred in the Rosenberg well.

It is not certain if drawdown occurred in the Hyatt well due to pumping at Stillman. Although corrected water-level data for Hyatt suggests that there might have been some influence (see Figure 3-11), the well is pumped regularly and thus the response is likely obscured. Water–level fluctuations there did not correlate distinctly to changes in barometric pressure, and the corrected water-level data for the Hyatt well exhibits a rising trend prior to cessation of pumping at Stillman. As a result, the inferred drawdown response at Hyatt made using the corrected water-level data is less certain than at other locations.

Table 3-1 summarizes maximum drawdown and time of first observed response (since pumping began at Stillman) for each observation well.

Byers Avenue Well

As expected based on their proximity to the Stillman well, response to pumping (drawdown) was observed earliest at both the Round-Up and Byers Avenue wells (Figure 3-14 and Table 3-1). Although both observation wells are almost exactly the same distance from the Stillman well (approximately ¾ mile), the response time at the Byers Avenue well lagged the Round-Up well response time by approximately 14 minutes. This delayed response in the Byers Avenue well (relative to the Round-Up well) suggests either a limited hydraulic connection, or the presence of additional permeable interflows that effectively delay initial response time and limit drawdown. Because no substantial negative boundary conditions that would limit hydraulic connection are apparent, the response likely results from additional saturated thickness at the Byers Avenue well.

For the first 15 minutes of pumping, small water-level fluctuations (less than one-tenth of a foot) were observed at the Byers Avenue well (see Figures 3-5 and 3-14). A steady declining trend became apparent after 15 minutes. The apparent fluctuations in the Byers Avenue well may be attributable to measurement difficulty caused by groundwater flowing down the sides of the borehole ("cascading") from above the water level. Drawdown does not appear to have begun at the Byers Avenue well until approximately 15 minutes of pumping at Stillman had elapsed.

The ability of additional (un-pumped) zone(s) to contribute water to the wellbore in response to reduced pressure in the pumped zones could delay the apparent arrival of the hydraulic response. In addition, the contribution of water from an "un-pumped" interval(s) would limit the magnitude of the response, resulting in an apparent transmissivity estimate greater than actually exists between the two locations. Both conditions were observed in the Byers Avenue data, and similar conditions probably exist for other wells (i.e., Hospital, SW21st, Wood, Sherwood). However, the total drawdown at most wells was even less than at Byers Avenue, leading to calculated transmissivity values that are improbably high and not likely representative of actual aquifer conditions between Stillman and each respective well.

Round-Up Well

The hydraulic response to pumping at Stillman arrived at the Round-Up well within 1 minute of the onset of pumping, suggesting direct hydraulic connection. However, the Round-Up well exhibited roughly four times the drawdown observed at the Byers well, despite the fact that they are equidistant from Stillman (see Figure 3-14). Because no obvious negative boundary conditions are apparent in any of the three data sets, the difference in hydraulic response at Round-Up is a function of a lower aquifer transmissivity. Therefore, either the thickness of the permeable portion of the aquifer or the hydraulic conductivity of the permeable portion of the aquifer decreases in the vicinity of the Round-Up well.

3.1.3 Aquifer Parameter Estimates

Stillman Well - Pumping Data

The target pumping rate for the Stillman well aquifer test was 2000 gpm. However, observations made during the pumping period indicated that this rate fluctuated by as much as +/- 50 gpm. These fluctuations were probably responses to changes in distribution system pressure, and were observed to occur over periods ranging from several seconds to a few minutes. An abbreviated data set provided by the City of Pendleton confirmed the approximate magnitudes of the pumping rate fluctuations, and identified that there is insufficient resolution in the rate data to quantitatively evaluate late-time drawdown changes in the Stillman well.

A constant or near-constant pumping rate is a fundamental requirement for using non-equilibrium equations to solve for various aquifer parameters (i.e., transmissivity and storativity). A distinct "flattening" of water levels during intermediate periods of pumping are evident in the Stillman hydrographs (Figures 3-3 and 3-3b) and drawdown plot (Figure 3-12). The lack of similar response in nearby observation wells (Byers Avenue and Round-Up), and the lack of a corresponding response in the Stillman recovery data (Figure 3-13) suggests the effect is well-specific and related to pumping rate changes.

Early-time response (i.e., that prior to 70 minutes of pumping) does exhibit a fairly uniform increase in drawdown. Therefore, an early-time transmissivity was calculated for Stillman using the Cooper-Jacob "Straight-Line" method. As indicated on Figure 3-12, a straight line was plotted through early-time pumping data and used to calculate a transmissivity estimate of 264,000 gpd/ft. This early-time transmissivity represents conditions very near the well.

Stillman Well – Recovery Data

The Cooper-Jacob method was also used to estimate early-time (i.e., less than 70 minutes) and late-time transmissivity using the Stillman well recovery data. Because the influence of pumping rate fluctuations is minimized or dampened during recovery response, these estimates are likely to be more representative than those derived from pumping data. As shown on Figure 3-13, a straight line was plotted through early-time recovery data and used to calculate a transmissivity estimate of approximately 406,000 gpd/ft. Similarly, a transmissivity value of 960,000 gpd/ft was calculated using late-time recovery data collected just prior to pump reactivation (the brief reactivation of the Stillman pump during the recovery period perturbed the recovering water-level trend).

Byers Avenue and Round-Up Wells – Pumping Data

In addition to the Byers Avenue and Round-Up wells, drawdown was also observed at the Hospital well, Wood well, Well No. 6 (Sherwood), probably the SW 21st Street well, and possibly the Hyatt well. Data obtained from those wells is useful in predicting the radius of influence from pumping and potential recharge operations at the Stillman well. However, aquifer parameters were not calculated for these other responding observation wells. The relatively great distance from Stillman to these five wells increases the potential for changing aquifer conditions and possible pumping interference to produce misleading results. All of these wells exhibited either very limited or poorly-defined response to pumping (relative to the Round-Up and Byers Avenue wells). Transmissivity values calculated from those wells would likely be artificially high due to changes in well depth, permeability, and saturated thickness, and thus would not represent actual aquifer conditions between the pumping well and the observation well. The response to ASR operations at the Stillman well will be governed primarily by aquifer parameters derived from data obtained from the pumping and the nearest responding observation wells (i.e., Byers Avenue and Round-Up).

The Cooper-Jacob method was also used to estimate transmissivity and storativity from pumping and recovery data obtained at the two closest observation wells with the highest-resolution data sets: Round-Up and Byers Avenue. As indicated on Figure 3-14, estimated transmissivity values of approximately 361,600 gpd/ft and 1,148,000 gpd/ft were calculated from Round-Up and Byers Avenue late-time drawdown data, respectively. The Byers response suggests that the Byers well is in hydraulic connection to permeable zones in addition to those that contribute water to the Stillman well. The contribution from these zones (in response to lowering heads in zones that are influenced by Stillman pumping) will cause the aquifer transmissivity to appear substantially higher than is actually present.

To estimate the storativity of the aquifer in the immediate vicinity of the pumping well, it is necessary to fit a straight line to the early-time drawdown data before aquifer boundaries have potentially become an influence. As indicated on Figure 3-14, storativity values of 7.3×10^{-5} and 3.3×10^{-4} were calculated using Round-Up and Byers Avenue early-time drawdown data, respectively. These values are consistent with expected values of storativity for confined basalt aquifers.

Byers Avenue and Roundup Wells - Recovery Data

Recovery data from observation wells was also used to calculate estimates of transmissivity using the Cooper-Jacob method. This additional calculation provides an independent check of transmissivity values calculated from pumping drawdown data. As shown on Figure 3-15, estimated transmissivity values of approximately 409,000 gpd/ft and 2,514,000 gpd/ft were calculated from Round-Up and Byers Avenue well data, respectively. Storativity cannot be determined from recovery data. Table 3-2 summarizes estimated aquifer parameters calculated from both pumping and observation well data:

It is possible that transmissivity estimates, particularly the values obtained from the Byers Avenue data, are artificially high. While these apparent transmissivity values are diagnostic, it is possible that they do not actually represent the transmissivity of the aquifer between the well locations. As described below, it is the limited amount of drawdown that causes the transmissivity estimates to appear high. There are two conditions that commonly limit (or dampen) the expected response:

1. A hydraulic boundary (i.e. a low-permeability fault) limits the hydraulic response to pumping.
2. Changes in saturated thickness between wells.

Because no substantial negative boundary conditions that would limit the hydraulic connection are apparent in the Stillman well data, the response at Byers Avenue likely results from additional saturated thickness. If an observation well intersects permeable zones that are not intersected by the pumping well, they will contribute water to the wellbore in response to lowering pressures in the pumped zone. This additional contribution of water to the wellbore (relative to that contributed to the Stillman well) will cause the arrival of the hydraulic response to appear delayed, and will minimize the magnitude of the response. It is likely that the data from the Byers Avenue well is affected by this condition.

To further analyze recovery data, it is common to plot drawdown versus a dimensionless elapsed time ratio (t/t'), which is the ratio of the total running elapsed time since the pump was turned on (t) and the total running elapsed time since the pump was turned off (t'). Drawdown plots using the elapsed time ratio place early recovery data towards the right side of the graph, with progressively later recovery data plotted towards the left side. An extrapolation of recovery data to $t/t' = 1$ can provide an estimate of residual water level change. Prior to the brief pump reactivation period, the recovery data for the Stillman well (Figure 3-16) was trending toward 0.10 feet of residual drawdown at $t/t' = 1$. This indicates that when recovery time is equal to the time of pumping, the well is expected to be essentially fully recovered. This indicates that no hydraulic boundaries appear to have either:

1. Limited the amount of recharge to the aquifer in the vicinity of the well (resulting in a lower static water level), or,
2. Contributed water to the system during the pumping period (resulting in higher static water level).

The recovery data from the Byers Avenue and Round-Up wells (Figure 3-15) show differing responses, yet the pre-storm pumping event data are both converging to approximately the same amount of residual drawdown. Consistent with its lower apparent transmissivity, the Round-Up response indicates that recharge is limited in that direction, and a residual drawdown of about 0.20 feet is projected at $t/t' = 1$. The last three measurements at the Byers Avenue well indicate that water levels are recovering more rapidly and toward a higher-than-static water level of about 0.60 feet at $t/t' = 1$. However, these points are affected by the blackout-caused pumping, and the pre-black-out data indicate a residual drawdown similar to the Roundup well.

3.1.4 Stillman Well Performance

Specific capacity (which is equal to pumping rate (gpm) divided by drawdown (feet) at a given time) is a common measure of well performance. For a given pumping rate, a well with a higher specific capacity will have less drawdown than a well with a lower specific capacity. Therefore, the greater the specific capacity, the better the well performance. Specific capacity typically does not remain constant, but tends to decrease with time as the drawdown increases. For the Stillman aquifer test, specific capacity values ranged from 48.7 gpm/ft near the start of pumping to 45.4 gpm/ft at the conclusion of the pumping period. Based on experience with other aquifer tests performed in confined basalt aquifers, this rate of specific capacity change is very low, and well performance for Stillman at approximately 2000 gpm is expected to remain consistent for extended pumping periods.

Figure 3-17 is a plot of specific capacity versus drawdown in the Stillman well. Although the resolution of the pumping-rate data is coarse, it is apparent from the plot that the distribution of specific capacity is erratic. Since the water level (drawdown) remained nearly constant, the fluctuations in specific capacity likely resulted from apparent rather than actual variations in the pumping rate. If the variability indicated by the rate data actually occurred, the water levels would likely have exhibited more variability than was observed. On the other hand, the low accuracy of the rate measurements suggest that some portion of the hydraulic response observed during pumping is the result of slight and gradual rate changes that could not be discerned from the low resolution rate data.

3.1.5 Evaluation of Possible Groundwater-Surface Water Interaction

Because of the proximity of the Stillman well to the Umatilla River, the possibility of a direct surface water connection to the deep basalt aquifer was evaluated. This evaluation was based primarily on an assessment of the hydrogeologic framework at the Stillman well, and substantiated by a comparison of several key field parameters obtained from groundwater and surface water (Umatilla River) samples.

Since intensive monitoring began for this study, the static water level in the Stillman well has ranged from approximately 268 ft bgs (September 2000) to 252 ft bgs (March 2001). The river is only about 75 feet north of the Stillman well, yet there is significant vertical separation between the riverbed and the level of groundwater saturation. Groundwater flow in basalt aquifers occurs primarily through horizontal or near-horizontal interflow zones. Vertical groundwater flow between interflows is usually relatively insignificant, and typically occurs only through fractures or along fault planes, if either is present. In addition, the presence of even thin low-permeability sedimentary interbeds can significantly retard vertical groundwater flow. Finally, the storativity values calculated for the Stillman well indicate that the aquifer there is confined, and aquifer test results did not identify the presence of a local recharge boundary. These factors combine to show that there is little likelihood of a direct surface water connection with the deep basalt aquifer in the vicinity of the Stillman well.

In an average year, the Stillman well is typically pumped at 2000 gpm, 24 hours per day, 7 days per week from June through October. Pumping also occurs during the other months, but at lower frequency due to diminished demand. If a hydraulic connection existed between the Umatilla River and the well (i.e., the basalt aquifer), this magnitude of pumping each year would draw water from the river toward the well and water quality at the well would reflect, at least in part, surface water chemistry. Mixing of surface and groundwater would most certainly occur, and thus field parameter values would not be expected to exactly match surface water values. However, even though the well had not operated for approximately 32 days prior to the test, trends for the groundwater field parameters measured over the duration of the 48-hour aquifer test would nonetheless be expected to move towards the river water composition.

During the Stillman aquifer test, the following groundwater parameters were measured periodically by City of Pendleton staff:

- pH
- Temperature
- Electrical conductivity
- Oxidation-reduction potential (ORP)
- Turbidity
- Dissolved oxygen (DO).

These same parameters were measured on November 20, 2000 in samples obtained from the Umatilla River, from the City water distribution system, and from a nearby supply spring (Mission Spring). At that time the distribution system was being supplied solely by the spring sources. Although these data were obtained approximately 2 weeks prior to measuring the Stillman groundwater parameters, values would not have changed appreciably within that period.

At all of its production wells the City operates water-lubricated line-shaft turbine pumps, and the lubrication systems are usually allowed to operate continuously. As a result of this practice, a significant volume of chlorinated distribution system water likely accumulates in the sub-surface during non-pumping periods. Therefore, the composition of water initially pumped from the well is also expected to reflect to some degree the composition of distribution system water.

Field parameter data are presented in Figures 3-18 through 3-23. The first ten minutes of pH, conductivity, and temperature measurements clearly suggest the presence of treated distribution system water near the Stillman well. For each of those three parameters the initial measurements were very close to the average values for the same parameters measured in the distribution system water. All six groundwater field parameters then exhibited steady changes (increases or decreases) during the first 100-300 minutes of pumping, after which time values for each parameter mostly stabilized. It is inferred that the period during which field parameter values changed represents the time required to purge the distribution system water introduced to the subsurface via continuous operation of the pre-lube system.

Trends of groundwater pH, electrical conductivity, turbidity, temperature and dissolved oxygen values clearly show divergence away from respective surface water values. Consistent with the dissolved oxygen trend, groundwater ORP values (Figure 3-23) also stabilized at values less than average ORP values for the river water. Each of the Stillman field parameter values stabilized at levels typical of groundwater in a basalt aquifer, and were not characteristic of surface water chemistry. This further suggests that no hydraulic connection between the Umatilla River and the aquifer appears to exist in the vicinity of the Stillman well.

3.1.6 Aquifer Test Summary

The aquifer test conducted at the Stillman well leads to the following broad conclusions:

- The aquifer is relatively unbounded and does not appear to be compartmentalized in the vicinity of the Stillman well.
- In general, the aquifer responded in a relatively uniform and predictable fashion to pumping. Differences in the hydraulic response to pumping at the Stillman well are likely the result of variability in individual interflows, well depth, and well construction.
- Aquifer transmissivity values are quite high in the vicinity of the Stillman well, ranging from 264,000 (early-time pumping) to 960,000 gpd/ft (late-time recovery). Transmissivity values this high will easily support the efficient recharge and recovery of stored water.
- Aquifer transmissivity values calculated for the Byers Avenue are most likely artificially high.
- The aquifer system exhibits no water quality or hydraulic response that suggests a direct hydraulic connection with any nearby surface water feature.
- No hydraulic conditions that could limit the feasibility of developing an ASR program at the City of Pendleton were observed.

3.2 Stillman Well Video Survey

A video survey was performed of the Stillman well on January 9, 2001. The purpose of the video was to assess the integrity of the well casing for future ASR use and to assist in the identification of water-bearing basalt interflow zones. A detailed log of the video observations is included in Appendix B, and Figure 3-24 depicts the geologic structure and construction details of the Stillman well. A summary of the observations is as follows:

- The casing extends from the surface to 184 feet bgs, consistent with the OWRD Water Well Report that indicates that a 30-inch diameter casing extends from 1 to 10 feet bgs and a 24-inch casing extends from 10 to approximately 186 feet bgs.
- Visible mineralization and staining indicate that the casing has leaked in the past at several welded joints (112, 130, 153, and 163 ft bgs) and at the base (184 ft bgs). However, no active leaking was observed at the time the video was recorded. Because the top of basalt is only about 10 ft bgs and two interflow zones are inferred to exist above the base of the casing, the historical leakage does not likely represent connection between two discrete aquifers, but is instead attributable to the interflows that are

periodically saturated. The basalt is observed to be saturated and contributing water to the open borehole immediately below the casing, also indicating that perched permeable portions of the aquifer exist above the static water level (the static water level in the well was 252 ft bgs at the time the video was recorded).

- Various debris (e.g., abandoned airlines, cables, intake strainer) was observed beginning at approximately 230 ft bgs. The density of debris increased with depth, such that the video camera could not be advanced beyond 633 ft bgs. The Water Well Report indicates that total borehole depth is 700 ft bgs. The City removed the blockage and opened the well to the total borehole depth in July 2001.
- Below the bottom of casing, the video revealed distinct basalt flows separated by interflow zones. The flow zones were comprised of more competent rock characterized by a smoother and rounder borehole wall, a massive and blocky rock structure, and occasional columnar jointing. Water visibility also tended to decrease in the flow zones. The interflow zones were identified by a very irregular and sometimes recessed borehole wall, the presence of a rubbly and vesicular rock texture, and evidence of oxidation and mineralization. Water visibility also increased in some interflow zones.

  The interflow zones identified in the video correlated well with interpretations made from the driller's log for the Stillman well, identifying six distinct (or primary) interflow zones below the bottom of casing:

  - 197 to 215 feet bgs (18 feet thick) – above the static water level in the well (252 ft bgs)
  - 300 to 310 feet bgs (10 feet thick)
  - 316 to 330 feet bgs (14 feet thick)
  - 379 to 397 feet bgs (18 feet thick)
  - 416 to 423 feet bgs (7 feet thick)
  - 429 to 460 feet bgs (31 feet thick)

Additional zones of permeability may exist below the blockage, and these data cannot define the relative contribution of individual zones. Figure 3-24 depicts the location of the inferred interflow zones within the Stillman well, including those above the bottom of the casing (inferred from the drilling log). The permeable interflow zone from approximately 197 to 220 feet bgs is saturated and contributes water to the open borehole. Because water levels in the borehole will likely rise to this level during recharge, water will be stored in this zone during recharge. We believe that because this zone is saturated, the water will move away from the well under an induced hydraulic gradient rather than a gravity gradient, and thus may be mostly recoverable.

4 Storage Capacity of the Basalt Aquifer

This section describes the physical characteristics of a basalt aquifer that determine its storage capacity for ASR operations. Principally, three aquifer parameters are used to determine an aquifer's storage capacity:

- *Transmissivity* - the product of hydraulic conductivity and saturated thickness; a measure of the ease with which water flows through the aquifer
- *Storativity* - the amount of water that can be pumped from, or injected to, an aquifer with a given change in head (i.e., water level)
- *Effective porosity* - the percentage of the aquifer containing interconnected pore spaces through which water is readily transmitted.

Aquifers with high transmissivity, storativity, and porosity can accept, store, and yield large volumes of groundwater. Aquifers with high transmissivity and low storativity, which is typical of basalt aquifers, are also suitable for recharge operations, but head changes resulting from recharge tend to occur over greater distances than in aquifers with higher storativity values. Porosity in a basalt aquifer is generally concentrated in interflow zones, and to a lesser degree in fracture zones if present.

This section describes the predicted aquifer response to ASR operations specifically for the Stillman well. Because representative aquifer parameter data are not available for the Byers Avenue well, potential ASR effects at that well were not quantified. Only general assumptions of planned recharge volumes at Byers Avenue were made to account for simultaneous ASR operations at Byers and Stillman.

4.1 Conceptual ASR Storage Model

Conceptual operation of ASR consists of injecting drinking water into an aquifer for storage and later recovery of that water for potable use. The injected water will displace in-situ groundwater, mostly in a lateral direction along interflow zones. Initially, as source water is injected the pressure head in a confined system will increase in the vicinity of the recharge well, with a logarithmic decrease in pressure with distance from the well. Over time, the increase in pressure head will be distributed laterally and radially until it encounters boundaries (if they exist) within the aquifer. If an aquifer boundary is encountered (e.g., a fault zone containing cemented breccia, or a ground-water divide), the radial migration of the pressure pulse is limited. This tends to increase recharge pressure at the ASR well, which results in water levels or pressure head increasing at a more rapid rate in the aquifer. The amount and areal extent of water level or pressure head increase depends on the transmissivity and storativity of the aquifer.

Results from the Stillman aquifer test performed in December 2000 indicate that the basalt aquifer is confined, with no apparent compartmentalization of the aquifer near Stillman. Confined aquifer storage means that groundwater is at a pressure greater than atmospheric pressure, which causes slight expansion of the aquifer matrix and compression of the water itself. In a confined aquifer, storativity is principally a function of the expansion of the aquifer matrix and compression of water, and consequently is a very small value. This means that for a given volume of water, a large aquifer area is required to store water. The Stillman test results indicate that the aquifer is laterally extensive, so storage capacity will not be a limiting factor for ASR operations.

The high transmissivity and low storativity values typical for basalt aquifers result in head (water level) changes that occur over large areas in response to pumping and recharge of wells. Although recharge and recovery might cause changes in water levels several miles away, the water is exchanged from a portion of the aquifer that is actually much closer to the well. This occurs because in a confined aquifer the pressure change resulting from an exchange of water travels much farther than the water itself.

The distance a given volume of recharge water will actually travel from a well during the storage period can be estimated by considering a simple conceptual model of ASR (the "bubble model") for basalt aquifers. The bubble model neglects mixing of recharge source and native groundwater, but it does provide initial estimates of ASR storage volume and areal effect. During the recharge phase, source water displaces native groundwater through interflow zones in an assumed radial pattern, creating a "bubble" of recharge water. In a basalt aquifer, the bubble exists as a number of tabular shaped bodies of recharge source water.

4.2 Estimated Aquifer Storage Capacity

Because groundwater levels have been declining in the Pendleton area for decades, it is apparent that the lower water levels will allow a significant volume of additional storage. Aquifer storage capacity can be approximated by computing the volume of water that can be stored in the aquifer at a given recharge well over a specified period. The stored water volume is governed by the quantity of treated drinking water available for recharge, and the rate and duration of recharge.

Actual rates of recharge, and thus total recharge volume, will vary with changes in distribution system demand and duration of water availability. For Pendleton, the total period of water availability will depend on streamflow in the Umatilla River. For this preliminary evaluation, a six-month (November through April) operational-scale recharge period was assumed. Since production rates at the Stillman well will vary from 0-2400 gpm, a rate of 1900 gpm (approximately 80% of the maximum production rate) was selected as a reasonable estimate for recharge. At a recharge rate of 1900 gpm, or 2.74 mgd, approximately 492.5 million gallons of treated drinking water could be stored in the aquifer near Stillman over a 6-month winter recharge period. Estimated storage rates and volumes are presented in Section 6 of this report.

4.2.1 Storage Area

The maximum size of the stored "bubble" depends on the total injected volume and characteristics of the aquifer. The size of the conceptual bubble that displaces native groundwater is calculated using the following equation:

Radius of bubble = $(V/(7.48 \times pi \times b \times n_e))^{1/2}$

where: V = volume of water injected (gallons)

b = total aquifer thickness (feet)

n_e = effective porosity

Table 4-1 presents calculated sizes of a simplified recharge bubble created by injecting water at the Stillman well for probable ranges of recharge volumes. The total aquifer thickness (b) is the cumulative thickness of interflow zones, and was estimated from analysis of the drilling log and from observations made during the video survey of the Stillman well. A median porosity of 0.15 for the interflow zones is supported by the findings of LaSala and Doty (1971).

Table 4-1 Calculated Recharge Bubble Size - Stillman Well

Volume of injected water (V) (million gallons)	Total thickness of water producing zones (b) (feet)	Effective porosity of water producing zones (n_e)	Approximate radius of recharge bubble (feet)
500	80	0.15	1,300
400	80	0.15	1,200
300	80	0.15	1,000
200	80	0.15	850

The maximum calculated "bubble" radius of 1,300 feet is conservatively large because the total volume injected at Stillman is likely to be much lower. Actual ASR operations (described in Section 6) will include recharge at both the Byers Avenue well and Stillman well. It is assumed that the Byers well will inject at a relatively constant rate of up to 1,550 gpm, and the Stillman well will vary between zero and 2,350 gpm based on water availability and system demand changes. Over the same six-month period, the volume injected at the Byers Avenue well would be approximately 389 mg. Assuming similar aquifer characteristics, this would result in a storage "bubble" with a radius of about 1,200 feet originating from the Byers well. Because the Byers Avenue and Stillman wells are 4,120 feet apart, and mutual interference would limit the movement of water between the two wells, the recharge "bubbles" of stored water are not expected to intersect even under these maximum-storage conditions. Estimated migration of recharge water during the storage period is discussed in Section 4.3.1 of this report.

4.2.2 Water-Level Change During Recharge

The specific capacity of the Stillman well was measured to be approximately 45 gpm/ft at the end of the aquifer test, with no indication that it would change significantly with additional pumping. In open-hole basalt aquifer systems, there is little correlation between pumping specific capacity and recharge specific capacity; well performance during recharge has been observed to be both better and worse than pumping performance at individual wells. Differences appear to be well-specific and a function of turbulent well losses.

To be conservative, we will assume that the long-term recharge specific capacity (SC) at the Stillman well will be 25% lower than the observed pumping SC, or approximately 34 gpm/ft. At this SC, recharging at a maximum rate of 2400 gpm would result in approximately 71 feet of water level rise in the wellbore during recharge. Assuming interference from recharge at the Byers well will add another 10 feet of water level increase (likely a conservative over-estimate), water levels in the Stillman wellbore would be expected to rise as much as 81 feet during recharge. Because the current static water level is approximately 255 feet bgs, this would raise the water level to approximately 174 feet bgs during recharge. High groundwater levels during recharge do not appear to have the potential to limit ASR operations.

4.2.3 Water-Level Change during Storage Period

The water level changes that result from ASR operations depend on several factors:

- The storage capacity of the aquifer system as a whole
- The regional water budget of the aquifer system (i.e. precipitation, recharge, pumping, and discharge)
- The relative significance of the storage volume, and the associated reduction in groundwater pumping, relative to the regional water budget.

Because precipitation and recharge trends vary with time, and it is beyond the scope of this study to quantify the elements of the regional water budget, long-term water-level trends resulting from ASR operations are predicted. Based on the groundwater flow patterns described in Section 2 (water moving toward a structural and hydraulic depression centered near Pendleton), it seems likely that ASR operations will have a significant impact on long-term static water-level trends.

Short-term water-level changes can be roughly estimated based on the results of the aquifer test data. Although the blackout-induced pumping during the recovery period caused the residual drawdown estimates to be approximate, it appears that the removal of 8.6 mg during the aquifer test resulted in between 0.1 and 0.2 feet of residual drawdown (water level change). If this relationship is assumed to remain constant for recharge (it will not be constant because saturated zones above the static water level will be affected), storing the maximum volume from both Byers Avenue and Stillman (880 mg) could result in between 10 and 20 feet of water-level increase (over pre-recharge static levels) during the storage period.

4.3 Potential for Loss of Stored Water

There are three mechanisms that can result in the loss of stored water:

1. Rapid migration away from the recovery well during the storage period
2. Loss to nearby production wells
3. Discharge to surface water features

The potential for these conditions to result in loss of stored water in Pendleton are discussed below.

4.3.1 Estimated Migration During Storage Period

During storage, the bubble(s) of recharge water may migrate slowly away from the recharge well(s), driven by the groundwater gradient. The distance and direction that the recharge water might move are determined by the magnitude of the hydraulic gradient and direction of groundwater flow, the effects of other nearby pumping wells, and the length of time the water is stored. Groundwater gradients and directions for the ASR study area were discussed in Section 2.5.2, and aquifer parameters were calculated in Section 3.1.3 of this report. The average groundwater flow velocity can be estimated using the relationship:

$$qv = K(i)/n_e$$

where:

qv = average linear groundwater flow velocity

K = the hydraulic conductivity, or T/b

i = hydraulic gradient

n_e = effective porosity

The area actually required to store the recharge volume at the Stillman well will be limited to a relatively small area (see Section 4.2.1). Using the early-time recovery transmissivity estimate (406,000 gpd/ft), a gradient (i) of 0.00030 ft/ft and an assumed aquifer thickness (b) of 80 feet, the average groundwater flow velocity (qv) near the Stillman well is estimated to be:

K = ((406,000 gpd/ft) / (7.48 gal/cf)) /80 ft) = 679 ft/d;

qv = (679 ft/d) (0.00030 ft/ft)/(.15) ;

qv = 1.4 ft/d

This groundwater velocity estimate assumes a uniform gradient not influenced by nearby pumping, and is not the flow velocity away from the well during recharge. Based on this estimate, the distance that the stored water might move during an assumed 1 month storage period could be approximately 42 feet, or about 3% of the expected maximum bubble radius at the Stillman well. It must be emphasized that this is probably a conservative (i.e., maximum) estimate for stored water migration. As depicted on Figure 2-7 (Groundwater Map), groundwater flow directions tend to converge from nearly all directions toward a structural and hydraulic depression centered near downtown Pendleton. Therefore, movement of a recharge "bubble" created at either the Byers Avenue or Stillman wells will tend to be limited by the localized convergence of groundwater directions. This factor, coupled with the low hydraulic gradients, suggests that there appears to be little risk that stored water will not be recoverable due to migration during the storage period.

4.3.2 Potential Loss to Nearby Production Wells

Stored recharge water could be lost if intercepted by other pumping wells. Large-scale pumping, both municipal and private, does occur within and near the ASR study area throughout the year. Due to their proximity to the Stillman well, pumping of the Round-Up and Byers Avenue wells will most influence the directional fate of the stored recharge volume at Stillman. The predicted influence of these two wells, with variable pumping and recharge schedules, is not within the scope of this study. It is likely that during recharge water will preferentially migrate west from Stillman due to mutual interference with Byers, and east from Byers due to mutual interference with Stillman. The magnitude of these effects is expected to be relatively small, and are expected to be reversed during recovery pumping. As a result, there should be no net loss of stored water as recharge and recovery operations stabilize over time.

4.3.3 Potential Discharge to Surface

As discussed in Section 3.1.3.4 of this report, it is highly improbable that there is a hydraulic connection between the Umatilla River and the deep basalt aquifer at the Stillman well. Thus it is doubtful that recharge water will be lost to surface discharge. Although none were identified in the study area, springs exist in portions of the Umatilla River valley, typically along the base of basalt bluffs forming the valley walls (Gonthier & Harris, 1977). While the groundwater level is anticipated to increase to approximately 175 feet bgs during recharge, this level will be far below either the riverbed or springs that might exist on the valley floor.

5 Water Quality

To evaluate the potential for geochemical reactions that might result from mixing native groundwater and recharge source water from the future water treatment plant (WTP), analytical results from two groundwater samples and the projected WTP water chemistry (based on membrane pilot test results) were compared. A surface water sample from the Umatilla River was also obtained to compare to the groundwater chemistries. This evaluation was conducted to determine if chemical reactions could occur which might adversely affect ASR well performance, flow properties of the basalt aquifer, or recovered water quality.

5.1 Data Sources and Evaluation Methods

For this water quality evaluation, native groundwater samples were collected from the Stillman and Byers Avenue wells, and a surface water sample was collected from the Umatilla River. On November 20, 2000, City of Pendleton staff collected the Stillman groundwater sample, the surface water sample from the Umatilla River near the proposed WTP intake location, and a distribution system sample from the City Shop. The distribution system sample was collected for reference purposes only. On December 4, 2001, the City obtained an additional native groundwater sample from the Byers Avenue Well. Field parameters (temperature, pH, conductivity, oxidation-reduction potential and dissolved oxygen) were measured during sample collection. The samples were submitted to UMPQUA Research Company for analysis of geochemical constituents and regulated and unregulated contaminants. Contaminant analyses were performed to establish complete baseline water quality prior to ASR implementation. Analytical results are summarized in Table 5, and copies of laboratory analytical data sheets are included in Appendix C.

The actual recharge (source) water to be used for the pilot testing program will not be available until the water treatment plant (WTP) is constructed in late 2002. Therefore, average recharge water quality was estimated, or projected, from WTP membrane pilot-testing data described in Section 5.2.

The water compatibility evaluation involved an appraisal of existing analytical data and thermodynamic equilibrium modeling using the EQ3NR computer model. The modeling was performed to predict possible geochemical effects, such as precipitation or dissolution of minerals, that might occur upon mixing native groundwater and recharge water from the future WTP. A 50:50 mixture of groundwater and (projected) recharge water was simulated to represent the maximum difference in the mixture of the two water types. During recharge the two waters will combine within an advancing front as the recharge water moves into the aquifer. Typically, the mixed volume represents about 10 to 20 percent of the total recharge water volume of the first cycle. Unless controlled by temperature- and density-driven circulation, the percentage of mixed water in the recovered volume tends to decrease with subsequent cycles as the recharge water displaces native groundwater within the recharge zone around the well. Because actual aquifer mineralogy data from core samples are not available, potential chemical reactions between the projected recharge water and native groundwater were evaluated only from the present chemical equilibrium phases of the two waters. Note that because of the continuous operation of the pre-lubrication systems at city wells, disinfected surface water has been recharging the aquifer near some wells for a number of years with no apparent detrimental effect.

5.2 Projected Recharge Source Water Quality

The projected average recharge water is a very dilute calcium-magnesium-bicarbonate type (Figures 5-1 and 5-2) containing 76 milligrams per liter (mg/L) total dissolved solids (TDS) with a very slightly acidic pH of 6.7 (Table 5). It is an oxidized water with a oxidation-reduction potential (Eh) of about positive 600 millivolts (mV) in approximate equilibrium with dissolved oxygen (DO) in the atmosphere. The estimated DO for the recharge water is essentially saturated at 9.3 mg/L. Silica is estimated at a relatively elevated 32 mg/L, but this concentration is normal in surface water in contact with basalt-rich sediment (the drinking water from the City Shop contained 40.2 mg/L silica).

Iron, manganese, and other metal and trace element concentrations for the recharge source water are expected to be less than the same concentrations in the current drinking water as a result of the water treatment process and oxidation resulting from contact with the atmosphere. Estimated dissolved iron for the future recharge water is an average of 0.13 mg/L and dissolved manganese is 0.006 mg/L. The distribution system (City Shop) sample contained 0.227 mg/L total iron, and total manganese was not detected above a detection limit of 0.01 mg/L. The somewhat higher iron concentration in the existing drinking water may be related to dissolution of minerals in the aquifer and/or the iron piping in the distribution system. However, the pH of the drinking water was slightly lower than the pH estimated for the recharge water (6.4 and 6.7 respectively), thus the current drinking water is slightly more aggressive (more likely to dissolve minerals and metals) than is expected for the future recharge water. The slightly elevated aluminum concentration in the projected recharge water is a byproduct of the treatment process.

Barium is not predicted for recharge source water, and it was the only trace element detected in the drinking water sample at 1.25 mg/L (which is below the MCL of 2.0 mg/L). Barium was also detected in the Umatilla River sample at 0.149 mg/L. The presence of barium in the drinking water and river water samples is probably attributable to feldspars (sodium and calcium aluminosilicates) present in the local mineralogy, and is relatively elevated because the drinking water sulfate concentration is a very low 1.71 mg/L. Because barium precipitates with dissolved sulfate to form the insoluble mineral barite, the higher sulfate concentration of the projected recharge water (2.9 mg/L, with a maximum of 9.0 mg/L) will probably result in lower barium concentrations. There is insufficient barium and sulfate to expect any significant barite precipitation.

The estimated average total organic carbon (TOC) for the recharge source water is a slightly elevated 2.2 mg/L (3.0 mg/L maximum). TOC for the distribution system sample (City Shop) was 1.9 mg/L. For the recharge source water, estimated total Kjeldahl nitrogen (TKN) is 0.27 mg/L (1.2 mg/L maximum). The TKN is the sum of the ammonia nitrogen (0.07 mg/L) and organic forms of nitrogen (0.20 mg/L), which are about twice the nitrate concentration (0.11 mg/L). Organic forms of nitrogen include the amino group (NH_2) associated with organic carbon.

The average total phosphorus concentration estimated for recharge water is 0.05 mg/L (0.29 mg/L maximum). Even though the average nutrient concentrations (phosphorus, nitrogen species and TOC) are relatively low, maximum potential concentrations suggest that a residual chlorine (or other comparable disinfectant) concentration of about one mg/L is recommended in the recharge water to reduce the probability of microbial activity in and near the wellbore when the well is idle.

The projected recharge water is undersaturated with respect to calcite (calcium carbonate) and other carbonates, but is in equilibrium with respect to albite (sodium aluminosilicate), alunite (potassium aluminosilicate), iron oxyhydroxide and cristobalite (silica). "Equilibrium" means that the water does not have a tendency to either dissolve or precipitate a mineral, "undersaturated" means that the water has a tendency to dissolve the mineral, and "supersaturated" means that the water has a tendency to precipitate the mineral. The low TDS of this water means that most minerals that are marginally to significantly insoluble (for example, clays) are supersaturated while those that commonly contribute to the TDS of natural water (for example, calcite) are undersaturated. As a result, recharge water with this chemistry will tend to dissolve calcite.

5.3 Receiving Groundwater Quality

Native groundwater samples were obtained from the Stillman and Byers Avenue wells, which will be the first two ASR pilot test locations. Because the water chemistries for the two samples are somewhat different, the analytical results for each sample location are discussed separately.

5.3.1 Stillman Well Groundwater Sample

The native (receiving) groundwater sample obtained from the Stillman well is a calcium-bicarbonate type, which is chemically similar to the projected recharge source water (Figures 5-1 and 5-2). Both the Stillman groundwater and the recharge source water are moderately-hard, with Total Dissolved Solids (TDS) concentrations of 210 mg/L and 76 mg/L, respectively (Table 5). The Stillman groundwater sample had an alkaline field pH of 7.8, and is oxidizing with a measured Eh of 500 mV. The dissolved oxygen (DO) was less than the projected recharge source water (6.3 mg/L versus 9.3 mg/L), but agrees with the degree of oxidation indicated by the Eh value. Silica in the Stillman sample was greater than that in the projected recharge source water (50.4 mg/L versus 32 mg/L), but it is not high enough to be a concern.

The Stillman native groundwater chemical analysis has a relatively high cation/anion balance error (38 percent), with slightly higher cations but significantly lower anions required for a mass balance. It is possible that precipitation of some component(s) prior to analysis might account for the high ionic balance error. Based on the assessment of chemical equilibrium, calcium carbonate probably precipitated, depleting a fraction of both the calcium and bicarbonate (alkalinity) since neither the sulfate nor chloride concentrations were sufficient to lead to precipitation. The ionic imbalance does not significantly impact this evaluation because most of the characteristics of the native groundwater chemistry from the Stillman well will remain consistent.

For the Stillman groundwater sample, the iron, manganese, and other metal and metalloid concentrations (arsenic and antimony) were below respective detection limits, as is expected from the Eh and pH values (Table 5). Barium was the only trace inorganic element detected at a low concentration of 0.21 mg/L (barium MCL is 2.0 mg/L). This is significantly less than the barium detected in the drinking water sample and illustrates that the higher sulfate concentration (16.7 mg/L) in the Stillman groundwater will control the barium concentration.

The TOC of the native groundwater at 1.0 mg/L is about half that of both the projected recharge water and existing drinking water. This indicates a lower potential for disinfection by-product (DBP) formation when residual chlorine is introduced. Similarly, total phosphorus concentration of 0.023 mg/L is about half that of the projected recharge water, reflecting the higher calcium concentration in the groundwater which tends to precipitate with orthophosphate to form the essentially insoluble mineral apatite. Ammonia is essentially the same, but the nitrate concentration of 1.09 mg/L in groundwater is about ten times that of the projected recharge water nitrate concentration (0.11 mg/L).

The Stillman native groundwater sample contained low concentrations of some disinfection by-products (DBPs). Minor concentrations of all four trihalomethanes (THMs) were reported with 0.003 mg/L chloroform, 0.0029 mg/L bromodichloromethane, 0.0025 mg/L dibromochloromethane, and 0.0009 mg/L bromoform, for a total THM concentration of 0.0093 mg/L (the MCL for total THM is 0.08 mg/L). It is likely that the majority and perhaps all of the THMs were introduced into the aquifer through drinking water which supplies the pre-lubrication system for the pump. City operations commonly allow pre-lube systems to run continuously, introducing significant volumes of water into the subsurface during idle periods. The drinking water sample from the City Shop contained 0.0162 mg/L total trihalomethanes.

Evaluation of the field parameter data collected during the December aquifer test suggest that all of the drinking water introduced from the pre-lubrication system may not have been purged from the aquifer prior to collecting the November sample. THMs will be monitored during the initial ASR cycles to determine if they are being generated; however, THMs are not typically created in the subsurface, and are usually observed to decrease rapidly with storage time in the aquifer.

No other organic compounds were detected in the Stillman native groundwater sample except phthalates at 0.0022 mg/L (the MCL for phthalates is 0.006 mg/L) (see Table 5). However, phthalates detected at this low concentration are typically found to be laboratory artifacts. It would be very unusual to find phthalates in a native groundwater, and particularly so when there are no other organic compounds present in the sample. Therefore, recovered water samples will be analyzed to confirm that phthalates are not present.

Radon in the Stillman groundwater sample was reported at 143 picocuries per liter (pCi/L), with a standard deviation of 21 pCi/L. The drinking water sample (City Shop) contained 75 pCi/L, with a standard deviation of 20 pCi/L. These activities are well within the MCL for radon of 300 pCi/L. Radon is a naturally-occurring radioactive daughter product of radium, and is probably a mineralogical component of the basalt aquifer. Since it is an inert gas, radon does not participate in chemical reactions within the aquifer, and a significant portion of radon tends to leave groundwater when it is exposed to atmospheric conditions. Radon also undergoes radioactive decay (half decaying every 3.8 days) to metals that become strongly adsorbed to iron oxyhydroxide. ASR has little effect on radon activity.

Native groundwater at the Stillman well is in equilibrium with respect to calcite, albite, iron oxyhydroxide, cristobalite and saponite. Saponite is a calcium-magnesium-iron-silicoaluminum clay common in aquifers containing basaltic sediments. Saponite commonly attaches to the surfaces of aquifer particles. Calcite is almost exactly at equilibrium, suggesting that it may have precipitated after sample collection and/or during analysis. The iron oxyhydroxide equilibrium suggests that iron and therefore many other metals are not mobile in the groundwater.

5.3.2 Byers Avenue Well Groundwater Sample

The receiving (native) groundwater from the Byers Well is a sodium-bicarbonate (soft) water chemistry type with a dilute TDS of 225 mg/L. The major ion chemistry of this groundwater is considerably different from the calcium-bicarbonate type (moderately hard) water chemistry type of both the projected recharge water and the groundwater from the Stillman Well (Figure 5-1). The Byers well groundwater has an alkaline field pH of 8.4, and is also oxidizing with a measured Eh of positive 416 mV. The DO was considerably less than that of the projected recharge water (2.69 versus 9.3 mg/L), but agrees with the degree of oxidation indicated by the Eh (416 mV). Silica was not determined in the original (12/04/01) Byers native groundwater sample, so it was modeled with both a 30 and 45 mg/L concentration.

The Byers Avenue well groundwater chemical analysis has a relatively high cation/anion balance error (16 percent), with slightly lower anions but significantly lower cations required for a mass balance. Similar to the Stillman well sample, calcium carbonate probably precipitated, depleting a fraction of both the calcium and bicarbonate (alkalinity).

For the Byers Avenue groundwater sample, metal (cadmium, chromium, copper, iron, lead, nickel, silver and thallium) and metalloid (arsenic, antimony and selenium) concentrations were below their respective detection limits, as is expected from the Eh and pH values (Table 5). Mercury and barium were also below their respective detection levels. Dissolved manganese was the only trace inorganic element detected and this was at a very low concentration of 0.013 mg/L. The total manganese of 0.014 mg/L is essentially the same concentration as that of the dissolved manganese, a common characteristic of manganese in groundwater. Manganese is typically one of the first metals released under low oxidizing conditions.

The TOC of the Byers groundwater at 0.72 mg/L is about a third of that of the projected recharge water. This indicates a lower potential for disinfection by-product (DBP) formation when residual chlorine is introduced. The total phosphorus concentration of 0.193 mg/L, which is almost four times that of the projected recharge water, reflects the sodium-bicarbonate water chemistry type with a very low calcium concentration.

Similar to total phosphorus, ammonia in the Byers groundwater is about four times higher than the projected recharge water (0.3 versus 0.07 mg/L, respectively). Nitrate, on the other hand, is only about twice that of the projected recharge water (0.28 versus 0.11 mg/L, respectively).

The groundwater sample obtained on December 4, 2001 from the Byers Avenue well was analyzed for drinking water parameters required by the Oregon Department of Health (OHD) and the Oregon Department of Environmental Quality (DEQ). Analytes required by OHD for the Byers sample were different from when the Stillman well was sampled in November 2000 (pers. comm., D. Nelson/OHD, 10/01). The primary difference between the two sample periods concerned required unregulated contaminants. Also, many required potential contaminants had already been analyzed on the native groundwater from the Byers well during recent previous sampling events. Respective sample dates are noted on Table 5.

Organic compounds were not detected in the groundwater sample from the Byers well. Also, unlike in the Stillman well sample, disinfection by-products were not detected, which indicates that chlorinated water from the pre-lubrication system was not being introduced to the Byers grounwater. No other detected analytes exceeded respective maximum allowable concentrations.

Native groundwater at the Byers well, with an estimated 30 mg/L silica, is in equilibrium with respect to albite and sepiolite, slightly supersaturated with respect to calcite, iron oxyhydroxide and cristobalite and slightly undersaturated with respect to a high-iron smectite. Increasing the modeled silica concentration to 45 mg/L does not affect calcite (carbonate mineral), but increases the supersaturation level for albite (silicate mineral) and cristobalite (solid silica mineral). A groundwater sample obtained from the Byers Avenue well on February 25, 2002, contained a silica concentration of 61.0 mg/L (Table 5). This is significantly greater than the 30-45 mg/L silica concentrations estimated as inputs to the thermodynamic equilibrium modeling. The higher actual silica concentration would increase the modeled supersaturation levels of cristobalite and amorphous silica. However, this does not change the conclusion of this assessment.

5.3.3 Comparison of Stillman and Byers Avenue Groundwater Chemistries

The Byers Avenue well groundwater is a sodium-bicarbonate (soft) water chemistry type, which is considerably different from the calcium-bicarbonate (moderately hard) type of both the groundwater from the Stillman well and the projected recharge water (Figure 5-1). The different water chemistries for the two groundwater samples is likely attributable to significant flow contribution from a deep interflow zone that exists at Byers but not at Stillman. The presence of this deep Byers interflow is depicted on Figure 2-8, the Hydrogeologic Cross-Section. Observations made during the Stillman well aquifer test also support the claim that different hydraulic regimes exist in the basalt aquifer at the two wells (Section 3.1). The analytical and thermodynamic modeling results indicate probable mixing of groundwater from the Byers-only deep interflow zone with shallower groundwater that is essentially the same as that pumped from the Stillman well. Mixing is likely occurring within or near the Byers Avenue wellbore.

The equilibration of the Byers groundwater with respect to sepiolite (a magnesium-silicate mineral) suggests that shallower, magnesium-rich groundwater, such as at Stillman, may be reacting with silica from the deeper Byers-only well interval to precipitate this mineral. Also, manganese was detected in the Byers groundwater (0.013 mg/L) but not in the Stillman sample. Manganese is typically one of the first metals released under low oxidizing conditions. This implies that manganese is originating from the deeper Byers-only interval, which has an Eh lower than that of the Stillman groundwater. The actual Eh of water from the deeper interflow is probably lower than the measured Eh from the Byers sample, which is representative of a mixture of the shallow and deep groundwaters.

Ammonia and nitrate concentrations for the Byers and Stillman groundwater samples are not appreciably different. However, the ammonia that originates from the deeper Byers-only interflow may be diluted by mixing with the significantly-lower ammonia in the shallower (Stillman) groundwater, while the converse may be true of the nitrate. The ammonia and nitrate nitrogen species respond to Eh in much the same way that metals do. Ammonia is typical of low-oxidizing to reduced aquifer conditions, while nitrate is restricted to oxidized aquifer conditions. Therefore, the higher ammonia and lower nitrate concentrations in the Byers groundwater sample, in addition to the low but detectable dissolved manganese concentration, indicates a low degree of oxidation in the deeper Byers-only interflow.

The phosphorous concentration in the Byers groundwater is almost an order of magnitude greater than in the Stillman groundwater (0.193 mg/L and 0.023 mg/L, respectively). This reflects the sodium-bicarbonate water type, with very low calcium concentration, of the Byers groundwater (Figure 5-1). The Stillman groundwater is a calcium-bicarbonate type. Calcium in groundwater tends to precipitate with orthophosphate to form the essentially-insoluble mineral apatite. Therefore, calcium in the Stillman groundwater likely reacted with phosphorous to form apatite, thus depleting the Stillman phosphorous concentration relative to that in the Byers groundwater. Groundwater from the Byers-only deeper interflow probably contains a higher total phosphorous concentration than that which was actually measured (Table 5 and Figure 5-1). Also, modeling results indicate that mixing between the two groundwaters will immediately result in the precipitation of calcium carbonate.

With continued pumping over extended periods, there may be considerable changes in the Byers well water chemistry compared to that of the Stillman well. This is because the Byers well is apparently producing water from two depth intervals which contribute discretely different groundwater chemistries. This water chemistry evaluation, coupled with observations made during the Stillman aquifer test, suggests that the deep interflow present only at Byers contributes a relatively significant volume of water to that well.

5.4 Compatibility of Projected Recharge Source Water and Receiving Groundwater

Based on the available water chemistry data and geochemical modeling (EQ3NR), the projected recharge source water and receiving groundwater do not appear to present any fatal flaws for ASR at the Pendleton site. However, trends in the recovered water chemistry will probably be complex.

The modeled mixtures of the projected recharge water and the Stillman and Byers groundwater types appear to provide some water quality benefits, and adverse chemical reactions do not appear likely. The low TDS, relatively aggressive and undersaturated recharge water will become more stable by mixing with the native groundwater types. As shown on Figures 5-1 and 5-2, the Stillman groundwater and the projected recharge source water are very similar chemically, the major difference being the relative concentrations of TDS. The modeling identified no apparent adverse chemical reactions likely to occur where the Stillman groundwater and the projected recharge water mix. For the Byers Avenue groundwater, modeling indicates that calcite is slightly undersaturated in a 50:50 mixture of the projected recharge water and native groundwater. Therefore, calcite should not precipitate when these two waters mix, but this depends on the representativeness of the Byers groundwater analysis.

Because it is so dilute (unbuffered), the recharge water may chemically react with the aquifer mineralogy and rapidly become similar to that of the respective native groundwaters (Stillman and Byers Avenue). The recharge water is an aggressive water and will tend to react to a slight degree with the more soluble minerals within the aquifer. In groundwater near the Stillman well, the recharge water will tend to dissolve calcium and convert carbon dioxide to alkalinity to approach calcite equilibrium. In groundwater near the Byers Avenue well, the recharge water will more likely retain more of a calcium-bicarbonate than a sodium-bicarbonate water chemistry type.

Potential chemical reactions between the projected recharge water and the basalt aquifer matrix are more important than those between the recharge water and the two distinct native groundwater types (Stillman and Byers). However, none of the potential reactions (water/water or water/aquifer matrix) are expected to present a fatal flaw to ASR at either the Stillman or Byers Avenue well locations.

5.5 Recovered Water Quality

No water quality issues or concerns are expected for water recovered from either the Stillman or Byers Avenue wells. The significant difference in the groundwater chemistry of the Byers well and the projected recharge water as shown on the trilinear diagram (Figure 5-1) will facilitate monitoring of the fraction of recharge water recovered from that well. Conversely, the Stillman groundwater and projected recharge water are chemically very similar.

Although there is potential for trace DPBs to form in the recharge source water as a result of normal chlorination practice, the native groundwater TOC concentration was about half that of the current drinking water, and thus additional formation of DBPs is not expected. Furthermore, previous studies and experience have shown that DBPs attenuate rapidly in the subsurface as they react with the aquifer matrix, and are commonly not present in recovered water samples.

5.6 Water Quality Summary and Conclusions

Based on the available water chemistry data and thermodynamic equilibrium modeling (EQ3NR) performed for this evaluation, the projected recharge water and the receiving groundwaters appear to be chemically compatible, and mixtures of the different waters do not appear to present any limitations for ASR at the Pendleton site. It is recommended that to fully evaluate the potential for geochemical reactions, storage time between recharge and recovery should be at least two days during the initial cycle and at least one-week during larger-volume ASR cycles. Because organic nitrogen and total organic carbon (TOC) will be present in the source water, and ammonia plus phosphorus concentrations are somewhat elevated in the native groundwater, a residual chlorine (or other appropriate disinfectant) of about 1 mg/l should be trickled into the well during idle periods to control/eliminate microbial activity in and near the well.

6 Recommendations for ASR Pilot Test Program Development

The ASR pilot test program at the City of Pendleton will utilize excess production capacity from the new WTP as recharge source water. Although the WTP may be expanded to provide additional capacity in the future, we recommend that the pilot testing program and ASR Limited License application encompass only the wells that can utilize the approximately 2,500 gpm of excess winter-spring capacity that will be available for the foreseeable future. If and when the WTP is expanded, an addendum to the Limited License can be requested and the pilot test workplan can be modified to accommodate additional pilot testing at the new well(s).

This document provides much of the information required for an ASR Limited License application, as described in OAR 690-350-020. Once approved, the ASR Limited License permits the applicant to conduct ASR pilot testing for a period of up to 5 years. However, there are two additional items that must be submitted to complete the application process: a Limited License application and an ASR Pilot Test Program. These documents will be submitted separately to minimize the amount of work required if changes to a license or test program become necessary. City staff will complete the application for a Limited License, and CH2M HILL will prepare the ASR Pilot Test Program to be attached to the Limited License application. Before the Limited License application can be submitted, a pre-application conference is required to be held with the Oregon state agencies (OWRD, DEQ, and OHD) to review the anticipated scope and schedule for the pilot test program. The Limited License application is a two-page form requiring general information such as:

- Name, address, and telephone number of the applicant.
- Date(s) of the pre-application conference(s).
- Source of the recharge water for ASR.
- Capacity of the ASR pilot testing program, including maximum diversion rate, recharge rates, storage volumes, storage durations, and withdrawal rates.
- The requested duration of the Limited License (5-year maximum).
- Proposed use or disposal of the recovered water.
- A contingency plan for disposal of stored water if it is not fit for the specified beneficial use.
- Ultimate capacity of the permanent ASR project to be permitted, including maximum diversion rate, recharge rates, storage volumes, storage durations, and withdrawal rates.
- Water availability or water right statement.
- Legal land use statement.

- Compliance with the OHD plan submission and review requirements (OAR 333-061-0060).

To provide the supplemental information required to accompany the application, the ASR Pilot Test Program will include:

- A description of the proposed source, maximum diversion rate, recharge rates, storage volumes, storage durations, withdrawal rates, and recharge schedule.
- A map showing the point of diversion, and the location of ASR pilot test and observation wells.
- Water-quality sampling plan including constituents, schedule, and a QA/QC plan.
- Water-level monitoring plan.
- Proposed system design information, including well construction information (all wells) and wellhead assembly and piping system for each ASR well.

The ASR Pilot Test Program will provide for a multi-well program, including ASR piloting at the Stillman well and the Byers Avenue well.

For a comprehensive description of the ASR pilot testing, please refer to the ASR Pilot Test Program for the City of Pendleton. After the first year of pilot testing has been completed, a technical memorandum describing Cycle 1 and 2 operations and results will be prepared and submitted to OWRD prior to beginning Cycle 3 (year 2). At the completion of the 5-year pilot period, a Pilot Test report will be prepared and submitted in support of the permanent ASR permit.

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TABLES

TABLE 2-1 CERTIFICATED WATER RIGHTS, CITY OF PENDLETON (REVISED 08/01)

Pendleton ASR Feasibility Study

Source	Certificate Number	Permit Number	Rate (cfs)	Priority Date	Description	Location	Comments	Production	Drawdown
SURFACE WATER	2604	D 2604 by decree	2.0	1885	Umatilla River	Just above the confluence with Wildhorse Creek. About RM 56.7.	Change of POD (RM 57.3) was requested with OWRD (12/00) and is being processed.	N/A	N/A
	2582	D 2582 by decree	0.5	1890	Umatilla River	Above the Round-Up Grounds. About RM 55.5.	Change of POD (RM 57.3), beneficial use, and place of use was requested with OWRD (03/01) and is being processed.	N/A	N/A
	3927	S 472	4.0	1910	Wenix Spring	About RM 73.5.	Secondary POD (RM 57.3) was requested with OWRD (04/01) and is being processed. Combined flow from Springs pass through Weir House at about RM 72.7. Gravity line capacity limited to 8.4 cfs (5.4 mgd) during Winter/Spring months. Water generally turned out due to water quality issues during Winter/Spring months. Gravity line monthly flow historically averages 3.85 cfs during Summer/Fall months. Lowest daily measured flow historically averages 2.85 cfs during Summer/Fall months.	Springs produce greater than 8.4 cfs during Winter/Spring months. Total flow produced not measured.	N/A
	7993	S 1197	3.0	1912	Shaplish Spring	About RM 75.2.			
	8052	S 9007	2.7	1929	Simon Spring	About RM 76.0.			
	8051	S 9006	2.0	1929	Longhair Spring	About RM 78.0.			
		ORS 538.450	All Water	1941	North Fork Umatilla River	RM 57.3 (new intake site located just east of the City limits on the Umatilla River)	New POD and Anotice of intent@ language established by legislation amending ORS 538.450 and becoming effective 01/02. Signed MOA with the CTUIR incorporated into amended ORS 538.450.	New POD limited to 23.3 cfs.	N/A
GROUNDWATER	20838	U 152	3.1	1944	Well # 1	(Byers Well) SE Byers & SE 18th.	Floor elev. 1093.08-ft. Well depth: 774-ft. 250 hp, 16-stage 10QKH bowls, 270-feet 10-inch column, 40-feet 8-inch column, and two SS access tubes (installed 06/01). TDH - 555-feet.	1300 gpm to 1370 gpm	Summer: 32-feet w/SC about 42 gpm/ft.
	46096	G 2204	0.9	1962					
	20840	U 579	2.51	1953	Well #2	(Round-Up Well) Roy Raley Park near SW 10th (bridge).	Floor elev. 1053.14-ft. Well depth: 761-feet. 350 hp, 5-stage 14HC bowls, and 340-feet 10-inch column (bowls set 06/99). Flow throttled down to reduce air entrainment. TDH - 580-ft (normal production).	Throttled: about 1250 gpm. Normal: about 1800 gpm	Summer: 19-feet w/SC about 66 gpm/ft @ 1250 gpm. 43-feet w/SC about 42 gpm/ft @ 1800 gpm
	46095	G 2203	3.1	1962					
	20839	U 418	1.11	1951	Well #3	(SW 21st Street Well) SW Hailey & SW 21st.	Floor elev. 1061.84-ft. Well depth: 1009-ft. 100 hp, 15-stage 10MA bowls, and 290-feet 8-inch column. TDH - 595-ft.	500 gpm to 600 gpm.	Summer: 65-feet w/SC about 8.5 gpm/ft.
	46094	G 2202	0.2	1962					
	23741	U 670	2.0	1954	Well #4	(Hospital Well) EOCI parking lot across from NW Carden.	Floor elev. 1047.59-ft. Well depth: 852-ft. 125 hp, 8-stage 12M75 bowls, and 240-feet 8-inch column (installed 07/99). TDH - ___-feet.	750 gpm to 850 gpm	Summer: 27-feet w/SC about 30 gpm/ft.
	29147	G 1160	5.3	1958	Well #5	(Stillman Well) Stillman Park on SE 5th.	Floor elev. 1070.73-ft. Well depth: 700-ft. 400 hp, 6-stage 14RM bowls, and 370-feet of 12-inch column (installed 06/01). TDH - 575-feet.	2100 gpm to 2300 gpm	Summer: 48-feet w/SC about 46 gpm/ft.

TABLE 2-2 PERMITTED WATER RIGHTS, CITY OF PENDLETON – (REVISED 08/01)

Pendleton ASR Feasibility Study Permitted Water Rights - Revised 08/01

Source	File Number	Permit Number	Rate (cfs)	Priority Date	Description	Location	Comments	Production	Drawdown
SURFACE WATER	S1069	458	8.0	1910	North Fork Umatilla River	Mouth of the North Fork Umatilla River	Permit amendment for change of POD (RM 57.3) requested with OWRD (02/01) and is being processed.	N/A	N/A
GROUNDWATER	G2463	G2410	Total not to exceed 20 cfs (6.7 cfs each)	1962	Well #6	(Sherwood Well) SW 37th & north of SW Hailey	Monitoring well only. Ground surface about 1075-ft. Well depth: 1501-ft.	N/A	N/A
				1962	Well #9	(South Hill Well)	undeveloped	N/A	N/A
				1962	Well #10	(Crispin Well)	undeveloped	N/A	N/A
				1962	Well #12	(McCormack Well)	undeveloped	N/A	N/A
				1962	Well #14	(West End or Hell Well) Intersection of Rieth Road & Murietta Road	Well house construction to be completed by Winter 2002. Expected production capacity - 1500 gpm (130 psi) and fire flow - 2000 gpm (40 psi). * Note: G3044 & G465 are certificated rights from the old Brogoitti Well. The tranfer (T8434) is in process with OWRD and a protest filed by Rieth Water District. The contested case hearing has yet to be scheduled.	Pump test (01/01): 1000 gpm. To be developed for 1500 gpm.	1000 gpm: 60-ft w/SC about 16 gpm/ft. Extrapolated 1500 gpm: 135-ft w/SC about 11 gpm/ft.
	40893	G3044*	1.33	1965					
	28602	G465*	1.21	1957					
	G3443	G3225	6.7	1966	Well #7	(Mission Well) 2 mile SE of Cayuse Road & Mission Hwy	Floor elev: 1464.10-ft. Well depth: 800-ft. 60 hp, 8-stage 10M41 bowls, and 435-feet of 8-inch column (installed 10/91). TDH - 300-feet.	300 gpm to 500 gpm	Summer: 124-ft w/SC about 2.5 gpm/ft.
			6.7	1966	Well #11	(WWTP or McKay Creek Well) End of 28th Drive at the WWTP.	Top of well casing elev: 1007.31-ft. Well depth: 357-ft. Used for domestic use at WWTP and a neighbor. 7.5 hp submersible pump.	500 gpm (pump test - 08/96)	Pump test: 9-ft w/SC about 55 gpm/ft.
	Transfer 5605	G6773	1.52	1976	Well #8	(Prison Well) Back of EOCI near the guard gate.	Floor elev. 1027.38-ft. Well depth: 500-ft. 200 hp, 16-stage 10BKH bowls, and 265-feet of 8-inch column (installed 07/88). TDH: 700-ft.	1200 gpm to 1300 gpm	Summer: 12-ft w/SC about 104 gpm/ft.
	G11326	G10508	5.18	1984					

Table 2-3 OBSERVATION WELL SUMMARY

Pendleton ASR Feasibility Study

Well / Owner	OWRD Well Log ID	Well Usage	Distance from Stillman Well (ft)	Approx. Ground Surface Elev. (ft msl)	Well Depth (ft)	Approx. Water Level Elev. (ft msl)
Byers Avenue (Well No. 1) / City of Pendleton	UMAT 531	Municipal	4,120	1093	774	815-820
Round-Up (Well No. 2) / City of Pendleton	UMAT 53635	Municipal	3,950	1053	761	815-820
SW 21st St (Well No. 3) / City of Pendleton	UMAT 53636	Municipal	7,200	1062	1009	760
Hospital (Well No. 4) / City of Pendleton	Not on record	Municipal	7,600	1048	852	815-820
Stillman (Well No. 5) / City of Pendleton	UMAT 530	Municipal	NA	1071	700	815-820
Sherwood (Well No. 6) / City of Pendleton	Not on record	Observation only	11,500	1065	1500	815-820
WWTP (Well No. 11) / City of Pendleton	UMAT 512	Municipal (WWTP only)	13,100	1006	357	815-820
Dallas Well / Dave Dallas	UMAT 50667	Private (domestic)	21,000	1575	538	1405
Rosenberg Well / Jim Rosenberg	UMAT 5329	Private (domestic)	4,270	1340	700	990-1000
Blue Mtn Community College / BMCC	UMAT 533	Private (irrigation)	8,700	1,165	600	990-1000
Wood Well / Duane Wood	UMAT 6304 / 53588	Private (domestic)	8,300	1,110	825	815-820
Hyatt Well / Clifford Hyatt	UMAT 50514	Private (domestic)	15,800	1,155	522	815-820

TABLE 3-1 OBSERVATION WELLS – EARLIEST RESPONSE TIME AND MAXIMUM DRAWDOWN

Observation Well	Distance from Pumping Well	Earliest Observed Response Time	Maximum Drawdown
Round-Up Well	3,950 ft	1 min	3.01 ft
Byers Avenue Well	4,120 ft	15 mins	0.80 ft
Hospital Well	7,600 ft	Approximately 46 mins	0.41 ft
Wood Well	8,300 ft	Approximately 107 mins	0.85 ft (estimated)
SW 21st Street Well	7,200 ft	Uncertain	0.41 ft (estimated)
Sherwood Well	11,500 ft	Between 524 and 1397 mins	0.17 ft
WWTP Well	13,100 ft	N/A	N/A
Hyatt Well	15,800 ft	Uncertain	Uncertain

TABLE 3-2 ESTIMATED AQUIFER PARAMETERS

Stillman (Pumping) Well		
Data Source	**Early-Time Transmissivity**	**Late-Time Transmissivity**
Pumping	264,000 gpd/ft	N/A
Recovery	406,000 gpd/ft	960,000 gpd/ft
Average	335,000 gpd/ft	960,000 gpd/ft

Observation Wells		
Data Source	**Late-time Transmissivity**	**Storativity**
Byers pumping	1,148,000 gpd/ft	3.3×10^{-4}
Byers recovery	2,514,000 gpd/ft	N/A
Average	1,831,000 gpd/ft	3.3×10^{-4}
Round-Up pumping	361,600 gpd/ft	7.3×10^{-5}
Round-Up recovery	409,300 gpd/ft	N/A
Average	385,500 gpd/ft	7.3×10^{-5}

Table 5 - City of Pendleton ASR Feasiblity Study - Water Quality Parameters

INORGANIC PARAMETERS							
Analyte	MDL	MCL	STILLMAN WELL (Native Groundwater[1], 11/00)	BYERS WELL (Native Groundwater[3,4])	Projected WTP Recharge (Source) Water[2]	UMATILLA RIVER[1] (at proposed WTP Intake, 11/00)	CURRENT DRINKING WATER[1] (City Shop, 11/00)
Alkalinity (as CaCO3) *(mg/L)*			111	133	34	32.1	57.1
Aluminum *(mg/L)*	0.005		ND	0.021	0.18	ND	ND
Ammonia *(mg/L)*	0.05		0.069	0.300	0.070	ND	ND
Antimony *(mg/L)*	0.003	0.006	ND	ND	0	ND	ND
Arsenic *(mg/L)*	0.01	0.05	ND	ND	0	ND	ND
Barium *(mg/L)*		2.0	0.21	ND	0	0.149	1.25
Beryllium *(mg/L)*	0.0002	0.004	ND	ND	0	ND	ND
Bicarbonate (as CaCO3) *(mg/L)*			138	151	41	38.7	71.7
Cadmium *(mg/L)*	0.001	0.005	ND	ND	0	ND	ND
Calcium *(mg/L)*			42.2	13.1	7.1	9.06	12.8
Carbonate (as CaCO3) *(mg/L)*	3		ND	ND	--	ND	ND
Chloride *(mg/L)*			9.28	23.5	2.4	1.89	2.82
Chromium *(mg/L)*	0.02	0.1	ND	ND	0	ND	ND
Color *(color units)*	5		ND	ND	8	ND	ND
Copper *(mg/L)*	0.01		ND	ND	0	ND	ND
Corrosivity *(SI)*			-0.57	-1.38	--	-1.4	-2.1
Cyanide *(mg/L)*	0.02	0.2	ND	ND	--	ND	ND
Fluoride *(mg/L)*		4.0	0.39	0.79	0	0.1	0.11
Hardness (as CaCO3) *(mg/L)*			94.0	42.4	32.0	31	62.4
Iron (Total) *(mg/L)*	0.02		ND	ND	0.78	0.05	0.227
Iron (Dissolved) *(mg/L)*	0.02		--	--	0.13	--	--
Lead *(mg/L)*	0.002	0.015	ND	ND	0	ND	ND
Magnesium *(mg/L)*			7.76	2.36	2.7	3.16	4.64
Manganese (Total) *(mg/L)*	0.01		ND	0.014	0.01	ND	ND
Manganese (Dissolved) *(mg/L)*	0.01		--	0.013	0.006	--	--
Mercury *(mg/L)*	0.001	0.002	ND	ND	--	ND	ND
MBAS *(mg/L as LA)*	0.02		ND	ND	--	0.062	ND
Nickel *(mg/L)*	0.02	0.1	ND	ND	0	ND	ND
Nitrate (as N) *(mg/L)*	0.1	10.0	1.09	0.28	0.11	ND	0.57
Nitrite (as N) *(mg/L)*	0.01	1.0	0.022	ND	0.02	ND	ND
Nitrate+Nitrite (as N) *(mg/L)*	0.1	10.0	1.11	0.28	0.006	ND	0.57
Total Kjedahl Nitrogen (TKN)			--	--	0.27	--	--
Odor *(TON)*			4.0	ND	--	3.0	2.0
Phosphorus (Total) *(mg/L)*			0.023	0.193	0.05	0.023	0.045
Potassium *(mg/L)*			5.78	9.23	2	1.85	2.44
Selenium *(mg/L)*	0.003	0.05	ND	ND	0	ND	ND
Silica *(mg/L)*			50.4	61.0	32.0	29.8	40.2
Silver *(mg/L)*	0.01		ND	ND	0	ND	ND
Sodium *(mg/L)*			29.7	52.5	4.7	5.74	5.41
Sulfate *(mg/L)*			16.7	29.9	1.8	1.81	1.71
Thallium *(mg/L)*	0.001	0.002	ND	ND	0	ND	ND
Total Dissolved Solids *(mg/L)*			210	225	76	80.0	87.0
Turbidity *(NTU)*			0.53	0.19	0.03	2.32	2.66
Zinc *(mg/L)*	0.02	--	ND	ND	0	ND	ND

Notes:

1 - Analytical results of 11/20/2000 sample
2 -Based on WTP Membrane Pilot Study data
3 - All except silica from 12/04/01 sample
4 - Silica from 02/25/02 sample

mg/L : milligrams per liter
µS/cm : micro-Siemen/centimeter
mV : millivolt
NTU : nephelometric turbidity unit

ND : Not Detected at MDL
NA : Not Applicable
MDL : Method Detection Limit
MCL : Maximum Contaminant Level

Table 5 - City of Pendleton ASR Feasiblity Study - Water Quality Parameters

Field Parameter or Analyte	MDL	MCL	STILLMAN WELL (Native Groundwater[1], 11/00)	BYERS WELL (Native Groundwater[3]	Projected WTP Recharge (Source) Water[2]	UMATILLA RIVER[1] (at proposed WTP intake, 11/00)	CURRENT DRINKING WATER[1] (City Shop,11/00)
FIELD PARAMETERS							
Specific Conductance (*μ mho/cm*)		<500	312	413	79	85	110
Dissolved Oxygen (*mg/L*)			6.3	2.69	9.3	11.4	8.4
Eh(*mV*)			500	416	600	510	600
pH (*pH units*)		6.5-8.5	7.8	8.4	6.7	7.5	6.4
Temperature (deg C)			19.0	18.9	14.2	--	--
DISINFECTION BY-PRODUCTS							
Chloroform (*mg/L*)	0.0005		0.0030	ND	NA	ND	0.0133
Bromodichloromethane (*mg/L*)	0.0005		0.0029	ND	NA	ND	0.0029
Dibromochloromethane (*mg/L*)	0.0005		0.0025	ND	NA	ND	ND
Bromoform (*mg/L*)	0.0005		0.0009	ND	NA	ND	ND
Total Trihalomethanes (*mg/L*)		0.080	0.0093	ND	NA	ND	0.0162
Monochloroacetic Acid (*mg/L*)			--	ND	NA	--	--
Dichloroacetic Acid (*mg/L*)			--	ND	NA	--	--
Trichloroacetic Acid (*mg/L*)			--	ND	NA	--	--
Monobromoacetic Acid (*mg/L*)			--	ND	NA	--	--
Dibromoacetic Acid (*mg/L*)			--	ND	NA	--	--
Haloacetic Acids (HAA-5) (*mg/L*)		0.060	--	ND	NA	--	--
MISCELLANEOUS							
Radon (*pCi/L*)			143 +/- 21	--	NA	35 +/- 19	75 +/- 20
Asbestos (*MFL*)		7 MFL	ND	ND	NA	ND	ND
Total Organic Carbon (*mg/L*)			1	0.72	2.2	2	1.9
Hydrogen Sulfide (*mg/L*)	0.1000		ND	--	NA	ND	ND

Notes:
1 - Analytical results of 11/20/2000 sample
2 -Based on WTP Membrane Pilot Study data
3 - Analytical results of 12/04/01 sample
MDL : Method Detection Limit
MCL : Maximum Contaminant Level

mg/L : milligrams per liter
μS/cm : micro-Siemen/centimeter
mV : millivolt
NTU : nephelometric turbidity unit

ND : Not Detected at MDL
NA : Not Applicable
-- : not analyzed

Table 5 - City of Pendleton ASR Feasiblity Study - Water Quality Parameters

SYNTHETIC ORGANIC CHEMICALS (SOCs) - Regulated							
Analyte	MDL	MCL	STILLMAN WELL (Native Groundwater[1], 11/00)	BYERS WELL (Native Groundwater[3]	Projected WTP Recharge (Source) Water[2]	UMATILLA RIVER[1] (at proposed WTP intake, 11/00)	CURRENT DRINKING WATER[1] (City Shop,11/00)
2,4-D *(mg/L)*	0.0002	0.07	ND	ND	NA	ND	ND
2,4,5-TP (Silvex) *(mg/L)*	0.0004	0.05	ND	ND	NA	ND	ND
Adipates *(mg/L)*	0.001	0.4	ND	ND	NA	ND	ND
Alachlor (Lasso) *(mg/L)*	0.0004	0.002	ND	ND	NA	ND	ND
Atrazine *(mg/L)*	0.0002	0.003	ND	ND	NA	ND	ND
Benzo(a)pyrene *(mg/L)*	0.00004	0.0002	ND	ND	NA	ND	ND
BHC-gamma (Lindane) *(mg/L)*	0.00002	0.0002	ND	ND	NA	ND	ND
Carbofuran *(mg/L)*	0.001	0.04	ND	ND	NA	ND	ND
Chlordane *(mgL)*	0.0004	0.002	ND	ND	NA	ND	ND
Dalapon *(mg/L)*	0.002	0.2	ND	ND	NA	ND	ND
Dibromochloropropane (DBCP) *(mg/L)*	0.00002	0.0002	ND	ND	NA	ND	ND
Dinoseb *(mg/L)*	0.0004	0.007	ND	ND	NA	ND	ND
Diquat *(mg/L)*	0.0004	0.02	ND	ND	NA	ND	ND
Endothall *(mg/L)*	0.01	0.1	ND	ND	NA	ND	ND
Endrin *(mg/L)*	0.00002	0.002	ND	ND	NA	ND	ND
Ethylene dibromide (EDB) *(mg/L)*	0.00001	5E-05	ND	ND	NA	ND	ND
Glyphosate *(mg/L)*	0.01	0.7	ND	ND	NA	ND	ND
Heptachlor epoxide *(mg/L)*	0.00002	0.0002	ND	ND	NA	ND	ND
Heptachlor *(mg/L)*	0.00004	0.0004	ND	ND	NA	ND	ND
Hexachlorobenzene *(mg/L)*	0.0001	0.001	ND	ND	NA	ND	ND
Hexachlorocyclopentadiene *(mg/L)*	0.0002	0.05	ND	ND	NA	ND	ND
Methoxychlor *(mg/L)*	0.0002	0.04	ND	ND	NA	ND	ND
Pentachlorophenol *(mg/L)*	0.00008	0.001	ND	ND	NA	ND	ND
Phthalates *(mg/L)*	0.001	0.006	0.0022	ND	NA	ND	ND
Picloram *(mg/L)*	0.0002	0.5	ND	ND	NA	ND	ND
Polychlorinatedbiphenyls - PCBs *(mg/L)*	0.0002	0.0005	ND	ND	NA	ND	ND
Simazene *(mg/L)*	0.0001	0.004	ND	ND	NA	ND	ND
Toxaphene *(mg/L)*	0.001	0.003	ND	ND	NA	ND	ND
Vydate (Oxamyl) *(mg/L)*	0.002	0.2	ND	ND	NA	ND	ND

Notes:
1 - Analytical results of 11/20/2000 sample
2 -Based on WTP Membrane Pilot Study da
3 - Analytical results of 08/14/01 sample
MDL : Method Detection Limit
MCL : Maximum Contaminant Level

mg/L : milligrams per liter
µS/cm : micro-Siemen/centimeter
mV : millivolt

ND : Not Detected at MDL
NA : Not Applicable
-- : not analyzed

Table 5 - City of Pendleton ASR Feasiblity Study - Water Quality Parameters

Analyte	MDL	MCL	STILLMAN WELL (Native Groundwater[1], 11/00)	BYERS WELL (Native Groundwater)	Projected WTP Recharge (Source) Water[2]	UMATILLA RIVER[1] (at proposed WTP intake, 11/00)	CURRENT DRINKING WATER[1] (City Shop,11/00)
SYNTHETIC ORGANIC CHEMICALS (SOCs) - Unregulated							
3-Hydroxycarbofuran *(mg/L)*	0.004	--	ND	--[3]	NA	ND	ND
Aldicarb *(mg/L)*	0.002	--	ND	--[3]	NA	ND	ND
Aldicarb sulfoxide *(mg/L)*	0.003	--	ND	--[3]	NA	ND	ND
Aldicarb sulfone *(mg/L)*	0.001	--	ND	--[3]	NA	ND	ND
Aldrin *(mg/L)*	0.0001	--	ND	--[3]	NA	ND	ND
Butachlor *(mg/L)*	0.001	--	ND	--[3]	NA	ND	ND
Carbaryl *(mg/L)*	0.004	--	ND	--[3]	NA	ND	ND
Dicamba *(mg/L)*	0.0005	--	ND	--[3]	NA	ND	ND
Dieldrin *(mg/L)*	0.0001	--	ND	--[3]	NA	ND	ND
Methomyl *(mg/L)*	0.004	--	ND	--[3]	NA	ND	ND
Metolachlor *(mg/L)*	0.002	--	ND	--[3]	NA	ND	ND
Metribuzin *(mg/L)*	0.001	--	ND	--[3]	NA	ND	ND
Propachlor *(mg/L)*	0.001	--	ND	--[3]	NA	ND	ND
UNREGULATED CONTAMINANT MONITORING RULE - LIST 1[3]							
Perchlorate *(mg/L)*	0.005	--	--[3]	ND[4]	NA	--[3]	--[3]
DCPA-mono acid *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
DCPA-di acid *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
Methyl-tert Butyl Ether (MTBE) *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
Nitrobenzene *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
2,4-Dinitrotoluene *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
2,6-Dinitrotoluene *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
Acetochlor *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
4,4'-DDE *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
EPTC *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
Molinate *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]
Terbacil *(mg/L)*	0.001	--	--[3]	ND[4]	NA	--[3]	--[3]

Notes:

1 - Analytical results of 11/20/2000 sample
2 -Based on WTP Membrane Pilot Study dat
3 - see explanation in text
4 - Analytical results from 02/26/02
MDL : Method Detection Limit
MCL : Maximum Contaminant Level

mg/L : milligrams per liter
µS/cm : micro-Siemen/centimeter
mV : millivolt

ND : Not Detected at MDL
NA : Not Applicable
-- : not analyzed

Table 5 - City of Pendleton ASR Feasiblity Study - Water Quality Parameters

Analyte	MDL	MCL	STILLMAN WELL (Native Groundwater[1], 11/00)	BYERS WELL (Native Groundwater)	Projected WTP Recharge (Source) Water[2]	UMATILLA RIVER[1] (at proposed WTP Intake, 11/00)	CURRENT DRINKING WATER[1] (City Shop,11/00)
VOLATILE ORGANIC CHEMICALS (VOCs) - Regulated							
1,1-Dichloroethylene *(mg/L)*	0.0005	0.007	ND	ND[3]	NA	ND	ND
1,1,1-Trichloroethane *(mg/L)*	0.0005	0.2	ND	ND[3]	NA	ND	ND
1,1,2-Trichloroethane *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
1,2-Dichloroethane *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
1,2-Dichloropropane *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
1,2,4-Trichlorobenzene *(mg/L)*	0.0005	0.07	ND	ND[3]	NA	ND	ND
1,2-Dichlorobenzene *(mg/L)*	0.0005	0.6	ND	ND[3]	NA	ND	ND
1,4-Dichlorobenzene *(mg/L)*	0.0005	0.075	ND	ND[3]	NA	ND	ND
Benzene *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
Carbon tetrachloride *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
Chlorobenzene *(mg/L)*	0.0005	0.1	ND	ND[3]	NA	ND	ND
cis-1,2-Dichloroethylene *(mg/L)*	0.0005	0.07	ND	ND[3]	NA	ND	ND
Ethylbenzene *(mg/L)*	0.0005	0.7	ND	ND[3]	NA	ND	ND
Methylene chloride *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
Styrene *(mg/L)*	0.0005	0.1	ND	ND[3]	NA	ND	ND
Tetrachloroethylene *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
Toluene *(mg/L)*	0.0005	1.0	ND	ND[3]	NA	ND	ND
Total Xylenes *(mg/L)*	0.0005	10.0	ND	ND[3]	NA	ND	ND
trans-1,2-Dichloroethylene *(mg/L)*	0.0005	0.1	ND	ND[3]	NA	ND	ND
Trichloroethylene *(mg/L)*	0.0005	0.005	ND	ND[3]	NA	ND	ND
Vinyl chloride *(mg/L)*	0.0005	0.002	ND	ND[3]	NA	ND	ND
VOLATILE ORGANIC CHEMICALS (VOCs) - Unregulated							
Chloroform *(mg/L)*	0.0005	--	0.0025	ND[4]	NA	ND	0.0130
Bromodichloromethane *(mg/L)*	0.0005	--	0.0023	ND[4]	NA	ND	0.0030
Dibromochloromethane *(mg/L)*	0.0005	--	0.0025	ND[4]	NA	ND	ND
Bromoform *(mg/L)*	0.0005	--	0.0006	ND[4]	NA	ND	ND
Chloromethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
Bromomethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
Chloroethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
2,2-Dichloropropane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,1-Dichloropropene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,1-Dichloroethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
Dibromomethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
cis-1,3-Dichloropropene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
trans-1,3-Dichloropropene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,3-Dichloropropane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,1,1,2-Tetrachloroethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,1,2,2-Tetrachloroethane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,2,3-Trichloropropane *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
Bromobenzene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
2-Chlorotoluene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
4-Chlorotoluene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND
1,3-Dichlorobenzene *(mg/L)*	0.0005	--	ND	--[5]	NA	ND	ND

Notes:
1 - Analytical results of 11/20/2000 sample
2 -Based on WTP Membrane Pilot Study data
3 - Analytical results of 08/14/01 sample
4 - Analytical results of 12/04/01 sample
5 - not required; see text
mg/L : milligrams per liter
µS/cm : micro-Siemen/centimeter
mV : millivolt
MDL : Method Detection Limit
MCL : Maximum Contaminant Level
ND : Not Detected at MDL
NA : Not Applicable
-- : not analyzed

FIGURES

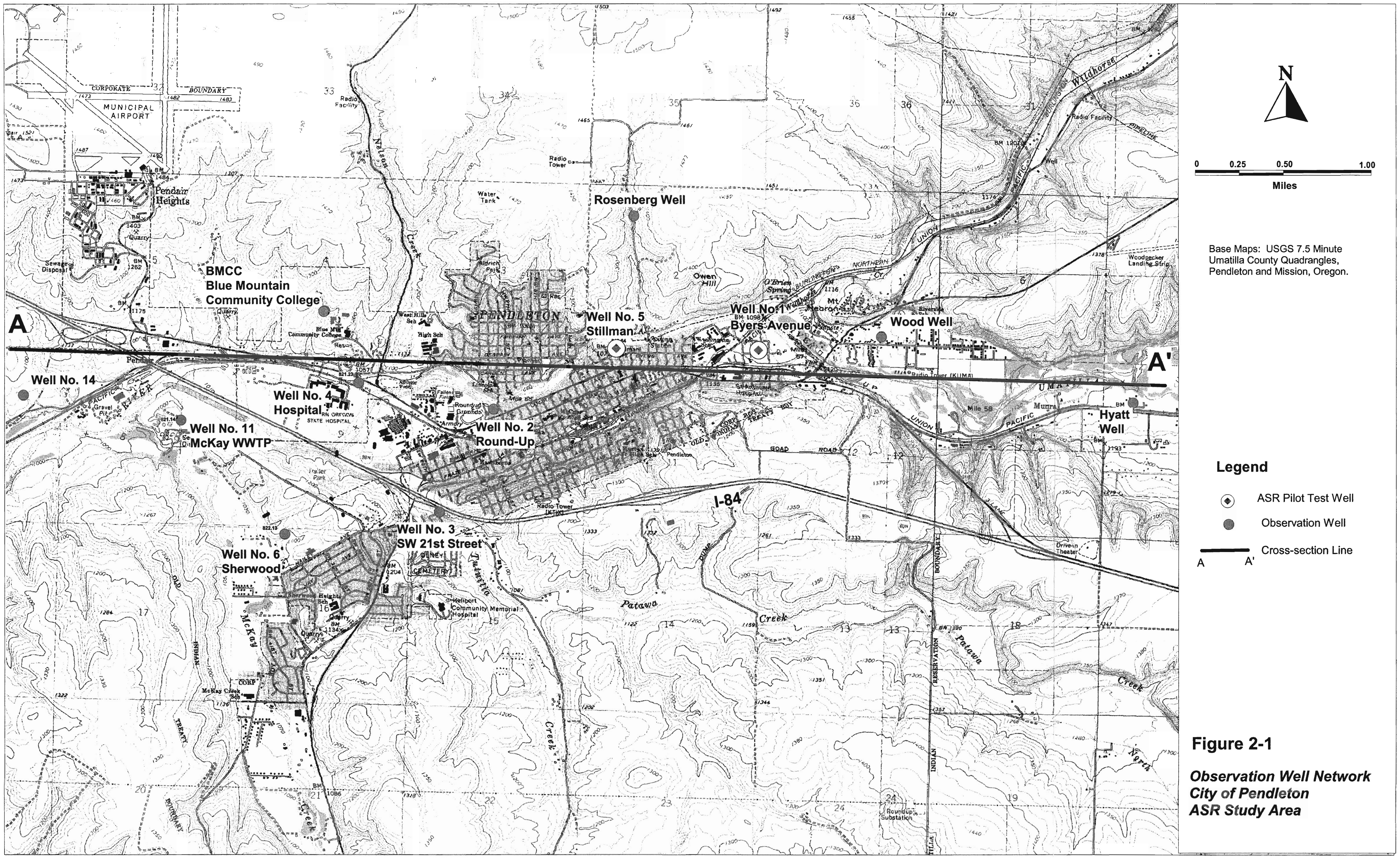
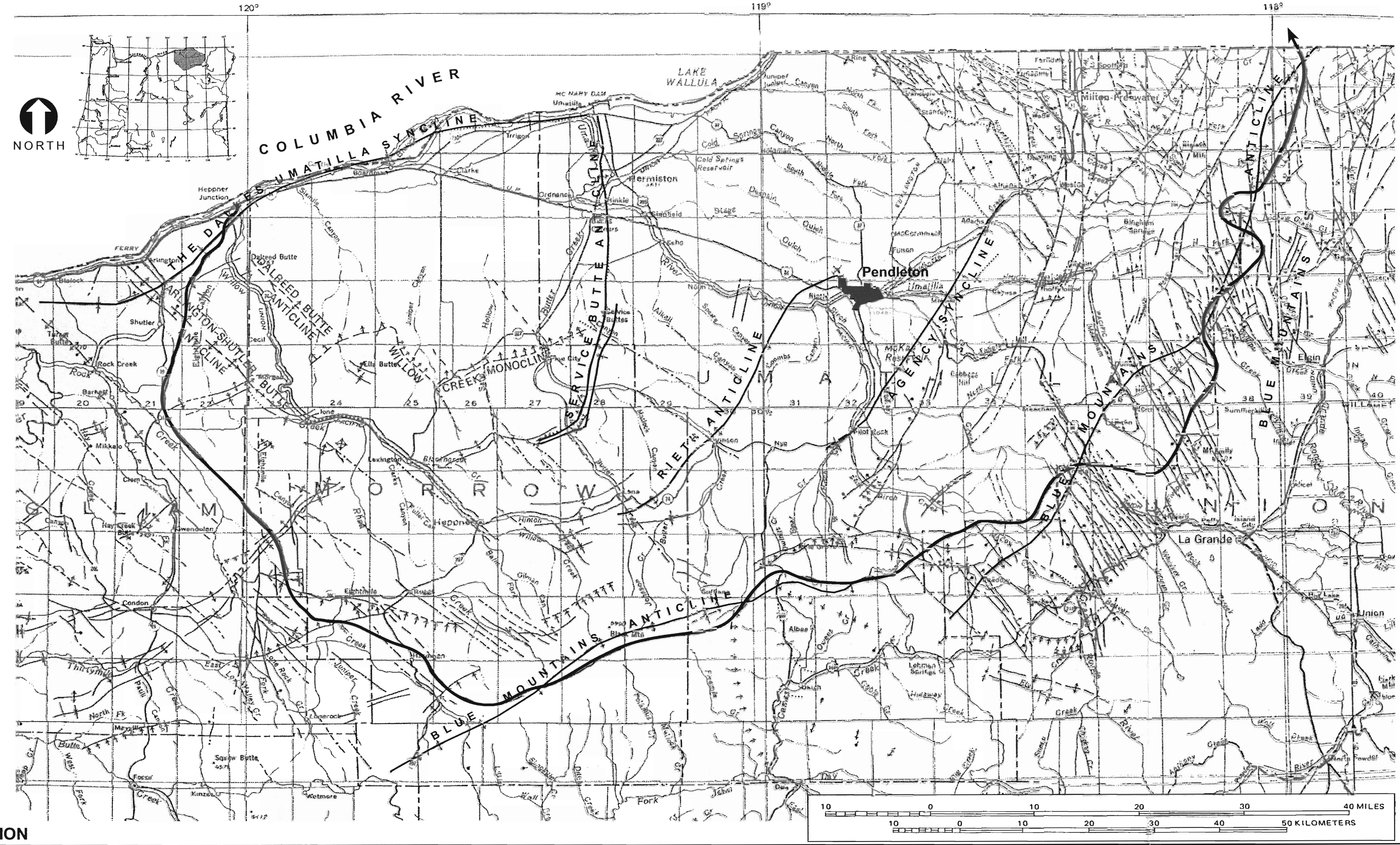


Figure 2-1

Observation Well Network
City of Pendleton
ASR Study Area



EXPLANATION

UMATILLA RIVER BASIN

FAULT — *Dashed where appropriately located; dotted where concealed*

- High-angle fault; bar and ball on downthrown side
- Thrust fault; sawteeth on upper plate
- Strike-slip fault; showing indeterminate relative horizontal movement
- Oblique-slip fault; showing relative horizontal and vertical movement. Bar and ball on downthrown side

FOLD — *Shows direction of plunge if any; dashed where approximately located; dotted where concealed*

- Crestline of upright anticline
- Troughline of syncline

MONOCLINE — *Dashed where approximately located; dotted where concealed*

- Abrupt increase of dip in direction of arrows
- Abrupt decrease of dip in direction of arrows

LINEAMENT — *Prominent photo or topographic lineament; possibly a strike-slip fault*

CH2MHILL

FIGURE 2-2
Map of the Umatilla River Basin, Oregon, showing structural features of the Columbia River Basalt (from Gonthier, 1990)

CITY OF PENDLETON
ASR HYDROGEOLOGIC FEASIBILITY STUDY

Deschutes-Columbia Plateau

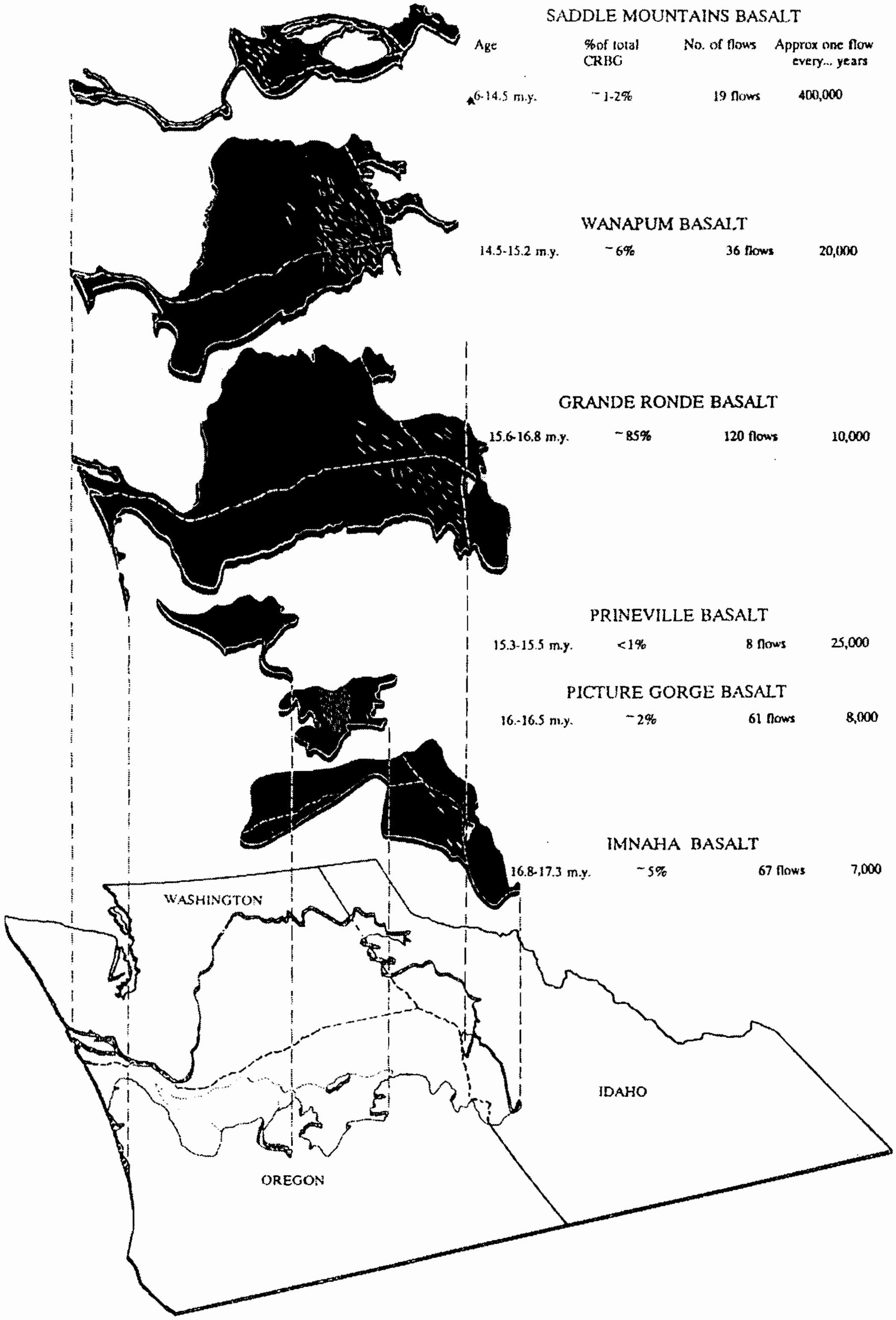


Figure 2-3

CH2MHILL

Distribution of basalt formations within the Columbia River Group (from Orr & Orr, 1999; after Beeson and Moran, 1979; Beeson Tolan, and Anderson, 1989)

GEOLOGIC FRAMEWORK: BASALT STRATIGRAPHY						GEOLOGIC FRAMEWORK: SEDIMENT STRATIGRAPHY	HYDROLOGIC FRAMEWORK: STUDY UNIT	
						Sediments of Miocene through Holocene age (glaciofluvial, fluvial, lacustrine, eolian, and ash fall materials). Locally includes sediments of the Palouse, Latah, Ringold, and Ellensburg Formations, and the Dalles Group (Farooqui and others, 1981).	Columbia Plateau Aquifer System	Overburden aquifer
MIOCENE: Upper Miocene, Middle Miocene	COLUMBIA RIVER BASALT GROUP	YAKIMA BASALT SUBGROUP	Saddle Mountains Basalt	Lower Monumental Member Ice Harbor Member Buford Member Elephant Mountain Member Pomona Member Esquatzel Member Weissenfels Ridge Member Asotin Member Wilbur Creek Member Umatilla Member			Columbia Plateau Aquifer System	Saddle Mountains unit
						Saddle Mountains–Wanapum Interbed	Columbia Plateau Aquifer System	Confining unit
MIOCENE: Middle Miocene	COLUMBIA RIVER BASALT GROUP	YAKIMA BASALT SUBGROUP	Wanapum Basalt	Priest Rapids Member Roza Member Frenchman Springs Member Eckler Mountain Member			Columbia Plateau Aquifer System	Wanapum unit
						Wanapum–Grande Ronde Interbed	Columbia Plateau Aquifer System	Confining unit
MIOCENE: Middle Miocene, Lower Miocene	COLUMBIA RIVER BASALT GROUP	YAKIMA BASALT SUBGROUP	Grande Ronde Basalt		Magnetostratigraphic Units: N_2, R_2, N_1, R_1, T, N_0, R_0		Columbia Plateau Aquifer System	Grande Ronde unit
MIOCENE: Lower Miocene	COLUMBIA RIVER BASALT GROUP	Picture Gorge Basalt					Columbia Plateau Aquifer System	Grande Ronde unit
MIOCENE: Lower Miocene	COLUMBIA RIVER BASALT GROUP	Imnaha Basalt					Columbia Plateau Aquifer System	Grande Ronde unit
Lower Tertiary to Precambrian	Basement rocks (pre–Columbia River Basalt Group)						Basement confining unit	

W072001002 PDX 159167.GW.P1 7.2.1 dw

Figure 2-4

Correlation of geologic framework with hydrologic framework. (From Gonthier, 1990)

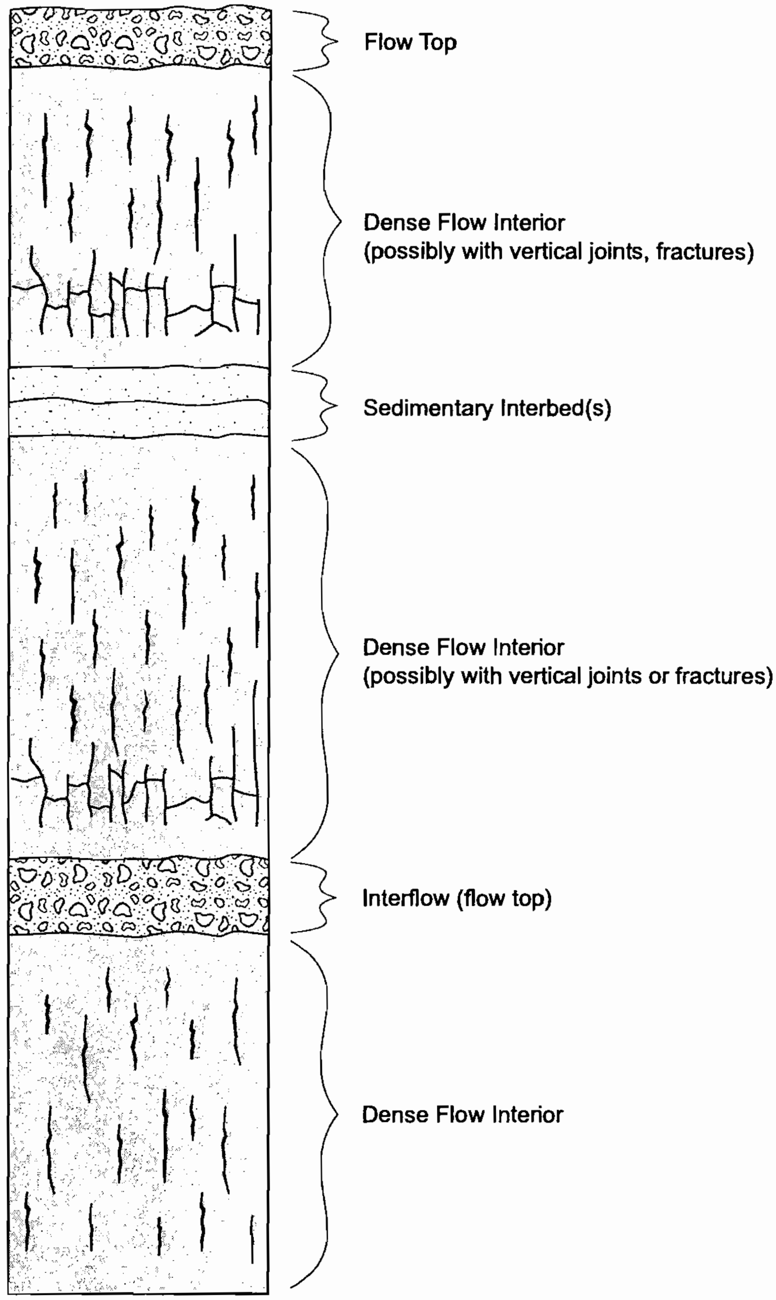
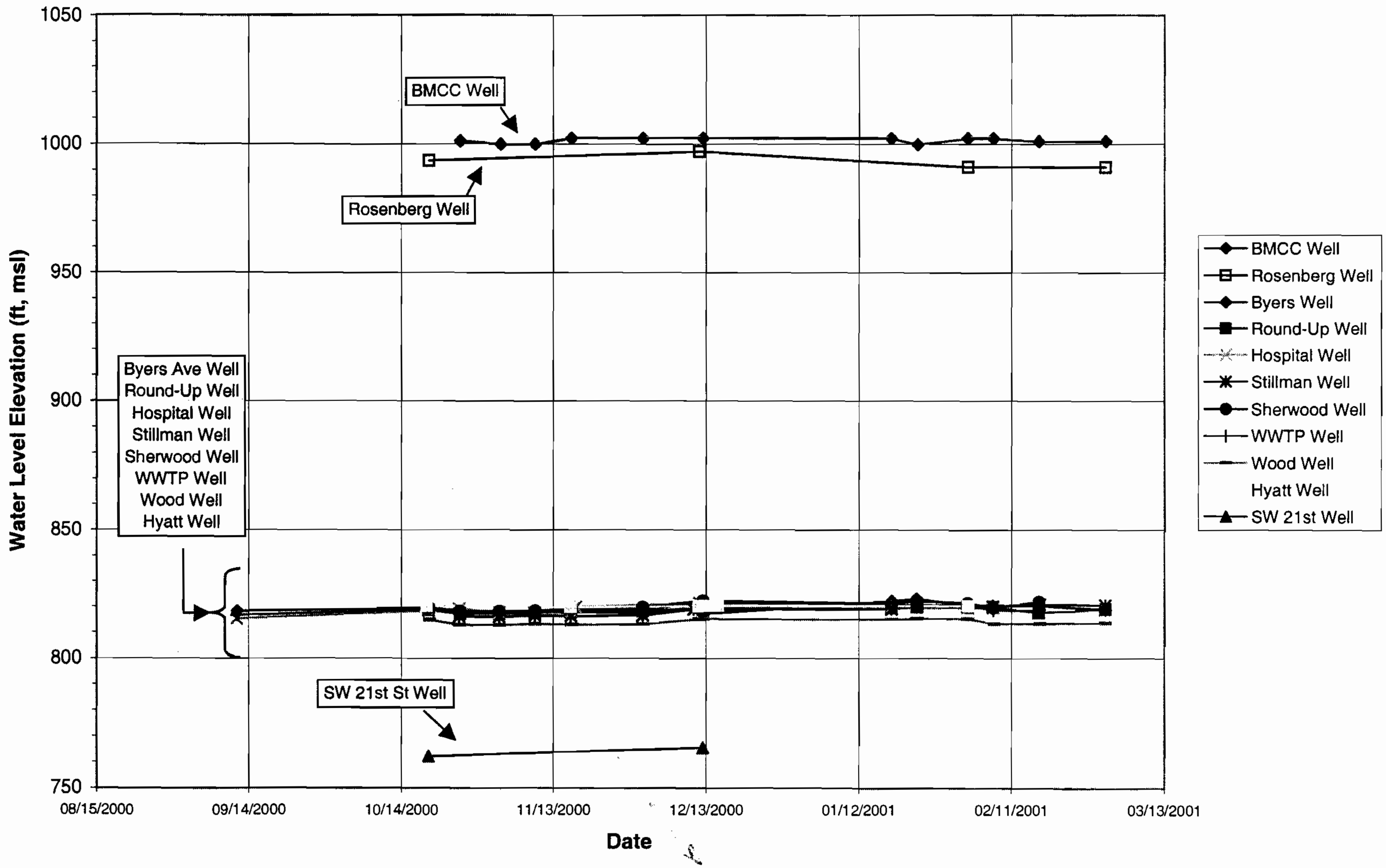
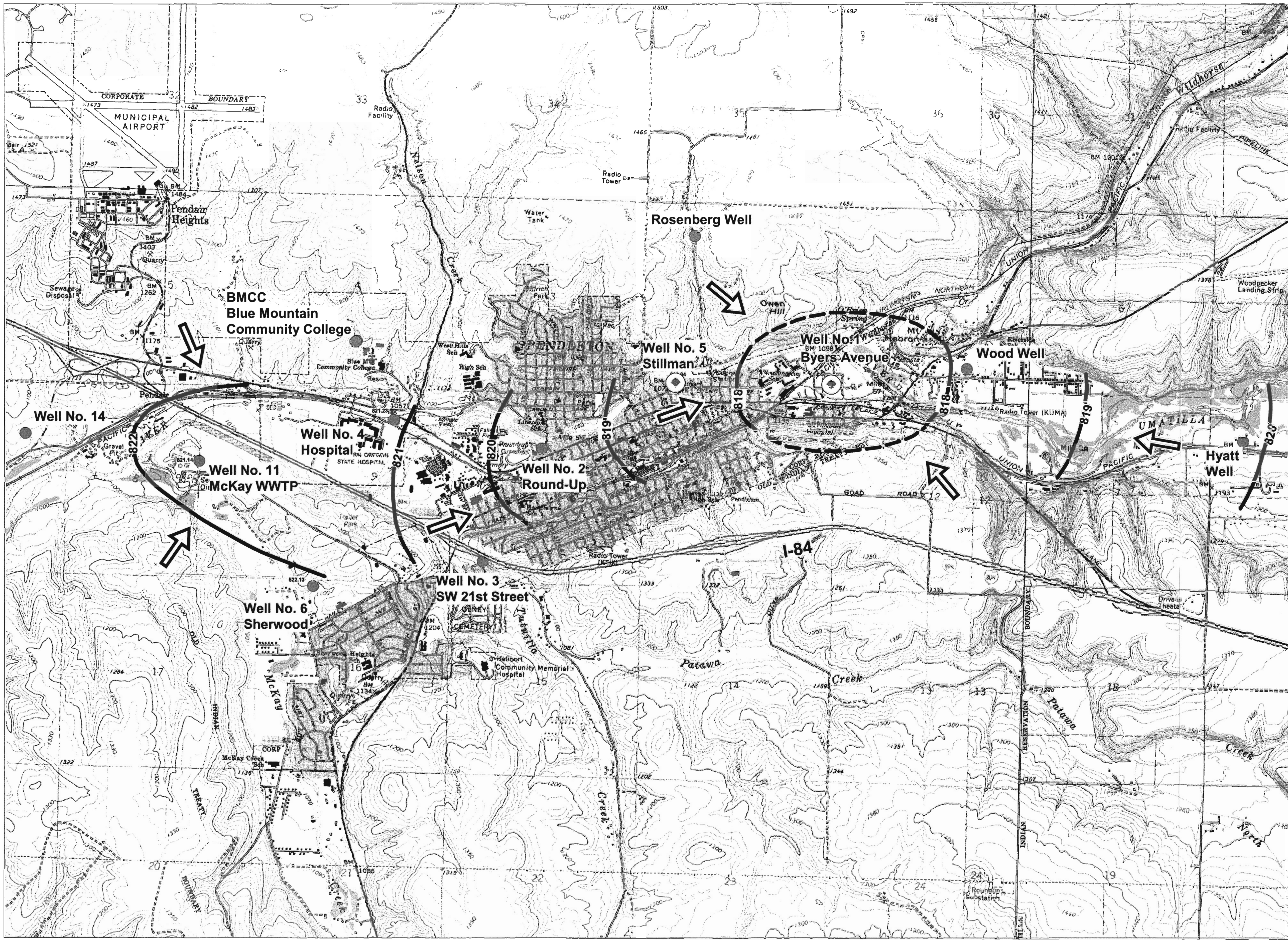


FIGURE 2-5
Typical Basalt Flow Structures in the Columbia River Basalt Group

Figure 2-6
Observation Well Water Level Elevations (WLE)





N

0 0.25 0.50 1.00

Miles

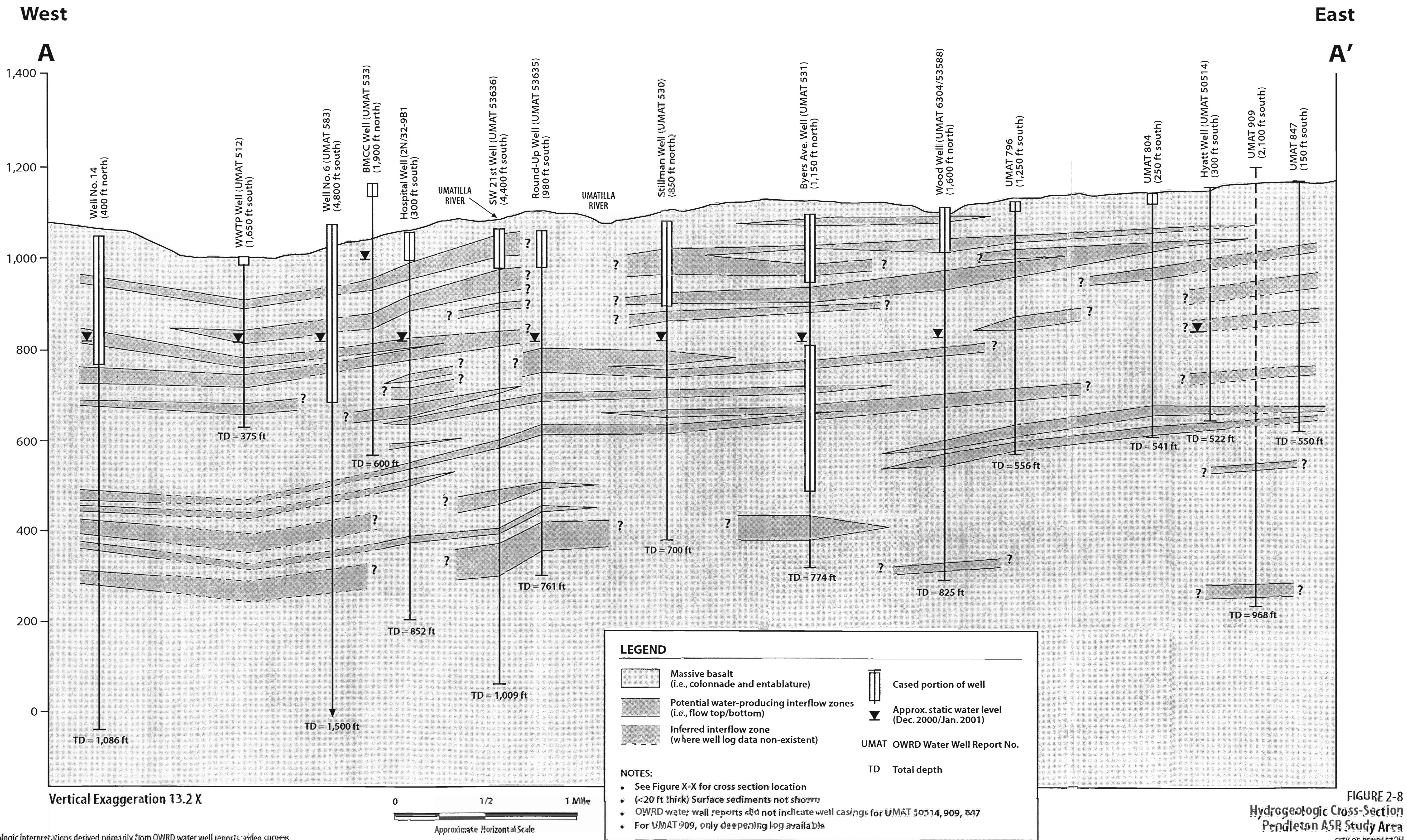
Base Maps: USGS 7.5 Minute Umatilla County Quadrangles, Pendleton and Mission, Oregon.

Legend

- ASR Pilot Test Well
- Observation Well
- 817 Equipotential Line
- Inferred groundwater flow direction

Figure 2-7

Groundwater Map (12/12/2000) - City of Pendleton ASR Study Area



Source: Geologic interpretations derived primarily from OWRD water well reports; video surveys of Stillman and Byers Avenue wells; Hogenson (1964); Hansen and others (1994).

FIGURE 2-8
Hydrogeologic Cross-Section Pendleton ASR Study Area
CITY OF PENDLETON
ASR HYDROGEOLOGIC FEASIBILITY STUDY

CH2MHILL

Figure 3-1 : Pre-Aquifer Test
Water-Level Elevations
(Corrected for Barometric Pressure Changes)

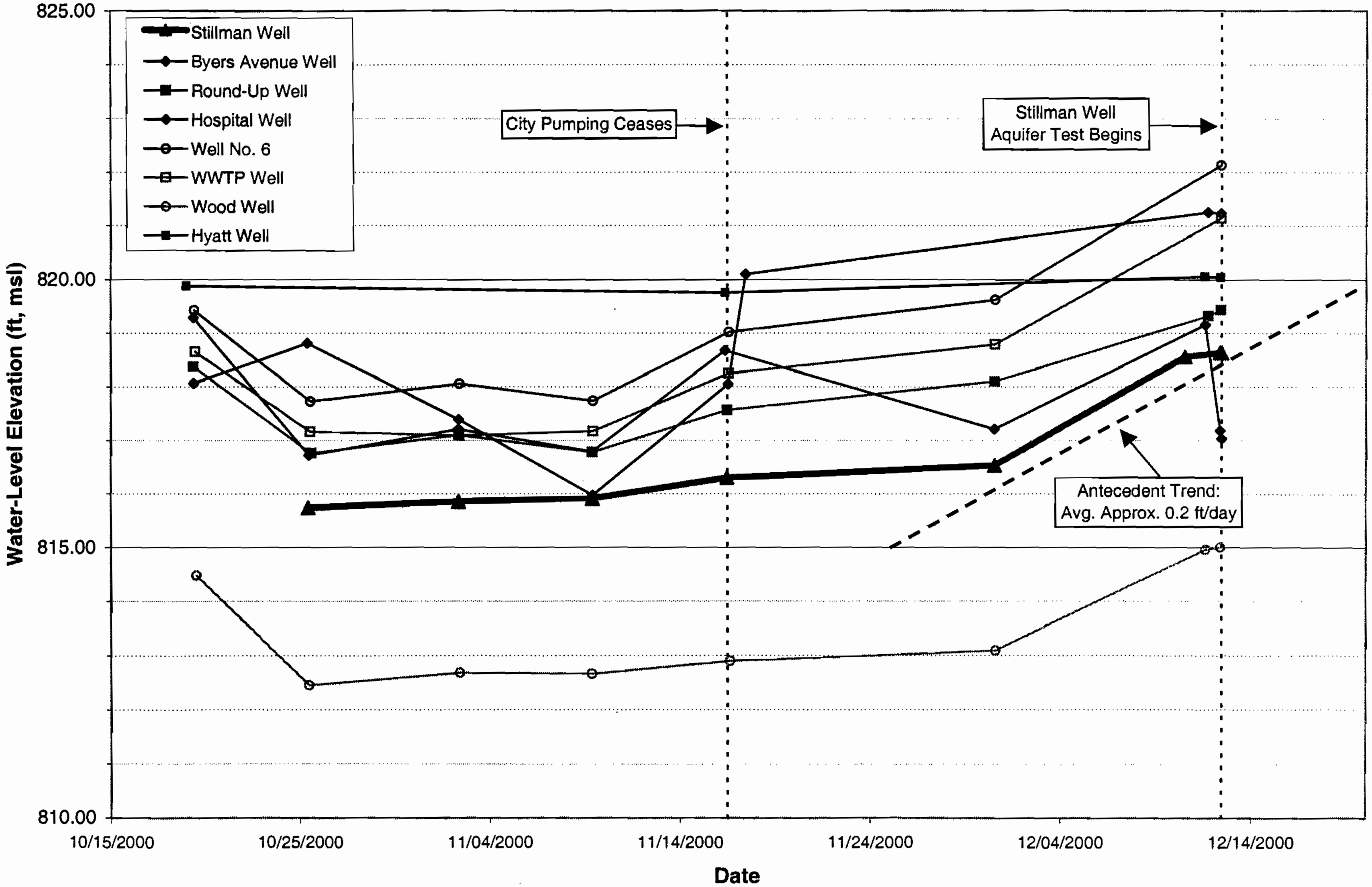


Figure 3-2 : Barometric Pressure, Pendleton Airport, November and December, 2000

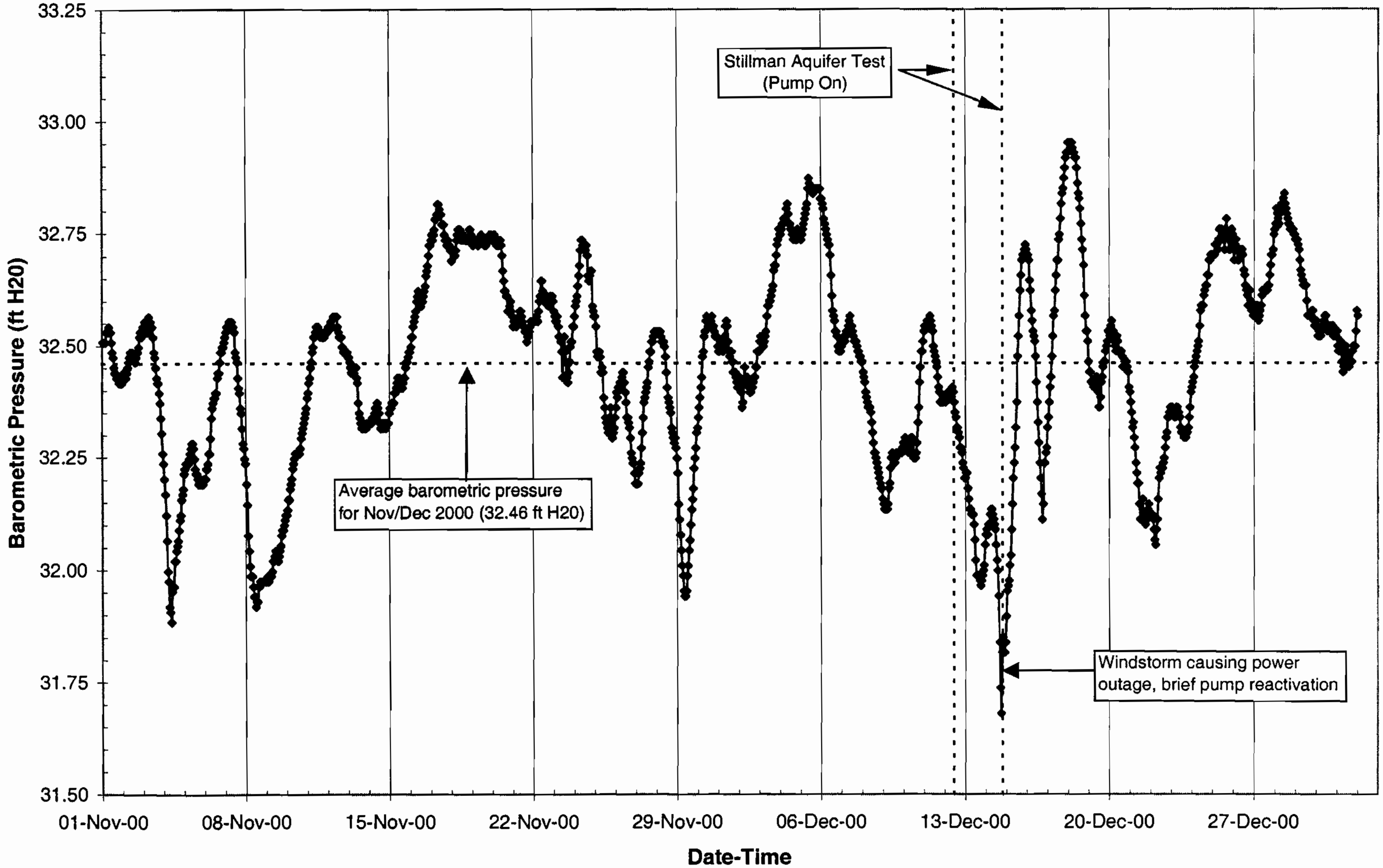


Figure 3-3
Stillman Well Hydrograph

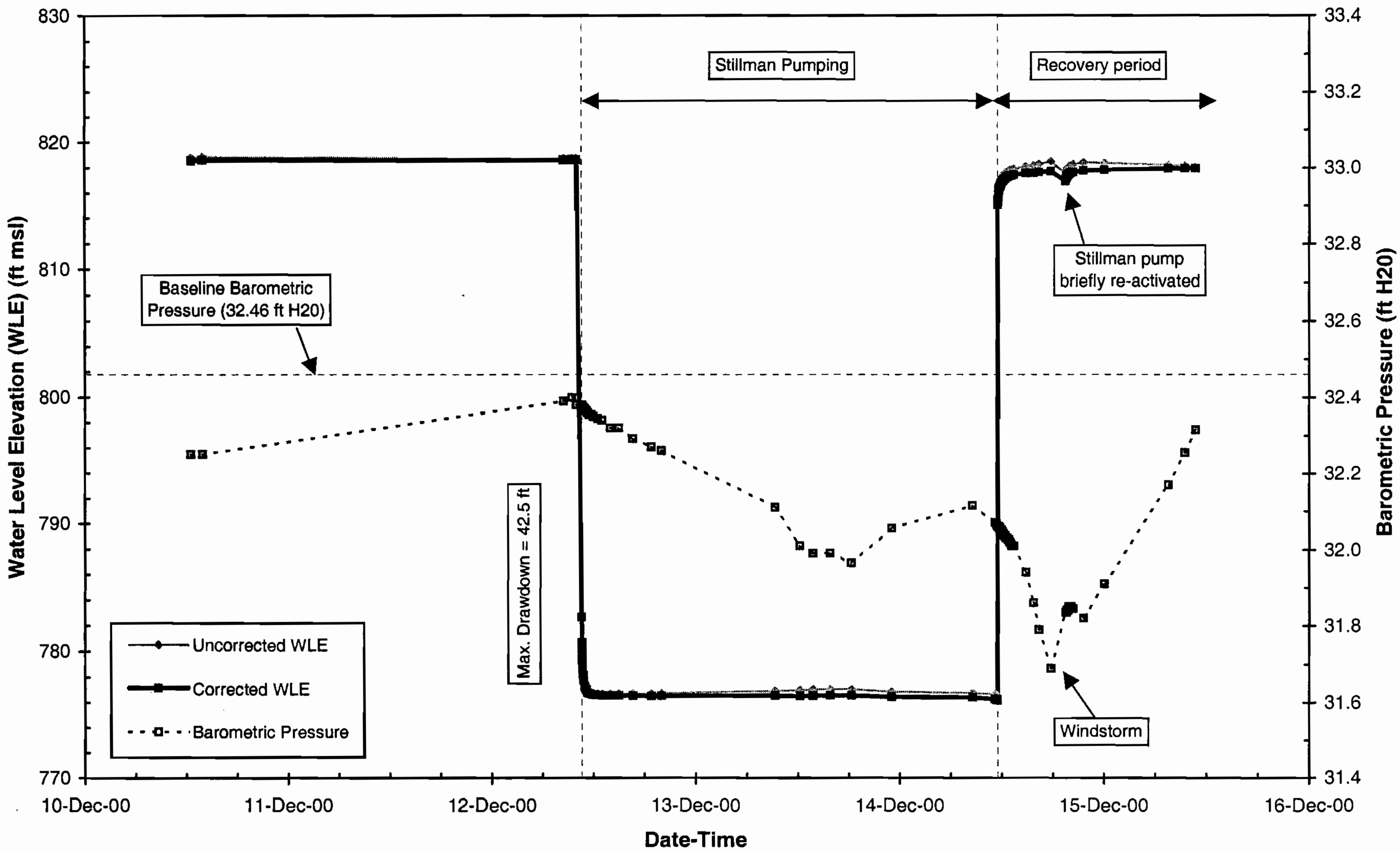


Figure 3-3b
Pumping Hydrograph - Stillman Well

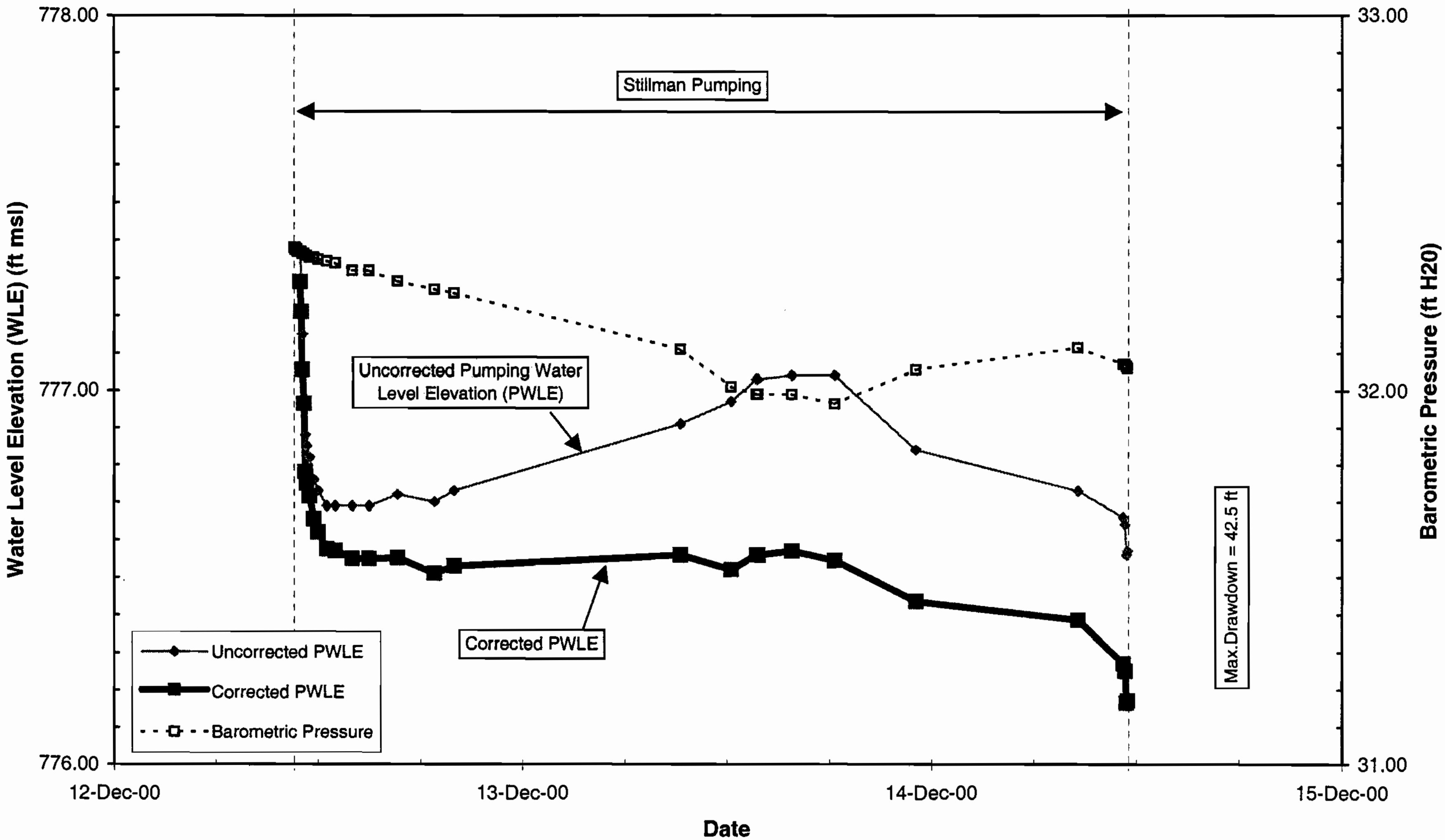


Figure 3-4
Round-Up Well Hydrograph
Stillman Aquifer Test

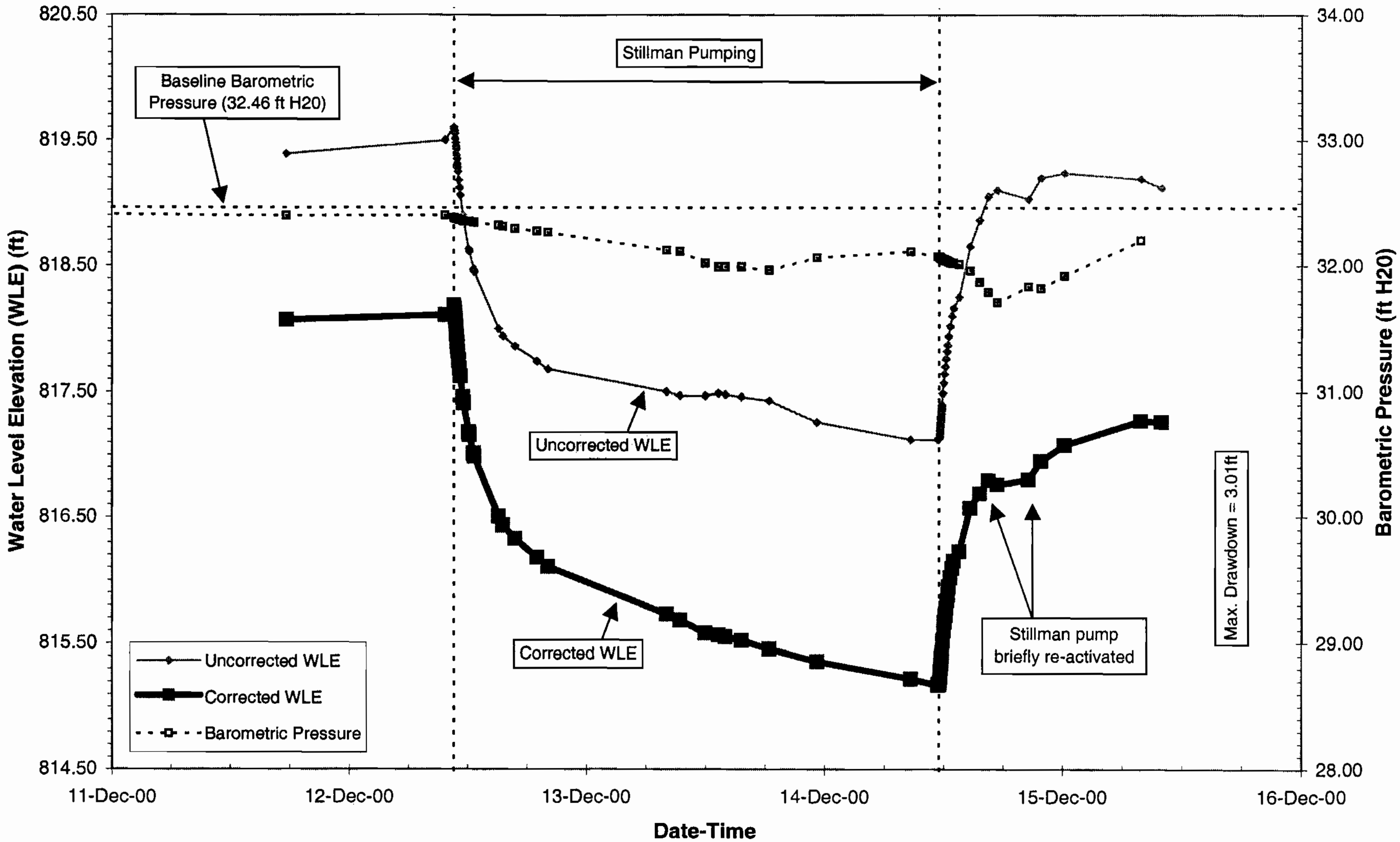


Figure 3-5
Byers Avenue Well Hydrograph
Stillman Aquifer Test

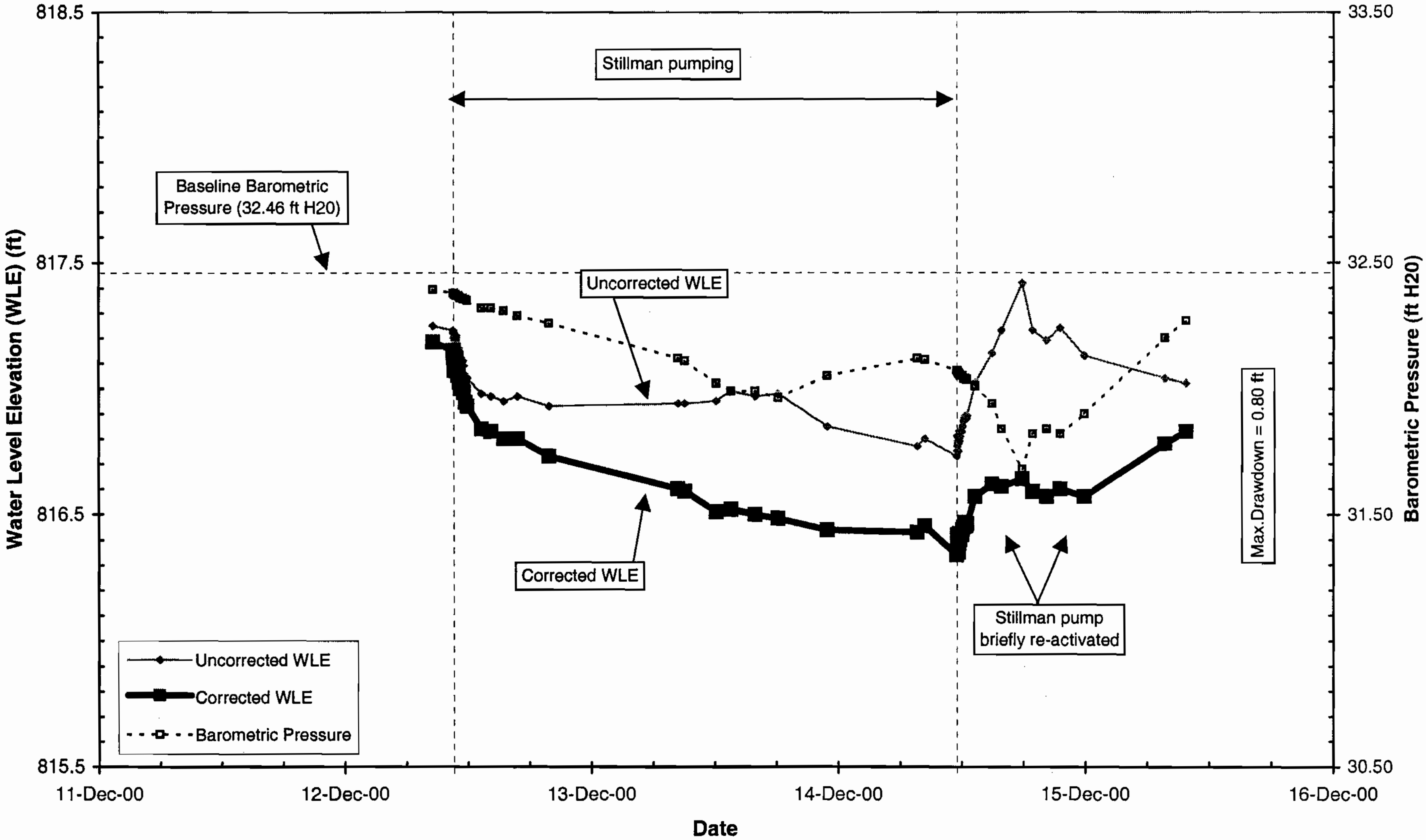


Figure 3-6
Wood Well Hydrograph
Stillman Aquifer Test

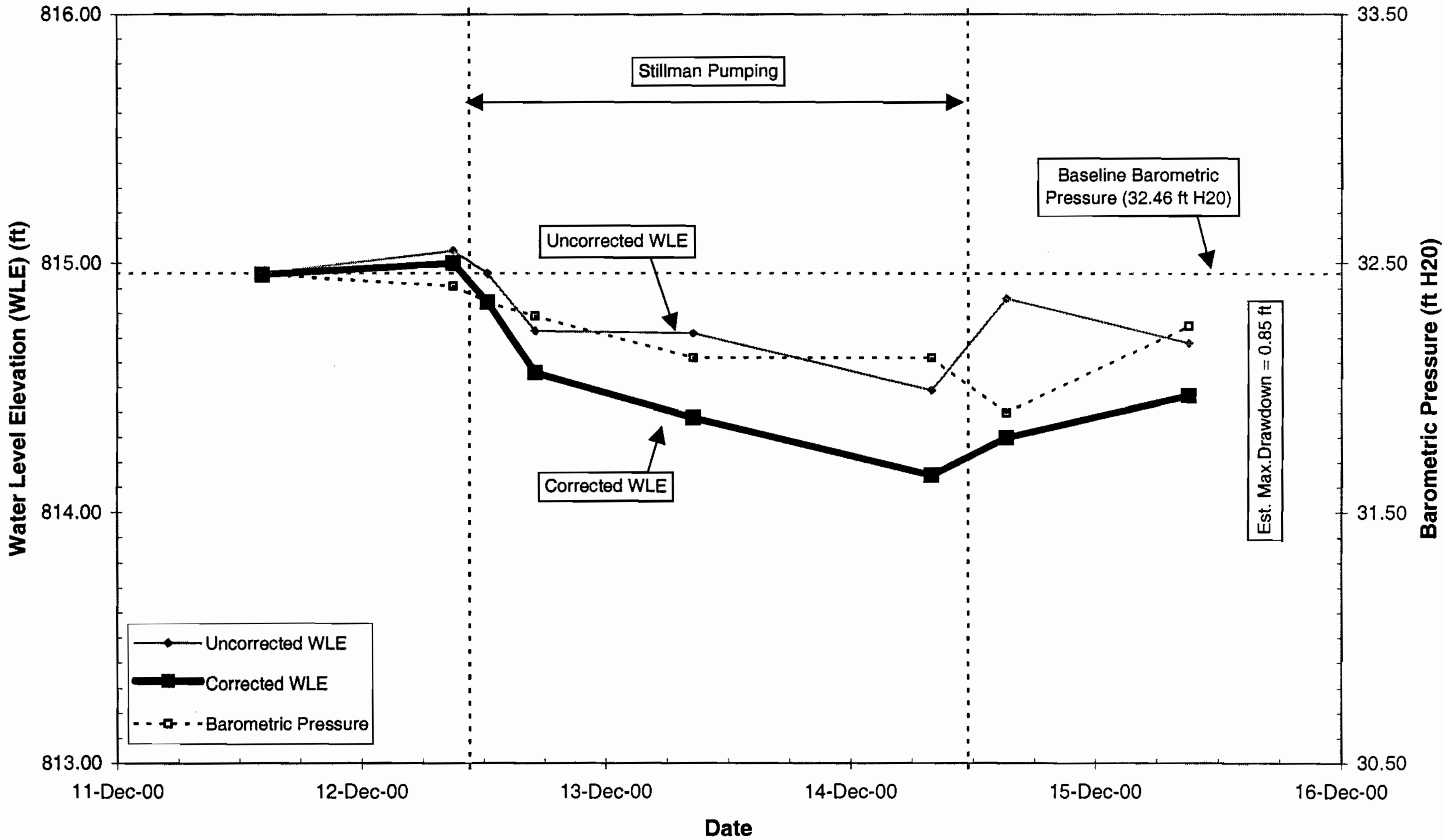


Figure 3-7
Hospital Well Hydrograph
Stillman Aquifer Test

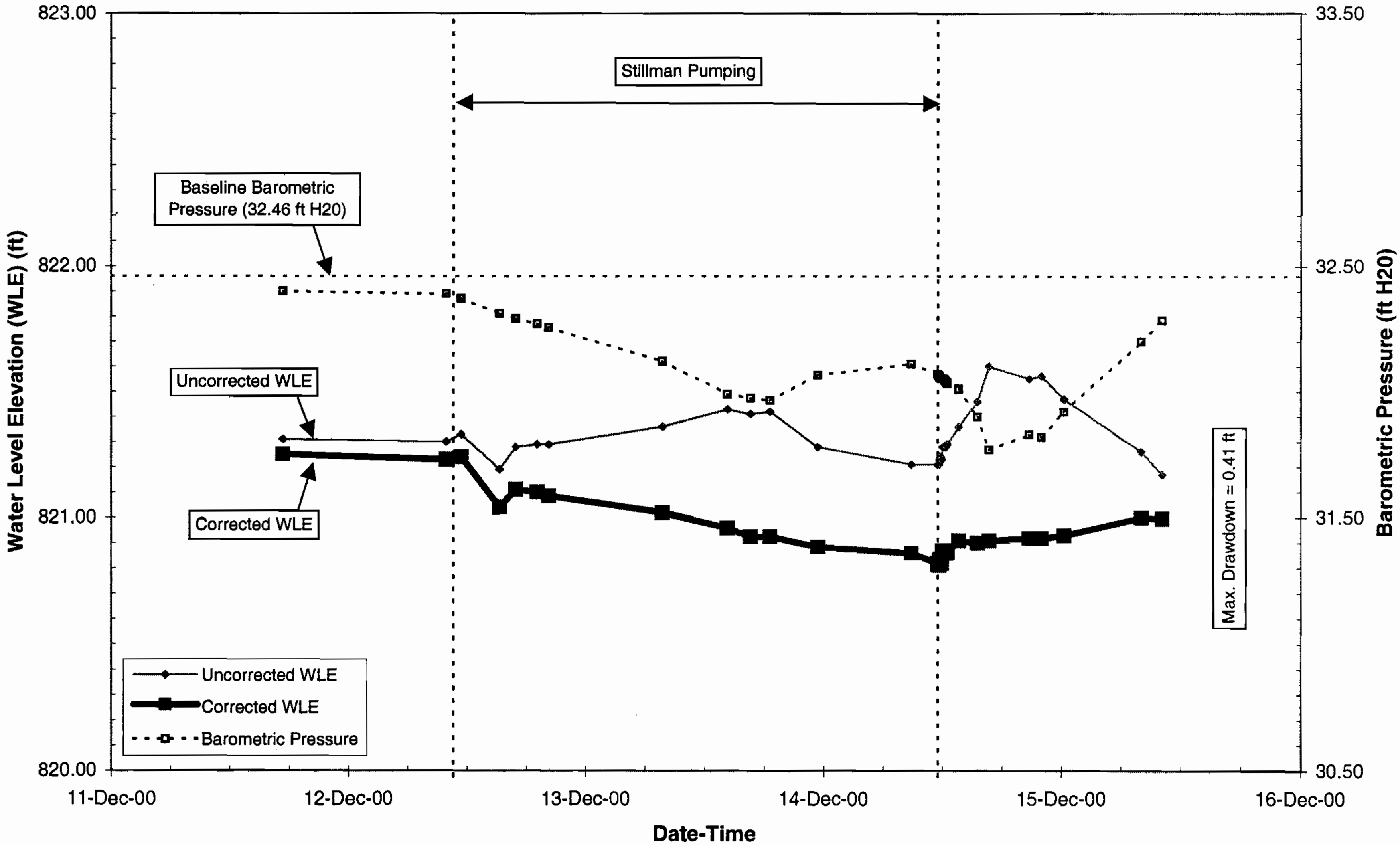


Figure 3-8
Sherwood Well (No. 6) Hydrograph
Stillman Aquifer Test

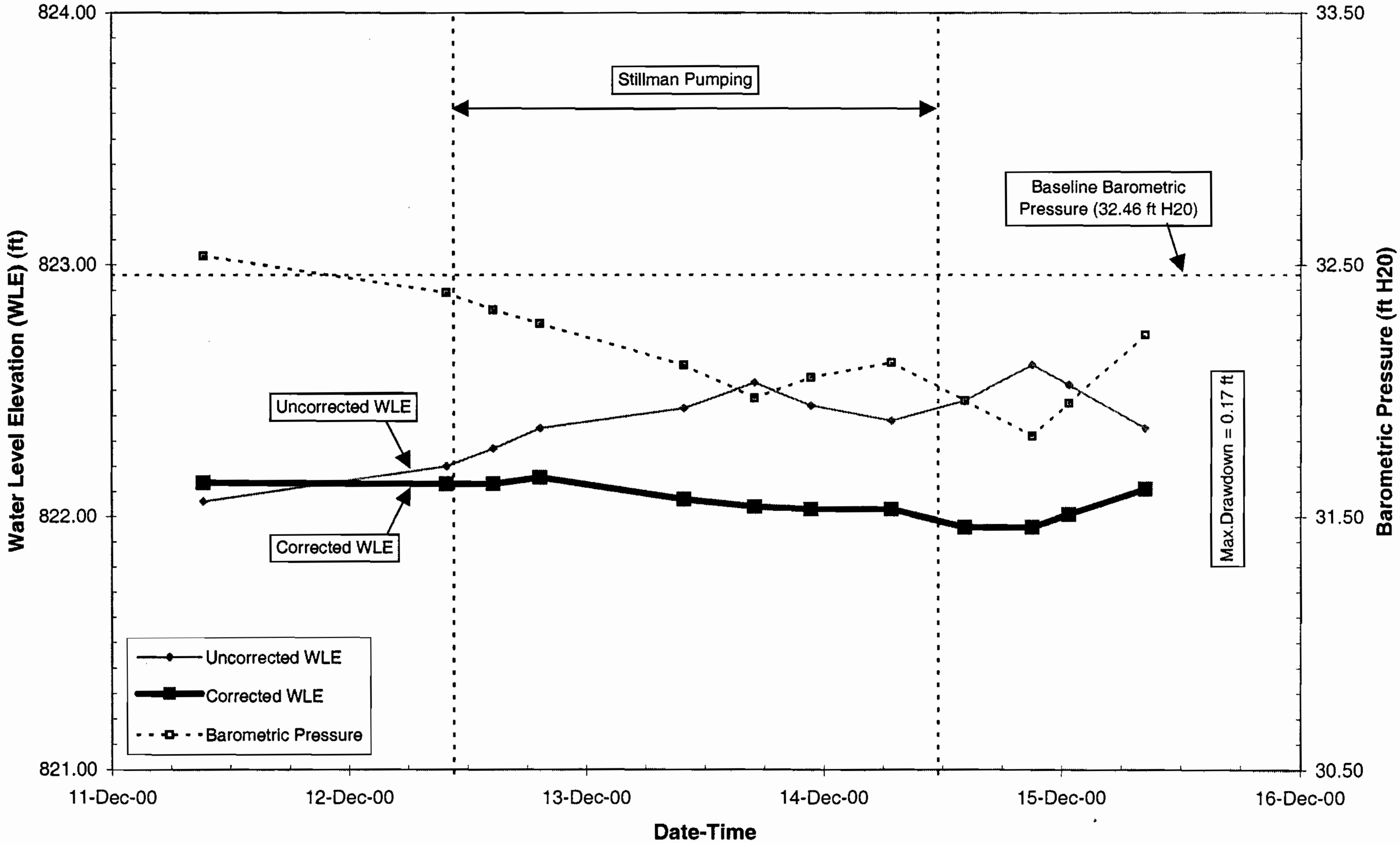


Figure 3-9
WWTP Well Hydrograph
Stillman Aquifer Test

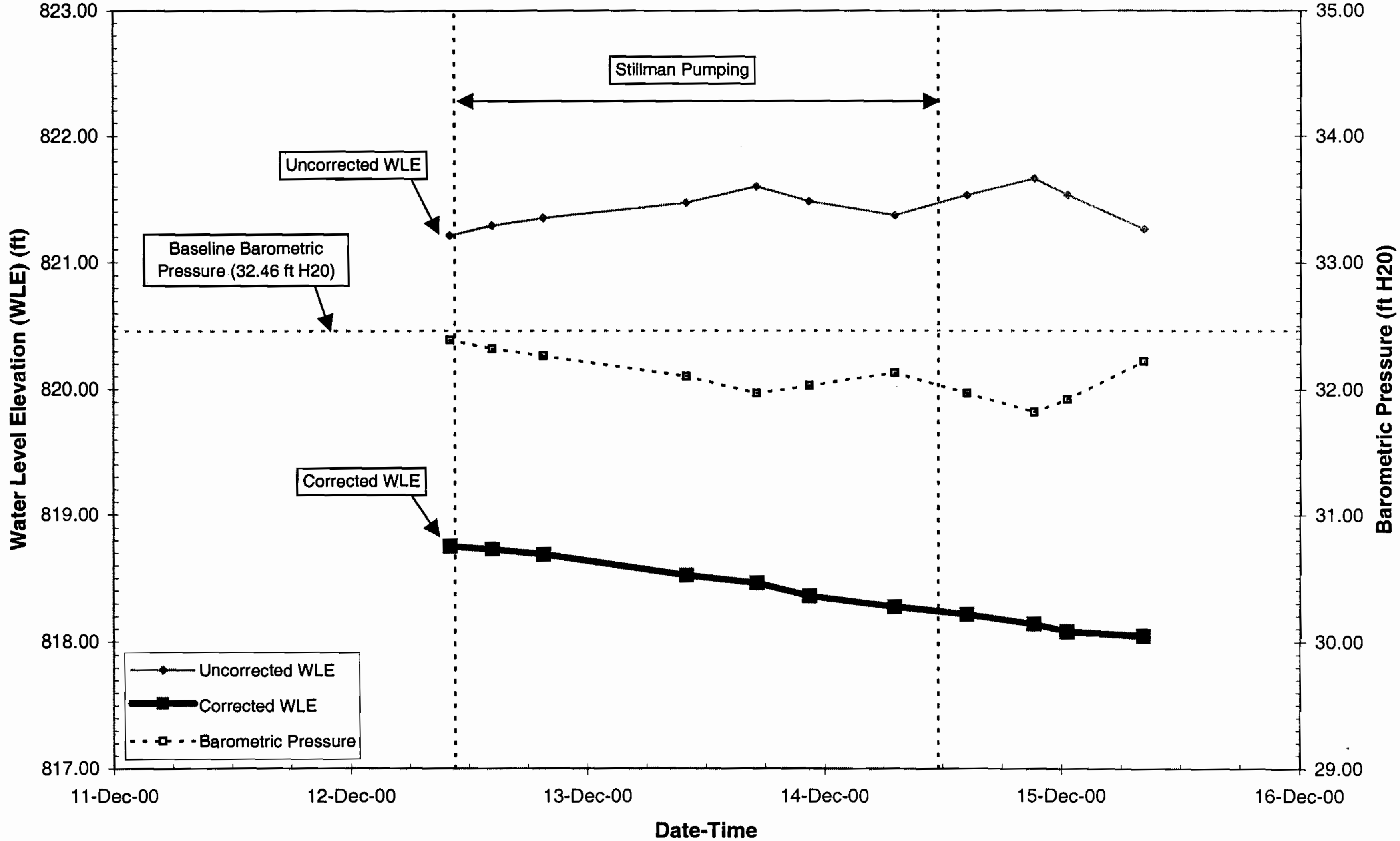


Figure 3-10
SW 21st Well Hydrograph
Stillman Aquifer Test

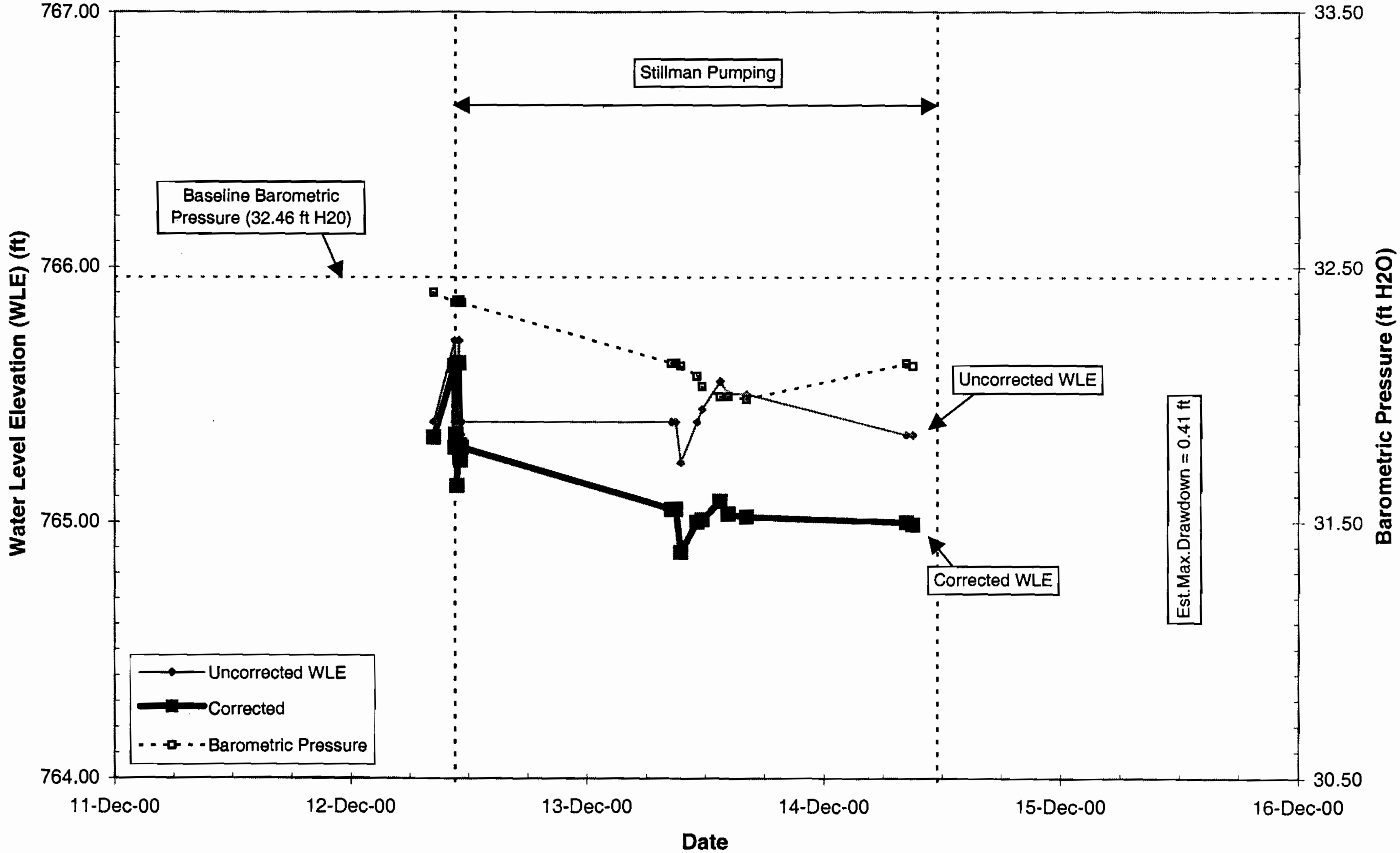


Figure 3-11
Hyatt Well Hydrograph
Stillman Aquifer Test

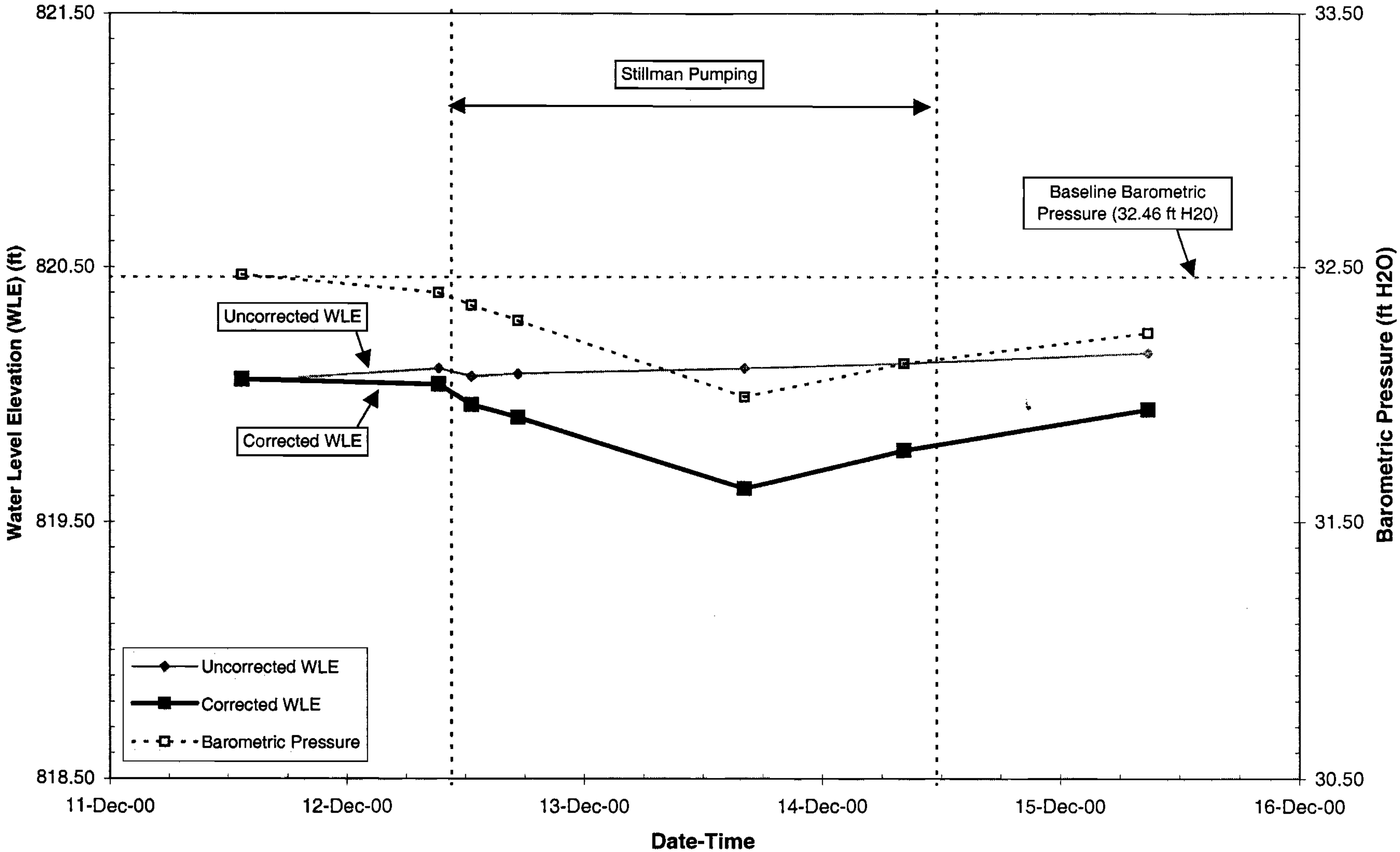


Figure 3-12
Drawdown vs t (Elapsed Pumping Time),
Stillman Well

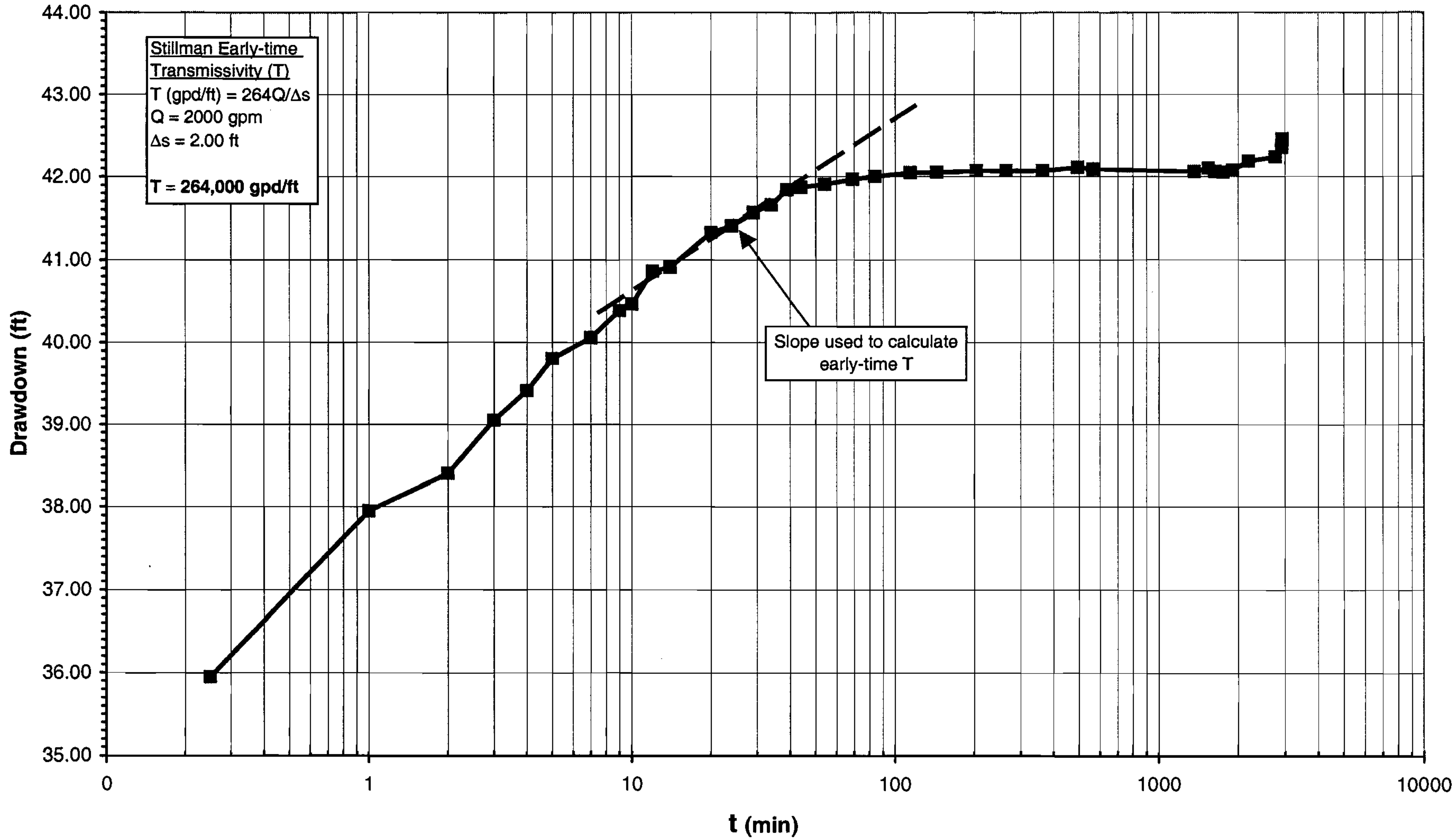


Figure 3-13
Residual (Recovery) Drawdown vs t' (Elapsed Time Since Pump Off)
Stillman Well

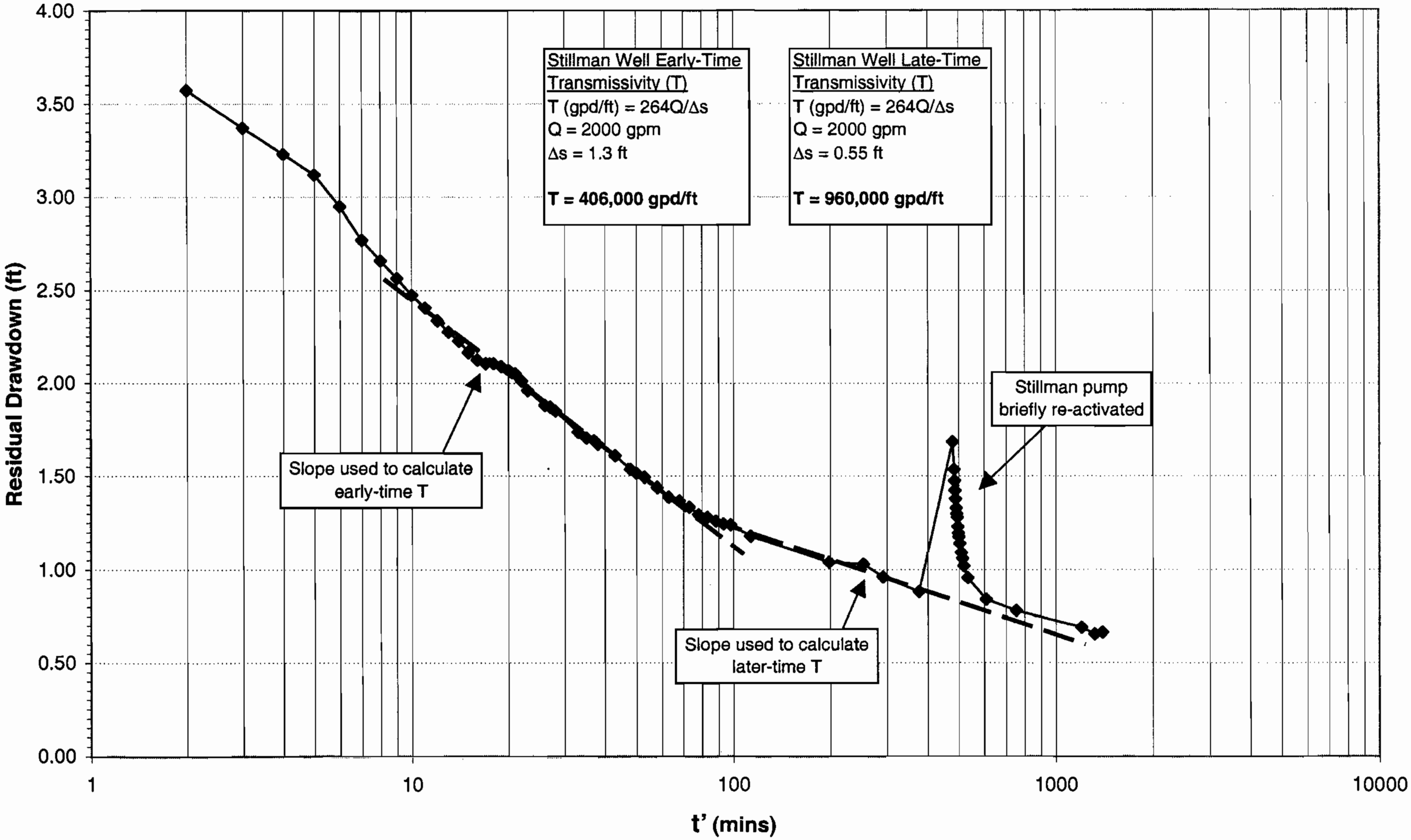


Figure 3-14 : Drawdown vs t (Elapsed Pumping Time), Round-Up & Byers Avenue Wells

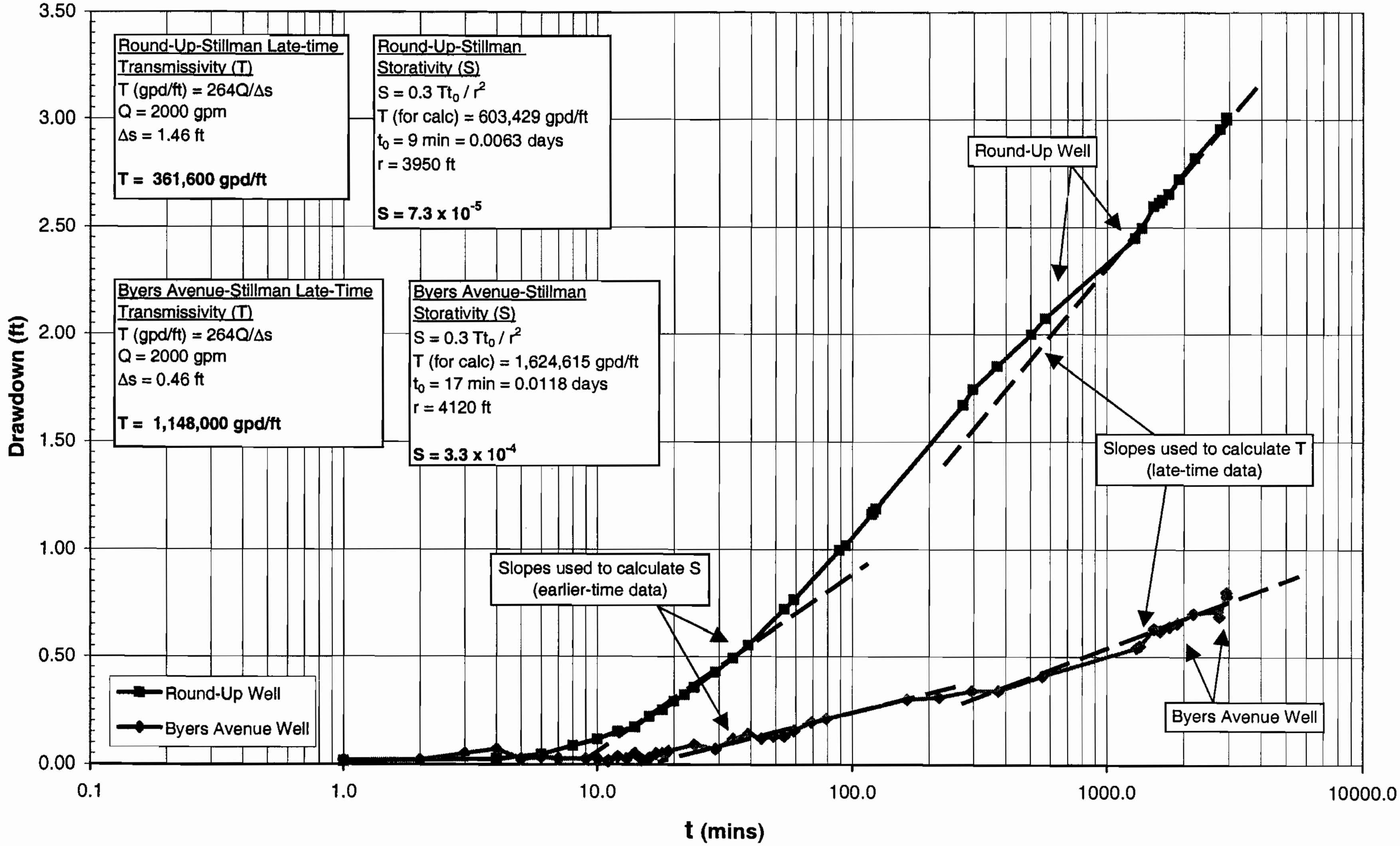


Figure 3-15: Recovery (Residual) Drawdown vs t/t', Round Up & Byers Avenue Wells

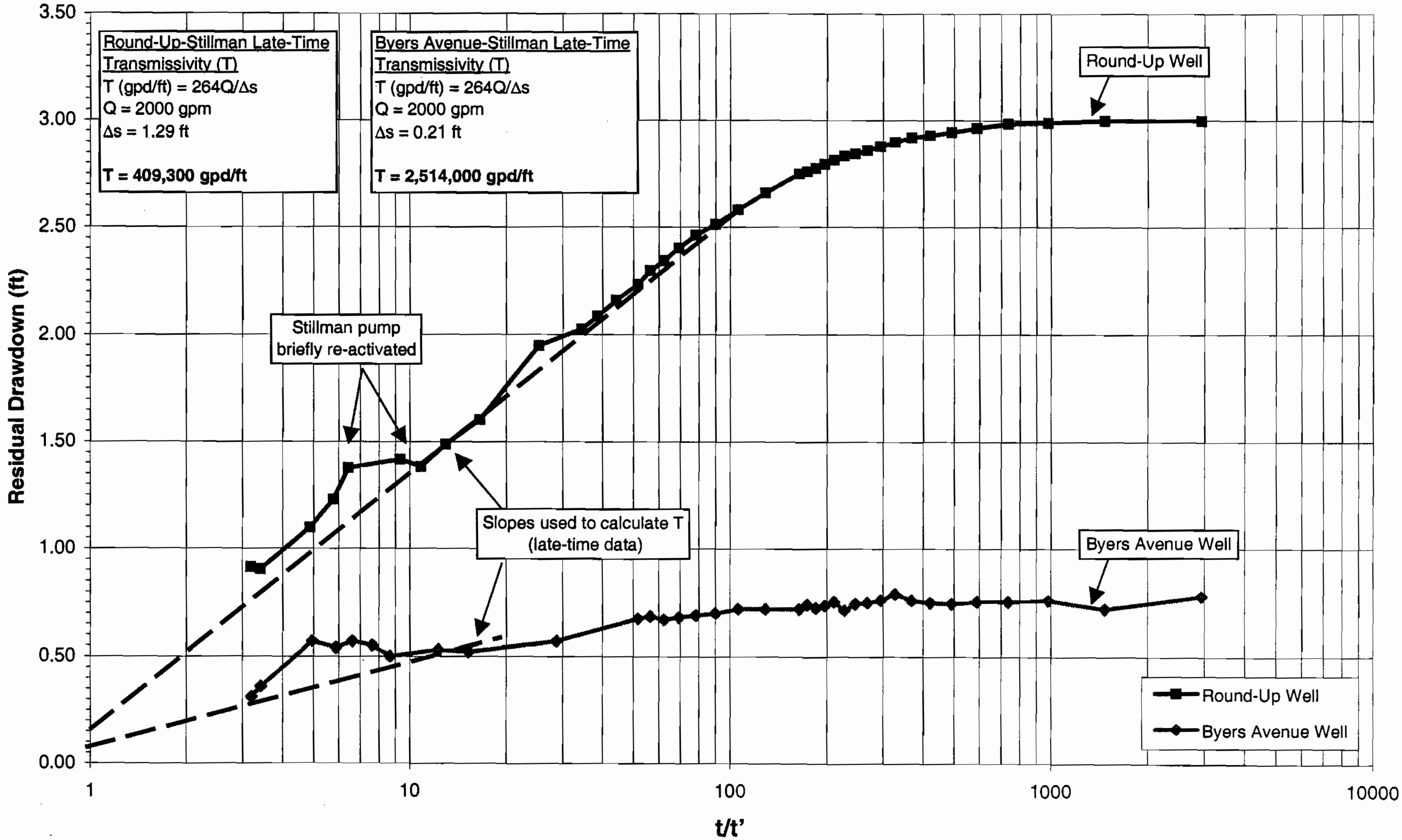


Figure 3-16
Residual (Recovery) Drawdown vs t/t',
Stillman Well

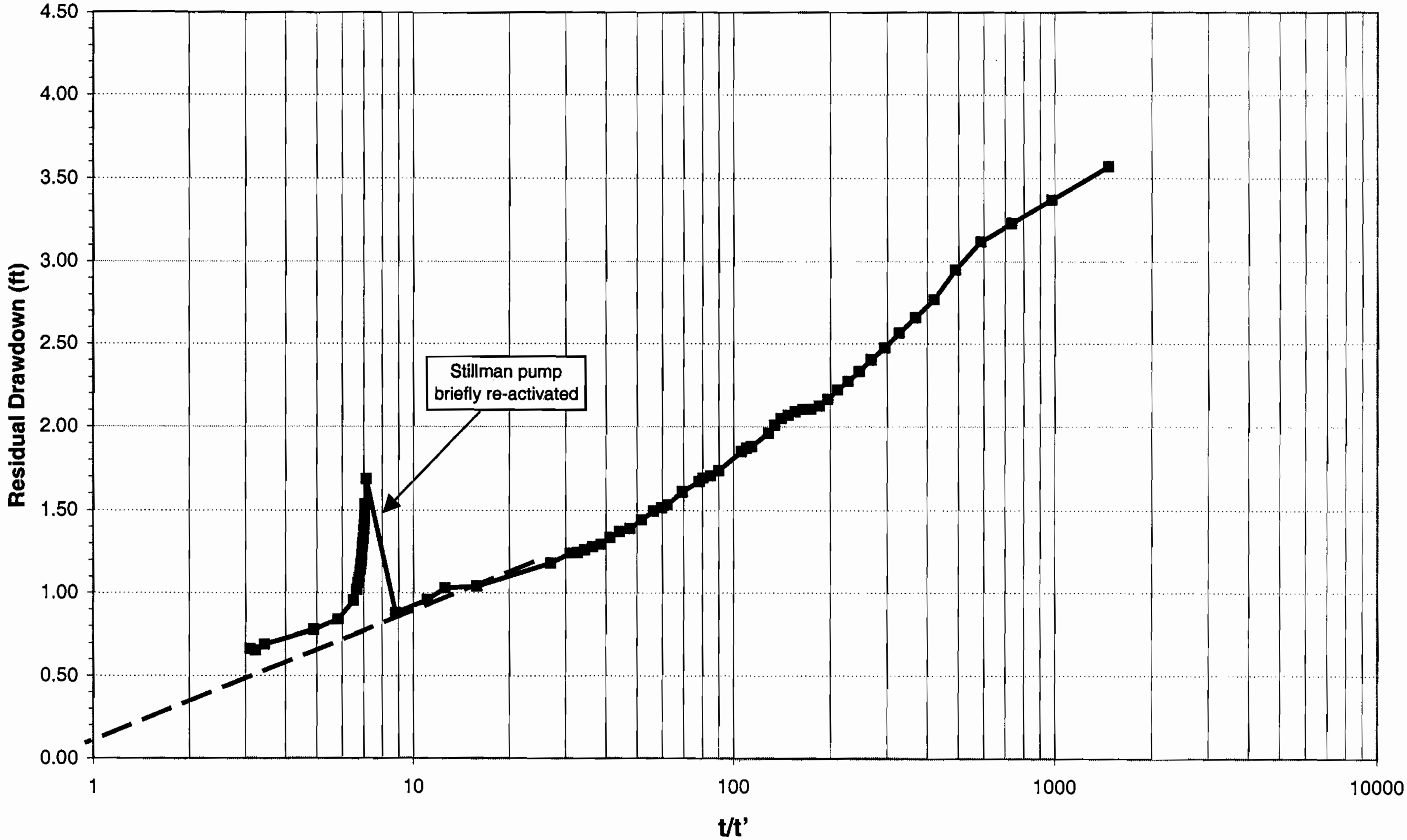


Figure 3-17
Stillman Well
Specific Capacity & Drawdown
vs t (Elapsed Pumping Time)

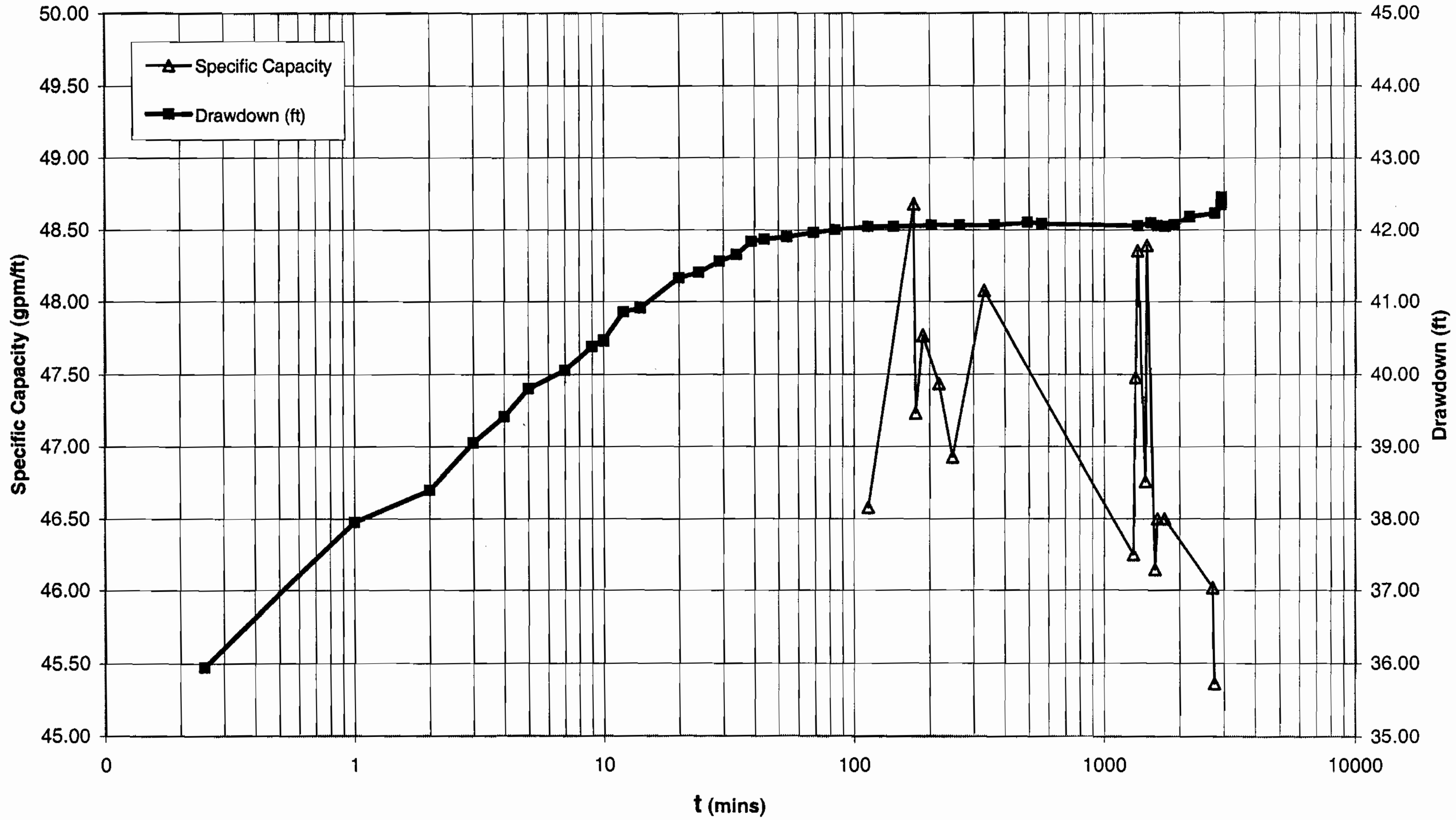


Figure 3-18
Groundwater pH & Drawdown vs
Elapsed Pumping Time

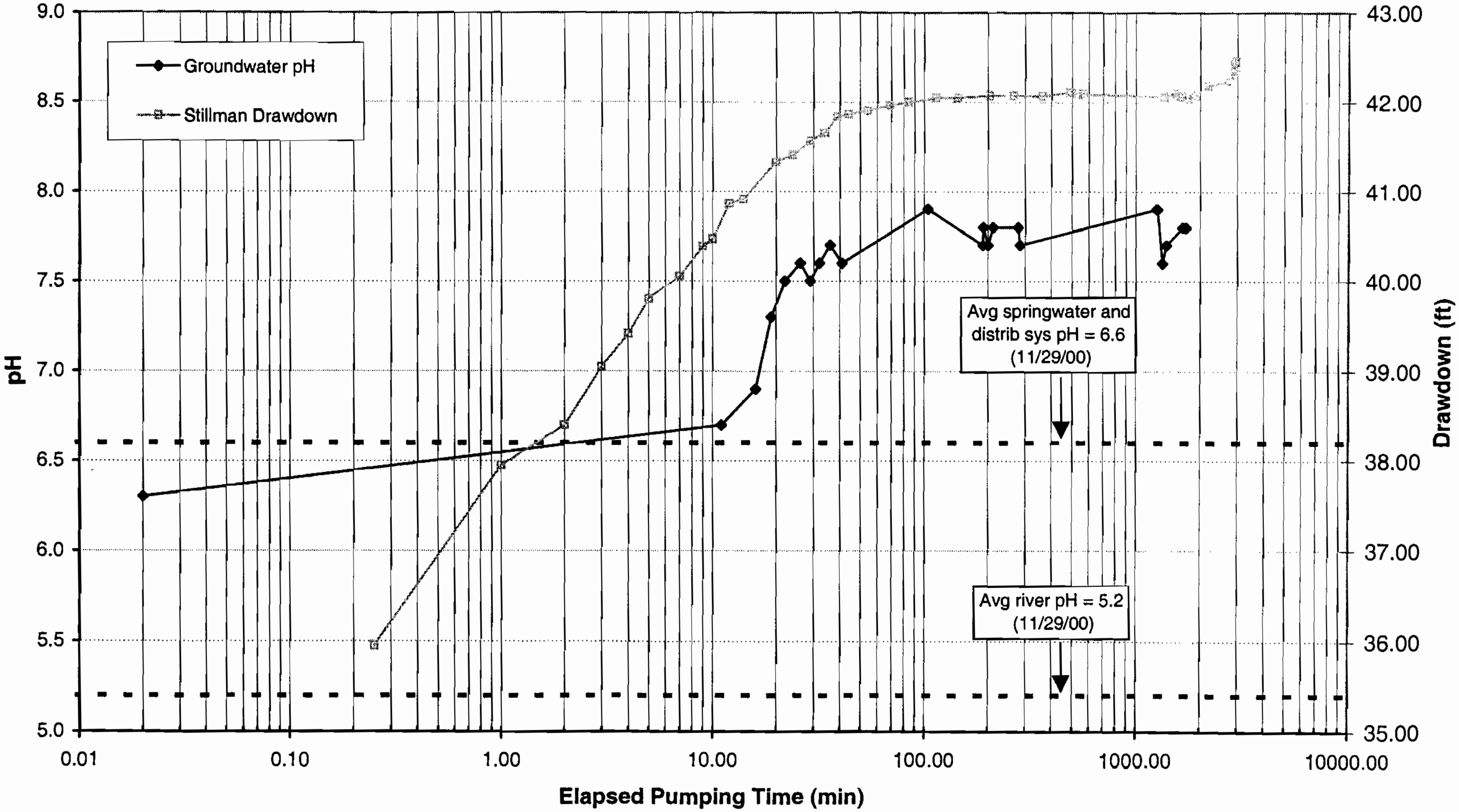


Figure 3-19
Groundwater Conductivity & Stillman Drawdown
vs Elapsed Pumping Time

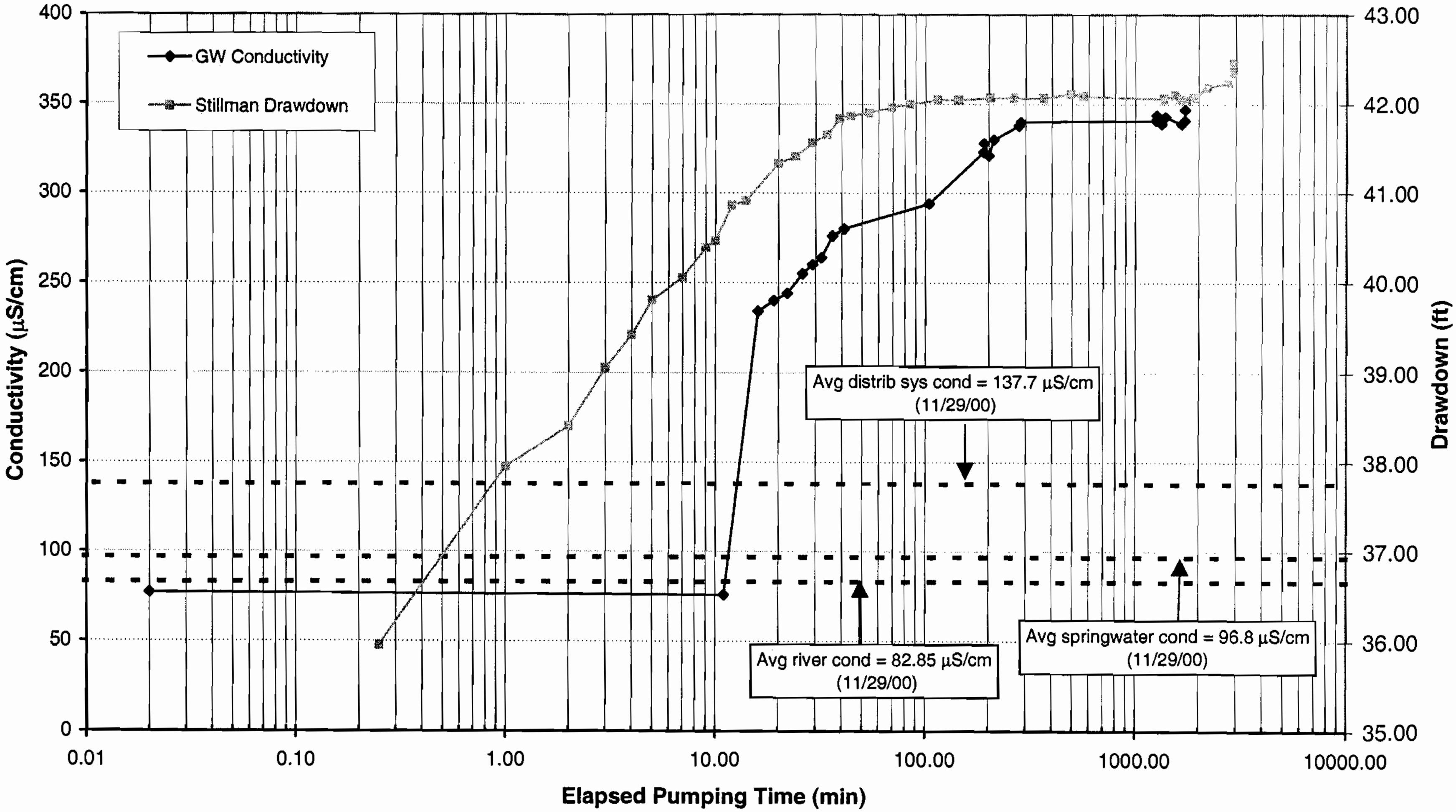


Figure 3-20
Groundwater Turbidity & Stillman Drawdown
vs Elapsed Pumping Time

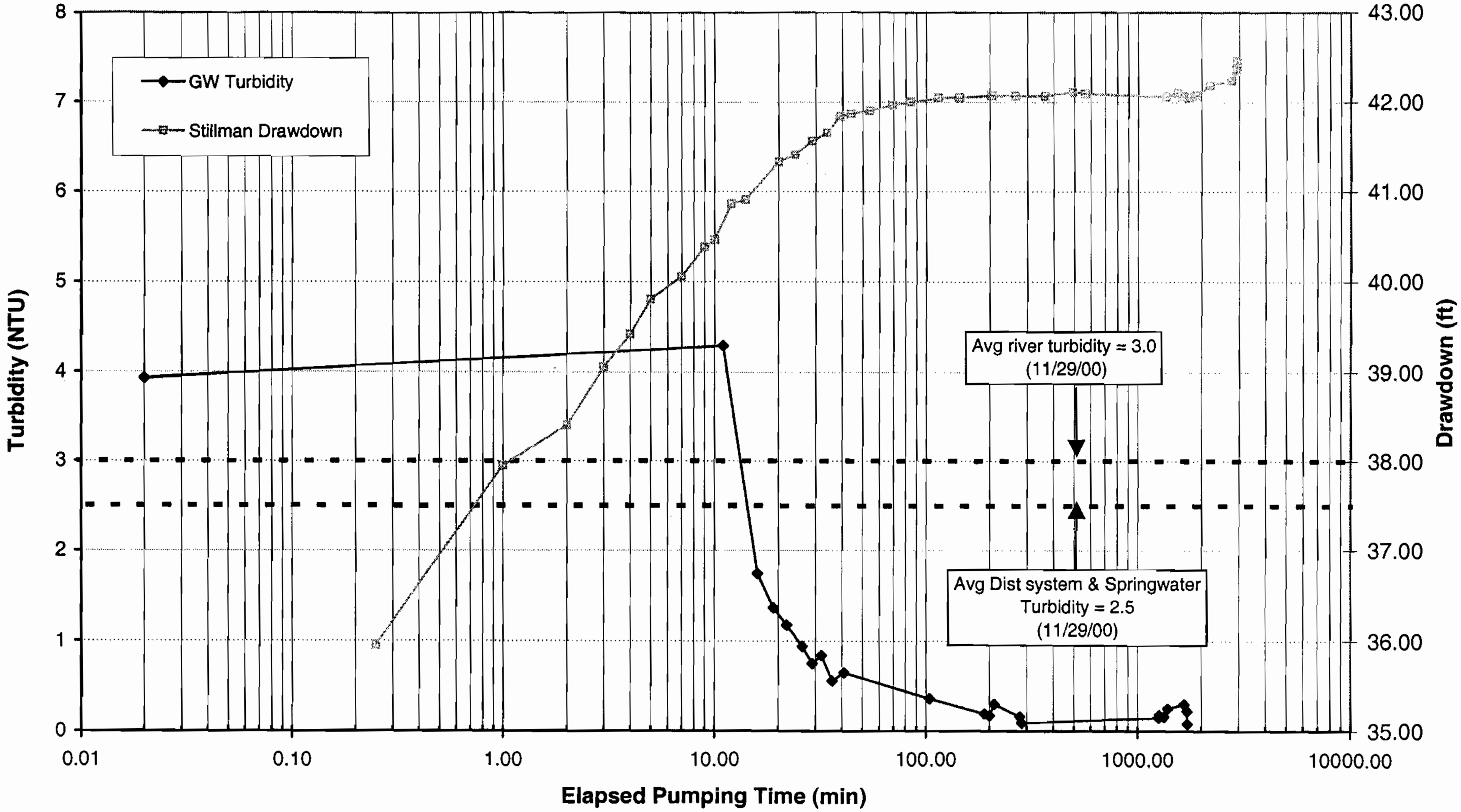


Figure 3-21
Groundwater Temperature & Stillman Drawdown vs Elapsed Pumping Time

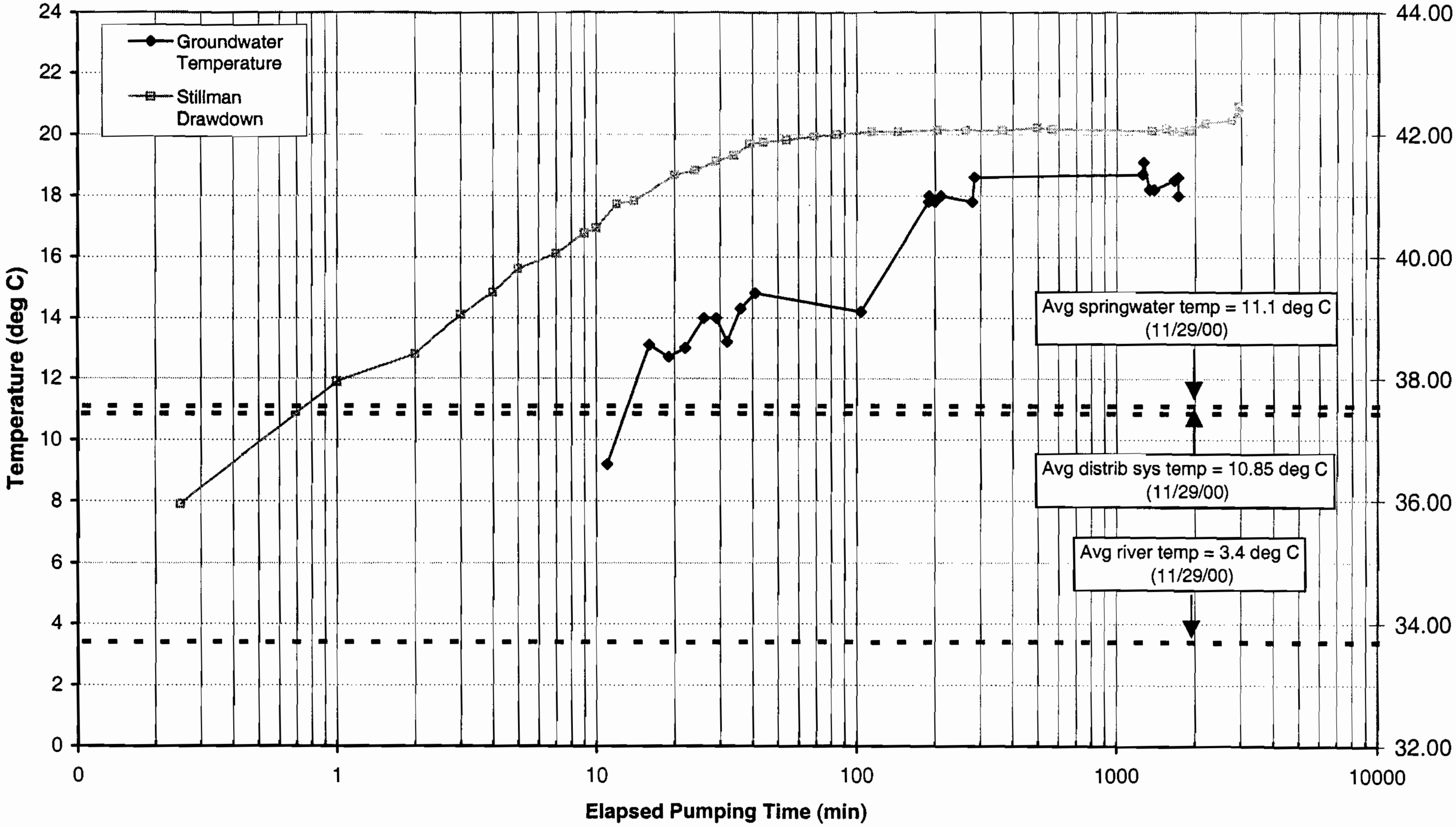


Figure 3-22
Groundwater Dissolved Oxygen (DO) & Drawdown vs Elapsed Pumping Time

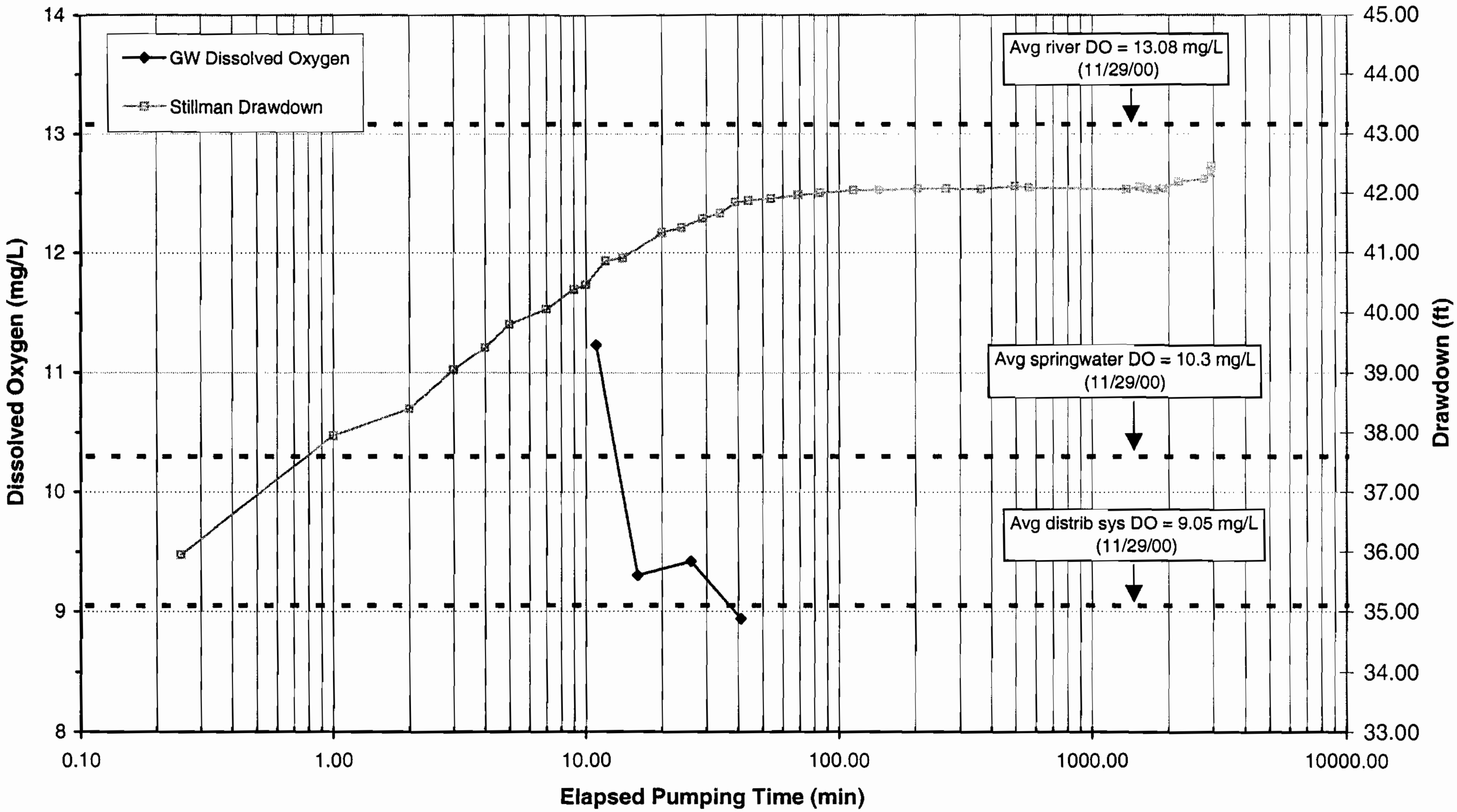
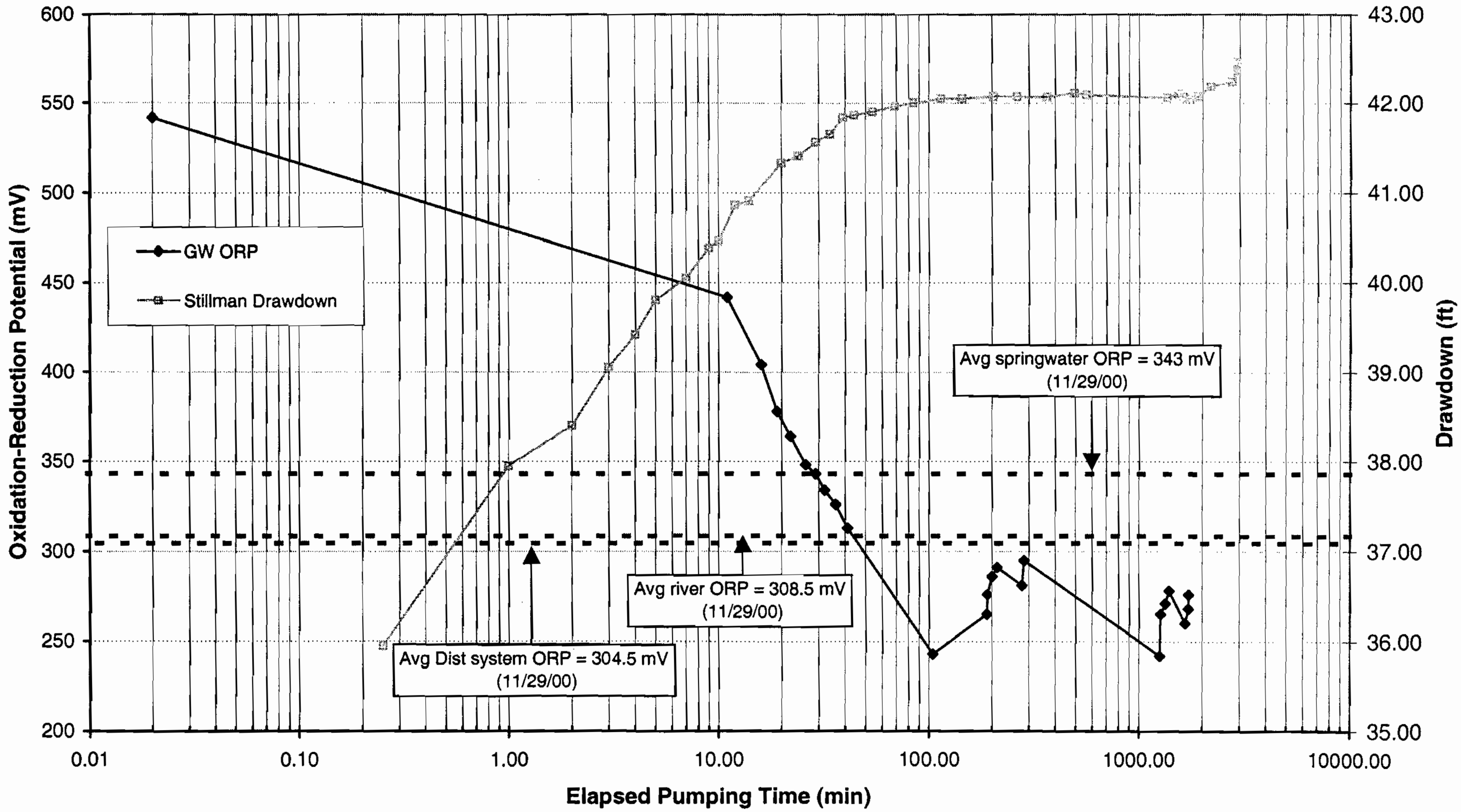
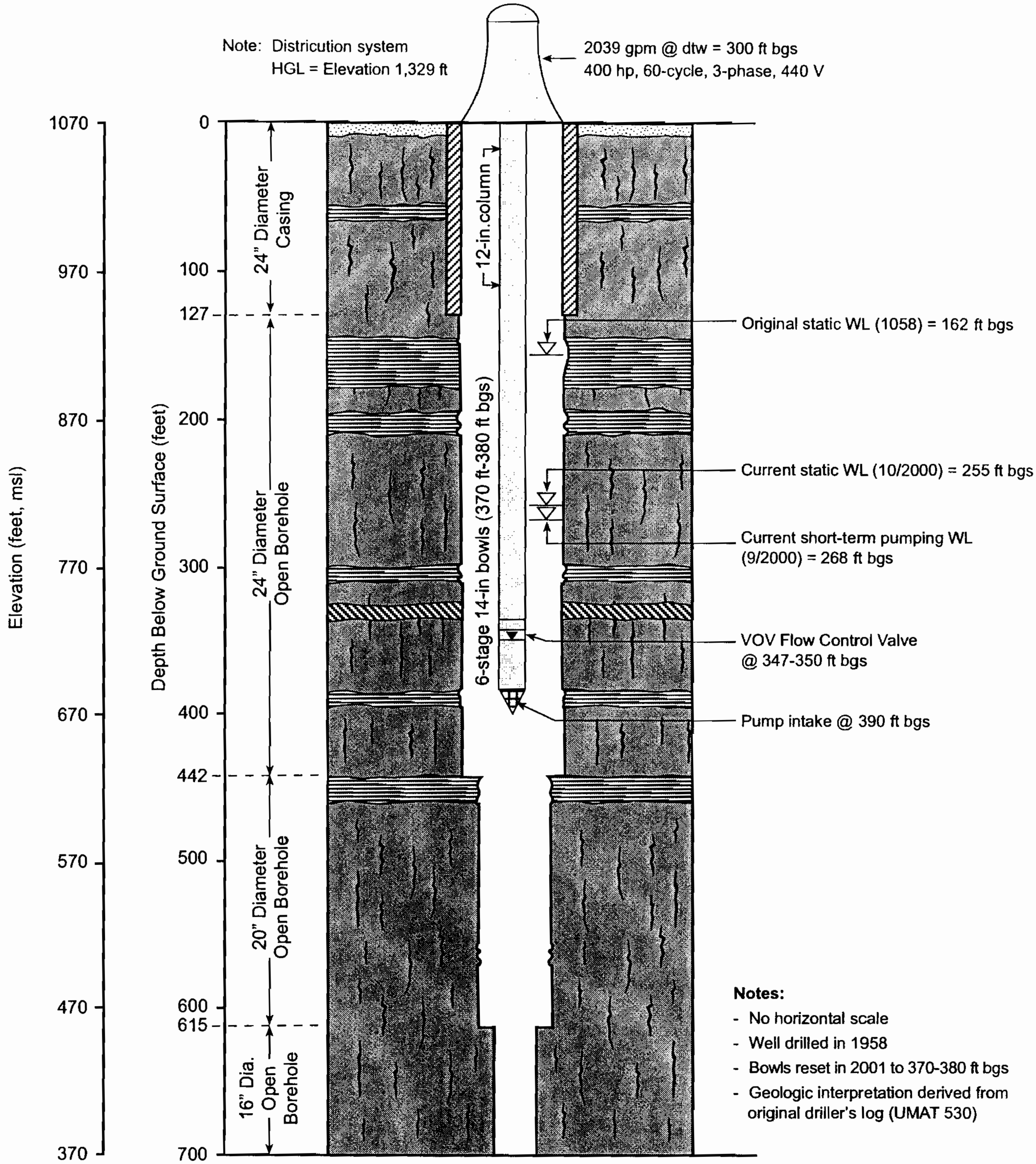


Figure 3-23
Groundwater ORP & Stillman Drawdown
vs Elapsed Pumping Time





Notes:
- No horizontal scale
- Well drilled in 1958
- Bowls reset in 2001 to 370-380 ft bgs
- Geologic interpretation derived from original driller's log (UMAT 530)

LEGEND

- Water Level Measurement
- Clay, Silt, and Sand
- Columbia River Basalt Group Flows
  - Potentially water-producing interflow zones
  - "Creviced basalt," according to driller's note
  - Massive interior flow zones with columnar jointing

WL = water level
HGL = hydraulic grade line
bgs = below ground surface
msl = mean sea level
dtw = depth to water

FIGURE 3-24
Stillman (No. 5) Well
Construction Details and Geologic Log

Fig 5-1 Stillman, Byers Avenue and Projected Source Waters

City of Pendleton ASR Feasibility Study

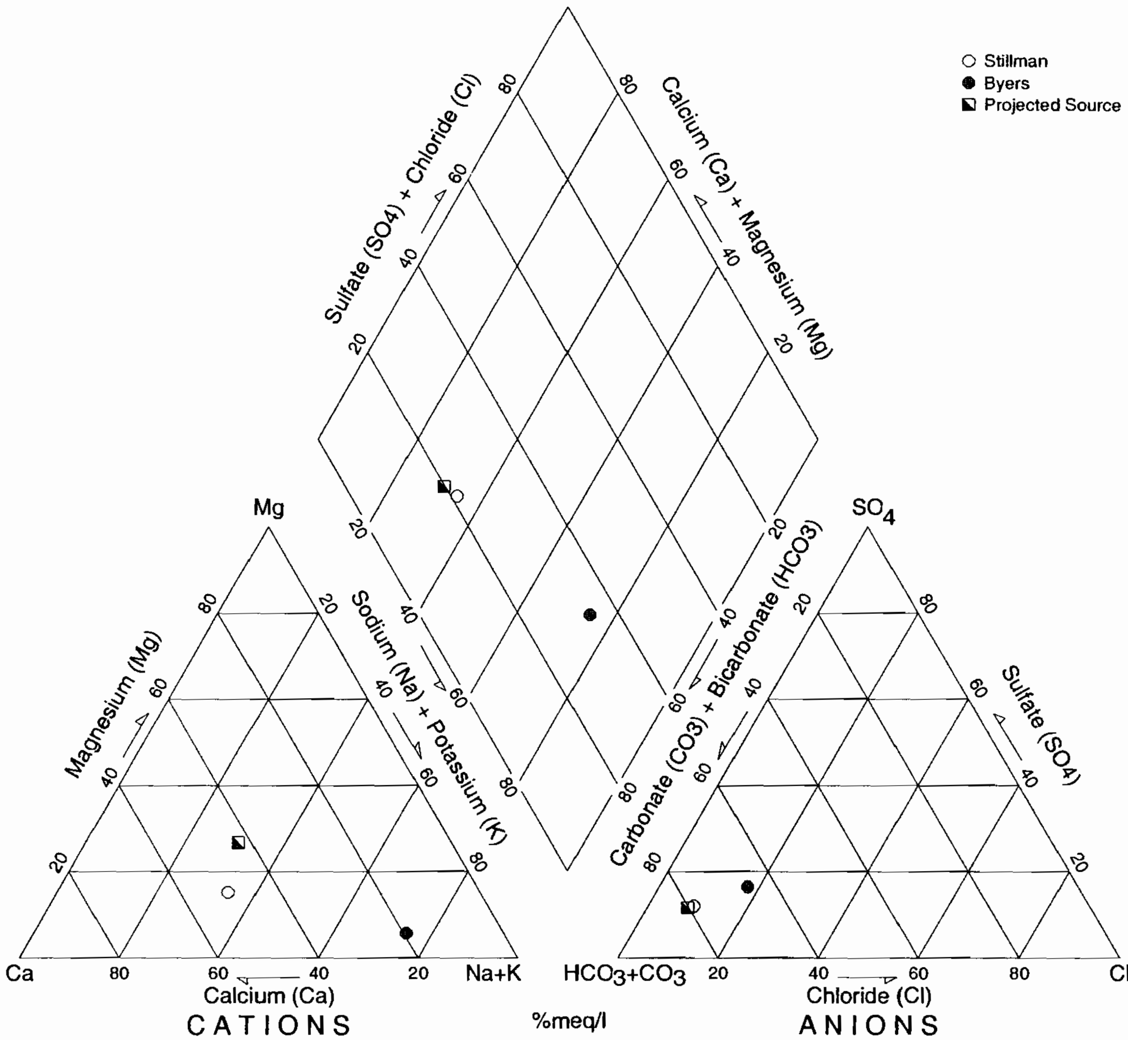
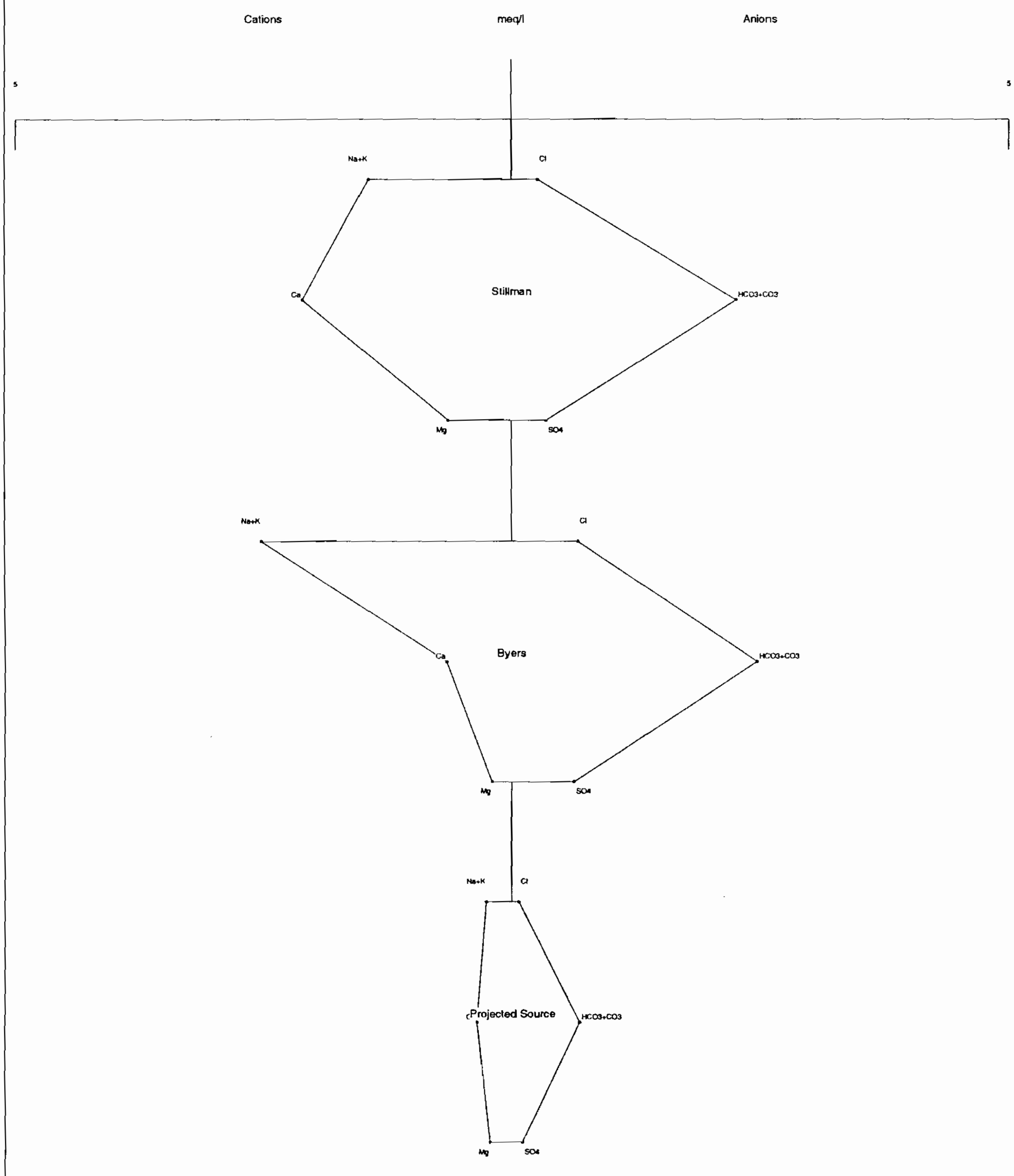


Fig 5-2 Stillman, Byers Avenue, and Projected Source Waters

City of Pendleton ASR Feasibility Study



APPENDIX A

UMAT 512

Telephone Call from Paul Rydman 10/15/71 [illegible]

2N/32E-9c

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

RECEIVED
MAR 1 1966
STATE ENGINEER
SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)

State Well No. ~~2N/31-36~~

State Permit No.

(1) OWNER:
Name CITY OF PENDLETON
Address PENDLETON, ORE.

(2) LOCATION OF WELL:
County UMATILLA Driller's well number 4222
NW ¼ NW ¼ Section 36 T. 2N R. 31E W.M.
Bearing and distance from section or subdivision corner

(3) TYPE OF WORK (check):
TEMPORARY
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☒
If abandonment, describe material and procedure in Item 12.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:
Rotary ☒ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(6) CASING INSTALLED:
Threaded ☐ Welded ☒
30 " Diam. from 0 ft. to 8 ft. Gage .375
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(7) PERFORATIONS:
Perforated? ☐ Yes ☒ No
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(8) SCREENS:
Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:
Well seal—Material used in seal
Depth of seal ft. Was a packer used?
Diameter of well bore to bottom of seal in.
Were any loose strata cemented off? ☐ Yes ☐ No Depth
Was a drive shoe used? ☐ Yes ☒ No
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off

(10) WATER LEVELS:
Static level 99 ft. below land surface Date 1/19/66
Artesian pressure lbs. per square inch Date

(11) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
APROX 700 GPM WITH "AIR "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ☐ Yes ☒ No

(12) WELL LOG:
Diameter of well below casing 8
Depth drilled 357 ft. Depth of completed well 357 ft.

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

MATERIAL	FROM	TO
TOP SOIL GRAVEL AND BOULDERS	0	8
HARD GREY BASALT	8	28
MED. HARD GREY BASALT	28	97
RED LAVA	97	102
MED HARD GREY BASALT	102	160
BROWN BROKEN BASALT	160	187
MED. HARD BLACK BASALT	187	208
HARD GREY BASALT	208	225
BROKEN GREY BASALT (WATER)	225	246
HARD GREY BASALT	246	260
BROWN BROKEN LAVA (WATER)	260	285
REDDISH BROWN LAVA	285	324
MED. HARD BLACK BASALT	324	330
HARD GREY BASALT	330	338
BROWN BROKEN LAVA (WATER)	338	352
HARD GREY BASALT	352	357
(A CEMENT PLUG HAS BEEN		
PLACED IN 8 INCH HOLE AT		
20-22 ft LEVEL, THEN A		
LID WELDED ON THE 30 INCH		
CASING)		

Work started NOV 15 1965 Completed JAN 20 1966
Date well drilling machine moved off of well JAN 20 1966

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

Water Well Contractor's Certification:

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

NAME R.J. STRASSER DRILLING Co
(Person, firm or corporation) (Type or print)
Address 8110 SE SUNSET LANE PORTLAND OR.

Drilling Machine Operator's License No. 56 AND 39[illegible]

[Signed] Robert L. Strasser
(Water Well Contractor)

Contractor's License No. 10 Date FEB 25, 1966

RECEIVED APR 20 1965 STATE ENGINEER

OBSERVATION WELL

UMAT 583

16bo

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

WATER WELL REPORT
STATE OF OREGON
(Please type or print)

State Well No. 2N/32-16B

State Permit No.

(1) OWNER:
Name CITY OF PENDLETON
Address PENDLETON ORE.

(2) LOCATION OF WELL:
TUTUILLA
County UMATILLA Driller's well number 4187
¼ ¼ Section 16 T. 2N. R. 32E W.M.
Bearing and distance from section or subdivision corner

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
andonment, describe material and procedure in Item 12.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(6) CASING INSTALLED:
Threaded ☐ Welded ☒
24 " Diam. from 0 ft. to 91 ft. Gage .375
20 " Diam. from 0 ft. to 390 ft. Gage .375
" Diam. from ft. to ft. Gage

(7) PERFORATIONS:
Perforated? ☐ Yes ☒ No
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(8) SCREENS:
Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:
Well seal—Material used in seal CEMENT GROUT
Depth of seal ft. Was a packer used? NO
Diameter of well bore to bottom of seal in.
Were any loose strata cemented off? ☐ Yes ☐ No Depth
Was a drive shoe used? ☐ Yes ☒ No
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off

(10) WATER LEVELS:
Static level 159 ft. below land surface Date 2/15/65
Artesian pressure lbs. per square inch Date

(11) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? R.J. STRASSER DRILLING C
Yield: 525 gal./min. with 361 ft. drawdown after 8 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 72° Was a chemical analysis made? ☐ Yes ☒ No

(12) WELL LOG:
Diameter of well below casing 16 AND 12
Depth drilled 1500 ft. Depth of completed well 1500 ft.

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

MATERIAL	FROM	TO
SEE ATTACHED SHEET		

Work started OCT 30 1964 Completed FEB 23 1965
Date well drilling machine moved off of well FEB 23 1965

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

Water Well Contractor's Certification:

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

NAME R.J. STRASSER DRILLING CO
(Person, firm or corporation) (Type or print)
Address 8110 SE. SUNSET LANE PORTLAND ORE.
Drilling Machine Operator's License No. 54
[Signed] Robert L. Strasser
(Water Well Contractor)
Contractor's License No. 10 Date APR. 17, 1965

(USE ADDITIONAL SHEETS IF NECESSARY)

RN/32-[illegible]

Log of Well # 6 at Pendleton, Oregon

0 - 13	Boulders and top soil
13 - 33	black basalt
33 - 40	brownish grey basalt
40 - 43	grey basalt
43 - 47	broken black with clay
47 - 60	red basalt
60 - 82	soft red basalt (some water)
82 - 94	hard grey basalt
94 - 101	medium hard brown basalt
101 - 143	hard grey and brown basalt
143 - 153	red and yellow soap stone
153 - 164	reddish brown medium hard basalt
164 - 165	soapstone
165 - 169	brown medium hard basalt
169 - 174	medium hard black basalt
174 - 226	hard grey and black basalt
226 - 252	brownish red basalt and soapstone
252 - 256	medium hard brown basalt
256 - 272	medium hard black basalt
272 - 290	broken grey basalt
290 - 293	medium hard black basalt with clay
293 - 303	black porous basalt
303 - 322	black broken basalt
322 - 323	hard black basalt with clay
323 - 367	porous brown basalt and soapstone
367 - 371	broken black basalt
371 - 378	medium hard red and grey
378 - 381	yellow clay
381 - 388	medium hard brown and grey
388 - 409	hard grey basalt
409 - 446	black basalt
446 - 468	medium hard grey basalt
468 - 473	dark grey basalt, green clay seams
473 - 494	hard grey basalt
494 - 505	porous black basalt
505 - 577	medium hard black basalt
577 - 593	hard grey basalt
595 - 614	medium hard grey basalt
614 - 635	hard grey basalt
[illegible] - [illegible]	broken red rock
[illegible] - [illegible]	porous black basalt
[illegible] - [illegible]	medium hard grey basalt
[illegible] - [illegible]	hard grey basalt
[illegible]	[illegible] and black broken
[illegible]	[illegible] black basalt
[illegible]	[illegible] hard [illegible] basalt
[illegible] - [illegible]	hard grey basalt
[illegible] - [illegible]	medium hard grey
823 - 851	hard grey basalt
851 - 863	brown and black porous
863 - 872	hard grey basalt
872 - 883	reddish grey basalt
883 - 911	medium hard black
911 - 993	hard grey basalt
993 - 1004	brown and black porous
1004 - 1008	hard black basalt
1008 - 1022	hard grey basalt
1022 - 1038	brown and black
1038 - 1142	hard grey basalt
1142 - 1165	porous brown basalt
1165 - 1193	red basalt and clay
1193 - [illegible]	hard grey basalt
[illegible] - 1334	brown basalt
1334 - 1353	medium hard black basal
[illegible] - [illegible]	hard grey basalt
[illegible] - [illegible]	porous [illegible] black
[illegible]	[illegible]
[illegible]	[illegible]
[illegible] - [illegible]	hard grey

RECEIVED
APR 23 1965
STATE ENGINEER
SALEM, OREGON

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion.

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

UMAT 533

State Well No. 3N/32E-4b
State Permit No.

WM Calc 7/29/85

(1) OWNER:
Name Blue Mountain Community College
Address P.O. Box 100
Pendleton, Ore 97801

(2) TYPE OF WORK (check):
New Well ☑ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☑ Driven ☐
Cable ☐ Jetted ☐
☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☑ Test Well ☐ Other ☐

(5) CASING INSTALLED:
Threaded ☐ Welded ☐
12" Diam. from +2 ft. to 28 ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS:
Perforated? ☐ Yes ☑ No
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☑ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☑ No If yes, by whom? Farmore
Yield: 780 gal./min. with 150 ft. drawdown after 12 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 65 Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used Portland Cement
Well sealed from land surface to 25 ft.
Diameter of well bore to bottom of seal 16 in.
Diameter of well bore below seal 10 in.
Number of sacks of cement used in well seal 20 sacks
How was cement grout placed? Pumped

Was a drive shoe used? ☐ Yes ☑ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☑ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☑ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County Umatilla Driller's well number
SE ¼ NW ¼ Section 5 T. 3N R. 32E W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found 310 ft.
Static level 300 ft. below land surface. Date 3-13-
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing 10"
Depth drilled 600 ft. Depth of completed well 600 ft.
Formation: Describe color, texture, grain size and structure of materials and show thickness and nature of each stratum and aquifer penetrated with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Broken Basalt	0	1	
Brown Basalt	1	20	
Red Basalt & yellow Clay	20	30	
Brown Basalt	30	60	
Black Basalt	60	130	
Black Clay + Black Basalt	130	148	
Black Basalt	148	174	
Brown Basalt	174	215	
Red & Black Broken Basalt	215	235	
Black Basalt	285	285	
Red Basalt + Gray Tuff	285	[illegible]	
Black Basalt	315	372	
Red + Black Basalt	372	428	
Black Basalt	428	503	
Red Basalt + yellow Tuff	503	520	H₂O
Black Basalt	520	600	

Work started March 7 1980 Completed March 13 1980
Date well drilling machine moved off of well March 13 1980

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Ladd Horn (Drilling Machine Operator) Date 3-21, 1980
Drilling Machine Operator's License No. 1345

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name Ladd Horn Well Drilling (Person, firm or corporation) (Type or print)
Address Rt 1 Box 14 Pilot Rock, Ore
[Signed] Ladd Horn (Water Well Contractor)
Contractor's License No. 739 Date 3-21- 1980

UMAT 53636

2N/32-10N(1) ccc

Application No. U 455
Permit No. U 418
Well No. 3

21st well -

UMATLLA Co

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

City of Pendleton

Date of Report October 19, 1953

1. Location of well: SW 1/4 SW 1/4 of Section 10 Twp. 2N Rge. 32E, W. M.
2. Name of nearest natural surface stream Umatilla River
3. Distance from well to that stream: 3,700 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: ______ feet.
5. Date of beginning drilling or digging. December 23, 1951
6. Date well was completed Oct. 1, 52

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
Clay & Rock	At surface	6 ft.
Broken Basalt	6' ft.	26 ft.
Broken Rock	32' ft.	24 ft.
Basalt Rock, Some mud	56 ft.	198 ft.
Basalt	254 ft.	409 ft.
Broken Rock & Clay	663 ft.	8 ft.
Basalt	671 ft.	338 ft.
	ft.	ft.
	ft.	ft.

Remarks: Final depth 1009

WELL INFORMATION

8. Diameter of well 16" inches. Depth of well 1009 feet.
9. Depth at which water was first encountered 56 feet.
10. Water level when completed: 153 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.:

132-10-14

UMAT 53636

PUMP INFORMATION

12. Manufacturer of pump: Peerless Pump Division
13. Address: R.M. Wade & Co; 106 SE Hawthorne; Portland 12, Ore.
14. Data on name or base plate:

15. Data on pump bowl assembly: 15 bowls, 9½ inches Diameter; 7" O.D. Strainer, 15" long;

16. Size of pump: 500 gpm
17. Rated capacity: 500 gpm gallons per minute.
18. Rated speed: 1750 revolutions per minute.
19. Number of stages: 15
20. Size of intake pipe: 6" Suction — 8" Column
21. Size of discharge pipe:
22. Length of intake pipe: 290' (Column only)
23. Length of discharge pipe:
24. Suction lift: (difference in elevation between water surface in well and pump) 153'
25. Discharge lift: (difference in elevation between pump and end of discharge line) 260
26. Depth of pump intake below ground surface: 322 3/4 feet.
27. Remarks:

MOTOR OR ENGINE INFORMATION

28. Name of manufacturer: Westing House
29. Address:
30. Type of motor or engine: Vertical hollow Shaft, Squirrel Cage induction type, Weatherproof Cover electric motor
31. Data on name or base plate: 3 phase; 480 Volt

32. Rated horsepower: 100
33. Rated speed of motor or engine: 1750 revolutions per minute.
34. Rated Capacity of Pump (with described motor)

500 g.p.m. at 536 ft. head Total dyna	
g.p.m. at ft. head	
g.p.m. at ft. head	
g.p.m. at ft. head	
g.p.m. at ft. head	

35. Remarks:

UMAT 53636   2N/32-10N1

CAPACITY TEST

36. Date of test: Sept 8, 1952 37. Temperature of water 64 °F. or ____ °C.
38. Motor speed during test: 1450 to 1550 RPM
39. Test made by (weir, tank or other means): 6" orfice & 10" std Pipe 1550 RPM

40.

Pounds pressure	TOTAL HEAD	*Total lift in feet	Gallons per min.	•Feet to water level	¤Draw-down	+Time
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	490	260 ft.	107 ft.	12:15 M. PM
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	490	260 ft.	107 ft.	12:30 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	500	260 ft.	107 ft.	1:00 M.
____ lbs.	Gauge at pump	Total 275 ft. ____ in.	510	265 ft.	112 ft.	1:30 M.
____ lbs.	Gauge at pump	Total 275 ft. ____ in.	510	265 ft.	112 ft.	2:00 M.
____ lbs.	Gauge at pump	Total 275 ft. ____ in.	510	265 ft.	112 ft.	2:30 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	2:45 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	3:00 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	3:30 M.
____ lbs.	Gauge at pump	Total 275 ft. ____ in.	559	265 ft.	112 ft.	4:00 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	4:15 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	4:45 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	5:15 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	6:00 M.
____ lbs.	Gauge at pump	Total 270 ft. ____ in.	540	260 ft.	107 ft.	6:45 M.
____ lbs.	Gauge at pump	Total 277 ft. ____ in.	586	267 ft.	114 ft.	7:00 M.
____ lbs.	Gauge at pump	Total 277 ft. ____ in.	586	267 ft.	114 ft.	7:30 M.

* Difference in elevation between water level in well and outlet of pump test line.
• Distance from ground level to water surface in well.
¤ Distance water level is lowered during time interval.
\+ Hour and minute at which observation was made.

41. Installation will work efficiently under normal head of 536 ft.
42. Water is discharged into: Distribution System
43. Was water lowered to pump intake by test? Yes
44. Remarks: Surface Water flows into well at 38' depth

GENERAL INFORMATION

45. Name of contractor or other party who drilled or dug well: A. A. Durand
Address: 115 Reese Ave., Walla Walla, Wash.
46. Pump and motor were installed by: R. M. Wade & Company
Address: Same as above
47. Capacity test was made by: A.A. Durand
Address: Same as above
48. General remarks:

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NOV 25 1953
STATE ENGINEER
SALEM, OREGON

UMAT 53635

2N/32-10F (1)

City of Pendleton

Application No. U-627
Permit No. U U-579
Well No. #2

UMATILLA Co

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Date of Report Nov. 23, 1953

1. Location of well: SE¼ of NW¼ of Section 11 Twp. 2N Rge. 32E W. M.
2. Name of nearest natural surface stream Umatilla River
3. Distance from well to that stream: 200 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: 15 feet.
5. Date of beginning drilling or digging: July 1948
6. Date well was completed Nov. 1948

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
gravel & rock	At surface	17 ft.
Black basalt	17 ft.	363 ft.
Broken basalt	363 ft.	370 ft.
Basalt	370 ft.	570 ft.
Loose basalt & sand	570 ft.	575 ft.
Hard basalt	575 ft.	670 ft.
Red basalt	670 ft.	728 ft.
Black basalt	728 ft.	760 ft.
	ft.	ft.

Remarks:

WELL INFORMATION

8. Diameter of well 16 inches. Depth of well 761 feet.
9. Depth at which water was first encountered Unknown feet.
10. Water level when completed: 140 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.: Well caved at 570 feet. Water stood in hole from depth of 15 feet, on down. however at (430) ft. depth - water level rose from ~~130 to~~ ~~140 ft~~ 140 to 130 ft.

430

~~Water temp 49°F~~

UMAT 53635

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STATE ENGINEER
SALEM. OREGON

2N/32-10F

PUMP INFORMATION

12. Manufacturer of pump: Peerless
13. Address: Agent- R.M. Wade, Portland Oregon.
14. Data on name or base plate: Peerless # 83999 - 10" type G.A.

15. Data on pump bowl assembly: 169' 10½" Column + 8'-7¾" of bowls + 19'-9¾"-10" Suction + 2'-4¾" Screen = 200'-8¼" total
16. Size of pump: 12" bowls
17. Rated capacity: 1000 gallons per minute.
18. Rated speed: 1750 revolutions per minute.
19. Number of stages: 9
20. Size of intake pipe: 12"
21. Size of discharge pipe: 12"
22. Length of intake pipe: 10 ft.
23. Length of discharge pipe: 30 ft.
24. Suction lift: (difference in elevation between water surface in well and pump) ~~[illegible]~~ none
25. Discharge lift: (difference in elevation between pump and end of discharge line) 450 ft. TDH.
26. Depth of pump intake below ground surface: 200 feet.
27. Remarks:

MOTOR OR ENGINE INFORMATION

28. Name of manufacturer: Westinghouse
29. Address: Portland, Oregon
30. Type of motor or engine: Electric motor
31. Data on name or base plate: 440 V. 150 HP 3ph. 60~ 1760 rpm.

32. Rated horsepower: 150
33. Rated speed of motor or engine: 1760 revolutions per minute.

34. Rated Capacity of Pump (with described motor)

g.p.m.	at	ft. head
1000	450	

35. Remarks: Pump is operated at a relatively constant head.

UMAT 53635

RECEIVED 21/32-10 F(1)
NOV 25 1953
STATE ENGINEER
SALEM, OREGON

CAPACITY TEST

36. Date of test: 9/30/53 37. Temperature of water 50 °F. or ____ °C.
38. Motor speed during test: 1700 to 2000 rpm.
39. Test made by (weir, tank or other means): ~~[illegible]~~ orfice.

40.

Pounds pressure	TOTAL HEAD	*Total lift in feet	Gallons per min.	°Feet to water level	¤Draw-down	+Time
24" ~~lbs.~~	Gauge at pump	Total 170 ft. — in.	1540	168 ft.	28 ft.	8 A.M.
~~[illegible]~~ ~~lbs.~~	Gauge at pump	Total ~~[illegible]~~ in.		ft.	ft.	M.
30 ~~lbs.~~	Gauge at pump	Total 176 ft. — in.	1711	174 ft.	34 ft.	3:u p.M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
34" ~~lbs.~~	Gauge at pump	Total ~~[illegible]~~ ft. ~~—~~ in.	1820	180 ft.	40 ft.	10 p.M.
___ lbs.	Gauge at pump	Total 182 ft. 10 in.		ft.	ft.	M.
~~[illegible]~~ ~~lbs.~~	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.

* Difference in elevation between water level in well and outlet of pump test line.
° Distance from ground level to water surface in well.
¤ Distance water level is lowered during time interval.
\+ Hour and minute at which observation was made.

41. Installation will work efficiently under normal head of 280 ft.
42. Water is discharged into: Distribution System.
43. Was water lowered to pump intake by test? No.
44. Remarks: Power not available to lower water to pump intake.

GENERAL INFORMATION

45. Name of contractor or other party who drilled or dug well: A.A. Durrand & Son. Address: Walla Walla, Wn.
46. Pump and motor were installed by: R. M. Wade & Co. Address: Portland, Ore.
47. Capacity test was made by: Paul Durrand. Address: Walla Walla Wn.
48. General remarks: ____

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STATE ENGINEER
SALEM, OREGON

OBSERVATION WELL

App G1273

File Original and First Copy with the STATE ENGINEER, SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON

UMAT 530

State Well No. 2N/32-2N (1)

State Permit No.

CCd

(1) OWNER:

Name: City of Pendleton

Address: Pendleton, Oregon

(2) LOCATION OF WELL:

County: Umatilla — Owner's number, if any: Stillman Park Well

SW ¼ SW ¼ Section 2 T. 2N R. 32 E. W.M.

Bearing and distance from section or subdivision corner:
NE corner of Block 22 bordered by SE 5th, SE Byers, SE 4th and the Umatilla River Levee
Block 22 Addition, Original Town of Pendleton

(3) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 11.

PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:

Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(6) CASING INSTALLED:

Threaded ☐ Welded ☒

30" Diam. from 1 ft. to 10 ft. Gage 3/8"
24" Diam. from 0 ft. to 185'10" ft. Gage 3/8"
" Diam. from ft. to ft. Gage

(7) PERFORATIONS:

Perforated? ☐ Yes ☐ No

Type of perforator used

SIZE of perforations in. by in.

perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(8) SCREENS:

Well screen installed ☐ Yes ☐ No

Manufacturer's Name

Type Model No.

Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:

Was well gravel packed? ☐ Yes ☒ No Size of gravel:

Gravel placed from ft. to ft.

Was a surface seal provided? ☒ Yes ☐ No To what depth? 185 ft.

Material used in seal— Neat cement annular seal

Did any strata contain unusable water? ☐ Yes ☐ No

Type of water? Depth of strata

Method of sealing strata off

(10) WATER LEVELS:

Static level 162' 2" ft. below land surface Date

Artesian pressure lbs. per square inch Date

Log Accepted by:

[Signed] Andrew J. Browning (Owner) City Manager Date 12-1, 1958

(11) WELL TESTS:

Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? Midco

Yield: 2400 gal./min. with 85'6" ft. drawdown after 45 hrs.
" " " "
" " " "

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water 60° Was a chemical analysis made? ☒ Yes ☐ No

(12) WELL LOG:

Diameter of well 30 x 24 x 20 x inches.

Depth drilled 700 ft. Depth of completed well 700 ft.

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

MATERIAL	FROM	TO
Soft black topsoil	0	1
Hard black boulders	1	4
Med. hard grey boulders	4	10
Dark hard basalt	10	53
Soft brown clay	53	66
Clay & broken basalt	66	68
Med. dark broken basalt	68	116
Hard dark basalt	116	131
Soft red and green clay	131	134
Medium black basalt	134	154
Soft black clay & broken rock	154	158
Medium dark broken rock	158	177
Dark hard basalt	177	195
Dark Medium broken basalt	195	210
Dark medium basalt	210	224
Dark hard basalt	224	288
Dark medium basalt	288	300
Soft brown cinders	300	310
Dark medium basalt	310	320
Brown medium basalt	320	347
Dark hard basalt	347	352
Medium brown basalt	352	354
Medium dark basalt	354	385
Medium brown basalt	385	392
(see attached sheet)		

Work started May 20 1958. Completed Oct. 24 1958

(13) PUMP:

Manufacturer's Name

Type: H.P.

Well Driller's Statement:

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

NAME Midland Drilling Co.
(Person, firm, or corporation) (Type or print)

Address P. O. Box 637, Walla Walla, Washington

Driller's well number 10

[Signed] E. J. Jungmann (Well Driller) E. J. Jungmann, V.

License No. 236 Date Nov. 21, 1958

(USE ADDITIONAL SHEETS IF NECESSARY)

Pendleton, Oregon Stillman Park Well

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SALEM, OREGON

2N/32-2

	DIAM.	DEPTH FROM	TO	FT.	SWL	FORMATIONS & CONTENTS -- WORK
		392	425			Medium hard dark basalt
		425	445			Medium brown basalt
		445	453			Soft brown broken basalt
		453	458			Medium brown basalt
		458	496			Medium hard dark basalt
		496	502			Hard dark basalt
		502	512			Medium dark basalt
		512	515			Hard dark basalt
		515	553			Medium dark basalt
		553	557			Hard dark basalt
		557	682			Medium dark basalt
		682	700			Medium hard dark basalt

2N/32-2 ccd

CITY OF PENDLETON, OREGON

AQUIFER TEST

DATE 11.15.60 SHEET 1 OF 5

DATE	TIME	ACCUM. MINUTES	BAROM. CORRECTION FROM 4:46 P.M. 9/20/60 FEET WATER	WELLS AND ZERO WATER ELEVATIONS - M.S.L. 909.18 STILLMAN DRAWDOWN FEET	909.18 STILLMAN Q - G.P.M.	909.20 BYERS DRAWDOWN FEET	909.20 BYERS Q - G.P.M.	906.16 BANK DRAWDOWN FEET	~~907.18~~ ROUND-UP DRAWDOWN FEET	906.1 REMARKS
			100%							STATE HOSPITAL
9/20	4:46P	0	0	0	START					AND 21st STREET
	:47	1	0	56.13	2400					PUMPS STOPPED
	:51	5	0	66.13	2500					3:54 PM STILLMAN
	:57	11	0	68.13	2500					ON 4:45 PM
	5:03	17	0	68.63	2480					
	:10	24	0	69.30	2480					
	:19	33	0			0	—			
	:26	40	0						0	
	7:27	161	0	70.63	2430					
	:35	169	0							
	:46	180	0							
	8.38	232	+0.01	70.62	2420					
	10:54	368	0.02	70.60	2410					
	11:00	374								
	:10	384								
	:31	405	0.03	70.38	2400					
9/21	6:55A	849	0.08	70.30	2400					
	8.43	957	0.09	70.42	2400					
	9.00	974	0.09			0.66	—			
	:30	1004	0.09						+0.09	
	3:40P	1374	-0.02						-0.06	
	4:00	1394	-0.02	70.65	2400					
	:25	1419	-0.02			0.69	—			
	:45	1439	-0.02	70.65	2400					
	5:00	1454								
	9:25	1719								
	:45	1739	-0.01	70.39	2400					
	:55	1749								
9/22	7:40A	2334	-0.06						-1.27	
	8:05	2359	-0.06			0.8[illegible]	—			
	:25	2379	[illegible]	70.77	[illegible]					
	2:30P	2744	-0.21	[illegible]	[illegible]			0.21		
	7:05	3019	-0.25						-0.83	
	:15	3029	-0.25	71.17	[illegible]			0.19		
	:25	3039	[illegible]			0.92	—			
9/23	7:15A	3749	-0.19						-1.06	
	8:15	3569	[illegible]	[illegible]	[illegible]			0.09		
	:30	[illegible]	-0.15			0.98	—			
	7:00P	4454	-0.14						-1.03	

CH2M
CORNELL, HOWLAND, HAYES & MERRYFIELD

#1358

CITY OF PENDLETON, OREGON

AQUIFER TEST

DATE 11.15.60 100%

SHEET 2 OF 5

DATE	TIME	ACCUM. MINUTES	BAROM. CORRECTION FROM 4:46 P.M. 9/20/60 FEET WATER	WELLS AND ZERO WATER ELEVATIONS - M.S.L.						REMARKS
				909.18		909.20		906.16	~~907.18~~ 906.1	
				STILLMAN		BYERS		BANK	ROUND-UP	
				DRAWDOWN FEET	Q - G.P.M.	DRAWDOWN FEET	Q - G.P.M.	DRAWDOWN FEET	DRAWDOWN FEET	
9/23	7:15 P	4469	-0.14	70.60	240[illegible] –			0.11		
	:30	4484	-0.14			0.89	–			
9/24	7:07 A	5181	-0.14						-1.03	
	:55	5229	-0.12	70.17	24[illegible]			0.13		
	8:05	5239	-0.12			0.78	–			Stillman
	← (40 mins) →									"Q"
9/24	8:45 A	0	-0.11	[illegible]	3000 –			0.11		increase
	9:00	15	-0.11			0.82	–		-1.06	
	:45	60	-0.12	104.21	[illegible]			0.62		
	10:45	120	-0.12	104.30	2915			0.78		
	11:00	135	-0.12			0.95	–		-0.55	
	:45	180	-0.11	104.41	2910			0.85		
	12:45 P	240	-0.10	104.69	2900 +			0.90		
	1:00	255	-0.10			1.02	–		-0.48	
	:45	300	-0.10	104.69	2900 +			0.94		
	2:45	360	-0.12	104.71	2900 +			0.97		
	3:00	375	-0.12			1.04	–		-0.46	
	4:45	480	-0.14	104.98	2900 +			1.00		
	5:00	495	-0.14			1.14	–		-0.44	
	6:45	600	-0.16	105.00	[illegible] +			1.02		
	7:00	615	-0.16			1.16	–		-0.42	
	8:45	720	-0.16	105.09	2900 +			1.03		
	9:00	735	-0.16			1.08	–		-0.42	
9/25	7:05 A	134[illegible]	-0.08						-0.42	
	8:00	1395	[illegible]7	105.66	29[illegible] +			1.04		
	:20	14[illegible]5	-0.07			1.15	–			
	6:50 P	2045	-0.09						-0.33	
	7:45	2100	-0.09	105.68	2900			1.09		
	8:00	2115	-0.09			1.17	–			
9/26	7:05 A	2780	-0.03						-0.22	
	8:00	2835	-0.03	105.81	2900			1.10		
	20	2855	-0.03			1.20	–			
	7:00 P	3495	-0.10						-0.32	
	:10	3505	-0.10	106.25	2900			1.14		
	:20	3515	-0.10			1.27	–			
9/27	7:00 A	4215	-0.02						-0.31	
	:50	4265	-0.01	106.08	2900			1.12		
	8:05	4280	-0.01			1.26	–			
	11:50	[illegible]	-0.03	106.01	2900			1.14		
	2:30 P	4665	-0.08	105.98	2890			1.16		

CH2M
CORNELL, HOWLAND, HAYES & MERRYFIELD

CITY OF PENDLETON, OREGON

AQUIFER TEST

DATE 11.15.60 100%

SHEET 2 OF 5

DATE	TIME	ACCUM. MINUTES	BAROM. CORRECTION FROM 4:46 P.M. 9/20/60 FEET WATER	WELLS AND ZERO WATER ELEVATIONS - M.S.L. 909.18 STILLMAN DRAWDOWN FEET	909.18 STILLMAN Q - G.P.M.	909.20 BYERS DRAWDOWN FEET	909.20 BYERS Q - G.P.M.	906.16 BANK DRAWDOWN FEET	~~907.18~~ 906.1 ROUND-UP DRAWDOWN FEET	REMARKS
9/23	7:15 P	4469	-0.14	70.60	240[illegible] —			0.11		
	:30	4484	-0.14			0.89	—			
9/24	7:07 A	5181	-0.14						-1.03	
	:55	5229	-0.12	70.17	24[illegible]			0.13		
	8:05	5239	-0.12			0.78	—			STILLMAN
	← (40 mins) →									"Q"
9/24	8:45 A	0	-0.11	101.54	3000 —			0.11		INCREAS.
	9:00	15	-0.11			0.82	—		-1.06	
	:45	60	-0.12	104.21	[illegible]			0.62		
	10:45	120	-0.12	104.30	2915			0.78		
	11:00	135	-0.12			0.95	—		-0.55	
	:45	180	-0.11	104.41	2910			0.85		
	12:45 P	240	-0.10	104.69	2900 +			0.90		
	1:00	255	-0.10			1.02	—		-0.48	
	:45	300	-0.10	104.69	2900 +			0.94		
	2:45	360	-0.12	104.71	2900 +			0.97		
	3:00	375	-0.12			1.04	—		-0.46	
	4:45	480	-0.14	104.98	2900 +			1.00		
	5:00	495	-0.14			1.14	—		-0.44	
	6:45	600	-0.16	105.00	[illegible]			1.02		
	7:00	615	-0.16			1.16	—		-0.42	
	8:45	720	-0.16	105.09	2900+			1.03		
	9:00	735	-0.16			1.08	—		-0.42	
9/25	7:05 A	134[illegible]	-0.08						-0.42	
	8:00	1395	[illegible]	105.66	[illegible]			1.04		
	:20	1415	-0.07			1.15	—			
	6:50 P	2045	-0.09						-0.33	
	7:45	2100	-0.09	105.68	2900			1.09		
	8:00	2115	-0.09			1.17	—			
9/26	7:05 A	2780	-0.03						-0.22	
	8:00	2835	-0.03	105.81	2900			1.10		
	20	2855	-0.03			1.20	—			
	7:00 P	3495	-0.10						-0.32	
	:10	3505	-0.10	106.25	2900			1.14		
	:20	3515	-0.10			1.27	—			
9/27	7:00 A	4215	-0.02						-0.31	
	:50	4265	-0.01	106.08	2900			1.12		
	8:05	4280	-0.01			1.26	—			
	11:50	[illegible]	-0.03	106.01	2900			1.14		
	2:30 P	4665	-0.06	105.98	2890			1.16		

C·H₂M CORNELL, HOWLAND, HAYES & MERRYFIELD

CITY OF PENDLETON, OREGON
AQUIFER TEST

DATE 11.15.60. 100% SHEET 3 OF 5

DATE	TIME	ACCUM. MINUTES	BAROM. CORRECTION FROM 4:46 P.M. 9/20/60 FEET WATER	WELLS AND ZERO WATER ELEVATIONS - M.S.L. 909.18 STILLMAN		909.20 BYERS		906.16 BANK	~~907.18~~ 906· ROUND-UP	REMARK
				DRAWDOWN FEET	Q - G.P.M.	DRAWDOWN FEET	Q - G.P.M.	DRAWDOWN FEET	DRAWDOWN FEET	
9/27	2:45P	4680	-0.09						-0.33	
	3:15	4710	-0.09			1.22	—			POWER OUTAGE
	4.52	4807	-0.10	103.69	2900			1.16		
	6:55	4950	-0.10						-0.32	
	7:13	4968	-0.10	104.53	2900			1.18		
	:25	4980	-0.10			1.27	—			
9/28	7:05A	5660	-0.07						-0.26	
	9:05	5720	-0.06	105.11	2900			1.21		
	:25	5740	-0.06			1.31	—			
	11:50	5945	-0.08	105.15	2900			1.22		
	3.15P	6150	-0.15	105.16	2900			1.24		
	:20	6155	-0.15						-0.27	
	4:00	6195	-0.16			1.49	2150			BYER.
	:10	6205	-0.16	105.17	2900	19.45	2150	1.24		PUMP O
	:20	6215	-0.16	105.17	2900	20.87	2100	1.24		
	:30	6225	-0.16	105.25	2900	21.87	2100	1.24		
	:40	6235	-0.17	105.26	2900	22.71	2100	1.25		
	:50	6245	-0.17	105.35	2900	23.30	1850	1.25		
	5:00	6255	-0.17	105.35	2900	23.55	1850	1.25		
	:20	6275	-0.17						-0.25	
	6:00	6315	-0.18	105.52	2900			1.28		
	:10	6325	-0.18			24.72	1800			
	:25	6340	-0.18						-0.24	
	7:00	6375	-0.17	105.68	2900			1.31		
	:10	6385	-0.17			25.54	1750			
	:25	6400	-0.17						-0.25	
	8:00	6435	-0.17	105.76	2900			1.36		
	:12	6447	-0.17			25.79	1700			
	:25	6460	-0.17						-0.25	
	9:00	6495	-0.17	105.76	2900			1.39		
	:10	[illegible]	-0.17			26.04	1700			
	:20	6515	-0.17						-0.16	
	10:00	6555	-0.17	105.25	2900			1.42		
	:13	6568	-0.17			25.[illegible]	1700			
	:24	[illegible]	-0.17						-0.16	
9/29	12:45	6715	-0.16						-0.01	
	:50	6725	-0.16	106.31	2900			1.47		
	1:20	6755	-0.16			[illegible]	1700			
	2:40	6835	-0.17						0	
	:50	6845	-0.17	106.19	2900			1.51		

C·H2·M CORNELL, HOWLAND, HAYES & MERRYFIELD

CITY OF PENDLETON, OREGON
AQUIFER TEST

DATE 11.15.60 100%

DATE	TIME	ACCUM. MINUTES	BAROM. CORRECTION FROM 4:46 P.M. 9/20/60 FEET WATER	WELLS AND ZERO WATER ELEVATIONS - M.S.L. 909.18 STILLMAN DRAWDOWN FEET	STILLMAN Q - G.P.M.	909.20 BYERS DRAWDOWN FEET	BYERS Q - G.P.M.	906.16 BANK DRAWDOWN FEET	~~907.16~~ 906.16 ROUND-UP DRAWDOWN FEET	REMARKS
9/29	3:20A	6875	-0.17			26.38	1650			
	4:40	6955	-0.17						0	
	:50	6965	-0.17	106.18	2900			1.54		
	5:20	6995	-0.17			26.54	1675			
	7:05	7100	-0.16						-0.01	
	8:00	7155	-0.15	106.24	2900			1.57		
	:12	7167	-0.15			27.19	1725			
	2:20P	7535	-0.24			28.53	1725			
	:30	7545	-0.24	106.25	2900			1.64		
	:45	7560	-0.20						+0.03	
	7:00	7815	-0.27						+0.10	
	:14	7829	-0.27	106.25	2900			1.68		
	:30	7845	-0.27			28.56	1700			
9/30	7:05A	8540	-0.27						+0.10	
	:55	8590	-0.28	106.51	2900			1.77		
	8:15	8610	-0.28			28.07	1700			
	2:10P	8965	-0.38			29.84	1800			
	:20	8975	-0.38	107.20	2900			1.80		
	:30	8985	-0.38						+0.13	
	6:50	9245	-0.41						+0.16	
	7:00	9255	-0.41	106.56	2900			1.82		
	:20	9275	-0.41			28.70	1650			
10/1	7:05A	9980	-0.25						+0.17	
	:55	10030	-0.25	106.90	2900			1.85		
	8:00	10035	-0.25			28.21	1750			
	5:20P	10555	-0.29						+0.21	
	:30	10605	-0.29	106.54	2900			1.89		
	:50	10625	-0.29			28.75	1650			
10/2	7:05A	11420	-0.18						+0.26	
	:40	11455	-0.18	107.00	2900			1.83?		
	8:10	11485	-0.18			28.55	1650			
	10:15	11610	-0.18	107.[illegible]	—	25.72	—	1.86		STILLMAN STOPPED. BYERS STOPPED.
10/2	10:15A	0	-0.18	[illegible]	—	15.64	—			
	:25	10	-0.17	3.31	—	13.74	—			
	:35	20	-0.18	[illegible]	—	13.49	—			
	:45	30	-0.19	[illegible]	—	10.75	—			
	:55	40	-0.19	2.07	—	10.42	—			
	11:05	50	-0.19	1.9[illegible]	—	9.75	—			
	:15	60	-0.19	1.91	—	8.76	—	-0.11		

CH2M
CORNELL, HOWLAND, HAYES & MERRYFIELD

CITY OF PENDLETON, OREGON

AQUIFER TEST

DATE 11.15.60 SHEET 5 OF 5

DATE	TIME	ACCUM. MINUTES	BAROM. CORRECTION FROM 4:46 P.M. 9/20/60 FEET WATER	WELLS AND ZERO WATER ELEVATIONS - M.S.L. 909.18 STILLMAN DRAWDOWN FEET	STILLMAN Q - G.P.M.	909.20 BYERS DRAWDOWN FEET	BYERS Q - G.P.M.	906.16 BANK DRAWDOWN FEET	~~907.18~~ ROUND-UP DRAWDOWN FEET	906.16 REMARKS
11/2	11 35A	20	-0.20						-2.38	
	12:15P	120	-0.21			6.15	—			
	.25	130	-0.21	1.64	—			-1.07		
	:35	140	-0.22						-2.61	
	1:15	180	-0.23			5.38	—			
	:25	190	-0.23	1.57	—			-1.21		
	:35	200	-0.23						-2.77	
	2:15	240	-0.24			4.81	—			
	:25	250	-0.24	1.42	—			-1.46		
	:35	260	-0.24						-2.93	
	3:15	300	-0.25			4.50	—			
	:25	310	-0.25	1.34	—			-1.54		
	:35	320	-0.25						-3.00	
	4.15	360	-0.27			4.10	—			
	:25	370	-0.27	1.28	—			-1.59		
	:35	380	-0.27						-3.06	
	6:15	480	-0.28			3.51	—			
	:25	490	-0.28	1.25	—			-1.78		
	:35	500	-0.28						-3.05	
	8.15	600	-0.26			3.07	—			
	:25	610	-0.26	1.23	—			-1.83		
	35	620	-0.26						-3.16	
	10.15	720	-0.26			2.51	—			
	:25	730	-0.26	1.23	—			-1.86		
	:35	740	-0.26						-3.16	
11/3	8:00	1305	-0.34			1.90	—			
	:15	1320	-0.34	0.97	—			-2.00		
	:25	1330	-0.34						-2.49	210 ST. ON 9A…
	10.00	1425	-0.37					-2.04		STATE HOSP. TA…
	5:00P	1845	-0.44					-2.05		PUMP O… 4-30 P…
	6.45	1950	-0.43					-2.02		STILLMAN ON.
	[illegible]	[illegible]	-0.38					0.70		
11/4	12:15A	2220	-0.36					0.88		STILLMAN OFF.
	2.00	[illegible]	-0.34					-0.87		STATE HOSP. OFF 2.30A
	4:00	[illegible]	-0.29					-1.33		
	10:00	[illegible]	-0.18					-1.86		
	12:00	[illegible]	-0.18					-1.90		STATE HOSP…
	2:00P	[illegible]	-0.20					-1.90		ON AN… 21… OFF 12-3…

STATE ENGINEER
Salem, Oregon

State Well No. 2N/32-2N(1)

County UMATILLA

Application No.

Water Level Record

OWNER: CITY OF PENDLETON OWNER'S NO. STILLMAN #5

Description of measuring point:

Date —1961—	Water Level Feet (below) Land Surface	DATE —1962—	WATER LEVEL FEET BELOW L.S.D.	Date —1962—	Water Level Feet (below) Land Surface	DATE	WATER LEVEL FEET BELOW L.S.D.
10-3	163.55	1-29	162.85	6-5	162.3 x	10-23	164.10
10-10	162.9 x	2-6	162.3 x	6-12	162.6	10-30	164.00
10-17	163.45	2-13	162.45	6-19	163.95 x	11-6	163.9
10-24	163.3 x	2-20	162.5	6-26	164.3	11-13	163.8
10-29	163.2	2-27	162.95 x	7-3	164.7 x	11-20	163.65
11-7	163.55 x	3-6	162.2 x	7-10	164.5	11-27	163.7
11-14	163.15	3-13	162.9	7-17	164.95 x	12-4	164.0
11-21	162.85	3-20	162.05 x	8-7	164.8 x	12-11	163.7
11-28	163.00 x	3-27	162.45	8-14	164.8	12-18	163.5
12-5	163.2	4-3	162.35 x	8-21	164.75 x	12-24	163.8
12-12	163.00	4-10	162.55	8-28	164.6	—1963—	
12-19	162.60 x	4-17	162.35	9-4	164.75 x	1-8	163.25
12-26	162.95	4-24	162.00 x	9-11	164.75	1-15	163.65
—1962—		4-30	162.45	9-18	164.25 x	1-29	163.5
1-2	162.8 x	5-7	162.00 x	9-25	164.45	2-5	163.5
1-9	163.2	5-14	162.20	10-2	164.00 x	2-12	163.75
1-16	162.75 x	5-22	162.25 x	10-9	163.7	2-21	164.2
1-23	162.95	5-28	162.4	10-16	164.6	2-26	163.6

REMARKS:

State Printing 89314

STATE ENGINEER
Salem, Oregon

State Well No. 2N/32-2N(1)

County Umatilla

Application No.

Water Level Record

#5

OWNER: City of Pendleton OWNER'S NO. STILLMAN W

Description of measuring point:

Date	Water Level Feet ~~(above)~~ (below) Land Surface	Remarks	Date 1961	Water Level Feet ~~(above)~~ (below) Land Surface	Remarks
1 3-61	162.4 x		5-9	161.65 x	
1-10-61	162.2		5-16	161.7	
1-17-61	162.1		5-23	161.75 x	
1 25-61	162.25		5-30	161.85	
1-30-61	161.8 x		6-6	161.8	
2 7-61	162.1		6-13	162.7 x	
2-14-61	162.1 x		6-20	163.7	
2-21-61	161.9		7-4	163.6	
2 28-61	162.2 x		7-11	164.15 x	
3-6-61	162.2		7-25	164.25	
3 14-61	161.6 x		8-1	164.3	
3 21-61	162.1		8-22	164.4 x	
3 28-61	162.2 x		8-28	164.25	
4-4-61	162.3		9-5	164.2	
4-11-61	161.7 x		9-12	163.9 x	
4-18-61	161.3		9-19	163.85	
4-25-61	162.9 x		9-26	163.8 x	
5-2-61	161.9				

REMARKS:

STATE ENGINEER
Salem, Oregon

State Well No. 2N/32-2N(1)

County UMATILLA

Application No.

Water Level Record

OWNER: CITY OF PENDLETON OWNER'S NO. STILLMAN #5

Description of measuring point:

Date -1963-	Water Level Feet ~~(above)~~ (below) Land Surface	DATE -1963-	WATER LEVEL FEET BELOW L.S.D.	Date -1963-	Water Level Feet ~~(above)~~ (below) Land Surface	DATE -1964-	WATER LEVEL FEET BELOW L.S.D.
3-5	163.5 x	7-9	165.2	11-12	164.5		163.8
3-12	163.3	7-16	165.7	11-19	163.9 x	3-24	163.8
3-19	163.8 x	7-23	165.9 x	11-26	164.3	4-1	164.0
3-26	163.3	7-30	165.75	12-3	164.45 x	4-7	164.0
4-2	163.4 x	8-6	165.85 x	12-10	164.6	4-15	163.8
4-9	163.25	8-13	165.65	12-17	164.5 x	4-21	163.9
4-16	163.2	8-20	165.75 x	12-24	164.15	4-28	163.6
4-23	163.4 x	8-27	165.35	-1964-	164.1 x	5-5	163.9
4-30	163.2	9-3	165.4 x	1-7	164.3	5-12	164.1
5-7	162.95 x	9-10	165.3	1-14	163.05 x	5-19	164.3
5-14	163.2	9-17	165.2 x	1-21	164.4	5-26	164.4
5-20	163.1 x	9-24	165.05	1-28	164.1 x	6-2	164.1
5-28	163.35	10-1	165.2 x	2-4	164.0	6-9	164.4
6-4	163.5 x	10-8	164.75	2-11	164.4 x	6-16	164.4
6-11	164.1	10-15	164.65	2-18	164.1	6-23	165.3
6-18	165.3 x	10-22	164.5 x	2-24	163.9 x	6-30	165.4
6-25	164.9	10-29	164.7	3-3	163.85	7-7	165.5
7-2	164.85 x	11-5	164.25 x	3-10	163.9 x	7-14	166.2
				3-17		7-21	166.9
						7-28	

REMARKS:

STATE ENGINEER
Salem, Oregon

UMAT 531

Well Record

STATE WELL NO. 2N/32-2R1
COUNTY Umatilla
APPLICATION NO.

OWNER: City of Pendleton

MAILING ADDRESS:

LOCATION OF WELL: Owner's No. 1

CITY AND STATE:

SE ¼ SE ¼ Sec. 2 T. 2 N./S., R. 32 E./W., W.M.

Bearing and distance from section or subdivision corner

Altitude at well 1,120 ft.

TYPE OF WELL: Drilled Date Constructed

Depth drilled 935 ft. Depth cased 147 ft.

Section 2

CASING RECORD: 20 inches

FINISH:

AQUIFERS: Basalt

WATER LEVEL: 185 ft. below land surface - 1948

PUMPING EQUIPMENT: Type Turbine H.P.

Capacity 1,800 G.P.M.

WELL TESTS:

Drawdown ft. after hours G.P.M.

Drawdown ft. after hours G.P.M.

USE OF WATER Public Supply Temp. °F. , 19

SOURCE OF INFORMATION USGS report - Umatilla River Basin

DRILLER or DIGGER

ADDITIONAL DATA:

Log Water Level Measurements Chemical Analysis X Aquifer Test

REMARKS:

APPENDIX C

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015	Date Reported: 12/15/00
PWS#: 4100613	Date Collected: 11/20/00
Source Name: Pendleton, City of	Time Collected: 1:10 PM
Sampled At:	Sampled By: RRSLLP

City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	Stillman Well 112000 Invoice# 4691

Synthetic Organic Chemicals (SOC's) — Matrix: Water

	URC Sample #:	201121-3				
	Sample ID:	Stillman Well 112000				
Analyte	Code/Method	Results	Units	MCL	Date Analyzed	Analyst
2,4-D	2105 / 515.1	ND@0.0002	mg/L	0.07	12/05/00	BKO
2,4,5-TP (Silvex)	2110 / 515.1	ND@0.0004	mg/L	0.05	12/05/00	BKO
Adipates	2035 / 525.2	ND@0.001	mg/L	0.4	12/01/00	BKO
Alachlor (Lasso)	2051 / 525.2	ND@0.0004	mg/L	0.002	12/01/00	BKO
Atrazine	2050 / 525.2	ND@0.0002	mg/L	0.003	12/01/00	BKO
Benzo(a)pyrene	2306 / 525.2	ND@0.00004	mg/L	0.0002	12/01/00	BKO
BHC-gamma (Lindane)	2010 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Carbofuran	2046 / 531.1	ND@0.001	mg/L	0.04	11/30/00	BKO
Chlordane	2959 / 508.1	ND@0.0004	mg/L	0.002	11/30/00	BKO
Dalapon	2031 / 515.1	ND@0.002	mg/L	0.2	12/05/00	BKO
Dibromochloropropane(DBCP)	2931 / 504.1	ND@0.00002	mg/L	0.0002	12/04/00	BKO
Dinoseb	2041 / 515.1	ND@0.0004	mg/L	0.007	12/05/00	BKO
Diquat	2032 / 549.2	ND@0.0004	mg/L	0.02	12/01/00	BKO
Endothall	2033 / 548.1	ND@0.01	mg/L	0.1	12/07/00	BEM
Endrin	2005 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Ethylene dibromide (EDB)	2946 / 504.1	ND@0.00001	mg/L	0.00005	12/04/00	BKO
Glyphosate	2034 / 547	ND@0.01	mg/L	0.7	12/10/00	BKO
Heptachlor epoxide	2067 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Heptachlor	2065 / 525.2	ND@0.00004	mg/L	0.0004	12/01/00	BKO
Hexachlorobenzene	2274 / 525.2	ND@0.0001	mg/L	0.001	12/01/00	BKO
Hexachlorocyclopentadiene	2042 / 525.2	ND@0.0002	mg/L	0.05	12/01/00	BKO
Methoxychlor	2015 / 525.2	ND@0.0002	mg/L	0.04	12/01/00	BKO
Pentachlorophenol	2326 / 515.1	ND@0.00008	mg/L	0.001	12/05/00	BKO
Phthalates	2039 / 525.2	**0.0022**	mg/L	0.006	12/01/00	BKO
Picloram	2040 / 515.1	ND@0.0002	mg/L	0.5	12/05/00	BKO
Polychlorinatedbiphenyls-PCBs	2383 / 508.1	ND@0.0002	mg/L	0.0005	11/30/00	BKO
Simazine	2037 / 525.2	ND@0.0001	mg/L	0.004	12/01/00	BKO
Toxaphene	2020 / 508.1	ND@0.001	mg/L	0.003	11/30/00	BKO
Vydate (Oxamyl)	2036 / 531.1	ND@0.002	mg/L	0.2	11/30/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

 Approved By:

201121-3soc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

SYNTHETIC ORGANIC CHEMICALS (SOC'S) - Unregulated

	URC Sample #:	201121-3				
	Sample ID:	Stillman Well 112000				
Unregulated SOC's	**Code/Method**	**Results**	**Units**	**MCL**	**Date Analyzed**	**Analyst**
3-Hydroxycarbofuran	2066 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Aldicarb	2047 / 531.1	ND@0.002	mg/L		11/30/00	BKO
Aldicarb sulfoxide	2043 / 531.1	ND@0.003	mg/L		11/30/00	BKO
Aldicarb sulfone	2044 / 531.1	ND@0.001	mg/L		11/30/00	BKO
Aldrin	2356 / 525.2	ND@0.0001	mg/L		12/01/00	BKO
Butachlor	2076 / 525.2	ND@0.001	mg/L		12/01/00	BKO
Carbaryl	2021 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Dicamba	2440 / 515.1	ND@0.0005	mg/L		12/05/00	BKO
Dieldrin	2070 / 525.2	ND@0.0001	mg/L		12/01/00	BKO
Methomyl	2022 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Metolachlor	2045 / 525.2	ND@0.002	mg/L		12/01/00	BKO
Metribuzin	2595 / 525.2	ND@0.001	mg/L		12/01/00	BKO
Propachlor	2077 / 525.2	ND@0.001	mg/L		12/01/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

201121-3soc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/11/00
Date Collected: 11/20/00
Time Collected: 1:10 PM
Sampled By: RRSLLP

Mailing Address for Report	Sample Information
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	Stillman Well 112000 Invoice# 4691

Radon — Matrix: Water

URC Sample #: **201121-3**
Sample ID: Stillman Well 112000

Analyte	Method Code	Results	Units	MCL	Date Analyzed	Analyst
Radon	EPA 913.0	143±21	pCi/L		*	*

* Tests were performed by Truesdail Laboratories. Inc.

MCL = Maximum Contaminant Level
ND = None Detected

Approved By:

201121-3rad

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015 PWS#: 4100613 Source Name: Pendleton, City of Sampled At:	Date Reported: 12/20/00 Date Collected: 11/20/00 Time Collected: 1:10 PM Sampled By: RRSLLP
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	Stillman Well 112000 Invoice# 4691
Volatile Organic Chemicals (VOC's)	Method: EPA 524.2 Matrix: Water

URC Sample #:	201121-3	Date Analyzed:	12/1/00
Sample ID:	Stillman Well 112000	Analyst:	BKO

REGULATED ANALYTES	Code	Results mg/L	MCL mg/L
1,1-Dichloroethylene	2977	ND@0.0005	0.007
1,1,1-Trichloroethane	2981	ND@0.0005	0.2
1,1,2-Trichloroethane	2985	ND@0.0005	0.005
1,2-Dichloroethane	2980	ND@0.0005	0.005
1,2-Dichloropropane	2983	ND@0.0005	0.005
1,2,4-Trichlorobenzene	2378	ND@0.0005	0.07
1,2-Dichlorobenzene	2968	ND@0.0005	0.6
1,4-Dichlorobenzene	2969	ND@0.0005	0.075
Benzene	2990	ND@0.0005	0.005
Carbon tetrachloride	2982	ND@0.0005	0.005
Chlorobenzene	2989	ND@0.0005	0.1
cis-1,2-Dichloroethylene	2380	ND@0.0005	0.07
Ethylbenzene	2992	ND@0.0005	0.7
Methylene chloride	2964	ND@0.0005	0.005
Styrene	2996	ND@0.0005	0.1
Tetrachloroethylene	2987	ND@0.0005	0.005
Toluene	2991	ND@0.0005	1.0
Total Xylenes	2955	ND@0.0005	10.0
trans-1,2-Dichloroethylene	2979	ND@0.0005	0.005
Trichloroethylene	2984	ND@0.0005	0.005
Vinyl chloride	2976	ND@0.0005	0.002

MCL = Maximum Contaminant Level
ND = None Detected at level indicated.

Approved By:

201121-3voc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

VOLATILE ORGANIC CHEMICALS (VOC'S) - Unregulated

Method: EPA 524.2 Matrix: Water

	URC Sample #:	201121-3				
	Sample ID:	Stillman Well 1				
UNREGULATED ANALYTES	Code	Results mg/L				
Chloroform	2941	**0.0025**				
Bromodichloromethane	2943	**0.0023**				
Dibromochloromethane	2944	**0.0025**				
Bromoform	2942	**0.0006**				
Chloromethane	2210	ND@0.0005				
Bromomethane	2214	ND@0.0005				
Chloroethane	2216	ND@0.0005				
2,2-Dichloropropane	2416	ND@0.0005				
1,1-Dichloropropene	2410	ND@0.0005				
1,1-Dichloroethane	2978	ND@0.0005				
Dibromomethane	2408	ND@0.0005				
cis-1,3-Dichloropropene	2413	ND@0.0005				
trans-1,3-Dichloropropene	2224	ND@0.0005				
1,3-Dichloropropane	2412	ND@0.0005				
1,1,1,2-Tetrachloroethane	2986	ND@0.0005				
1,1,2,2-Tetrachloroethane	2988	ND@0.0005				
1,2,3-Trichloropropane	2414	ND@0.0005				
Bromobenzene	2993	ND@0.0005				
2-Chiorotoluene	2965	ND@0.0005				
4-Chlorotoluene	2966	ND@0.0005				
1,3-Dichlorobenzene	2967	ND@0.0005				

MCL = Maximum Contaminant Level
ND = None Detected

201121-3voc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015	**Date Reported:** 12/23/00
PWS#:	**Date Collected:** 11/20/00
PWS Name:	**Time Collected:** 1:10 PM
Sampled At:	**Sampled By:** RRSLLP

Mailing Address for Report	**Sample Information**
City of Pendleton	**Stillman Well 112000**
Attn: Bob Patterson	
500 SW Dorion Avenue	**Invoice#**
Pendleton, OR 97801	**4691**
Miscellaneous	**Matrix:**
URC Sample #:	**201121-3**
Sample ID:	**Stillman Well**

Analyte	Method Code	Results	Units	MCL	Date Analyzed	Analyst
Hydrogen Sulfide	SM $4500S^{-2}$	ND@0.1	mg/L		11/29/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

Single

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/20/00
Date Collected: 11/20/00
Time Collected: 1:10 PM
Sampled By: RRSLLP

Mailing Address for Report	Sample Information
City of Pendleton	Stillman Well 112000
Attn: Bob Patterson	
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Total Trihalomethanes — Matrix: Drinking Water

URC Sample #: 201121-3
Sample ID: Stillman Well 112000

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Chloroform	EPA 524.2	0.0030	mg/L		12/01/00	BKO
Bromodichloromethane	EPA 524.2	0.0029	mg/L		12/01/00	BKO
Dibromochloromethane	EPA 524.2	0.0025	mg/L		12/01/00	BKO
Bromoform	EPA 524.2	0.0009	mg/L		12/01/00	BKO
Total Trihalomethanes	EPA 524.2	0.0093	mg/L		12/01/00	BKO

US:05

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-3tthm

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/13/00
Date Collected: 11/29/00
Time Collected: 9:49 AM
Sampled By: RR & LP

Mailing Address for Report	Sample Information
City of Pendleton	Stillman Well
Attn: Bob Patterson	
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Extended Inorganics — **Matrix:** Drinking Water

URC Sample #: **201121-3**
Sample ID: Stillman Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Dissolved Oxygen	SM 5210B	6.3	mg/L		12/01/00	MLH
Turbidity	SM 2130	0.53	NTU		12/01/00	MLH
MBAS	SM 5540C	ND@0.02	mg/L as LA		12/01/00	MLH
Color	SM 2120B	ND@5	Color Units		12/01/00	MLH
Odor	SM 2150B	4.0	TON		12/01/00	MLH
Total Alkalinity (as $CaCO_3$)	EPA 310.1	111	mg/L		12/08/00	MLH
Corrosivity	SM 2330B	-0.57	SI		12/11/00	KSO
Chloride	EPA 300.0	9.28	mg/L		11/21/00	KSO
Hardness (as $CaCO_3$)	SM 2340C	94.0	mg/L		12/11/00	MLH
Calcium	SM 3111B	42.2	mg/L		12/04/00	JMR
Aluminum	EPA 200.9	ND@0.005	mg/L		12/04/00	JMR
Copper	EPA 200.9	ND@0.01	mg/L		12/01/00	JMR
Iron	EPA 200.9	ND@.02	mg/L		12/04/00	JMR
Manganese	EPA 200.9	ND@0.01	mg/L		12/01/00	JMR
Silver	EPA 200.9	ND@0.01	mg/L		12/05/00	JMR
Zinc	SM 3111B	ND@0.02	mg/L		12/04/00	JMR
Total Dissolved Solids	SM 2540C	210	mg/L		12/05/00	MLH
Bicarbonate (as $CaCO_3$)	EPA 310.1	138	mg/L		12/08/00	MLH
Carbonate (as $CaCO_3$)	EPA 310.1	ND@3	mg/L		12/08/00	MLH
Ammonia	SM 4500NH3	0.069	mg/L		12/08/00	MLH
Total Phosphorus	SM 4500P	0.023	mg/L		12/04/00	MLH
Potassium	SM 3111B	5.78	mg/L		12/04/00	JMR
Magnesium	EPA 242.1	7.76	mg/L		12/04/00	JMR

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-3sec

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015 PWS#: 4100613 Source Name: Pendleton, City of Sampled At:	Date Reported: 12/13/00 Date Collected: 11/20/00 Time Collected: 1:10 PM Sampled By: RRSLLP
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	Stillman Well 112000 Invoice#
Inorganic Chemicals (IOC's)	Matrix: Water

	URC Sample #:	201121-3				
	Sample ID:	Stillman Well				
Analyte	**Code/Method** (EPA unless marked)	**Results**	**Units**	**MCL**	**Date Analyzed**	**Analyst**
pH	SM 4500-H+	7.2	pH Units	6.5-8.5	11/21/00	MLH
Specific Conductance	SM 2510A	312	µmho/cm	<500	11/21/00	MLH
Antimony	1074 / 200.9	ND@0.003	mg/L	0.006	11/30/00	JMR
Arsenic	1005 / 200.9	ND@0.01	mg/L	0.05	11/30/00	JMR
Barium	1010 / SM3113B	0.21	mg/L	2.0	11/27/00	JMR
Beryllium	1075 / 200.9	ND@0.0002	mg/L	0.004	12/05/00	JMR
Cadmium	1015 / 200.9	ND@0.001	mg/L	0.005	11/30/00	JMR
Chromium	1020 / 200.9	ND@0.02	mg/L	0.1	12/01/00	JMR
Lead	1030 / 200.9	ND@0.002	mg/L	0.015	11/24/00	JMR
Mercury	1035 / 245.1	ND@0.001	mg/L	0.002	12/08/00	JMR
Nickel	1036 / 200.9	ND@0.02	mg/L	0.1	11/30/00	JMR
Selenium	1045 / 200.9	ND@0.003	mg/L	0.05	11/30/00	JMR
Sodium	1052 / SM3111B	29.7	mg/L	20	11/29/00	JMR
Thallium	1085 / 200.9	ND@0.001	mg/L	0.002	11/22/00	JMR
Fluoride	1025 / 300.0	0.39	mg/L	4.0	11/21/00	JMR
Nitrate as N	1040 / 300.0	1.09	mg/L	10.0	11/21/00	KSO
Nitrite as N	1041 / 300.0	0.022	mg/L	1.0	11/21/00	KSO
Nitrate+Nitrite as N	1038 / 300.0	1.11	mg/L	10.0	11/21/00	KSO
Sulfate	1055 / 300.0	16.7	mg/L		11/21/00	KSO
Cyanide	1024/SM4500CN	ND@0.02	mg/L	0.2	12/07/00	MLH
Silica	1049/SM4500Si	50.4	mg/L		11/30/00	KSO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-3ioc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015	**Date Reported:** 12/15/00
PWS#: 4100613	**Date Collected:** 11/20/00
Source Name: Pendleton, City of	**Time Collected:** 11:45 AM
Sampled At:	**Sampled By:** RRSLLP

City of Pendleton	**River at Intake**
Attn: Bob Patterson	
500 SW Dorion Avenue	**Invoice#**
Pendleton, OR 97801	4691

Synthetic Organic Chemicals (SOC's) — **Matrix:** Water

	URC Sample #:	**201121-6**				
	Sample ID:	**Intake**				
Analyte	**Code/Method**	**Results**	**Units**	**MCL**	**Date Analyzed**	**Analyst**
2,4-D	2105 / 515.1	ND@0.0002	mg/L	0.07	12/05/00	BKO
2,4,5-TP (Silvex)	2110 / 515.1	ND@0.0004	mg/L	0.05	12/05/00	BKO
Adipates	2035 / 525.2	ND@0.001	mg/L	0.4	12/01/00	BKO
Alachlor (Lasso)	2051 / 525.2	ND@0.0004	mg/L	0.002	12/01/00	BKO
Atrazine	2050 / 525.2	ND@0.0002	mg/L	0.003	12/01/00	BKO
Benzo(a)pyrene	2306 / 525.2	ND@0.00004	mg/L	0.0002	12/01/00	BKO
BHC-gamma (Lindane)	2010 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Carbofuran	2046 / 531.1	ND@0.001	mg/L	0.04	11/30/00	BKO
Chlordane	2959 / 508.1	ND@0.0004	mg/L	0.002	11/30/00	BKO
Dalapon	2031 / 515.1	ND@0.002	mg/L	0.2	12/05/00	BKO
Dibromochloropropane(DBCP)	2931 / 504.1	ND@0.00002	mg/L	0.0002	12/04/00	BKO
Dinoseb	2041 / 515.1	ND@0.0004	mg/L	0.007	12/05/00	BKO
Diquat	2032 / 549.2	ND@0.0004	mg/L	0.02	12/01/00	BKO
Endothall	2033 / 548.1	ND@0.01	mg/L	0.1	12/07/00	BEM
Endrin	2005 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Ethylene dibromide (EDB)	2946 / 504.1	ND@0.00001	mg/L	0.00005	12/04/00	BKO
Glyphosate	2034 / 547	ND@0.01	mg/L	0.7	12/10/00	BKO
Heptachlor epoxide	2067 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Heptachlor	2065 / 525.2	ND@0.00004	mg/L	0.0004	12/01/00	BKO
Hexachlorobenzene	2274 / 525.2	ND@0.0001	mg/L	0.001	12/01/00	BKO
Hexachlorocyclopentadiene	2042 / 525.2	ND@0.0002	mg/L	0.05	12/01/00	BKO
Methoxychlor	2015 / 525.2	ND@0.0002	mg/L	0.04	12/01/00	BKO
Pentachlorophenol	2326 / 515.1	ND@0.00008	mg/L	0.001	12/05/00	BKO
Phthalates	2039 / 525.2	ND@0.001	mg/L	0.006	12/01/00	BKO
Picloram	2040 / 515.1	ND@0.0002	mg/L	0.5	12/05/00	BKO
Polychlorinatedbiphenyls-PCBs	2383 / 508.1	ND@0.0002	mg/L	0.0005	11/30/00	BKO
Simazine	2037 / 525.2	ND@0.0001	mg/L	0.004	12/01/00	BKO
Toxaphene	2020 / 508.1	ND@0.001	mg/L	0.003	11/30/00	BKO
Vydate (Oxamyl)	2036 / 531.1	ND@0.002	mg/L	0.2	11/30/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

 Approved By: [signature]

201121-6soc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

SYNTHETIC ORGANIC CHEMICALS (SOC'S) - Unregulated

	URC Sample #:	201121-6				
	Sample ID:	Intake				
Unregulated SOC's	Code/Method	Results	Units	MCL	Date Analyzed	Analyst
3-Hydroxycarbofuran	2066 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Aldicarb	2047 / 531.1	ND@0.002	mg/L		11/30/00	BKO
Aldicarb sulfoxide	2043 / 531.1	ND@0.003	mg/L		11/30/00	BKO
Aldicarb sulfone	2044 / 531.1	ND@0.001	mg/L		11/30/00	BKO
Aldrin	2356 / 525.2	ND@0.0001	mg/L		12/01/00	BKO
Butachlor	2076 / 525.2	ND@0.001	mg/L		12/01/00	BKO
Carbaryl	2021 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Dicamba	2440 / 515.1	ND@0.0005	mg/L		12/05/00	BKO
Dieldrin	2070 / 525.2	ND@0.0001	mg/L		12/01/00	BKO
Methomyl	2022 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Metolachlor	2045 / 525.2	ND@0.002	mg/L		12/01/00	BKO
Metribuzin	2595 / 525.2	ND@0.001	mg/L		12/01/00	BKO
Propachlor	2077 / 525.2	ND@0.001	mg/L		12/01/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

201121-6soc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/12/00
Date Collected: 11/20/00
Time Collected: 11:45 AM
Sampled By: RRSLLP

Mailing Address for Report	Sample Information
City of Pendleton	River at Intake
Attn: Bob Patterson	
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Radon — Matrix: Water

URC Sample #: **201121-6**
Sample ID: **Intake**

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Radon	EPA 913.0	35±19	pCi/L		*	*

*Tests were performed by Truesdail Laboratories, Inc.

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-6rad

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015 PWS#: 4100613 Source Name: Pendleton, City of Sampled At:	Date Reported: 12/20/00 Date Collected: 11/20/00 Time Collected: 11:45 AM Sampled By: RRSLLP
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	River at Intake Invoice# 4691
Volatile Organic Chemicals (VOC's)	Method: EPA 524.2 Matrix: Water

URC Sample #:	201121-6		Date Analyzed:	12/1/00
Sample ID:	Intake		Analyst:	BKO

REGULATED ANALYTES	Code	Results mg/L		MCL mg/L		
1,1-Dichloroethylene	2977	ND@0.0005		0.007		
1,1,1-Trichloroethane	2981	ND@0.0005		0.2		
1,1,2-Trichloroethane	2985	ND@0.0005		0.005		
1,2-Dichloroethane	2980	ND@0.0005		0.005		
1,2-Dichloropropane	2983	ND@0.0005		0.005		
1,2,4-Trichlorobenzene	2378	ND@0.0005		0.07		
1,2-Dichlorobenzene	2968	ND@0.0005		0.6		
1,4-Dichlorobenzene	2969	ND@0.0005		0.075		
Benzene	2990	ND@0.0005		0.005		
Carbon tetrachloride	2982	ND@0.0005		0.005		
Chlorobenzene	2989	ND@0.0005		0.1		
cis-1,2-Dichloroethylene	2380	ND@0.0005		0.07		
Ethylbenzene	2992	ND@0.0005		0.7		
Methylene chloride	2964	ND@0.0005		0.005		
Styrene	2996	ND@0.0005		0.1		
Tetrachloroethylene	2987	ND@0.0005		0.005		
Toluene	2991	ND@0.0005		1.0		
Total Xylenes	2955	ND@0.0005		10.0		
trans-1,2-Dichloroethylene	2979	ND@0.0005		0.005		
Trichloroethylene	2984	ND@0.0005		0.005		
Vinyl chloride	2976	ND@0.0005		0.002		

MCL = Maximum Contaminant Level
ND = None Detected at level indicated.

Approved By:

201121-6voc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

VOLATILE ORGANIC CHEMICALS (VOC'S) - Unregulated

Method: EPA 524.2 Matrix: Water

	URC Sample #:	201121-6				
	Sample ID:	Intake				
UNREGULATED ANALYTES	Code	Results mg/L				
Chloroform	2941	ND@0.0005				
Bromodichloromethane	2943	ND@0.0005				
Dibromochloromethane	2944	ND@0.0005				
Bromoform	2942	ND@0.0005				
Chloromethane	2210	ND@0.0005				
Bromomethane	2214	ND@0.0005				
Chloroethane	2216	ND@0.0005				
2,2-Dichloropropane	2416	ND@0.0005				
1,1-Dichloropropene	2410	ND@0.0005				
1,1-Dichloroethane	2978	ND@0.0005				
Dibromomethane	2408	ND@0.0005				
cis-1,3-Dichloropropene	2413	ND@0.0005				
trans-1,3-Dichloropropene	2224	ND@0.0005				
1,3-Dichloropropane	2412	ND@0.0005				
1,1,1,2-Tetrachloroethane	2986	ND@0.0005				
1,1,2,2-Tetrachloroethane	2988	ND@0.0005				
1,2,3-Trichloropropane	2414	ND@0.0005				
Bromobenzene	2993	ND@0.0005				
2-Chlorotoluene	2965	ND@0.0005				
4-Chlorotoluene	2966	ND@0.0005				
1,3-Dichlorobenzene	2967	ND@0.0005				

MCL = Maximum Contaminant Level
ND = None Detected

201121-6voc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#:
PWS Name:
Sampled At:

Date Reported: 12/23/00
Date Collected: 11/20/00
Time Collected: 1:10 PM
Sampled By: RRSLLP

Mailing Address for Report

City of Pendleton
Attn: Bob Patterson
500 SW Dorion Avenue
Pendleton, OR 97801

Sample Information

Intake at River

Invoice# 4691

Miscellaneous

Matrix: Water

URC Sample #: 201121-6
Sample ID: Intake

Analyte	Method Code	Results	Units	MCL	Date Analyzed	Analyst
Hydrogen Sulfide	SM $4500S^{-2}$	ND@0.1	mg/L		11/29/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By:

Single

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015	**Date Reported:** 12/20/00
PWS#: 4100613	**Date Collected:** 11/20/00
PWS Name: Pendleton, City of	**Time Collected:** 11:45 AM
Sampled At:	**Sampled By:** RRSLLP

Mailing Address for Report	**Sample Information**
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	River at Intake Invoice# 4691

Total Trihalomethanes — **Matrix:** Drinking Water

URC Sample #: **201121-6**
Sample ID: Intake

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Chloroform	EPA 524.2	ND@0.0005	mg/L		12/01/00	BKO
Bromodichloromethane	EPA 524.2	ND@0.0005	mg/L		12/01/00	BKO
Dibromochloromethane	EPA 524.2	ND@0.0005	mg/L		12/01/00	BKO
Bromoform	EPA 524.2	ND@0.0005	mg/L		12/01/00	BKO
Total Trihalomethanes	EPA 524.2	ND@0.0020	mg/L		12/01/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-6tthm

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/13/00
Date Collected: 11/29/00
Time Collected: 10:38 AM
Sampled By: RR & LP

Mailing Address for Report
City of Pendleton
Attn: Bob Patterson
500 SW Dorion Avenue
Pendleton, OR 97801

Sample Information
River at Intake

Invoice#
4691

Extended Inorganics

Matrix: Drinking Water

URC Sample #: 201121-6
Sample ID: Intake

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Dissolved Oxygen	SM 5210B	11.4	mg/L		12/01/00	MLH
Turbidity	SM 2130	2.32	NTU		12/01/00	MLH
MBAS	SM 5540C	0.062	mg/L as LA		12/01/00	MLH
Color	SM 2120B	ND@5	Color Units		12/01/00	MLH
Odor	SM 2150B	3.0	TON		12/01/00	MLH
Total Alkalinity (as $CaCO_3$)	EPA 310.1	32.1	mg/L		12/08/00	MLH
Corrosivity	SM 2330B	-1.4	SI		12/11/00	KSO
Chloride	EPA 300.0	1.89	mg/L		11/21/00	KSO
Hardness (as $CaCO_3$)	SM 2340C	31.0	mg/L		12/11/00	MLH
Calcium	SM 3111B	9.06	mg/L		12/04/00	JMR
Aluminum	EPA 200.9	ND@0.005	mg/L		12/04/00	JMR
Copper	EPA 200.9	ND@0.01	mg/L		12/01/00	JMR
Iron	EPA 200.9	0.050	mg/L		12/04/00	JMR
Manganese	EPA 200.9	ND@0.01	mg/L		12/01/00	JMR
Silver	EPA 200.9	ND@0.01	mg/L		12/05/00	JMR
Zinc	SM 3111B	ND@0.02	mg/L		12/04/00	JMR
Total Dissolved Solids	SM 2540C	80.0	mg/L		12/05/00	MLH
Bicarbonate ($CaCO_3$)	EPA 310.1	38.7	mg/L		12/08/00	MLH
Carbonate ($CaCO_3$)	EPA 310.1	ND@3	mg/L		12/08/00	MLH
Ammonia	SM 4500NH3	ND@0.06	mg/L		12/08/00	MLH
Total Phosphorus	SM 4500P	0.023	mg/L		12/04/00	MLH
Potassium	SM 3111B	1.85	mg/L		12/04/00	JMR
Magnesium	EPA 242.1	3.16	mg/L		12/04/00	JMR

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-6sec

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015 PWS#: 4100613 Source Name: Pendleton, City of Sampled At:	Date Reported: 12/13/00 Date Collected: 11/20/00 Time Collected: 11:45 AM Sampled By: RRSLLP
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	River at Intake Invoice#
Inorganic Chemicals (IOC's)	Matrix:

	URC Sample #:	201121-6				
	Sample ID:	Intake				
Analyte	Code/Method (EPA unless marked)	Results	Units	MCL	Date Analyzed	Analyst
pH	SM 4500-H+	7.5	pH Units	6.5-8.5	11/21/00	MLH
Specific Conductance	SM 2510A	85	μmho/cm	<500	11/21/00	MLH
Antimony	1074 / 200.9	ND@0.003	mg/L	0.006	11/30/00	JMR
Arsenic	1005 / 200.9	ND@0.01	mg/L	0.05	11/30/00	JMR
Barium	1010 / SM3113B	0.149	mg/L	2.0	11/27/00	JMR
Beryllium	1075 / 200.9	ND@0.0002	mg/L	0.004	12/05/00	JMR
Cadmium	1015 / 200.9	ND@0.001	mg/L	0.005	11/30/00	JMR
Chromium	1020 / 200.9	ND@0.02	mg/L	0.1	12/01/00	JMR
Lead	1030 / 200.9	ND@0.002	mg/L	0.015	11/24/00	JMR
Mercury	1035 / 245.1	ND@0.001	mg/L	0.002	12/08/00	JMR
Nickel	1036 / 200.9	ND@0.02	mg/L	0.1	11/30/00	JMR
Selenium	1045 / 200.9	ND@0.003	mg/L	0.05	11/30/00	JMR
Sodium	1052 / SM3111B	5.74	mg/L	20	11/29/00	JMR
Thallium	1085 / 200.9	ND@0.001	mg/L	0.002	11/22/00	JMR
Fluoride	1025 / 300.0	0.10	mg/L	4.0	11/21/00	JMR
Nitrate as N	1040 / 300.0	ND@0.1	mg/L	10.0	11/21/00	KSO
Nitrite as N	1041 / 300.0	ND@0.01	mg/L	1.0	11/21/00	KSO
Nitrate+Nitrite as N	1038 / 300.0	ND@0.1	mg/L	10.0	11/21/00	KSO
Sulfate	1055 / 300.0	1.81	mg/L		11/21/00	KSO
Cyanide	1024/SM4500CN	ND@0.02	mg/L	0.2	12/07/00	MLH
Silica	1049/SM4500Si	29.8			11/30/00	KSO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-6ioc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015	
PWS#: 4100613	Date Reported: 12/15/00
Source Name: Pendleton, City of	Date Collected: 11/20/00
	Time Collected: 9:40 AM
Sampled At:	Sampled By: RRSLLP

City of Pendleton
Attn: Bob Patterson
500 SW Dorion Avenue
Pendleton, OR 97801

City Shop

Invoice# 4691

Synthetic Organic Chemicals (SOC's)

Matrix: Water

	URC Sample #:	201121-4				
	Sample ID:	City Shop				
Analyte	Code/Method	Results	Units	MCL	Date Analyzed	Analyst
2,4-D	2105 / 515.1	ND@0.0002	mg/L	0.07	12/05/00	BKO
2,4,5-TP (Silvex)	2110 / 515.1	ND@0.0004	mg/L	0.05	12/05/00	BKO
Adipates	2035 / 525.2	ND@0.001	mg/L	0.4	12/01/00	BKO
Alachlor (Lasso)	2051 / 525.2	ND@0.0004	mg/L	0.002	12/01/00	BKO
Atrazine	2050 / 525.2	ND@0.0002	mg/L	0.003	12/01/00	BKO
Benzo(a)pyrene	2306 / 525.2	ND@0.00004	mg/L	0.0002	12/01/00	BKO
BHC-gamma (Lindane)	2010 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Carbofuran	2046 / 531.1	ND@0.001	mg/L	0.04	11/30/00	BKO
Chlordane	2959 / 508.1	ND@0.0004	mg/L	0.002	11/30/00	BKO
Dalapon	2031 / 515.1	ND@0.002	mg/L	0.2	12/05/00	BKO
Dibromochloropropane(DBCP)	2931 / 504.1	ND@0.00002	mg/L	0.0002	12/05/00	BKO
Dinoseb	2041 / 515.1	ND@0.0004	mg/L	0.007	12/05/00	BKO
Diquat	2032 / 549.2	ND@0.0004	mg/L	0.02	12/01/00	BKO
Endothall	2033 / 548.1	ND@0.01	mg/L	0.1	12/07/00	BEM
Endrin	2005 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Ethylene dibromide (EDB)	2946 / 504.1	ND@0.00001	mg/L	0.00005	12/04/00	BKO
Glyphosate	2034 / 547	ND@0.01	mg/L	0.7	12/010	BKO
Heptachlor epoxide	2067 / 525.2	ND@0.00002	mg/L	0.0002	12/01/00	BKO
Heptachlor	2065 / 525.2	ND@0.00004	mg/L	0.0004	12/01/00	BKO
Hexachlorobenzene	2274 / 525.2	ND@0.0001	mg/L	0.001	12/01/00	BKO
Hexachlorocyclopentadiene	2042 / 525.2	ND@0.0002	mg/L	0.05	12/01/00	BKO
Methoxychlor	2015 / 525.2	ND@0.0002	mg/L	0.04	12/01/00	BKO
Pentachlorophenol	2326 / 515.1	ND@0.00008	mg/L	0.001	12/05/00	BKO
Phthalates	2039 / 525.2	ND@0.001	mg/L	0.006	12/01/00	BKO
Picloram	2040 / 515.1	ND@0.0002	mg/L	0.5	12/05/00	BKO
Polychlorinatedbiphenyls-PCBs	2383 / 508.1	ND@0.0002	mg/L	0.0005	11/30/00	BKO
Simazine	2037 / 525.2	ND@0.0001	mg/L	0.004	12/01/00	BKO
Toxaphene	2020 / 508.1	ND@0.001	mg/L	0.003	11/30/00	BKO
Vydate (Oxamyl)	2036 / 531.1	ND@0.002	mg/L	0.2	11/30/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

 Approved By:

201121-4soc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

SYNTHETIC ORGANIC CHEMICALS (SOC'S) - Unregulated

	URC Sample #:	201121-4				
	Sample ID:	City Shop				
Unregulated SOC's	**Code/Method**	**Results**	**Units**	**MCL**	**Date Analyzed**	**Analyst**
3-Hydroxycarbofuran	2066 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Aldicarb	2047 / 531.1	ND@0.002	mg/L		11/30/00	BKO
Aldicarb sulfoxide	2043 / 531.1	ND@0.003	mg/L		11/30/00	BKO
Aldicarb sulfone	2044 / 531.1	ND@0.001	mg/L		11/30/00	BKO
Aldrin	2356 / 525.2	ND@0.0001	mg/L		12/01/00	BKO
Butachlor	2076 / 525.2	ND@0.001	mg/L		12/01/00	BKO
Carbaryl	2021 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Dicamba	2440 / 515.1	ND@0.0005	mg/L		12/05/00	BKO
Dieldrin	2070 / 525.2	ND@0.0001	mg/L		12/01/00	BKO
Methomyl	2022 / 531.1	ND@0.004	mg/L		11/30/00	BKO
Metolachlor	2045 / 525.2	ND@0.002	mg/L		12/01/00	BKO
Metribuzin	2595 / 525.2	ND@0.001	mg/L		12/01/00	BKO
Propachlor	2077 / 525.2	ND@0.001	mg/L		12/01/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

201121-4soc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
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REPORT

OREGON STATE CERTIFIED LAB #015
PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/11/00
Date Collected: 11/20/00
Time Collected: 9:40 AM
Sampled By: RRSLLP

Mailing Address for Report	Sample Information
City of Pendleton	City Shop
Attn: Bob Patterson	112000
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Radon — Matrix: Water

URC Sample #: 201121-4
Sample ID: City Shop

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Radon	EPA 913.0	75±20	pCi/L		*	*

*Tests were performed by Truesdail Laboratories. Inc.

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-4rad

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015 PWS#: 4100613 Source Name: Pendleton, City of Sampled At:	Date Reported: 12/20/00 Date Collected: 11/20/00 Time Collected: 1:10 AM Sampled By: RRSLLP
City of Pendleton Attn: Bob Patterson 500 SW Dorion Avenue Pendleton, OR 97801	Invoice# 4691

Volatile Organic Chemicals (VOC's) — Method: EPA 524.2 — Matrix: Water

URC Sample #: 201121-4 — Date Analyzed: 12/1/00
Sample ID: City Shop — Analyst: BKO

REGULATED ANALYTES	Code	Results mg/L		MCL mg/L		
1,1-Dichloroethylene	2977	ND@0.0005		0.007		
1,1,1-Trichloroethane	2981	ND@0.0005		0.2		
1,1,2-Trichloroethane	2985	ND@0.0005		0.005		
1,2-Dichloroethane	2980	ND@0.0005		0.005		
1,2-Dichloropropane	2983	ND@0.0005		0.005		
1,2,4-Trichlorobenzene	2378	ND@0.0005		0.07		
1,2-Dichlorobenzene	2968	ND@0.0005		0.6		
1,4-Dichlorobenzene	2969	ND@0.0005		0.075		
Benzene	2990	ND@0.0005		0.005		
Carbon tetrachloride	2982	ND@0.0005		0.005		
Chlorobenzene	2989	ND@0.0005		0.1		
cis-1,2-Dichloroethylene	2380	ND@0.0005		0.07		
Ethylbenzene	2992	ND@0.0005		0.7		
Methylene chloride	2964	ND@0.0005		0.005		
Styrene	2996	ND@0.0005		0.1		
Tetrachloroethylene	2987	ND@0.0005		0.005		
Toluene	2991	ND@0.0005		1.0		
Total Xylenes	2955	ND@0.0005		10.0		
trans-1,2-Dichloroethylene	2979	ND@0.0005		0.005		
Trichloroethylene	2984	ND@0.0005		0.005		
Vinyl chloride	2976	ND@0.0005		0.002		

MCL = Maximum Contaminant Level
ND = None Detected at level indicated.

Approved By: [signature]

201121-4voc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

VOLATILE ORGANIC CHEMICALS (VOC'S) - Unregulated

Method: EPA 524.2 Matrix: Water

	URC Sample #:	201121-4				
	Sample ID:	City Shop				
UNREGULATED ANALYTES	Code	Results mg/L				
Chloroform	2941	**0.0130**				
Bromodichloromethane	2943	**0.0030**				
Dibromochloromethane	2944	ND@0.0005				
Bromoform	2942	ND@0.0005				
Chloromethane	2210	ND@0.0005				
Bromomethane	2214	ND@0.0005				
Chloroethane	2216	ND@0.0005				
2,2-Dichloropropane	2416	ND@0.0005				
1,1-Dichloropropene	2410	ND@0.0005				
1,1-Dichloroethane	2978	ND@0.0005				
Dibromomethane	2408	ND@0.0005				
cis-1,3-Dichloropropene	2413	ND@0.0005				
trans-1,3-Dichloropropene	2224	ND@0.0005				
1,3-Dichloropropane	2412	ND@0.0005				
1,1,1,2-Tetrachloroethane	2986	ND@0.0005				
1,1,2,2-Tetrachloroethane	2988	ND@0.0005				
1,2,3-Trichloropropane	2414	ND@0.0005				
Bromobenzene	2993	ND@0.0005				
2-Chlorotoluene	2965	ND@0.0005				
4-Chlorotoluene	2966	ND@0.0005				
1,3-Dichlorobenzene	2967	ND@0.0005				

MCL = Maximum Contaminant Level
ND = None Detected

201121-4voc

UMPQUA Research Company
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Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#:
PWS Name:
Sampled At:

Date Reported: 12/23/00
Date Collected: 11/20/00
Time Collected: 1:10 PM
Sampled By: RRSLLP

Mailing Address for Report	Sample Information
City of Pendleton	City Shop
Attn: Bob Patterson	
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Miscellaneous

Matrix:

URC Sample #: **201121-4**

Sample ID: **City Shop**

Analyte	Method Code	Results	Units	MCL	Date Analyzed	Analyst
Hydrogen Sulfide	SM 4500S^{-2}	ND@0.1	mg/L		11/29/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

Single

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/20/00
Date Collected: 11/20/00
Time Collected: 9:40 AM
Sampled By: RRSLLP

Mailing Address for Report	Sample Information
City of Pendleton	City Shop
Attn: Bob Patterson	112000
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Total Trihalomethanes — **Matrix:** Drinking Water

URC Sample #: **201121-4**
Sample ID: City Shop

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Chloroform	EPA 524.2	0.0133	mg/L		12/01/00	BKO
Bromodichloromethane	EPA 524.2	0.0029	mg/L		12/01/00	BKO
Dibromochloromethane	EPA 524.2	ND@0.0005	mg/L		12/01/00	BKO
Bromoform	EPA 524.2	ND@0.0005	mg/L		12/01/00	BKO
Total Trihalomethanes	EPA 524.2	0.0162	mg/L		12/01/00	BKO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-4tthm

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#: 4100613
PWS Name: Pendleton, City of
Sampled At:

Date Reported: 12/13/00
Date Collected: 11/29/00
Time Collected: 9:47 AM
Sampled By: RR & LP

Mailing Address for Report	Sample Information
City of Pendleton	City Shop
Attn: Bob Patterson	
500 SW Dorion Avenue	Invoice#
Pendleton, OR 97801	4691

Extended Inorganics — Matrix: Drinking Water

URC Sample #: 201121-4
Sample ID: City Shop

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Dissolved Oxygen	SM 5210B	8.4	mg/L		12/01/00	MLH
Turbidity	SM 2130	2.66	NTU		12/01/00	MLH
MBAS	SM 5540C	ND@0.02	mg/L as LA		12/01/00	MLH
Color	SM 2120B	ND@5	Color Units		12/01/00	MLH
Odor	SM 2150B	2.0	TON		12/01/00	MLH
Total Alkalinity (as $CaCO_3$)	EPA 310.1	57.1	mg/L		12/08/00	MLH
Corrosivity	SM 2330B	-2.1	SI		12/11/00	KSO
Chloride	EPA 300.0	2.82	mg/L		11/21/00	KSO
Hardness (as $CaCO_3$)	SM 2340C	62.4	mg/L		12/11/00	MLH
Calcium	SM 3111B	12.8	mg/L		12/04/00	JMR
Aluminum	EPA 200.9	ND@0.005	mg/L		12/04/00	JMR
Copper	EPA 200.9	ND@0.01	mg/L		12/01/00	JMR
Iron	EPA 200.9	0.227	mg/L		12/04/00	JMR
Manganese	EPA 200.9	ND@0.01	mg/L		12/01/00	JMR
Silver	EPA 200.9	ND@0.01	mg/L		12/05/00	JMR
Zinc	SM 3111B	ND@0.02	mg/L		12/04/00	JMR
Total Dissolved Solids	SM 2540C	87.0	mg/L		12/05/00	MLH
Bicarbonate ($CaCO_3$)	EPA 310.1	71.7	mg/L		12/08/00	MLH
Carbonate ($CaCO_3$)	EPA 310.1	ND@3	mg/L		12/08/00	MLH
Ammonia	SM 4500NH3	ND@0.05	mg/L		12/08/00	MLH
Total Phosphorus	SM 4500P	0.045	mg/L		12/04/00	MLH
Potassium	SM 3111B	2.44	mg/L		12/04/00	JMR
Magnesium	EPA 242.1	4.64	mg/L		12/04/00	JMR

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

201121-4sec

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#: 4100613
Source Name: Pendleton, City of
Sampled At:

Date Reported: 12/13/00
Date Collected: 11/20/00
Time Collected: 9:40 AM
Sampled By: RRSLLP

City of Pendleton
Attn: Bob Patterson
500 SW Dorion Avenue
Pendleton, OR 97801

City Shop
112000

Invoice#

Inorganic Chemicals (IOC's)

Matrix:

	URC Sample #:	**201121-4**				
	Sample ID:	**City Shop**				
Analyte	**Code/Method** (EPA unless marked)	**Results**	**Units**	**MCL**	**Date Analyzed**	**Analyst**
pH	SM 4500-H+	6.4	pH Units	6.5-8.5	11/21/00	MLH
Specific Conductance	SM 2510A	110	µmho/cm	<500	11/21/00	MLH
Antimony	1074 / 200.9	ND@0.003	mg/L	0.006	11/30/00	JMR
Arsenic	1005 / 200.9	ND@0.01	mg/L	0.05	11/30/00	JMR
Barium	1010 / SM3113B	1.25	mg/L	2.0	11/27/00	JMR
Beryllium	1075 / 200.9	ND@0.0002	mg/L	0.004	12/05/00	JMR
Cadmium	1015 / 200.9	ND@0.001	mg/L	0.005	11/30/00	JMR
Chromium	1020 / 200.9	ND@0.02	mg/L	0.1	12/01/00	JMR
Lead	1030 / 200.9	ND@0.002	mg/L	0.015	11/24/00	JMR
Mercury	1035 / 245.1	ND@0.001	mg/L	0.002	12/08/00	JMR
Nickel	1036 / 200.9	ND@0.02	mg/L	0.1	11/30/00	JMR
Selenium	1045 / 200.9	ND@0.003	mg/L	0.05	11/30/00	JMR
Sodium	1052 / SM3111B	5.41	mg/L	20	11/29/00	JMR
Thallium	1085 / 200.9	ND@0.001	mg/L	0.002	11/22/00	JMR
Fluoride	1025 / 300.0	0.11	mg/L	4.0	11/21/00	JMR
Nitrate as N	1040 / 300.0	0.57	mg/L	10.0	11/21/00	KSO
Nitrite as N	1041 / 300.0	ND@0.01	mg/L	1.0	11/21/00	KSO
Nitrate+Nitrite as N	1038 / 300.0	0.57	mg/L	10.0	11/21/00	KSO
Sulfate	1055 / 300.0	1.71	mg/L		11/21/00	KSO
Cyanide	1024/SM4500CN	ND@0.02	mg/L	0.2	12/07/00	MLH
Silica	1049/SM4500Si	40.2			11/30/00	KSO

MCL = Maximum Contaminant Level
ND = None Detected

Approved By:

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#: 4100613
Source Name: Pendleton, City of
Sampled At:

Date Reported: 12/15/00
Date Collected: 11/29/00
Time Collected: Various
Sampled By: RR LP

City of Pendleton
Attn: Bob Patterson
500 SW Dorion Avenue
Pendleton, OR 97801

Invoice#
4761

Total Organic Carbon - Low Level (0.1)

Matrix: Water

URC Sample #:		201130-25	201130-26	201130-27	201130-28			
Sample ID:		River At Intake	Stillman Well	City Shop	Spring at Mission			
URC Sample#	Units	Results	Results	Results	Results	Method	Date Analyzed	Analyst
Total Organic Carbon	mg/L	2.0	1.0	1.9	1.8	SM5310C	11/30/00	JTH

MCL = Maximum Contaminant Level
N = None Detected At Level Indicated

Approved By: [signature]

201130-25

TRANSMISSION ELECTRON MICROSCOPY ANALYTICAL REPORT

Contact: Ms. Lisa Johnson

Address: Umpqua Research Co.
PO Box 609 / 626 N.E. Division St.
Myrtle Creek, OR 97457

Job Site / No.

Report No.: 25455
Date: Dec-21-00
Total Samples Analyzed: 4
Sample Collector:

CLIENT SAMPLE # 201130-21

Laboratory Sample # 314-035-001

SAMPLE LOCATION

WATER SAMPLE DATA

Date/Time Collected	Nov-29-00 / 10:36 am	Volume Submitted (ml)	1000
Date/Time Lab Received	Dec-04-00 / 11:00 am	Volume Filtered (ml)	15
Date/Time Filtered	Dec-04-00 / 4:30 pm	Filter & Pore Size	MCE0.22um
Date/Time Analyzed	Dec-21-00 / 10:00 am	UV/Ozone Treated:	YES

IDENTIFIED STRUCTURES (>10um)			
ASBESTOS		OTHER	
CHRYS	AMPH	AMBIG	NON-ASB
NSD	NSD	NSD	NSD

CALCULATED ASBESTOS STRUCTURE CONCENTRATION (>10um)		
CHRYS	AMPH	TOTAL
< 0.2 MFL	< 0.2 MFL	< 0.2 MFL

COMMENTS

No Asbestos Detected. UV-Ozone Treated.

Filter Loading: HEAVY

SAED Photo ID Nos.

TEM / ANALYTICAL PARAMETERS

Grid Openings Scanned at 10,000X	8	Analytical Sensitivity	0.2 MFL
Grid Opening Area (mm2)	0.0097	95% UCL	0.64 MFL
Scan Area (mm2)	0.0776	95% LCL	0.0 MFL

NOTATION KEY

Chrys. - Chrysotile Asbestos
Amph. - Amphibole Asbestos
NSD - No Structures Detected
1 mm = 1 millimeter

1 um = 1 micron = 0.001 mm
MFL = Millions of Fibers per Liter
UCL = Upper Confidence Level
LCL = Lower Confidence Level

ANALYST SIGNATURE

LAB MANAGER SIGNATURE

TRANSMISSION ELECTRON MICROSCOPY ANALYTICAL REPORT

Contact: Ms. Lisa Johnson

Address: Umpqua Research Co.
PO Box 609 / 626 N.E. Division St.
Myrtle Creek, OR 97457

Job Site / No.

Report No.: 25455
Date: Dec-21-00
Total Samples Analyzed: 4
Sample Collector:

CLIENT SAMPLE # 201130-22

Laboratory Sample # 314-035-002

SAMPLE LOCATION

WATER SAMPLE DATA

Date/Time Collected	Nov-29-00 / 9:47 am	Volume Submitted (ml)	1000
Date/Time Lab Received	Dec-04-00 / 11:00 am	Volume Filtered (ml)	15
Date/Time Filtered	Dec-04-00 / 4:35 pm	Filter & Pore Size	MCE0.22um
Date/Time Analyzed	Dec-21-00 / 10:30 am	UV/Ozone Treated:	YES

IDENTIFIED STRUCTURES (>10um)			
ASBESTOS		OTHER	
CHRYS	AMPH	AMBIG	NON-ASB
NSD	NSD	NSD	NSD

CALCULATED ASBESTOS STRUCTURE CONCENTRATION (>10um)		
CHRYS	AMPH	TOTAL
< 0.2 MFL	< 0.2 MFL	< 0.2 MFL

COMMENTS

No Asbestos Detected. UV-Ozone Treated.

Filter Loading: HEAVY

SAED Photo ID Nos.

TEM / ANALYTICAL PARAMETERS

Grid Openings Scanned at 10,000X	8	Analytical Sensitivity	0.2 MFL
Grid Opening Area (mm2)	0.0097	95% UCL	0.64 MFL
Scan Area (mm2)	0.0776	95% LCL	0.0 MFL

NOTATION KEY

Chrys. - Chrysotile Asbestos
Amph. - Amphibole Asbestos
NSD - No Structures Detected
1 mm = 1 millimeter

1 um = 1 micron = 0.001 mm
MFL = Millions of Fibers per Liter
UCL = Upper Confidence Level
LCL = Lower Confidence Level

ANALYST SIGNATURE

LAB MANAGER SIGNATURE

TRANSMISSION ELECTRON MICROSCOPY ANALYTICAL REPORT

Contact: Ms. Lisa Johnson

Address: Umpqua Research Co.
PO Box 609 / 626 N.E. Division St.
Myrtle Creek, OR 97457

Job Site / No.

Report No.: 25455
Date: Dec-21-00
Total Samples Analyzed: 4
Sample Collector:

CLIENT SAMPLE # 201130-23

Laboratory Sample # 314-035-003

SAMPLE LOCATION

WATER SAMPLE DATA

Date/Time Collected	Nov-29-00 / 9:04 am	Volume Submitted (ml)	1000
Date/Time Lab Received	Dec-04-00 / 11:00 am	Volume Filtered (ml)	15
Date/Time Filtered	Dec-05-00 / 1:00 pm	Filter & Pore Size	MCE0.22um
Date/Time Analyzed	Dec-21-00 / 11:00 am	UV/Ozone Treated:	YES

IDENTIFIED STRUCTURES (>10um)			
ASBESTOS		OTHER	
CHRYS	AMPH	AMBIG	NON-ASB
NSD	NSD	NSD	NSD

CALCULATED ASBESTOS STRUCTURE CONCENTRATION (>10um)		
CHRYS	AMPH	TOTAL
< 0.2 MFL	< 0.2 MFL	< 0.2 MFL

COMMENTS

No Asbestos Detected. UV-Ozone Treated.

Filter Loading: HEAVY

SAED Photo ID Nos.

TEM / ANALYTICAL PARAMETERS

Grid Openings Scanned at 10,000X	8	Analytical Sensitivity	0.2 MFL
Grid Opening Area (mm2)	0.0097	95% UCL	0.64 MFL
Scan Area (mm2)	0.0776	95% LCL	0.0 MFL

NOTATION KEY

Chrys. - Chrysotile Asbestos
Amph. - Amphibole Asbestos
NSD - No Structures Detected
1 mm = 1 millimeter

1 um = 1 micron = 0.001 mm
MFL = Millions of Fibers per Liter
UCL = Upper Confidence Level
LCL = Lower Confidence Level

ANALYST SIGNATURE

LAB MANAGER SIGNATURE

ASBESTOS TEM LABORATORIES, INC. 1409 FIFTH STREET, BERKELEY, CA 94710 (510) 528-0108

TRANSMISSION ELECTRON MICROSCOPY ANALYTICAL REPORT

Contact:	Ms. Lisa Johnson		
Address:	Umpqua Research Co. PO Box 609 / 626 N.E. Division St. Myrtle Creek, OR 97457	Report No.:	25455
		Date:	Dec-21-00
		Total Samples Analyzed:	4
Job Site / No.		Sample Collector:	

CLIENT SAMPLE # 201130-24

Laboratory Sample # 314-035-004

SAMPLE LOCATION

WATER SAMPLE DATA

Date/Time Collected	Nov-29-00 / 10:14 am		Volume Submitted (ml)	1000
Date/Time Lab Received	Dec-04-00 / 11:00 am		Volume Filtered (ml)	15
Date/Time Filtered	Dec-05-00 / 1:05 pm		Filter & Pore Size	MCE0.22um
Date/Time Analyzed	Dec-21-00 / 11:30 am		UV/Ozone Treated:	YES

IDENTIFIED STRUCTURES (>10um)			
ASBESTOS		OTHER	
CHRYS	AMPH	AMBIG	NON-ASB
NSD	NSD	NSD	NSD

CALCULATED ASBESTOS STRUCTURE CONCENTRATION (>10um)		
CHRYS	AMPH	TOTAL
< 0.2 MFL	< 0.2 MFL	< 0.2 MFL

COMMENTS

No Asbestos Detected. UV-Ozone Treated.

Filter Loading: HEAVY

SAED Photo ID Nos.

TEM / ANALYTICAL PARAMETERS

Grid Openings Scanned at 10,000X	8	Analytical Sensitivity	0.2 MFL
Grid Opening Area (mm2)	0.0097	95% UCL	0.64 MFL
Scan Area (mm2)	0.0776	95% LCL	0.0 MFL

NOTATION KEY

Chrys. - Chrysotile Asbestos
Amph. - Amphibole Asbestos
NSD - No Structures Detected
1 mm = 1 millimeter

1 um = 1 micron = 0.001 mm
MFL = Millions of Fibers per Liter
UCL = Upper Confidence Level
LCL = Lower Confidence Level

ANALYST SIGNATURE

LAB MANAGER SIGNATURE

ASBESTOS TEM LABORATORIES, INC. 1409 FIFTH STREET, BERKELEY, CA 94710 (510) 528-0108

BYERS WELL FIELD PARAMETERS

Sampled 12-04-01, 11:00 AM on-site

pH	8.4
Specific Conductance (ave. of 2 readings)	413 µS
Temperature	66 °F (18.9 °C)
Oxidation/Reduction Potential	216 mV
Turbidity	0.19 NTU
Dissolved Oxygen (ave. of 2 readings)	2.69 ppm

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#:
PWS Name:
Sampled At:

Date Reported: 01/03/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Haloacetic Acid / EPA 552.2 — **Matrix:** water

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Monochloroacetic Acid	EPA 552.2	ND@0.002	mg/L		12/10/01	JCN
Monobromoacetic Acid	EPA 552.2	ND@0.001	mg/L		12/10/01	JCN
Dichloroacetic Acid	EPA 552.2	ND@0.001	mg/L		12/10/01	JCN
Trichloroacetic Acid	EPA 552.2	ND@0.001	mg/L		12/10/01	JCN
Dibromoacetic Acid	EPA 552.2	ND@0.001	mg/L		12/10/01	JCN
Total Haloacetic Acid - HAA5	EPA 552.2	ND@0.006	mg/L		12/10/01	JCN

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13haa

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 01/03/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Unregulated Contaminant Monitoring Rule — **Matrix:** Water

URC Sample #: 11205-13
Sample ID: Byers Well

	Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
*	Perchlorate	EPA 314.0	ND@0.005	mg/L		12/13/01	JCN
*	DCPA-mono acid	EPA 515.2	ND@0.001	mg/L		12/19/01	JCN
*	DCPA-di acid	EPA 515.2	ND@0.001	mg/L		12/19/01	JCN
*	Methyl-tert butyl ether (MTBE)	EPA 524.2	ND@0.001	mg/L		12/05/01	JCN
*	Nitrobenzene	EPA 524.2	ND@0.001	mg/L		12/05/01	JCN
*	2,4-Dinitrotoluene	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN
*	2,6-Dinitrotoluene	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN
*	Acetochlor	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN
*	4,4'-DDE	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN
*	EPTC	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN
*	Molinate	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN
*	Terbacil	EPA 525.2	ND@0.001	mg/L		12/19/01	JCN

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: John C Nair

* These are the parameters
I resampled on 2-26-02 at
UMPQUA's request. They were concerned with QA/QC.

11205-13ucmr

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 01/03/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Total Trihalomethanes Matrix: Drinking Water

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Chloroform	EPA 524.2	ND@0.0005	mg/L		12/05/01	JCN
Bromodichloromethane	EPA 524.2	ND@0.0005	mg/L		12/05/01	JCN
Dibromochloromethane	EPA 524.2	ND@0.0005	mg/L		12/05/01	JCN
Bromoform	EPA 524.2	ND@0.0005	mg/L		12/05/01	JCN
Total Trihalomethanes	EPA 524.2	ND@0.002	mg/L		12/05/01	JCN

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13tthm

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015 PWS#: Source Name: Sampled At:	Date Reported: 01/08/02 Date Collected: 12/04/01 Time Collected: 10:15 AM Sampled By: KK
City of Pendleton Attn: Karen King 1501 SE Byers Ave. Pendleton, OR 97801	Byers Well Well#1 Invoice# 8180
Inorganic Chemicals (IOC's)	Matrix: Drinking Water

	URC Sample #:	11205-13				
	Sample ID:	Byers Well				
Analyte	**Code/Method** (EPA unless marked)	**Results**	**Units**	**MCL**	**Date Analyzed**	**Analyst**
pH	SM 4500-H+	8.0	pH Units	6.5-8.5	12/05/01	MLH
Specific Conductance	SM 2510A	382	µmho/cm	<500	12/05/01	MLH
Antimony	1074 / 200.9	ND@0.003	mg/L	0.006	12/14/01	JMR
Arsenic	1005 / 200.9	ND@0.005	mg/L	0.05	12/06/01	JMR
Barium	1010 / SM3113B	ND@0.1	mg/L	2.0	12/06/01	JMR
Beryllium	1075 / 200.9	ND@0.0002	mg/L	0.004	12/07/01	JMR
Cadmium	1015 / 200.9	ND@0.001	mg/L	0.005	12/07/01	JMR
Chromium	1020 / 200.9	ND@0.02	mg/L	0.1	12/10/01	JMR
Lead	1030 / 200.9	ND@0.002	mg/L	0.015	12/13/01	JMR
Mercury	1035 / 245.1	ND@0.001	mg/L	0.002	12/11/01	JMR
Nickel	1036 / 200.9	ND@0.02	mg/L	0.1	12/07/01	JMR
Selenium	1045 / 200.9	ND@0.003	mg/L	0.05	12/10/01	JMR
Sodium	1052 / SM3111B	52.5	mg/L	20	12/12/01	JMR
Thallium	1085 / 200.9	ND@0.001	mg/L	0.002	12/10/01	JMR
Fluoride	1025 / 300.0	0.79	mg/L	4.0	12/05/01	JCN
Nitrate as N	1040 / 300.0	0.28	mg/L	10.0	12/05/01	JCN
Nitrite as N	1041 / 300.0	ND@0.01	mg/L	1.0	12/05/01	JCN
Nitrate+Nitrite as N	1038 / 300.0	0.28	mg/L	10.0	12/05/01	JCN
Sulfate	1055 / 300.0	29.9	mg/L		12/05/01	JCN
Cyanide	1024/SM4500CN	ND@0.05	mg/L	0.2	12/05/01	TDL
Chlorine (as Cl)		ND@0.05	mg/L		12/06/01	TDL
Chlorine Dioxide (as ClO_2)		ND@0.05	mg/L		12/05/01	JCN
Chlorite		ND@0.005	mg/L		12/05/01	JCN

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13ioc

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#:
PWS Name:
Sampled At:

Date Reported: 01/08/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180
Pendleton Secondary	Matrix: Drinking Water
URC Sample #:	11205-13
Sample ID:	Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
pH	SM 4500-H-B	8.0	pH Units		12/05/01	MLH
Specific Conductance	SM 2510A	382	umho/cm		12/05/01	MLH
Total Suspended Solids	SM 2540C	ND@1	mg/L		12/07/01	MLH
MBAS	SM 5540C	ND@0.02	mg/L as LA		12/06/01	MLH
Color	SM 2120B	ND@5	Color Units		12/06/01	MLH
Odor	SM 2150B	ND@1	TON		12/06/01	MLH
Total Alkalinity (as C_aCO_3)	EPA 310.1	133	mg/L		12/18/01	MLH
Corrosivity	SM 2330B	-1.38	SI		12/29/01	TDL
Chloride	EPA 300.0	23.5	mg/L		12/05/01	JCN
Hardness (as C_aCO_3)	SM 2340C	42.4	mg/L		12/19/01	MLH
Calcium	SM 3111B	13.1	mg/L		12/18/01	JMR
Aluminum	EPA 200.9	0.021	mg/L		12/05/01	JMR
Copper	EPA 200.9	ND@0.01	mg/L		12/15/01	JMR
Iron	EPA 200.9	ND@0.1	mg/L		12/18/01	JMR
Manganese (Total)	EPA 200.9	0.014	mg/L		12/18/01	JMR
Silver	EPA 200.9	ND@0.01	mg/L		12/27/01	JMR
Zinc	SM 3111B	ND@0.02	mg/L		12/13/01	JMR
Total Dissolved Solids	SM 2540C	225	mg/L		12/06/01	MLH
Total Organic Carbon	SM 5310C	0.72	mg/L		12/20/01	JMR
Mangancse(Dissloved)	EPA 200.9	0.013	mg/L		12/18/01	JMR
Ammonia(NH_3-N)	SM 4500NH_3	0.300	mg/L		12/21/01	MLH
Bicarbonate	SM 2320B	151	mg/L		12/18/01	MLH
Carbonate (as C_aCO_3)	SM 2320B	ND@3	mg/L		12/18/01	MLH
Magnesium (Total)	EPA 242.1	2.36	mg/L		12/13/01	JMR
Phosphorus (Total)	SM 4500P	0.193	mg/L		12/29/01	TDL
Potassium	EPA 258.1	9.23	mg/L		12/13/01	JMR

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13sec

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 01/15/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Asbestos Matrix: Water

URC Sample #: **11205-13**
Sample ID: **Byers Well**

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Asbestos	EPA 100.1/2	ND@0.2	MFL		*	*

*Asbestos test was performed by Montgomery Watson Laboratories in Pasadena, CA

MCL = Maximum Contaminant Level
ND – None Detected

Approved By: [signature]

11205-13

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
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REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 01/15/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Dioxin — Matrix: Water

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
2,3,7,8-TCDD	EPA-5 1613B	ND@3.5	pg/L		12/15/01	*

*The Dioxin test was performed by STL in Sacramento, CA

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13dioxin

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#:
PWS Name:
Sampled At:

Date Reported: 01/17/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Radiochemistry — Matrix: Water

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Gross Alpha	EPA 900.0	ND@1±1.578	pCi/L	5	01/15/02	MLH
Gross Beta	EPA 900.0	*	pCi/L		*	*

* I do not have the beta results yet, when I receive them I will forward them on to you.

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13gab

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 02/27/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report
City of Pendleton
Attn: Karen King
1501 SE Byers Ave.
Pendleton, OR 97801

Sample Information
Byers Well
Well#1

Invoice#
8180

Radiochemistry

Matrix: Water

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Gross Beta	EPA 900.0	10.4 ± 2.5	pCi/L		02/19/02	*

*The Gross Beta was tested at STL, Richland, WA

MCL = Maximum Contaminant Level
ND – None Detected

Approved By: [signature]

11205-13gb

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 02/27/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Uranium — **Matrix:** Water

URC Sample #: **11205-13**
Sample ID: **Byers Well**

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Uranium	SM 7500-U-C	ND@1.0±0.11	ug/L		02/19/02	*

*Uranium testing performed at STL, Richland WA

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13uranium

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015

PWS#:
PWS Name:
Sampled At:

Date Reported: 02/27/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180
City of the Dalles	Matrix:

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Strontium-90	EPA 905.0	ND@0.96 ± 0.41	pCi/L		02/19/02	*
Tritium	EPA 906.0	ND@303 ± 170	pCi/L		02/19/02	*
Iodine-131	EPA 901.1	ND@4.95 ± 2.90	pCi/L		02/19/02	*

*Tests performed at STL, Richland, WA.

MCL = Maximum Contaminant Level
ND = None Detected

Approved By:

11205-13iodine

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015
PWS#:
PWS Name:
Sampled At:

Date Reported: 02/27/02
Date Collected: 12/04/01
Time Collected: 10:15 AM
Sampled By: KK

Mailing Address for Report	Sample Information
City of Pendleton	Byers Well
Attn: Karen King	Well#1
1501 SE Byers Ave.	Invoice#
Pendleton, OR 97801	8180

Radium — Matrix: Water

URC Sample #: 11205-13
Sample ID: Byers Well

Analyte	Method Code	Results	Units	MCL	Date Analyzed	Analyst
Radium-226	ASTM D2460	ND@0.15 ± 0.08	pCi/L		02/19/02	*
Radium-228	ASTM D2460	ND@0.4 ± 0.2	pCi/L		02/19/02	*

*Radium Testing performed at STL, Richland WA

MCL – Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

11205-13radium

UMPQUA Research Company
P.O. Box 609 - 626 Division Street
Myrtle Creek, OR 97457
(541) 863-5201 Fax: (541) 863-6199

REPORT

OREGON STATE CERTIFIED LAB #015	
PWS#:	Date Reported: 03/20/02
PWS Name:	Date Collected: 02/25/02
Sampled At:	Time Collected: 12:45 PM
	Sampled By: Karen King

Mailing Address for Report	Sample Information
City of Pendleton Attn: Karen King 1501 SE Byers Ave. Pendleton, OR 97801	Byers Well - Well #1 Invoice# 8925
	Matrix: Water
URC Sample #:	20227-19
Sample ID:	Byers' Well #1

Analyte	Method	Results	Units	MCL	Date Analyzed	Analyst
Total Disslоved Iron	SM 2540C	0.039	mg/L		03/04/02	JMR
Silica	SM 4500Si	61.0	mg/L		03/12/02	TDL

MCL = Maximum Contaminant Level
ND = None Detected

Approved By: [signature]

20227-19

STATE ENGINEER
Salem, Oregon

State Well No. 2N/32-2R1

County Umatilla

Application No.

Chemical Analysis

OWNER City of Pendleton OWNER'S NO.

ANALYST Chaflton Laboritories Address Portland

Date of Collection 1/7/49

Point of Collection

	P.P.M.	E.P.M.
Silica (SiO_2)	40.	
Iron (Fe) Total	.01	
Manganese (Mn)		
Calcium (Ca)	27.	
Magnesium (Mg)	7.6	
Sodium (Na)	31.	
Potassium (K)		
Bicarbonate (HCO_3)	130.	
Carbonate (CO_3)	0.	
Sulfate (SO_4)	21.	
Chloride (Cl)	26.	
Fluoride (F)	.3	
Nitrate (NO_3)		
Boron (B)		
Dissolved Solids	217.	
Hardness as $CaCO_3$	98.	
Specific Conductance (Micromhos at 25°C)		
pH	7.7	
Percent Sodium		
Sodium Absorption Ratio (S.A.R.)		
CLASS		

Umatilla 2N/32-5

Oregon State Board of Health

SANITARY ENGINEERING LABORATORY

REPORT OF MINERAL ANALYSIS OF WATER

Location of source Pendleton   Description of source Beyers Well [illegible] (S.E. [illegible] & 19th)

Analysis by [illegible]   Date 11/22/54   Collected by ______   Date 6/24/54

RESULTS

243

	Parts per million
Turbidity	5
Color: Apparent ______ True	1
Odor: Hot ______ Cold	
Total Solids	300
Loss on Ignition	65
Silicon (SiO_2)	12
Chloride (Cl)	23
Sulfate (SO_4)	20
Calcium (Ca)	26
Magnesium (Mg)	18
Aluminum (Al)	0
Orthophosphates (PO_4)	Trace (less than .05 ppm)
Metaphosphates $(PO_3)_6$	
Alkalinity (as $CaCO_3$): Carbonate	8
Bicarbonate	129
Hardness (as $CaCO_3$)	99
Sodium ~~and Potassium~~ (as Na)	60
Iron (Fe)	.37
Manganese (Mn)	.05
Fluoride (F)	.4
Carbon Dioxide (CO_2)	1.3
pH	8.2

Remarks ______

PHE-10

5 UMAT 6304

2N/32E/1d

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

(START CARD) # 54138

Instructions for completing this report are on the last page of this form.

(1) OWNER: Well Number

Name Duane & Ardythe Wood
Address 507 N.E. O'Brian Pl.
City Pendleton State OR Zip 97801

(2) TYPE OF WORK
[x] New Well [ ] Deepening [ ] Alteration (repair/recondition) [ ] Abandonment

(3) DRILL METHOD:
[x] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger
[ ] Other

(4) PROPOSED USE:
[x] Domestic [ ] Community [ ] Industrial [ ] Irrigation
[ ] Thermal [ ] Injection [ ] Livestock [ ] Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval [ ] Yes [x] No Depth of Completed Well 575 ft.
Explosives used [ ] Yes [x] No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10"	0	99	Cement	0	99	25 sacks
6"	99	575				

How was seal placed: Method [ ] A [ ] B [x] C [ ] D [ ] E
[ ] Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	6"	+1	99	.250	[x]	[ ]	[x]	[ ]
Liner:								

Final location of shoe(s) 99

(7) PERFORATIONS/SCREENS:
[ ] Perforations Method
[ ] Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner

(8) WELL TESTS: Minimum testing time is 1 hour

[ ] Pump [ ] Bailer [x] Air [ ] Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
40		575	1 hr.

Temperature of water 59° Depth Artesian Flow Found
Was a water analysis done? [ ] Yes By whom
Did any strata contain water not suitable for intended use? [ ] Too little
[ ] Salty [ ] Muddy [ ] Odor [ ] Colored [ ] Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Umatilla Latitude Longitude
Township 2N N or S Range 32E E or W. WM.
Section 1 SW 1/4 SE 1/4
Tax Lot 300 Lot Block Subdivision
Street Address of Well (or nearest address) 507 N.E. O'Brian Pendleton, OR 97801

(10) STATIC WATER LEVEL:
87 ft. below land surface. Date 10-19-9
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:

Depth at which water was first found 146

From	To	Estimated Flow Rate	SWL
146	197	25	87
521	537	5	87
548	575	10	87

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SALEM, OREGON

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Clay soil	0	1	
Brown soil with gravel	1	7	
Gray basalt	7	18	
Red & brown basalt	18	36	
Gray basalt	36	70	
Red & brown basalt	70	93	
Gray basalt	93	146	
Gray basalt with green soapstone	146	197	WB
Gray basalt	197	236	
Red basalt	236	239	
Gray basalt	239	312	
Red & brown basalt	312	328	
Gray basalt	328	421	
Red basalt	421	452	
Gray basalt	452	521	
Red & brown basalt	521	537	WB
Gray basalt	537	548	
Red & brown basalt	548	575	WB

Date started 10-17-94 Completed 10-19-94

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number
Signed Date

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1218
Signed Patrick Wallace Date 10-22-9

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

UMAT 53588

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # 38506   (START CARD) # 53444

(1) OWNER: Well Number ______
Name Duane & Ardythe Wood
Address 507 N.E. O'Brian Pl.
City Pendleton State OR Zip 97801

(2) TYPE OF WORK
☐ New Well ☑ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☑ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☑ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 825 ft.
Explosives used ☐ Yes ☑ No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
6"	575	825	N/A			

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other
Backfill placed from ____ ft. to ____ ft. Material ______
Gravel placed from ____ ft. to ____ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
100+		825	1 hr.

Temperature of water 60° Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County Umatilla Latitude ______ Longitude ______
Township 2N N or S Range 32E E or W. WM.
Section 1 SW 1/4 SE 1/4
Tax Lot 300 Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) 507 N.E. O'Brian Pl. Pendleton, OR 97801

(10) STATIC WATER LEVEL:
87 ft. below land surface. Date 9-27-98
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:

Depth at which water was first found 805

From	To	Estimated Flow Rate	SWL
805	825	100+	

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Existing well	0	575	
Gray basalt	575	740	
Black basalt	740	756	
Gray basalt	756	805	
Black basalt with green soapstone	805	825	WB

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WATER RESOURCES DEPT.
SALEM, OREGON

Date started 9-24-98 Completed 9-27-98

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1218
Signed Patrick Wallace Date 9-30-98

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion.

RECEIVED FEB 7 1980 WATER RESOURCES DEPT SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

RECEIVED NOV - 9 1979 WATER RESOURCES DEPT. SALEM, OREGON

State Well No. 2N/33E-7bc
State Permit No.

UMAT 796

(1) OWNER:
Name HAROLD WHITE
Address R.R.
PENDLETON, OR, 97801

(2) TYPE OF WORK (check):
New Well ☑ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☑ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☑ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED: Threaded ☐ Welded ☐
6" Diam. from 0 ft. to 20 ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS: Perforated? ☐ Yes ☑ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☐ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☑ Yes ☐ No If yes, by whom? Owner
Yield: 40 G gal./min. with 7 ft. drawdown after 3 hrs.
" " "
" " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used NEAT CEMENT
Well sealed from land surface to 20 ft.
Diameter of well bore to bottom of seal 10 in.
Diameter of well bore below seal 6 in.
Number of sacks of cement used in well seal 5 sacks
How was cement grout placed? GROUT PUMP

Was a drive shoe used? ☐ Yes ☑ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☑ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County UMATILLA Driller's well number 012-79
SW ¼ NW ¼ Section 7 T. 2N R. 33 E W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found 262 ft.
Static level 257 ft. below land surface. Date 7-24-
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing 6
Depth drilled 556 ft. Depth of completed well 556 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
SOIL	0	13	
GRAVEL	13	14	
HARD GREY BASALT	14	78	
BROKEN " "	78	89	
MED. " "	89	108	
SOFT BROKEN "	108	131	
BROKEN " "	131	167	
HARD " "	167	258	
BROKEN W/SOAPSTONE	258	281	water
GREY "	281	426	
SOFT "	426	437	
HARD GREY "	437	503	
SOFT BROWN "	503	524	
HARD GREY "	524	545	
SOFT BROKEN "	545	556	water

Work started 7-10 1979 Completed 7-15 197
Date well drilling machine moved off of well 7-16 197

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] (signature) (Drilling Machine Operator) Date 7-31, 197
Drilling Machine Operator's License No. 886

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name WALLACE WELL Drlg. Co. (Person, firm or corporation) (Type or print)
Address PENDLETON, OR.
[Signed] (signature) (Water Well Contractor)
Contractor's License No. 583 Date 7-31, 197

(USE ADDITIONAL SHEETS IF NECESSARY)

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the

STATE ENGINEER, SALEM, OREGON 97310 within 30 days from the date of well completion.

UMAT 804

WATER WELL REPORT
STATE OF OREGON
(Please type or print)

(Do not write above this line)

RECEIVED OCT 14 1976 WATER RESOURCES DEPT SALEM, OREGON

State Well No. 2N/33E-

State Permit No.

(1) OWNER:

Name ROLAND R. CANADY

Address RT #1 BOX 48 PENDLETON, ORE. 97801

(2) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:

Rotary ☒ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):

Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED: Threaded ☐ Welded ☐

6 " Diam. from 0 ft. to 20 ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS: Perforated? ☐ Yes ☒ No.

Type of perforator used

Size of perforations in. by in.

perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No

Manufacturer's Name

Type Model No.

Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom?

Yield: gal./min. with ft. drawdown after hrs.
" APPROX. 20 GPM AIR LIFT "
" " " "

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m.

Temperature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION:

Well seal—Material used NEAT CEMENT

Well sealed from land surface to 20 ft.

Diameter of well bore to bottom of seal 10 in.

Diameter of well bore below seal 6 in.

Number of sacks of cement used in well seal 5 sacks

Number of sacks of bentonite used in well seal sacks

Brand name of bentonite

Number of pounds of bentonite per 100 gallons of water lbs./100 gals.

Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? depth of strata

Method of sealing strata off

Was well gravel packed? ☐ Yes ☒ No Size of gravel:

Gravel placed from ft. to ft.

(10) LOCATION OF WELL:

County UMATILLA Driller's well number 031-76

NE ¼ NE ¼ Section 7 T. 2N R. 33 E. W.M.

Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.

Depth at which water was first found 82 ft.

Static level 80 ft. below land surface. Date 10-7-

Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing 6

Depth drilled 541 ft. Depth of completed well 541 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. *Report each change in position of Static Water Level and indicate principal water-bearing strata.*

MATERIAL	From	To	SWL
SOIL	0	4	
BROWN BASALT	4	14	
GREY HARD "	14	80	
RED BROKEN "	80	95	WATER
GREY "	95	110	
BROKEN GREY "	110	131	
GREY HARD "	131	175	
BROKEN RED "	175	200	
HARD GREY "	200	476	
BROWN W/SOAPSTONE	476	498	WATER
GREY BASALT	498	525	
BROKEN BROWN W/SOAPSTONE	525	541	

Work started 10-6 1976 Completed 10-7 1976

Date well drilling machine moved off of well 10-7 1976

Drilling Machine Operator's Certification:

This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.

[Signed] Everett Wallace (Drilling Machine Operator) Date 10-10, 1976

Drilling Machine Operator's License No. 886

Water Well Contractor's Certification:

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

Name WALLACE WELL DRLG. CO. (Person, firm or corporation) (Type or print)

Address PENDLETON, ORE. 97801

[Signed] Everett Wallace (Water Well Contractor)

Contractor's License No. 583 Date 10-10, 1976

(USE ADDITIONAL SHEETS IF NECESSARY)

SP*45656-119

Umat 50514

RECEIVED

MAY 20 1997

WATER RESOURCES DEPT.
SALEM, OREGON

WELL I.D.# L08760

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

(START CARD) # 096908

Instructions for completing this report are on the last page of this form.

(1) OWNER: Well Number
Name Clifford & Anita Hyatt
Address RT 1 Box 11
City Pendleton State Ore Zip 97801

(2) TYPE OF WORK
☑ New Well ☑ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☑ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☑ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 522 ft.
Explosives used ☐ Yes ☑ No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
6	0	522				

How was seal placed: Method ☐ A ☑ B ☐ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	6			.25	☑	☐	☑	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
37		479	1 hr.
25		429	
10		354	

Temperature of water 62° Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Umatilla Latitude Longitude
Township 2N N or S Range 33E E or W. WM.
Section 8 NW 1/4 NW 1/4
Tax Lot 701 Lot Block Subdivision
Street Address of Well (or nearest address)

(10) STATIC WATER LEVEL:
330 ft. below land surface. Date 5-13-97
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 492

From	To	Estimated Flow Rate	SWL
492	510	40	330

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Gray Basalt	433	492	
Brown	492	502	
Brown	502	510	
Gray	510	522	

Date started 5-8-97 Completed 5-13-97

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
GREG DENNIS / TONY BOWMEN / RUSS OTTO WWC Number 1588 / 92-01
Signed Date 5-13-97

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 544
Signed Larry Burd Date 5-13-97

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

RECEIVED APR 1 1959 STATE ENGINEER SALEM, OREGON

UMAT 909

789

File Original and First Copy with the STATE ENGINEER, SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON

State Well No. 2N/33-8K(1)

6 0789

State Permit No. 10-699

(1) OWNER:

Name B Frank Bowman & Purchase (Wm)

Address Pendleton, Oregon

(2) LOCATION OF WELL:

County Umatilla Owner's number, if any— 3

NW ¼ SE ¼ Section 8 T. 2 N R. 33 E W.M.

Bearing and distance from section or subdivision corner

(3) TYPE OF WORK (check):

New Well ☐ Deepening ☒ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☐

Irrigation ☒ Test Well ☐ Other ☐

(5) TYPE OF WELL:

Rotary ☐ Driven ☐

Cable ☒ Jetted ☐

Dug ☐ Bored ☐

(6) CASING INSTALLED: Threaded ☐ Welded ☐

" Diam. from ft. to ft. Gage

" Diam. from ft. to ft. Gage

" Diam. from ft. to ft. Gage

(7) PERFORATIONS: Perforated? ☐ Yes ☐ No

Type of perforator used

SIZE of perforations in. by in.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

(8) SCREENS: Well screen installed ☐ Yes ☐ No

Manufacturer's Name

Type Model No.

Diam. Slot size Set from ft. to ft.

Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:

Was well gravel packed? ☐ Yes ☐ No Size of gravel:

Gravel placed from ft. to ft.

Was a surface seal provided? ☐ Yes ☐ No To what depth? ft.

Material used in seal—

Did any strata contain unusable water? ☐ Yes ☐ No

Type of water? Depth of strata

Method of sealing strata off

(10) WATER LEVELS:

Static level 24 ft. below land surface Date 2/27/59

Artesian pressure lbs. per square inch Date

Log Accepted by:

[Signed] B.F. Bowman (Owner) Date 3-11- 1959

(11) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? Driller

Yield: 750 gal./min. with 60 ft. drawdown after 4 hrs.

" " 60 " "

" " " "

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water 64 Was a chemical analysis made? ☐ Yes ☒ No

(12) WELL LOG: Diameter of well 10 inches.

Depth drilled 364 ft. Depth of completed well 968 ft.

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

MATERIAL	FROM	TO
Grey basalt (static 14')	604	614
Brown basalt (some water 50' static	614	619
Grey basalt	619	632
Black basalt	632	637
Grey basalt	637	657
Porous black basalt (water	657	664
Broken black basalt (seeping	664	665
Black basalt (Static 23'	665	720
Grey basalt	720	730
Black basalt	730	875
Grey basalt	875	935
Porous black basalt (water bearing no cuttings)	935	965
Grey basalt	965	968

This well was originally drilled in 1953 and has since failed and is drilled depper

Work started 19 Completed 19

(13) PUMP:

Manufacturer's Name

Type: H.P.

Well Driller's Statement:

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

NAME D.K. SMITH (Person, firm, or corporation) (Type or print)

Address Route 3, Walla Walla, Washington

Driller's well number

[Signed] D K Smith (Well Driller)

License No. 204 Date 3/11/59 19

(USE ADDITIONAL SHEETS IF NECESSARY)

WATER WELL REPORT
STATE OF OREGON

UMAT 847

RECEIVED
APR 2 1982
WATER RESOURCES DEPT
SALEM, OREGON

State Well No. 2N/33E-8a
State Permit No. Deepening

(1) OWNER:
Name Al Krager
Address RT 1 Box 112
City Pendleton State Oregon

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☑ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary Air ☑ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☑ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐
Thermal: Withdrawal ☐ Reinjection ☐

(5) CASING INSTALLED:
Steel ☐ Plastic ☐
Threaded ☐ Welded ☐
" Diam. from Existing ft. to ft. Gauge
" Diam. from ft. to ft. Gauge

LINER INSTALLED:
" Diam. from ft. to ft. Gauge

(6) PERFORATIONS:
Perforated? ☐ Yes ☑ No
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☑ No
Manufacturer's Name
Type Model No.
Diam. Slot Size Set from ft. to ft.
Diam. Slot Size Set from ft. to ft.

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
Air test 45 gal./min. with drill stem at 500 ft. 1 hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 59 Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Special standards: Yes ☐ No ☐
Well seal—Material used
Well sealed from land surface to Existing ft.
Diameter of well bore to bottom of seal in.
Diameter of well bore below seal in.
Number of sacks of cement used in well seal sacks
How was cement grout placed?

Was pump installed? Type HP Depth ft.
Was a drive shoe used? ☐ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☐ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☐ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County Umatilla Driller's well number
NE ¼ NE ¼ Section 8 T. 2N R. 33E W.M.
Tax Lot # Lot Blk Subdivision
Address at well location:

(11) WATER LEVEL: Completed well.
Depth at which water was first found 320' ft.
Static level 300 ft. below land surface. Date 7-29-
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing 6"
Depth drilled 470 ft. Depth of completed well 550 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Black Basalt	80	125	
Grey Basalt	125	140	
Black basalt - Red Scoria	140	160	
Black basalt	160	195	
Black basalt - Green Talc	195	240	
Black " " Brown Talc	240	270	
Black " "	270	290	
Black " " Brown - Talc	290	310	
Black "	310	320	
Black " " Brown - Talc	320	340	H2O
Black "	340	410	
Red Scoria	410	430	H2O
Black & Brown Basalt	430	500	
Black basalt - Green Talc	500	515	
Black basalt	515	528	
Brown basalt - Talc	528	550	

Work started 7-24 1981 Completed 7-29 198
Date well drilling machine moved off of well 7-29 198

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [signature] (Drilling Machine Operator) Date 7-29, 1981
Drilling Machine Operator's License No. 993

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name [signature] (Person, firm or corporation) (Type or print)
Address Rt 1 Box 4 P. Cot Rock, Oreg
[Signed] [signature] (Water Well Contractor)
Contractor's License No. 739 Date 7-29, 198

APPENDIX B

STILLMAN WELL VIDEO LOG (01/09/2001)

Approx. Depth (ft bgs)	Observations / Comments
112	Evidence of past water leakage (e.g., mineralization, bacterial growth) at welded joint in steel casing
130	Evidence of past water leakage (e.g., mineralization, bacterial growth) at welded joint in steel casing
153	Evidence of past water leakage (e.g., mineralization, bacterial growth) at welded joint in steel casing
163	Evidence of past water leakage (e.g., mineralization, bacterial growth) at welded joint in steel casing
184	Bottom of steel casing; evidence of past water leakage (e.g., mineralization, bacterial growth) from bottom of casing; no apparent leakage presently; basalt at base of casing is dry
186-197	Massive basalt; rock increasingly wet; minor volume of water flowing down borehole wall beginning @ 192 ft
197-215	Fine granular basalt, with increasing rubbly texture with depth; very weathered (oxidized); probable flow top; breakout of rock at 202-203 ft, very likely marking flow contact; water flow from borehole walls approx. 2-3 gpm
215-240	Blocky, moderately-competent basalt; columnar jointing beginning @ 220 ft; probable flow interior; increasing water flow down borehole walls; section of steel cable present from 230-237 ft bgs
252	Static water level in well; water slightly cloudy
240-285	Very massive, competent basalt, with little obvious jointing; smooth, round borehole walls
285-308	Increasingly vesicular (to scoriaceous), granular, oxidized, rubbly basalt; no apparent sedimentary interbedding; probable flow top contact at 285 ft
308-316	Contact with blocky, reddish, jointed basalt @ 308 ft
316-330	Contact with sedimentary interbed (laterite) at 316 ft; grades downward to very rubbly, highly weathered & mineralized basalt; clearing of water beginning @ 325 ft
330-342	More competent basalt; less rubbly than above; rounder borehole walls; probable flow interior
342-365	Very massive, competent basalt; very smooth & round borehole walls
365-379	Vertical columnar jointing; round & smooth borehole walls
379-385	Vesicular (to scoriaceous), oxidized basalt; still round & smooth borehole walls
385-416	Massive basalt, with decreasing vesicularity & oxidation; increasing water cloudiness @ 400 ft
416-429	Moderately rubbly, oxidized, scoriaceous basalt; grades to more competent, less vesicular rock with depth; probable flow contact at 416 ft
429-460	Oxidized & scoriaceous, but both decreasing with depth; rubbly & vuggy, with breakouts throughout range; probable flow top @ 429-430 ft; increasing water cloudiness @ 457 ft
460-470	Blocky, fractured basalt; large void in borehole wall & increasing water cloudiness @ 460 ft
470-560	Blocky, competent basalt; vertical columnar jointing @ 470 ft; increasing water cloudiness beginning @ 500 ft
560-633	Massive basalt, with some columnar breakouts (spalling); increasing water cloudiness beginning @ 560 ft; much debris present (e.g., top of old airline @ 570 ft, 2 pipes beginning @ 616 ft, much wire, hose & pipe @ 624 ft, top portion of well intake strainer @ 632 ft); video camera could not be advanced beyond 633 ft due to density of debris