3 July 2003

Mr. Bob Bower
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PO Box 68
Milton-Freewater, Oregon 97862

Subject: Test Site Hydrogeologic Assessment
Sediment Aquifer Study
K/J 026046.10

Dear Bob:

Kennedy/Jenks Consultants is pleased to present this letter report to the Walla Walla Basin Watershed Council (WWBWC). This letter report presents the results of a hydrogeologic assessment of the proposed shallow aquifer recharge test site (the test site) adjacent to the Hudson Bay Canal southeast of the WWBWC Office. This letter report was prepared as part of our letter contract with the WWBWC dated 13 February 2003 and amended 1 April 2003.

Introduction

The WWBWC is planning to sponsor a shallow aquifer recharge field test in the Walla Walla Basin (the Basin) just west of Milton-Freewater, Oregon. This letter report presents a preliminary hydrogeologic assessment of the proposed test site and the surrounding area. The area covered by this letter report includes an approximately 30 square mile area bounded on the north by the Washington/Oregon border, on the south by the base of the Horse Heaven Hills and Blue Mountains, to the east by a north-south line approximately 1 mile east of the Walla Walla River, and to the west by a north-south line through Umapine, Oregon (Attachment 1).

The proposed test site is located on approximately 9 acres adjacent to the south side of the Hudson Bay Canal (the Canal) in the east half of section 33, T6N, R35E (Attachment 1). This site is approximately 2 miles west of Milton-Freewater, Oregon, in Umatilla County. The test site was chosen because of its proximity to the Canal which will supply water for the test and the willingness of the land owner (Mr. H. Johnson) to allow construction of test infiltration ponds on the property.

The proposed test will be done with a facility consisting of three individual infiltration ponds lined up, one after the other, adjacent to the Canal. Approximately 50 cubic feet/second (cfs) of water will be available for diversion from the Canal into the upstream (easternmost) pond via a diversion structure. Water will then cascade from one pond to the next (from east to west) until it infiltrates out of the bottom of the pond(s). Any water escaping the final pond will be directed back into the Canal via a return pipe. In-flow from, and out-flow to, the Canal will be metered.

Testing is proposed for winter and early spring months when Walla Walla River flows (ultimate source of recharge water) are at their peak.

It is anticipated that recharge testing will be conducted under an ASR Limited License granted to the WWBWC by Oregon Department of Water Resources (OWRD) under OAR 690-350-0020. One of the requirements of the Limited License Application is to provide a supplemental preliminary hydrogeologic report describing groundwater conditions at the test site (OAR 690-350-0020 (3)(a)(b)(C)). This letter report, which is based predominantly on previously written reports and publicly available information, was written to meet this requirement.

This letter report focuses on suprabasalt sediments, the target for shallow aquifer recharge, and is subdivided into sections describing regional geology and hydrogeology, test site hydrogeology, surface water in the test site area (including springs), and groundwater and surface water quality. The assessment was done under the supervision of Mr. Terry Tolan, RG. The assessment is based largely on previously prepared and readily available reports and information. Attachments to this report include:

- Location map for the project area (Attachment 1)
- Structure contour and isopach maps for selected geologic units comprising the upper part of the shallow aquifer system (Attachments 2, 3, 4, and 5)
- A table summarizing geologic interpretations, well construction information, and water pumping data taken from water supply well logs used to assess area hydrogeology (Attachment 6)
- Draft test and monitoring plan (Attachment 7)

In addition, a number of reports and papers were reviewed for information relevant to this assessment. These reports are listed below.

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Kienle, C.F., 1980, Geologic reconnaissance of parts of the Walla Walla and Pullman, Washington, and Pendleton, Oregon 1^0 x 2^0 AMS quadrangles: Seattle, Washington, Consultant report to U.S. Army Corps of Engineers, Seattle District, 76 p., 3 plates, scale 1:125,000.

Lindsey, K.A., 1996, The Miocene to Pliocene Ringold Formation and associated deposits of the ancestral Columbia River system, south-central Washington and north-central Oregon: Washington Department of Natural Resources, Division of Geology and Earth Resources Open-File Report 96-8.

Mac Nish, R.D., and Barker, R.A., 1976, Digital simulation of a basalt aquifer system, Walla Walla River Basin, Washington and Oregon: Washington Department of Ecology Water-Supply Bulletin 44, 51 p.

Mann, G.M., and Meyer, C.E., 1993, Late Cenozoic structure and correlations to seismicity along the Olympic-Wallowa Lineament, northwest United States: Geological Society of America Bulletin, v. 105, no. 7, p. 853-871.

Newcomb, R.C., 1965, Geology and ground-water resources of the Walla Walla River Basin, Washington and Oregon: Washington Department of Conservation, Division of Water Resources Water-Supply Bulletin 21, 151 p, 3 plates.

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Price, C.E., 1960, Artificial recharge of a well tapping basalt aquifers, Walla Walla area, Washington: Washington Division of Water Resources, Water-Supply Bulletin 7, 50 p.

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Wozniak, K.C., 1995, Chapter 2 - Hydrogeology, *in*, Hydrogeology, groundwater chemistry, and land uses in the lower Umatilla Basin Groundwater Management Area, northern Morrow and Umatilla Counties, Oregon - Final Review Draft: Salem, Oregon, Oregon Department of Environmental Quality Report, p. 2.1-2.80.

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Other data sources used for the project include: (1) OWRD Water Well Reports (driller's logs) for water wells drilled in the project area, (2) interviews and conversations with people who have knowledge and/or experience with area groundwater, including OWRD staff, and (3) reconnaissance visits to the test site area. For this assessment it was assumed that well locations recorded on driller's logs are correct and the locations of wells were not independently field-verified.

Overview of the Test Site Area Geologic Setting

The most recent comprehensive geologic investigation of the suprabasalt sediments in the Basin, the strata which are the focus of this assessment, is Newcomb (1965). Our review of area geology is based on Newcomb (1965), more recent insights into area geology taken from reports describing regional suprabasalt sediment geology (Smith and others, 1989; Lindsey, 1996), and our ongoing work in the area on other projects. Since the emphasis of this hydrogeologic assessment is on the suprabasalt aquifer system, this section will focus primarily on the sedimentary strata and only briefly introduces the underlying Columbia River basalt.

Generally, suprabasalt sediments found in the Walla Walla Basin include (Figure 1):

- Holocene to Pliocene (?) alluvial gravel
- Pleistocene Cataclysmic Flood deposited sand and silt (Touchet Beds)
- Pleistocene loess (Palouse Formation)
- Miocene to Pliocene (?) conglomerate, sand, silt, and clay

Newcomb (1965) also described several terrace sequences within the Basin. These are not described in this letter report because they typically do not host aquifers. The basic physical characteristics and distribution of the uppermost 200 feet of the suprabasalt sediment sequence across the study area are briefly summarized in the following sections. We focus on the uppermost 200 feet of the suprabasalt sediment sequence because this is the stratigraphic interval that hosts the upper part of the shallow aquifer system, the primary target for proposed shallow aquifer recharge projects.

Holocene to Pliocene (?) Alluvial gravel

Basaltic, uncemented and nonindurated gravelly strata immediately underlies the groundsurface across much of the study area north of the base of the Horse heaven Hills. Based on the few outcrops of this unit described in reports (e.g., Newcomb, 1965), these strata are probably moderately to well bedded, have a silty to sandy matrix, and are generally uncemented. Our interpretation of borehole logs in the study area suggests the top of these strata appear to form a gently south-to-north dipping surface (Attachment 2). The alluvial gravel varies from absent to almost 120 feet-thick beneath the study area (Attachment 3). Many of the thicker accumulations of uncemented gravel appear to form elongate, linear tracts. Thickness variation in these strata are inferred to be the result of paleodeposition in stream channels, syndeposition folding and faulting, and post-deposition erosion and deformation.

These uncemented gravels are generally equivalent to Newcomb's (1965) younger alluvial sand and gravel and referred to in the remainder of this letter report as alluvial gravel. The alluvial gravel is interpreted to record deposition of sand and gravel in the Walla Walla Basin by streams draining off the adjacent Blue Mountains and Horse Heaven Hills. These streams were probably the recent ancestors of many of the modern streams in the Basin, including the Walla Walla River, Mill Creek, Cottonwood Creek, Dry Creek, and Pine Creek. The distribution of the alluvial gravel, in large part, probably reflects the orientation of the streams in which these strata were deposited.

The age of the alluvial gravel is not well constrained. Depending on where one is at in the Basin, the alluvial gravel unit appears to predate, be contemporaneous with, and younger than the Palouse Formation and Touchet Beds. If this is the case, the alluvial gravel may be late Pliocene to Holocene in age (e.g., greater than 2 million years to less than a few thousand or even hundreds of years old).

Pleistocene Cataclysmic Flood Deposits (Touchet Beds)

During the Pleistocene, Cataclysmic Floods (e.g., Missoula or Bretz Floods) periodically inundated the Walla Walla valley between approximately 1,000,000 and 12,000 years ago (Waitt and others, 1994). Sand and silt deposited in the Walla Walla Basin by these flood waters consist of well stratified, normally graded, interbedded felsic silt and felsic to basaltic fine to medium sand (Figure 2). Finer grained layers tend to be brown to tan colored, coarser layers brown to gray-brown colored. Individual beds (or layers) range from a few inches to less than 3 feet-thick. These strata do not commonly display significant cementing, although some pedogenic calcium carbonate (caliche or hardpan) is commonly observed in the upper parts of these deposits where they are exposed at the Earth's surface. A range of soft-sediment deformation features and cross-cutting clastic dikes are commonly found in this unit (Fecht and others, 1999).

These Cataclysmic Flood deposits, also known as Touchet Beds, form most of the small hills located across the Walla Walla valley floor and along the base of the Blue Mountains (Attachment 4) to an elevation of approximately 1100 feet above mean sea level (msl).

Pleistocene loess (Palouse Formation)

Massive to poorly stratified silt and very fine sand deposits that display evidence of pedogenic (soil forming) modification is found on the hills surrounding the Basin (Figure 3). Pedogenic calcium carbonate may also be found in these deposits which are thought to be eolian (wind-deposited) loess, also referred to as the Palouse Formation (Busacca and others, 2002). These loess deposits are thought to range from greater than 1 million years old to less than 10,000 year old, making it older than, and age-equivalent to, the Touchet Beds (Busacca and others, 2002).

The Palouse Formation may be present in the western to central parts of the study area and intercalated within Touchet Beds. However, we suspect loess is rare to absent in this area because of a lack of loess outcrops. The Palouse Formation does crop out on the highlands bordering the southern and eastern edge of the Basin. Some of the strata mapped on Attachment 4 may be part of the Palouse Formation, but it was not differentiated from the Touchet Beds because of a lack of borehole log information.

Mio-Pliocene strata

Variably indurated conglomerate, sand, silt, and clay is found in the subsurface beneath the Walla Walla Basin. Based on limited outcrop descriptions, field reconnaissance, and borehole log descriptions these indurated gravel and sand, may locally have a caliche cap, and is they predominantly are basaltic in composition (Figure 4). Based on drill cuttings collected from wells recently drilled near Milton-Freewater, Oregon, these strata may also contain some mica and quartz. These indurated gravelly strata (conglomerate) are continuous beneath the entire study area (Attachment 5), range between approximately 75 and 250 feet-thick, and are referred to as the Mio-Pliocene conglomerate. It is differentiated from younger alluvial gravel unit by its physical characteristics, including a greater degree of induration, cement, and weathering.

The Mio-Pliocene conglomerate, sand, silt, and clay are generally equivalent to Newcomb's (1965) old gravel unit and old clay units. Newcomb (1965) placed the old gravel unit stratigraphically above the old clay unit. However, review of driller's logs across the study area reveal: (1) the presence of interstratified silt and gravel lithologies throughout entire thickness of the Mio-Pliocene strata, (2) areas where strata correlative to one of the two units, old gravel and old clay, are absent, and/or (3) areas where the inferred contact between the old gravel and clay units varies greatly in depth over distances of less than one mile. Given this, it is likely that the top of the old clay unit and bottom of the old gravel unit is not a single, continuous surface as suggested by Newcomb (1965). It is more likely that these strata interfinger and that a distinctive old gravel unit and old clay unit can not always be differentiated.

The mixed conglomerate, sand, silt, and clay forming the Mio-Pliocene unit are assigned a Miocene to Pliocene age (approximately 10 to 2 million years old) based on degree of induration, evidence of greater weathering, and stratigraphic position. To our knowledge no absolute age dates are available for this unit. Mio-Pliocene deposits of the Walla Walla Basin probably record deposition by the ancestral Salmon/Clearwater/Snake and Walla Walla River systems and include river channel deposits, overbank and flood plain deposits, and lake deposits. The distribution of coarse channel deposits in this unit should reflect the orientation of the ancient streams in which these materials were deposited.

Columbia River Basalt Group

The basalt flows that crop out on the highland bordering the Basin and that underlie the sediment sequence in the Basin belong to the Miocene Columbia River Basalt Group. The top of the Columbia River basalt surface is generally found to lie at lower elevations from the south (where it crops out on the steep hillsides south and west of Milton Freewater at elevations of

850 feet and above) to the north beneath the suprabasalt sediment filling the Basin. Abrupt elevation changes in the top of basalt near the Basin edge are interpreted to reflect the presence of faults offsetting this surface. Because of the depth at which this unit is generally found within the study area, it is assumed for the purposes of this assessment that it is likely that the Columbia River basalt does not exert a significant influence over the hydrogeologic behavior of the shallow suprabasalt sediment aquifer system in the immediate area of the test site.

Structural Geology

The Walla Walla Basin is a structural basin that began to develop during Miocene time (approximately 16 million years ago) and has continued to develop to the present day (Kienle, 1980; USDOE, 1988). The Basin is bounded on the south by the Horse Heaven Hills, the east by the Blue Mountains, and to the north by the Palouse Slope. The southern and eastern edges of the Basin are fault controlled. The uppermost basalt which crops out around the edge of the Basin on the Horse Heaven Hills and Blue Mountains is down dropped at these bounding faults. The faults, and associated folds, found on the southern and eastern edge of the Basin probably extends into the subsurface beneath the Basin (Kienle, 1980; Swanson and others, 1981). The presence of these faults beneath the Basin are inferred to, in part, explain discontinuities seen in the distribution of suprabasalt sediments, especially Mio-Pliocene sedimentary strata, and the top of basalt.

Overview of the Study Area Hydrogeologic Setting

Groundwater in the Walla Walla Basin is found in two primary aquifer systems: (1) the suprabasalt sediment aquifer system which is primarily hosted by Mio-Pliocene conglomerate and to a lesser extent, the overlying alluvial gravel (2) the underlying Columbia River basalt aquifer system. The suprabasalt aquifer, which is the target for shallow aquifer recharge, is the focus of this section.

Physical properties

The majority of the suprabasalt aquifer is hosted by Mio-Pliocene conglomerate unit while the uppermost part of the aquifer is found, at least locally, in the younger alluvial gravel unit. The suprabasalt aquifer is generally characterized as unconfined, but it does, at least locally, display confined conditions. Variation between confined and unconfined conditions within the aquifer system is probably controlled by sediment lithology (e.g., facies – coarse versus fine) and induration (e.g., cementation, compaction). Groundwater movement into, and through, the suprabasalt aquifer also is inferred to be controlled by sediment lithology (e.g., facies - coarse versus fine) and induration (e.g., cementation, compaction).

Given the physical properties of the alluvial gravel (non-indurated sand and gravel) versus those of the Mio-Pliocene conglomerate (e.g., finer matrix and the presence of naturally occurring cement), Mio-Pliocene conglomerate probably has generally lower permeability and porosity than the alluvial gravel. Consequently, suprabasalt aquifer groundwater flow velocities are inferred to be less where the water table lies within the Mio-Pliocene conglomerate than where it lies within the younger, more permeable alluvial gravel. In addition, where the alluvial gravel is saturated, this uncemented, high permeability gravel and sand could form preferred pathways for groundwater movement and areas of increased infiltration capacity in the shallow parts of the suprabasalt aquifer system.

Very little hydraulic property information is available for the suprabasalt aquifer. Newcomb (1965) reports average effective porosity of 5 percent in the old gravel (e.g., the Mio-Pliocene conglomerate and sand). Given the physical characteristics of the overlying alluvial gravel, we suspect average effective porosity in it is higher. Modeling work by Barker and MacNish (1976) report estimated hydraulic conductivity and transmissivity of 1.5×10^{-4} feet/second to 7.6×10^{-3} feet/second and 10,000 feet^2/day to 60,000 feet^2/day, respectively, for the entire shallow aquifer. As with Newcomb's (1965) effective porosity estimate, we suspect hydraulic conductivity and transmissivity would be higher in saturated alluvial gravel than in saturated Mio-Pliocene conglomerate.

Groundwater level and flow direction

In the study, groundwater flow in the suprabasalt aquifer area is generally thought to be from south to north and northwest. There probably also is a component of groundwater movement towards the Walla Walla River where the suprabasalt water table near it is higher than the river. Where this occurs, the Walla Walla River is, in part, feed by groundwater discharge. However, along the course of the Walla Walla River through the study area, the suprabasalt water table may at least locally be below the bed of the river during much of the year. This is thought to be common between Milton-Freewater and the Stateline. When and where this occurs, such reaches of the river probably lose water to the suprabasalt aquifer.

WWBWC staff are collecting suprabasalt aquifer water level data from water supply wells located within the Basin between the Walla Walla River and Umapine. Water level data reported on well logs, and the few reports written for the Basin, suggest groundwater levels near the Walla Walla River (and many of the spring creeks) historically were relatively shallow, commonly less than 5 feet deep. With increased groundwater use over the past 20 years these water levels have generally declined, at least locally. This groundwater level decline is thought to account for, at least in part, the reduction in spring creek flow reported by many land owners in the Basin. Based on WWBWC water level data, the depth to suprabasalt aquifer groundwater ranges from 30 to 40 feet near Milton-Freewater, 3 to 10 feet along the Walla Walla River north of Milton-Freewater, 1 to 10 feet along the East and West Prongs of the Little Walla Walla, and 30 to 50 feet in the Umapine Area.

Aquifer recharge

Natural recharge to the suprabasalt aquifer is described by Newcomb (1965) to be from infiltration of surface water into the ground near the edge of the Basin where streams leave the adjacent basalt highlands and flow out onto the basin floor. The majority of this recharge probably occurs in the spring when streams flowing into the Basin reach peak discharges. Precipitation on parts of the Basin floor where the alluvial gravel and older, Mio-Pliocene strata lie at, or near, the surface also provides some natural recharge. With flood control and channelization of the Walla Walla River and smaller streams, natural recharge via infiltration from surface waters has probably decreased with continued development.

Artificial recharge of the suprabasalt aquifer has become an important component of the hydrologic system since the 1920's and 1930's. This recharge is thought to have historically contributed water to at least some shallow water wells and springs (Newcomb, 1965). Artificial recharge probably occurs through irrigation ditch leakage and infiltration past the root zone in irrigated fields. With the advent of ditch/channel lining and reduction in the practice of flood irrigation, this type of recharge has probably decreased.

Reduced natural and artificial recharge will, and probably does, at least in part account for decreased suprabasalt water table levels. These reduced levels probably account for reduced spring flows and base level discharge to the Walla Walla River. The objective of the proposed SASR project is to attempt to locally replenish groundwater in the suprabasalt aquifer and restore some spring flows and Walla Walla River baseflow.

Water Quality

The most up-to-date groundwater quality data for the study area is found in Richerson and Cole (2000), an Oregon Department of Environmental Quality (ODEQ) report prepared for the northern portion of Umatilla County between Milton-Freewater and the Stateline. Two water quality parameters presented in the ODEQ report suggest groundwater quality in the uppermost suprabasalt aquifer in the area is relatively good with regard to ODEQ standards. These parameters, total dissolved solids (TDS) and nitrate-N, range from 150 to 250 mg/l and 0.5 to 4.5 mg/l, respectively on the Oregon side of the Stateline. Concentrations of these parameters generally decrease from north to south toward where the Walla Walla River enters the valley. This trend suggests the introduction of low nitrate-N and TDS surface water into the groundwater system and supports Newcomb's (1965) conclusion that a significant amount of surface water recharge of shallow groundwater occurs where the Walla Walla River enters the Basin. The increase in TDS and nitrate-N concentrations as suprabasalt groundwater moves north into the Basin is inferred to be, at least in part, the result of the relative increase in recharge from irrigation water reaching the suprabasalt aquifer.

Test Site Hydrogeology

Geologic features control the physical characteristics of aquifer hosting materials, and therefore the distribution and movement of groundwater through an aquifer. Understanding the nature and occurrence of these features both regionally and locally provide constraints on testing, data interpretation, monitoring, mitigation, and final design. This section describes the basic hydrogeology in the immediate vicinity of the test site.

Information reviewed for this assessment report is interpreted to indicate that the uppermost 200 feet of the suprabasalt sediment sequence underlying the test site consists predominantly of gravelly strata assigned to the Mio-Pliocene conglomerate (Figure 5). Specific unit thicknesses and distribution in the immediate vicinity of the test site are as follows:

- Touchet Beds are thin to non-existent, being absent at, north, and east of the test site. A thin veneer of Touchet Beds are found northwest and south of the test site where the unit is 6 to 18 feet thick and less than 5 feet-thick, respectively. Given this distribution, the unit has no role in effecting recharge at the test site.

- The top of the alluvial gravel unit beneath the test site is essentially the ground surface. Beneath the test site these uncemented strata are interpreted to range from approximately 30 feet-thick at the east end to over 60 feet-thick at the west end (Figure 5). Based on our interpretations of well logs in the vicinity, this east to west thickening is inferred to be the result of these strata filling a depression in the top of the underlying, indurated Mio-Pliocene conglomerate.

- The origin of the low inferred to be in the top of the Mio-Pliocene conglomerate is not known. The location of the test site near the fault zone that bounds the base of the Horse Heaven Hills suggests this low could be a faulted depression formed in the top of the conglomerate. Alternatively, given the variable quality of driller's geologic descriptions we can not completely discount the possibility that this low is not present, it being the result of poor or inaccurate driller's descriptions. One of the objectives of site-specific characterization work will be to verify the presence of this feature. Mio-Pliocene conglomerate underlying the test site appears to be at least 100 feet-thick (Figure 5).

In the immediate vicinity of the test site the suprabasalt aquifer water table appears to be between 30 and 55 feet bgs. Based on our reconstruction of site-specific geology summarized in the preceding bullets and in Figure 5, this places the water table predominantly within the Mio-Pliocene conglomerate beneath the easternmost portion of the tests site. To the west, where the alluvial gravel thickens, the suprabasalt aquifer water table is interpreted to be within the alluvial gravel. In the test site area, suprabasalt aquifer groundwater flow is inferred to be from generally east to west-northwest. The degree of seasonal variability is not known

Review of first water and final water depth's reported on well logs in the immediate vicinity of the test site suggests the suprabasalt aquifer here consists of an unconfined zone overlying a deeper, semi-confined zone. The transition between these zones may lie approximately 75 feet bgs (Figure 5). The nature of the "confining" horizon(s) that causes this apparent change in aquifer character is not known, but inferred to be well cemented and/or fine grained layers within the upper 20 to 50 feet of the Mio-Pliocene conglomerate. Where the top of the Mio-Pliocene conglomerate drops into the low inferred to underlie and be situated west of the test site, this confining zone would be displaced to depths greater than 95 ft bgs and the overlying unconfined zone would be correspondingly thicker (Figure 5).

The assessment did not find any site-specific hydraulic properties data for any of the aquifers or the vadose zone underlying the Test Site. The only hydraulic properties data found are the general estimates provided in the regional discussions. These suggest porosity, hydraulic conductivity, and transmissivity of gravelly strata in the Basin of 5%, $1.5\text{x}10^{-4}$ to $7.0\text{x}10^{-3}$ ft/s, and 10,000 to 60,000 ft^2/d, respectively. A preliminary engineering report for the materials immediately below the test site (Hewes, 2003) indicates infiltration capacity in the alluvial gravel of 1.7 to 3.0 gpm/ft^2/foot of head. If these values persist across the entire thickness of the alluvial gravel, porosity, hydraulic conductivity, and transmissivity in the alluvial gravel beneath the test site is probably considerably higher than the regional estimates. If that is the case, the regional estimates are probably more indicative of Mio-Pliocene conglomerate hydraulic properties.

Well Assessment

The OWRD GRID database lists 176 wells in sections 33 and 34, T6N, R35E. Of these, 53 are listed in section 33. Most of these wells are less than 100 feet deep and appear to be open to the shallow aquifer groundwater system which is the target of shallow aquifer recharge. Less than 30 of the wells found in section 33 are in the inferred down gradient direction from the test site.

Surface Water

Surface water found in the vicinity of the test site includes: (1) the Canal, (2) Dugger Creek, (3) Johnson Creek, and (4) Goodman Spring Branch (Attachment 1). The basic characteristics of these four water bodies are discussed below:

- The Canal is an artificial stream operated to deliver irrigation water to users west of Milton-Freewater. The Canal has a capacity of up to approximately 100 cfs and many reaches of it are suspected to leak.

- Dugger Creek appears to be a natural creek that is currently feed by water leaking from, and/or discharged from, the Canal. The head of Dugger Creek is approximately ¾ to 1 mile west of the test site.

- Johnson Creek is a natural spring creek that flows from a spring located in the SE ¼ , SE ¼ , section 29, T6N, R35E, approximately ¾ to 1 mile west-northwest of the test site.

- Goodman Spring Branch is a natural creek that has been modified by channelization. It passes within less than ½ mile north of the test site, paralleling Sunnyside Road.

All three of the natural creeks are reported to have seen reduced flow in the past few years.

Water Quality

As described in the regional hydrogeologic setting, there is little water quality data for the area except what is reported in Richerson and Cole (2000). That report shows TDS and nitrate-N concentrations in groundwater beneath the test site of approximately 125 to 150 mg/l and 2 to 2.5 mg/l, respectively. These parameter concentrations compare to those of approximately 55 mg/l and <0.25 mg/l at Milton-Freewater, where the Walla Walla River enters the Basin. If, as Newcomb (1965) surmises and others suspect, groundwater chemistry near Milton-Freewater is affected by direct recharge from the Walla Walla River, this groundwater chemistry is probably reflective of surface water chemistry. Therefore, although not a direct measurement of surface water quality, this data is very suggestive of surface water quality and it suggests that recharge water delivered to the test site will be comparable to the water quality data reported in Richerson and Cole (2000).

Preliminary Conceptual Hydrogeologic Model and Possible Effects of Shallow Aquifer Recharge

The objective of this section is to briefly summarize a preliminary conceptual hydrogeologic model for the test site and speculate on possible effects of shallow aquifer recharge on the area surrounding the test site. One of the purpose of this is to identify data gaps to be filled by future site-specific work, including analysis of pilot test monitoring data. We anticipate that this conceptual model, and our assessment of recharge effects, will change as data is collected during subsequent characterization and monitoring activities.

Our conceptual model of how the test will work is summarized below:

1. Relatively good quality Walla Walla River water will be delivered to the test site during peak flow periods in the winter and early spring. This water will rapidly infiltrate from the ponds into the ground, moving downwards through the alluvial gravel.
2. If the alluvial gravel and Mio-Pliocene conglomerate contact is located below the water table at the site:
    a. There may be some lateral spreading of recharge water on the top of the Mio-Pliocene conglomerate,
    b. Spreading will probably be predominantly to the west, into the low spot inferred to be present in the top of the Mio-Pliocene conglomerate, and
    c. If this low turns out to be present, it may act to slow the movement of recharge water away from the test site and provide recharge pathways deeper into the Mio-Pliocene conglomerate than would be the case if the contact was flat.
3. If the water table is above the alluvial gravel and Mio-Pliocene contact, movement of groundwater offsite will be relatively rapid through a saturated alluvial gravel interval. If this is the case, the actual direction of movement can not be determined at this time.
4. Given the groundwater quality trends seen in Richerson and Cole (2000), we infer that recharge will generally improve groundwater quality in the test site area.
5. At this time we do not know what effect, if any, recharge will have on the spring creeks potentially down gradient of the test site. This is in large part due to the lack of site-specific data and information, including water levels, aquifer hydraulic properties, storage data, and ground water velocity and flow direction. These are specific targets of site characterization and pilot test monitoring data collection.

Conclusions and Recommendations

The test site is underlain by uncemented alluvial gravel which overlies indurated Mio-Pliocene conglomerate. Unfortunately, little test site-specific data is available upon which to build a detailed understanding of test site hydrogeology. For example:

- The depth of the suprabasalt aquifer water table at the test site is not well constrained, it could lie either above or below the alluvial gravel/Mio-Pliocene conglomerate contact.

- Although suprabasalt groundwater probably flows from the east to the west-northwest, suprabasalt groundwater flow direction, velocity, and seasonally variability are essentially unknown at the test site.

- A significant portion of the suprabasalt aquifer in the test site area displays at least some evidence of semi-confined conditions.

- The low in the top of the Mio-Pliocene conglomerate currently inferred to be present just west of the test site, based on very limited subsurface data. If present, it could serve to facilitate recharge to deeper parts of the suprabasalt aquifer. If it seems likely that it will, testing and monitoring will need to be designed to not only assess shallower aquifer impacts but also deeper semi-confined suprabasalt aquifer impacts.

- Suprabasalt aquifer and Walla Walla River (Hudson Bay Canal) water quality is generally good, although up-to-date water quality data, including most importantly up gradient and down gradient variations at the test site is unknown.

In addition to addressing the bullet listed above, we recommend that site-specific characterization and monitoring address the following issues:

- Identify the three-dimensional extent of the alluvial gravel and Mio-Pliocene conglomerate beneath the test site. This is important to understanding how recharge water will probably move as the uncemented strata may provide for more rapid water movement, both downwards and laterally towards springs, then likely in the more cemented Mio-Pliocene conglomerate.

- Evaluate the inferred low in the top of the Mio-Pliocene conglomerate just west of the test site. If this feature is present, it could affect the amount of recharge that may reach deeper portions of the suprabasalt aquifer.

- The nature and distribution of a possible confining layer within the upper portion of the Mio-Pliocene conglomerate should be investigated in order to better define the thickness and distribution of the unconfined aquifer. If the unconfined aquifer is absent, or only present seasonally, identifying the nature and extent of the confining layer is important since it will inhibit both downward or upward movement of groundwater. Knowing the extent of this confining layer will provide information on where recharge water may tend to collect and spread atop this layer.

If you have any questions concerning the results of this report please do not hesitate to contact Terry Tolan in our Tri-Cities office at (509) 734-9763. It has been a pleasure working with you on this and we look forward to continuing to work with you on this project.

Very truly yours,

KENNEDY/JENKS CONSULTANTS

Terry Tolan, R.G.
Hydrogeologist

Kevin Lindsey, Ph.D.
Project Manager

Enclosure

cc: file

Figures

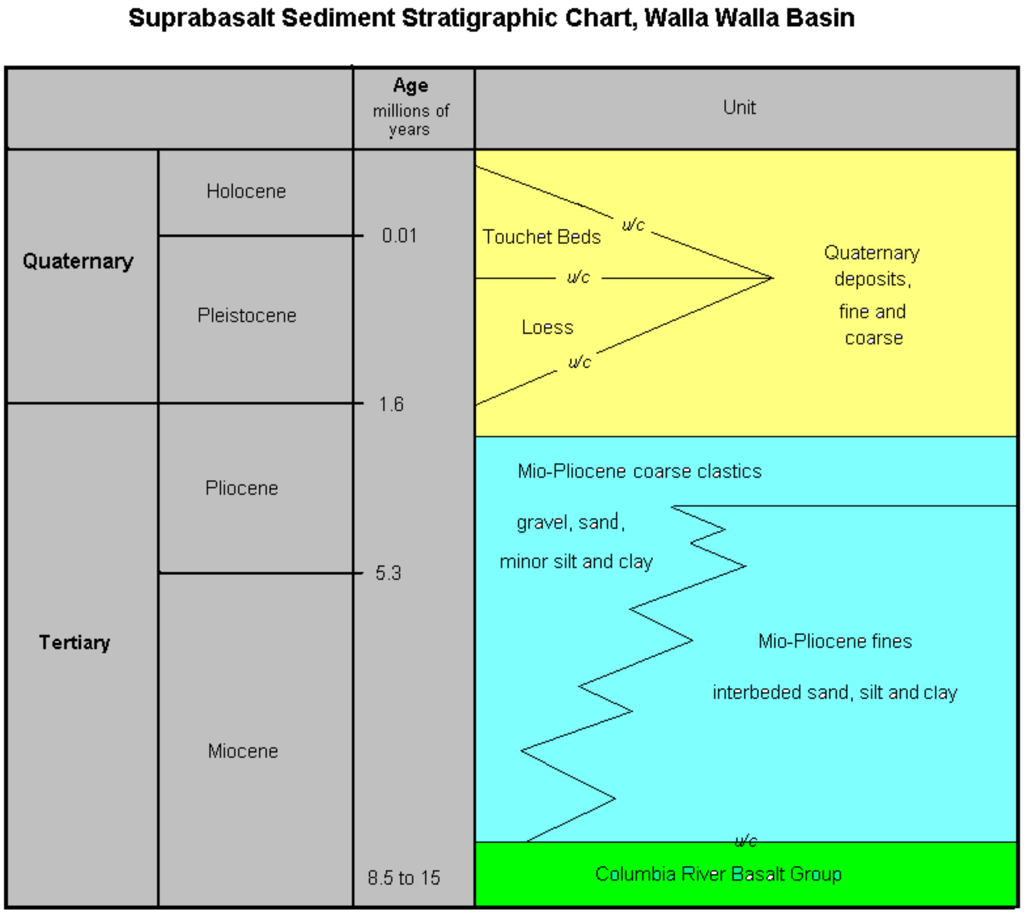
Suprabasalt Sediment Stratigraphic Chart, Walla Walla Basin

Figure 1. Stratigraphic chart for the suprabasalt sediments in the Walla Walla Basin (*u/c* refers to unconformities).

Figure 2. Photograph of interbedded sand and silt typical of the Touchet Beds. Darker layers are sandy, lighter colored layers are silty.

Figure 3. Photograph of massive bedded loess typical of the Palouse Formation.

Figure 4. Photograph of indurated basaltic gravel interpreted to be the Mio-Pliocene conglomerate. Note the caliche horizon at the top of the outcrop.

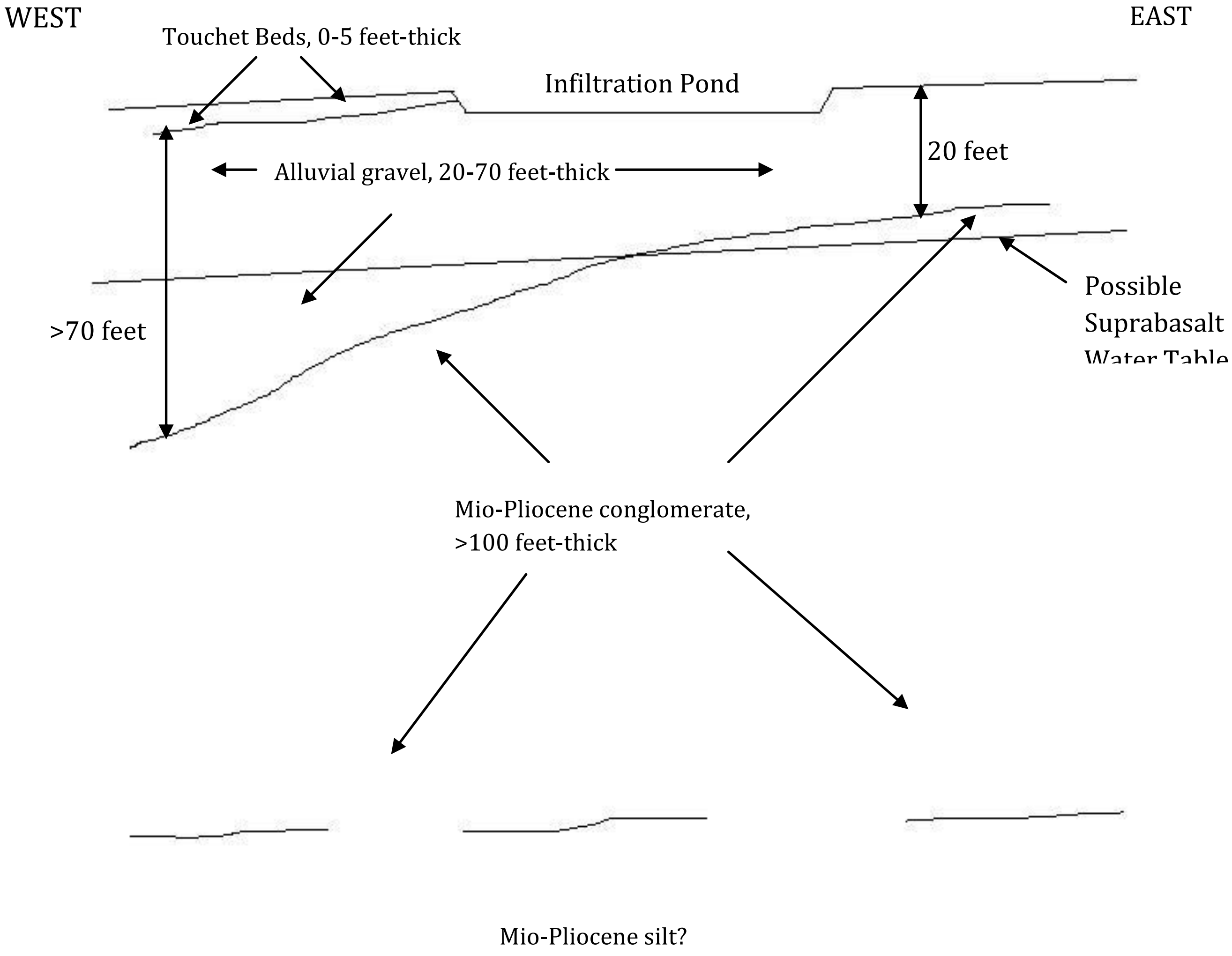

Figure 5. Schematic hydrogeologic cross-section of test site area.

Attachment 6

Well Data Table

Well ID	T/R-sec	easting	northing	year drilled	Surf elev	Touchet top	Touchet isopach	alluvial gravel top	alluvial gravel isopach	Mio-Pliocene conglomerate top	Mio-Pliocene conglomerate isopach	first water	static water
U3885	5/35-1	1850613.13455	1536246.45310		990	NP	0	990	10	NP	0		
U3899	5/35-1	1852276.92661	1536137.15289		1020	1020	12	1008	16	992	175		
U3909	5/35-1	1848682.16421	1534619.09445		1000	1000	3	NP	0	997	157		
U3914	5/35-1	1850479.54541	1536720.08734		1000	NP	0	1000	3	997	157		
U3918	5/35-2	1843472.18763	1535068.43975		961	961	6	955	24	931	40		
U3922	5/35-2	1843314.30956	1536234.30863		948	NP	0	948	48	900	22		
U3930	5/35-2	1846751.19387	1533404.64769		1000	NP	0		0	1000	43		
U3934	5/35-2	1847783.47361	1534740.53912		1000	NP	0	1000	3	997	157		
U3937	5/35-2	1843824.37719	1536683.65393		948	NP	0	948	55	893	40		
U3940	5/35-3	1843071.42021	1535384.19590		958	958	2	956	10	946	120		
U3941	5/35-3	1842500.63023	1535882.11907		939	NP	0	939	34	905			
U3950	5/35-4				909	909	10	NP	0		0		
U3951	5/35-4	1834716.02653	1535177.73996		952	952	20	NP	0	932	132		
U3955	5/35-5	1828060.85832	1535869.97461		873	873	8	NP	0	NP	0		
U3962	5/35-12	1850503.83434	1529931.32998		1066	NP	0	1066	28	1038	42		
U3963	5/35-12	1852094.75959	1529554.85148		1068	NP	0	1068	21	1047	27		
U3965	5/35-12	1851961.17045	1527186.68031		1115	NP	0	NP	0	1115	41		
U4187	6/35-13	1852517.79188	1553631.25840	1987	808	808	9	NP	0	799	>141	14	17
U4195	6/35-13	1848225.17240	1554922.84501		810	810	34	NP	0	776	>162	39	29
U4202	6/35-13	1849184.58533	1555870.11348		813	813	44	769	36	740			
U4204	6/35-13	1850161.76518	1553825.56988	1961	818	818	37	NP	0	781	>85		40
U4206	6/35-13	1853319.32674	1553133.33523		817	?	?	?	?	?	?		
U4217	6/35-14	1844678.98787	1553441.21997	1985	800	NP	0	800	32	768	>68	92	24
U4219	6/35-14	1847508.64881	1553161.89721	1983	820	820	9	811	0	811	>114	23	7.5
U4224	6/35-14	1844934.02169	1554582.79992	1975	789	789	18	771	33	738	>74	24	34
U4249	6/35-15	1841686.37895	1555266.71729		768	NP	0	768	10	758			
U4256	6/35-16	1836304.48646	1554187.46077		762	762	14	748	4	744			
U4258	6/35-16	1837283.01236	1552921.13313	1967	800	800	46	NP	0	754	>104	62	62
U4273	6/35-17	1830490.89136	1552906.74304	1960	730	730	3.5	NP	0	726.5	>196		42
U4275	6/35-17	1828677.74041	1553223.32495	1959	725	725	25	700	15	685	>217		40
U4279	6/35-17	1831857.94961	1554316.97155	1954	730	730	9	NP	0	721	355		
U4282	6/35-18	1821842.44915	1553352.83573	1972	665	665	21	NP	0	644	>82	46	38
U4289	6/35-19	1826461.66703	1547568.02081	1984	723	723	46	NP	0	677	91	46	13
U4293	6/35-19	1824605.34583	1550330.91749	1977	698	698	3	695	57	638	>97	28	30
U4304	6/35-19	1825785.33295	1548632.88724	1957	710	710	12	NP	0	698	>88		18
U4305	6/35-19	1825137.77904	1549510.68254	1958	705	705	18	687	62	625	>120		50
U4317	6/35-20	1830318.21032	1547683.14151	1988	761	761	20	741	21	720	>64	80	38
U4319	6/35-21	1835570.59202	1550489.20845	1987	770	NP	0	770	22	748	>103	51	46
U4327	6/35-21	1832850.86561	1549194.10063	1968	761	761	6	NP	0	755	>104		31
U4329	6/35-21	1833455.24925	1549150.93037		767	767	17	NP	0	750	108		

Well ID	T/R-sec	easting	northing	year drilled	Surf elev	Touchet top	Touchet isopach	alluvial gravel top	alluvial gravel isopach	Mio-Pliocene conglomerate top	Mio-Pliocene conglomerate isopach	first water	static water
U4332	6/35-21	1837527.64384	1552244.79904	1965	780	780	22	758	43	715	>98		32.5
U4345	6/35-21	1835081.32907	1547467.29020		797	797	9	788	5	783	354		
U4347	6/35-21	1833210.61778	1547668.75142	1951	785	785	20	NP	0	765	>169		22
U4348	6/35-21	1837412.52314	1550618.71923	1943	782	782	3	779	15	764	>153	40	44
U4367	6/35-22	1839168.11374	1549021.41958	1974	819	819	12	NP	0	807	330	21	26
U4369	6/35-22	1842636.12468	1552546.99087	1969	810	810	27	783	9	774	>82	47?	54
U4370	6/35-22	1840952.48451	1549194.10063		840	840	47	NP	0	793	37		
U4381	6/35-22	1841038.82504	1549597.02306		840	840	7	833	31	802	240		
U4404	6/35-23	1843360.86335	1549077.08306		840	840	35	805	15	790			
U4406	6/35-23	1847210.65956	1552125.34442	1979	815	815	4	811	36	775	>80	75	20
U4412	6/35-23	1843482.30802	1548154.10353	1975	840	840	9	831	36	795	>87	12	30
U4416	6/35-23	1845206.82242	1548105.52566		850	850	8	842	25	817	226		
U4452	6/35-23	1847635.71593	1547692.61376	1946	850	850	8	NP	0	842	144	NR	NR
U4461	6/35-24	1850683.97728	1550728.73065		846	846	65	NP	0	781			
U4462	6/35-24	1848631.56226	1549660.01751	1987	840	840	18	822	17	805	>111	65	29
U4464	6/35-24	1848340.09504	1548700.60457	1985	850	850	5	845	7	838	>100	5	16
U4469	6/35-24	1849748.85328	1548239.11480	1982	856	856	5	851	18	833	>82	15	10
U4471	6/35-24	1852663.52549	1552526.11185		813	813	34	NP	0	779			
U4478	6/35-24	1850356.07666	1549380.69475	1977	845	845	39	806	>61			39	32
U4479	6/35-24	1851291.20066	1551117.35361	1977	840	840	28	812	52	760	>25	28	27
U4482	6/35-24	1851145.46705	1552441.10058	1977	839	839	25	814	>80			43	29
U4506	6/35-24	1848908.86094	1552726.49556		843	843	49	NP	0	794			
U4538	6/35-25	1852420.63614	1544535.05220	1979	890	NP	0	890	100	790	90	65	27
U4590	6/35-25	1851764.83489	1547291.84634	1934	859	NP	0	859	27	832	63	NR	NR
U4599	6/35-25	1852967.13718	1543818.52862	1926	892	892	6	NP	0	886	>26	NR	6
U4610	6/35-25	1852262.75806	1546490.31148	pre-1917	870	870	20	NP	0	850	>155	NR	NR
U4642	6/35-26	1848157.92803	1542482.63719	1981	917	NP	0	917	7	910	>98	65	34
U4643	6/35-26	1843652.33057	1545324.44259	1977	865	NP	0	865	35	830	>67	38	28
U4644	6/35-26	1845000.36647	1542919.83802	1977	905	NP	0	905	24	881	>81	45	33
U4648	6/35-26	1845886.91260	1542519.07059	1974	908	NP	0	908	12	896	>103	61	49
U4653	6/35-26	1844077.38693	1542931.98249	1968	895	NP	0	895	20	875	>130	NR	54
U4690	6/35-26	1844878.92179	1545579.47641	1925	870	870	8	862	24	838	>68	NR	NR
U4691	6/35-26	1845291.83369	1546332.43340		863	863	10	NP	0	853			
U4707	6/35-27	1839687.61171	1545304.42671	1988	845	NP	0	845	42	803	>78	70	16
U4712	6/35-27	1840999.21421	1544041.40209	1982	865	NP	0	865	12	853	>138	49	34
U4714	6/35-27	1838133.11986	1545231.55991	1981	830	830	11	819	31	788	>113	44	32
U4715	6/35-27	1839204.86913	1547028.94110	1981	830	830	12	818	18	800	>125	45	20
U4718	6/35-27	1842760.16200	1542292.59876	1977	893	NP	0	893	41	852	>159	80	50
U4730	6/35-27	1841242.10356	1542183.29855		882	882	50	NP	0	832	330		
U4731	6/35-27	1842663.00626	1546518.87347		850	850	30	NP	0	820			

Well ID	T/R-sec	easting	northing	year drilled	Surf elev	Touchet top	Touchet isopach	alluvial gravel top	alluvial gravel isopach	Mio-Pliocene conglomerate top	Mio-Pliocene conglomerate isopach	first water	static water
U4759	6/35-28	1834534.50577	1543941.71892	1981	910	NP	0	910	46	864	>79	NR	14
U4762	6/35-28			1978	800	800	14	NP	0	786	>301	180	93
U4763	6/35-28	1836563.50802	1544344.64135	1978	830	830	5	NP	0	830	>118	35	23
U4764	6/35-28			1977	805	805	12	793	43	750	>51	24	12
U4774	6/35-28	1837498.86367	1545006.58535	1971	832	832	14	NP	0	818	>90	34?	23
U4775	6/35-28	1837426.91323	1542358.80936		846	846	12	NP	0	834	130		
U4785	6/35-34	1843119.99808	1538335.30152	1908	930	930	2	NP	0	928	>98	NR	20
U4797	6/35-29	1829138.22319	1545193.65648	1988	750	NP	0	750	10	740	>330	70	67
U4799	6/35-29	1827598.48390	1542258.07875	1978	750	750	11	739	83	656	>67	90	62
U4801	6/35-29	1828893.59172	1544934.63491	1976	750	NP	0	NP	0	750	>110	43	31
U4806	6/35-29	1828461.88911	1545222.43665	1954	745	NP	0	NP	0	745	>109	NR	20
U4808	6/35-29	1827497.75329	1546301.69317		731	731	11	720	46	674			
U4819	6/35-30	1823900.23157	1543941.71892	1985	710	710	6	704	11	693	>83	60	39
U4824	6/35-30	1821971.95993	1543812.20814	1977	692	NP	0	692	77	615	>28	31	26
U4828	6/35-30	1822418.05262	1545064.14569	1971	690	690	3	687	15	672	>90	NR	32
U4839	6/35-30	1821871.22932	1545121.70604	1955	685	NP	0	685	36	649	>101	NR	40
U4840	6/35-30	1823813.89105	1546431.20395	1955	702	702	5	697	30	667	>205	35(?)	14
U4848	6/35-31	1825166.55922	1541236.38259	1966	761	761	15	746	30	716	>60	NR	30
U4853	6/35-32	1830635.48544	1537181.57710		856	856	12	NP	0	NP	0		
U4856	6/35-32	1827656.04425	1541610.52485	1981	762	762	16	746	17	729	>87	16	16
U4857	6/35-32	1829190.29380	1539853.35996		833	833	8	825	4	NP	0		
U4858	6/35-32	1830963.38606	1538845.36916	1979	840	840	12	828	23(?)	805?	>146	29	20
U4859	6/35-32	1832445.01110	1538918.23596	1970	815	815	6	NP	0	809	>132	30?	19
U4864	6/35-32				833	833	32	NP	0	801	193		
U4873	6/35-33	1837314.94259	1537655.21134	3/82	876	876	3	873	31	842	>171	110	67
U4876	6/35-34	1841771.96218	1540314.84973	1908	903	NP	0	903	44	859	>56	NR	42
U4879	6/35-33	1834594.58186	1538602.47981	3/80	837	837	2	835	8	827	265	125	70
U4880	6/35-33	1832462.33326	1541912.71667	12/79	804	804	18	NP	0	786	>112	65	16
U4881	6/35-33	1832566.45578	1539270.42552	10/79	817	817	3	814	38	776	>95	60	32
U4882	6/35-33	1835815.22350	1541092.48172	8/79	842	NP	0	842	35	807	>150	173	60
U4888	6/35-33	1833138.66734	1540991.75111	12/71	815	815	6	809	2	807	>97	24	24
U4897	6/35-33	1837266.36472	1538578.19087	4/53	870	870	3	867	29	838	>118		52
U4898	6/35-33	1833793.04700	1538371.73492	-/16	834	834	3	NP	0	831	>87		35
U4903	6/35-33	1835153.22736	1540630.60589	-/26	834	834	10	824	>65				
U4906	6/35-33	1832894.35640	1539270.42552	-/22	819	819	3	NP	0	816	>47		6
U4907	6/35-33	1833800.61134	1540991.75111	<-/20	821	821	10	811	>30				20
U4912	6/35-33	1833793.04700	1538031.68983	1916	835	NP	0	835	3	832	>137		
U4914	6/35-33	1837825.01022	1537400.17752	-/15	882	882	2	880	28	852	>60		20
U4917	6/35-33	1835201.80523	1539306.85892	1910	835	NP	0	835	95	740	>21		32
U4924	6/35-34	1839585.95802	1539233.99212	1988	893	NP	0	893	18	875	72	50	111

Well ID	T/R-sec	easting	northing	year drilled	Surf elev	Touchet top	Touchet isopach	alluvial gravel top	alluvial gravel isopach	Mio-Pliocene conglomerate top	Mio-Pliocene conglomerate isopach	first water	static water
U4929	6/35-34	1842889.25319	1537448.75539	1982	925	NP	0	925	38	887	>214	148	110
U4936	6/35-34	1842743.51958	1538906.09149	1978	924	NP	0	924	120	804	>42	45	15
U4938	6/35-34	1843083.56467	1538019.54536	1977	932	NP	0	932	41	891	>101	35	36
U4939	6/35-34	1841152.59433	1537132.99923	1977	922	NP	0	922	70	852	>50	80	47
U4946	6/35-34	1839950.29205	1539768.34869	1973	891	NP	0	NP	0	891	>125	117	45
U4948	6/35-34	1842415.61896	1539962.66017	1971	895	NP	0	895	40(?)	855?	>88	61(?)	41
U4954	6/35-34	1840011.01438	1537157.28817		912	NP	0	912	20	892	169		
U4970	6/35-34	1842294.17428	1538311.01258	1960	923	NP	0	923	22	901	141	NR	40
U4971	6/35-34	1839646.68036	1537339.45518	1959	905	NP	0	905	20	885	>92	40	35
U4973	6/35-34	1842901.39766	1540144.82718	1959	915	NP	0	NP	0	915	>121	NR	23
U4975	6/35-34	1839525.23568	1536938.68775	1956	905	NP	0	905	26	879	>84	10	19
U5	6/35-30	1821986.35002	1546632.66516	1987	681	681	4	677	6	671	>111	40	39
U50011	6/35-13	1848856.68471	1553599.09805	1995	810	810	44	NP	0	766	>146	181	
U50016	6/35-33	1833222.25702	1537278.73284	11/95	865	865	29	836	10	826	>202	41	100
U50068	6/35-31	1822668.71473	1539671.19295	1996	738	738	42	696	>126?			90	60
U50069	5/35-12	1853357.78422	1531534.39969		1163	1163	11	NP	0	1152	115		
U5021	6/35-34	1838626.54508	1537436.61092	<1900	890	NP	0	890	1.5	888	>91		20
U5025	6/35-34	1838165.05532	1539404.01466	?	875	NP	0	875	3	872	>42		30
U50250	6/36-18	1854145.15053	1555865.84042		835	835	63	NP	0	772	144		
U5027	6/35-35	1843397.29675	1541183.17916		909	909	18	891	6		0		
U5039	6/35-35	1845063.11288	1537582.34453	1983	952	NP	0	952	98	854	>92	103	86
U5042	6/35-35	1845718.91413	1540132.68272	1982	933	NP	0	NP	0	933	226	80	70
U5043	6/35-35	1847625.59554	1537618.77793	1982	970	NP	0	970	34	936	>119	46	34
U5044	6/35-35	1845243.25582	1541462.50191	1982	918	NP	0	918	17	901	>85	75	60
U50473	6/35-36	1851706.13663	1539707.62635	1997	952	NP	0	952	18	934	>87	NR	38
U50478	6/35-34	1837837.15469	1539112.54744		875	NP	0	875	27	848	216		
U5048	6/35-35	1843970.11080	1536975.12115		947	NP	0	NP	0	947			
U5049	6/35-35	1845731.05860	1538869.65809	1981	947	NP	0	947	152 ?			114	50
U5050	6/35-35	1846069.07961	1541243.90150		922	NP	0	922	12	910			
U50516	5/35-4	1834752.45994	1536550.06479		921	921	55	NP	0	866	71		
U5052	6/35-35	1846567.00278	1541644.66893	1981	920	NP	0	920	30	890	>247	50	34
U5053	6/35-35	1843761.63078	1541608.23552	1979	908	NP	0	908	80	828	>20	80	45
U5057	6/35-35	1845158.24455	1541729.68020	1977	915	NP	0	915	30	885	>132	46	36
U50577	6/35-32	1831194.13094	1539100.40297		820	820	12	808	17	791	385		
U5058	6/35-35	1845706.76966	1537618.77793		958	NP	0	958	26	932	119		
U5059	6/35-35	1846629.74920	1540557.73908	1977	935	NP	0	935	27	908	>98	45	34
U50804	6/35-34			1997	930	NP	0	930	86(?)	844?	>96?	46	43
U5091	6/35-35			1960	944	NP	0	944	>167?			NR	60
U50953	6/35-34	1841529.07283	1538772.50235		905	NP	0	905	30	875	220		
U51035	6/35-13	1851655.53468	1554359.92645	1998	802	802	13	789	25	764	>120	14	5.5

Well ID	T/R-sec	easting	northing	year drilled	Surf elev	Touchet top	Touchet isopach	alluvial gravel top	alluvial gravel isopach	Mio-Pliocene conglomerate top	Mio-Pliocene conglomerate isopach	first water	static water
U51045	6/35-21	1834951.81829	1551438.95418		761	NP	0	NP	0	761			
U5121	6/35-36	1849908.75543	1540436.29440	1987	944	NP	0	944	40	904	>80	35	50
U5126	6/35-36	1848801.58481	1541365.34617	1985	931	NP	0	931	60	870	>41	55	34
U5128	6/35-36	1848789.44034	1541790.40254	1985	924	NP	0	924	55	869	>47	78	36
U5132	6/35-36	1849495.84354	1537460.89986		981	NP	0	981	10	971			
U5148	6/35-36	1851086.76879	1537485.18879	1961	980	NP	0	980	20	960	>115	NR	30
U51581	5/35-3				954	954	2	952	83	869	15		
U5172	6/36-19	1855505.33090	1550813.74192		843	843	28		0	815			
U51921	6/35-22	1839499.08574	1547884.60272	1998	820	820	48	NP	0	772	>110	52	69'
U5200	6/36-30	1853962.98352	1544486.47433	1978	900	NP	0	900	47	853	118	85	28
U5211	6/36-30	1855651.06451	1545846.65470		889	889	6	NP	0	883	145		
U5227	6/36-31	1856466.76791	1539792.63762		970	970	26	NP	0	944	233		
U5230	6/36-31	1854147.17461	1537983.11196		974		0	NP	0	974	467		
U5238	6/36-31	1856187.44516	1539780.49316		968	968	20	NP	0	948	180		
U52581	6/35-15	1842434.66346	1555827.93068	1998	770	770	5	765	19	746	>91	24	30
U5268	6/35-28	1835757.66315	1546963.63716	1989	810	810	9	801	34	767	>77	98	26
U5316	6/35-35	1845075.25735	1540569.88355	1989	930	NP	0	930	36	894	>149	60	43
U53413	6/35-15	1840707.85304	1553424.78617		781	NP	0	NP	0	781			
U53462	6/35-34			1999	905	NP	0	905	71(?)	834	>122?	41	33
U53471	6/35-17	1828720.91067	1555108.42633	1999	695	695	8	687	18	669	>123	55	43
U5358	6/35-36	1850613.13455	1537898.10069	1990	980	NP	0	980	38	942	>65	80	35
U53647	6/35-36	1851861.99063	1541875.41381	1999	920	920	5	915	60	855	>55	46	34
U53762	6/35-36	1853078.46146	1537788.80048	2000	980	980	5	975	68	907	>60	45	19
U53769	6/35-34	1839828.84737	1539962.66017	2000	890	890	2	888	66	822	>182	NR	49
U53863	6/36-19	1854764.51838	1547814.05844		859	859	6		0	853			
U53932	6/35-30	1822475.61297	1546647.05525	2000	685	NP	0	685	25(?)	660	>101	75	47
U53996	6/35-27	1842335.10564	1544405.73611	2000	870	NP	0	870	65	805	>60	40	34
U54050	6/35-36	1848487.85273	1537995.25643		964	964	2	NP	0	962			
U54063	6/35-26	1845413.27836	1547255.41293		859	859	10	849	66	783			
U5408	5/35-12	1851779.00344	1529907.04104		1063	NP	0	1063	26	1037	8		
U54134	6/35-26	1847149.93722	1545713.06555		879	879	4	NP	0	875	260		
U54145	6/35-36	1849046.49824	1538553.90193	2001	965	NP	0	965	51	914	>71	NR	47
U54341	6/35-34	1838506.16975	1541337.11320		863	NP	0	863	2	861	349		
U54464	6/35-35	1843277.87615	1539999.09357		918	NP	0	918	37	881	202		
U5464	6/35-28	1834361.82473	1542056.61754		822	822	9	NP	0	813	295		
U5477	6/35-35			1990	951	NP	0	951	95	856	>77	35	30
U5496	6/35-28	1835685.71272	1544272.69092		820	820	9	NP	0	811	387		
U5512	6/35-34	1838520.55983	1541135.65198	7/90	865	NP	0	865	34	831	>146	NR	42
U5530	5/35-3	1839391.64654	1534813.40593		920	920	18	NP	0	902	90		
U5625	6/35-14	1843173.07390	1554145.59909		781	781	5	776	36	740			

Well ID	T/R-sec	easting	northing	year drilled	Surf elev	Touchet top	Touchet isopach	alluvial gravel top	alluvial gravel isopach	Mio-Pliocene conglomerate top	Mio-Pliocene conglomerate isopach	first water	static water
U5657	6/35-27	1841035.64761	1545365.14905	1992	852	852	4	848	11	837	>289	55	34
U5670	6/35-34				909	NP	0	909	8	901	187		
U5743	6/35-30	1826101.91486	1546287.30308	1992	723	723	12	711	25	686	>148	55	52
U5841	6/35-21	1834635.23638	1550618.71923	1995	765	765	3	762	65	697	>147	42	36
U5958	6/35-25	1849202.35224	1544280.01838		899	NP	0	899	24	875			
U5965	6/35-36	1848548.57507	1540812.77290	1993	938	NP	0	938	23	915	>82	NR	34
U6017	6/35-13	1852505.64741	1554444.93772		813	813	44	NP	0	769			
U6053	6/35-34	1838225.77765	1538881.80256		879	NP	0	879	9	870	260		
U6192	6/35-20	1831512.58753	1552417.48009	1978	738	738	16	722	10	712	324	16	13
U6194	6/35-20	1829109.44302	1551913.82705	1955	745	745	67	NP	0	678	>208		68
U6196	6/35-20	1831095.27501	1549942.38514	1976	770	770	46	NP	0	724	>79	68	42
U6208	6/35-21	1837513.25375	1548733.61785	1978	797	979	7	790	63	727	>80	50	59
U6217	6/35-33	1832991.51214	1539853.35996	8/94	816	NP	0	816	16	800	>186	68	50
U6281	6/35-26	1843202.98527	1543964.26223	1994	878	NP	0	878	16	862	>94	55	40
U6342	6/35-15	1839945.17843	1554504.04268	1995	765	NP	0	765	35	730	>67		30
U6355	6/35-34	1838614.40062	1538651.05768		886	NP	0	NP	0	886	243		
U6377	6/35-33	1835138.88942	1541293.94293	6/95	835	835	12	823	28	795	>52	55	32
U6405	6/35-29	1831253.56596	1546272.91299	1995	768	768	10	758	54(?)	704?	>59?	25	55
U6441	6/35-26	1846117.65748	1545275.86472	1981	878	NP	0	878	15	863	>85	65	36
U6443	6/35-27	1840379.84636	1542183.29855	1981	865	NP	0	865	30	835	>140	60	36
U6445	6/35-29	1830505.28145	1545193.65648	1981	765	NP	0	765	27	738	>116	47	43
U6447	6/35-30	1823727.55053	1544949.02500	1982	703	NP	0	703	24	679	>96	60	18
U6449	6/35-30	1823612.42983	1546186.57247	1986	698	698	2	696	33	663	>67	NR	54
U6466	6/35-35	1838772.27869	1537120.85476		938	938	3	935	27	908			
U6468	6/35-35	1843581.48784	1537643.06687	1966	951	NP	0	NP	0	951	69	NR	73
U6475	6/35-36	1851026.04645	1540399.86100		939	939	23	NP	0	916	141		
U6509	5/35-1	1850030.20011	1534971.28401		1004	NP	0	1004	33	971	62		

Attachment 7

Test and Monitoring Plan

PRELIMINARY CHARACTERIZATION, MONITORING, AND TESTING PLAN, HUDSON BAY DITCH SHALLOW AQUIFER RECHARGE PROJECT

Introduction

Surface water and shallow groundwater in the Walla Walla Basin (the Basin) form an interconnected system. In some areas, especially upstream areas where streams leave the mountains and highlands surrounding the Basin to flow out onto the Basin floor, streams historically probably branched out onto the Basin floor and some of the water they carried seeped into the ground, recharging the shallow groundwater system. This shallow groundwater, recharged near the edge of the Basin, formed the main source of clean, cool groundwater found further down basin where it returned to the surface via springs and base flow to the Walla Walla River. Over the past 100 or more years this system has been modified both as a result of efforts to increase water supply for human use and to control flooding.

Shallow aquifer recharge is being explored in the Basin in large part to restore some fraction of the natural historical shallow aquifer recharge that has been lost, in part, because of modifications to surface water drainages in the Basin. These modifications have benefited the economic and social values of the Basin, but at some cost to natural habitat. It is hoped that shallow aquifer recharge projects, by mimicking natural historical shallow aquifer recharge that occurred in the Basin, will directly benefit habitat in streams that were in part maintained by natural spring and groundwater discharge.

The Walla Walla Basin Watershed Council (WWBWC), in cooperation with the Hudson Bay Improvement District (HBID), has proposed to test shallow aquifer recharge at a site located adjacent to the Hudson Bay Canal in section 33, T6N, R35E. At the test site a series of three infiltration ponds will be built. Water will be supplied to these ponds via a diversion from the canal. Recharge activities are proposed for winter and spring months when the Walla Walla River (the source of water for the canal) displays peak annual flows. The proposed shallow aquifer recharge testing will be done under an ASR Testing Limited License granted by Oregon Water Resources Department (OWRD) (OAR 690-350-0020).

The Limited License Application requires several supporting documents be attached (690-350-0020 (3)(b)), including (but not limited to) those describing proposed testing, groundwater conditions (including hydrogeologic conditions and groundwater quality), and source water quality. Some of this information is reported in the 3 July 2003 hydrogeologic assessment report. Information not included in the assessment report, but still needed for the Application, will be collected during proposed site-specific hydrogeologic characterization, monitoring, and testing. Preliminary characterization, monitoring, and testing plans are described here. These, especially the monitoring and testing plans, will be modified as information is collected.

Preliminary Test Site Specific Hydrogeologic Characterization

Site-specific hydrogeologic characterization is designed to identify and define local conditions which provide a technical basis for designing the monitoring which will be used to evaluate testing. For this project a number of characterization needs are outlined in the 3 July 2003 hydrogeologic assessment letter report. These needs include determining the physical properties of the geologic units underlying the test site, investigating the presence of a possible semi-confined aquifer in the upper part of the suprabasalt aquifer system, identifying aquifer hydraulic properties, and establishing suprabasalt aquifer baseline conditions, including seasonal variation, for groundwater depth, flow direction, and quality. These, and other site characterization issues, will be addressed using test site-specific hydrogeologic characterization data collected predominantly using:

1. Test pits, boreholes, and wells constructed for the direct observation of subsurface conditions,

2. Infiltration tests (constant and falling head) designed to evaluate spatial variability at a site both laterally and vertically (note, the water source for this activity may require a temporary permit),

3. Aquifer testing and water level measurements to evaluate baseline aquifer physical conditions before testing,

4. Surface and ground water quality data collected to evaluate the affect (if any) of test site operation on area groundwater quality,

5. Well and canal records describing water use in the project area, and

6. Water flow metering at the test site that indicates surface water in-flow and out-flow during testing.

At this time, geophysical investigations are not being considered because of the lack of subsurface control and ground truth data that could be used to constrain geophysical interpretations. The following sections describe proposed soils, geologic, hydrogeologic, surface water, and water quality characterization for this project.

Soils

The nature and extent of surface soils effect how fast water can infiltrate into the ground. However, the infiltration ponds proposed at the test site will be excavated through the surface soil layer. Therefore, surface soil conditions and properties are largely irrelevant to the project except in as far as the amount of soil at the site controls the amount of excavation needed for the infiltration ponds. The proposed characterization work will simply look at surface soils to the extent necessary to determine how much soil will probably need to be removed for infiltration pond construction.

Geology

Geologic features control the physical characteristics of aquifer hosting materials, and therefore the distribution and movement of groundwater through an aquifer. Understanding the nature and occurrence of these features, both regionally and locally, provide constraints on testing, data interpretation, monitoring, mitigation, and final design. The objective of geologic characterization is to develop a three dimensional physical framework that describes the materials hosting the vadose zone and groundwater at the test site. Within this framework, or conceptual model, the nature and distribution of those factors thought to control groundwater movement and distribution will be evaluated.

Site-specific geologic characterization will be accomplished largely through the analysis of data collected during the drilling of several proposed boreholes at the site and comparison of that data to information collected during the preparation of the hydrogeologic assessment report. A minimum of three boreholes are proposed for the immediate vicinity of the test site. One of these boreholes will be located on the inferred up-gradient side of the test site, two will be located on the inferred down-gradient side. In the assessment report we also recommend that at least one more down gradient well be placed near the test site. In addition, we recommend the placement of several additional boreholes located more distally from the test site in both the inferred up- and down-gradient directions. Subsurface hydrogeologic conditions will be interpreted via drilling cuttings and spilt-spoon sample logging.

The project hydrogeologic assessment identified work needed to complete site-specific hydrogeologic characterization. Hydrogeologic characterization targets, and the rational for them, are described below.

- It is likely that the uppermost, unconfined part of the shallow aquifer system, is hosted by predominantly uncemented alluvial gravel beneath the test site. However, it is not clear from the available data how deep the alluvial gravels extend and what their properties are beneath the test site. Identifying the three-dimensional extent of these strata is critical to the proposed testing because water probably will move more rapidly through these uncemented strata, both downwards and laterally, then in the deeper, more cemented Mio-Pliocene conglomerate that comprises the majority of the shallow aquifer system in the area.

- Area data indicates that, if present, the unconfined part of the shallow aquifer system at the site may be relatively thin and underlain by a semi-confined zone at depths of less than 75 feet bgs. Characterization will identify if this semi-confined zone is actually present, and if found, the nature of the confining layer separating it from the overlying unconfined zone and the basic hydrologic properties of the semi-confined zone. Knowing the nature and extent of the confined aquifer underlying the site is critical in evaluating if the proposed recharge will affect this deeper aquifer. If data collected indicates that the project could potentially affect this deeper aquifer, monitoring will need to be designed to not only assess shallower unconfined aquifer impacts but deeper confined aquifer impacts as well.

- The nature and distribution of the confining layer atop the confined aquifer should be identified in order to support evaluation of the thickness and distribution of the unconfined aquifer (if present). If the unconfined aquifer is absent, or only present seasonally, we will still need to identify the nature and extent of the confining layer because, just as it inhibits upward movement of groundwater, it will restrict the downward movement of recharge water. Knowing where the confining layer is will provide information on where recharge water collecting on top of it will spread to.

- Mapping for the assessment identified a potential depression in the top of the older Mio-Pliocene conglomerate below the western end, and west of, the test site. The depth, shape, and orientation of this feature will need to be evaluated because it will effect how the aquifer(s) underlying the test site respond to the testing. If an unconfined aquifer indeed underlies the site, this depression may act as a "reservoir" for water introduced into this aquifer. Alternatively, it may serve as a recharge pathway, hydrologically connecting the upper, unconfined part of the suprabasalt aquifer system with deeper, confined parts of the aquifer system.

The assessment did not provide any site-specific geologic properties data for any of the geologic units hosting the vadose zone and upper part of the suprabasalt aquifer underlying the test site.

Hydrogeology

Piezometers (observation wells) will be constructed in at least three of the borings drilled for geologic characterization. If additional geologic characterization boreholes are drilled (either close to or more distal from the test site) we also recommend that at least three of these be converted to observation wells. All but one of the boreholes converted to monitoring wells should be completed as 2-inch observation wells that fully penetrate the unconfined aquifer (if present) or above the confining layer (if unconfined aquifer not present). At least one of the geologic characterization boreholes should be of sufficient size to accommodate a 4-inch diameter well which will be used for aquifer testing.

Test site-specific hydrogeologic work would be done, in large part, concurrently with the site-specific geology work. The hydrogeologic assessment concluded that the following information must be collected for the uppermost part of the suprabasalt system at the test site:

- Depth, thickness, and lateral and vertical extent of the vadose zone and the uppermost aquifer(s) underlying a site.

- Nature and effect of perching layers (if any) in the vadose zone.

- Aquifer and vadose zone physical and hydrologic properties - including, grain size, matrix content, induration, hydraulic conductivity, transmissivity, porosity

- Groundwater flow direction and velocity, including both spatial and temporal variation

- Anthropomorphic effects, primarily changes in groundwater pumping, surface water (including canals), and irrigation activities.

Ideally, several months to several years of baseline hydrogeologic data should be collected prior to testing so that an adequate site background condition can be established against which test data can be compared to evaluate test success. Water level data will be collected periodically, with the sampling frequency initially being small, later decreasing as testing progresses and more is learned about water level variation in the target aquifer.

For characterization it is important to build monitoring wells in such a way as to provide means for accurately measuring the target aquifer. Well construction considerations are listed below:

- Most project wells will probably be 2 inch-diameter piezometer type installations. These should be built to ensure that they are monitoring the anticipated aquifer targets, and we recommend building to well construction standards and avoiding cost cutting measures designed to get more/cheaper wells (these commonly result in poorly built wells unsuitable for collection of the high quality data we feel is necessary to support the project).

- For aquifer testing, a 4 inch-diameter well is the minimum recommended diameter and at least one should be built.

- The minimum number of wells at the test site is 3, one up gradient and 2 down gradient. We do not recommend this. At a minimum we recommend 4 wells, one up and three down gradient, with more eventually being built as the test progresses and potentially unanticipated changes in the groundwater system are identified. Most, if not all, of these wells would be built in geotechnical borings drilled for geologic characterization.

- In addition to the wells built near the test site, it seems likely that wells will eventually need to be built more distant from the site. The purpose of these wells would be to more accurately trace the down gradient migration of recharge water away from the test site. A minimum of 4 wells, 1 well up gradient and 3 wells down gradient is again recommended. These might include at least some previously built groundwater supply wells that would be available for use. However, these should only be used if construction details can be verified and if they are not being used as water supply wells. Access to offsite well drilling locations will need to be acquired from willing land owners. Many offsite wells used in characterization may be unused water supply wells from which data is collected upon which to base decisions for building new monitoring wells.

- Aquifer testing designed to collect aquifer hydraulic property data will be part of site characterization. During aquifer testing, the 2-inch observation wells will be monitored to observe the effects of testing on the surrounding aquifer. Aquifer testing would include an 8 hour step drawdown test to establish probable sustainable yields in the suprabasalt aquifer, followed by a 24 to 72 hour constant discharge test. Water level data collected during aquifer testing will be analyzed using standard analysis techniques.

Combining the interpretations developed in the completed hydrogeologic assessment with the drilling and testing data collected during site specific characterization, a conceptual model of Test Site hydrogeologic conditions will be prepared.

Surface Water

One of the main objectives of the project is to increase surface water quantity and improve its quality. To document that, surface water bodies that the project might influence need to be identified and monitoring points on them established and characterized (includes collection of baseline data). These locations will be used as monitoring locations during subsequent testing.

The hydrogeologic assessment identified three spring-feed streams that are those most likely to be effected by shallow aquifer recharge, Goodman Spring Branch, Johnson Creek, and Dugger Creek. During test-site specific characterization these streams will be examined and monitoring points identified. At these points stream conditions will be photographed and stream conditions documented prior to the initiation of testing. Documentation of pre-test background conditions will include the following parameters:

- Flow volume and discharge
- Water temperature
- Water quality
- Hydrophilic plants and habitat quality

Sampling frequency will be designed to collect enough data to demonstrate the range of conditions likely at the monitoring points so that site background conditions can be documented enough to provide an adequate baseline to measure test results against.

Water Quality

Both surface and groundwater quality at the test site, and at likely down-gradient discharge points, needs to be documented. There are several reasons for this, including:

- We do not want to introduce contaminated water into the shallow aquifer via recharge activities and violate antidegradation rules. We need to establish background water quality parameter concentrations and monitor source-water quality periodically during testing and operations.
- Certain source-water conditions (e.g., turbidity) have the potential to degrade or even "plug" the recharge system. From an operational standpoint, one would monitor for those conditions and halt test operations when the source-water exceeded those conditions.

- Up-gradient groundwater quality needs to be monitored so that the effects of recharge on water quality can be differentiated from those water quality conditions caused by recharge activities, including leaching of vadose zone constituents by recharge water.

Sampling Quality Assurance and Quality Control (QA/QC) protocols will need to be established and followed for characterization and later monitoring. The sampling QA/QC protocol will need to describe:

- Sampling equipment
- Measurement techniques for field parameters
- Decontamination procedures
- Well purging guidance for groundwater samples
- Sampling methods
- Chain of custody and sample handling procedures
- Record keeping
- QA/QC guidelines

Parameters to be tested for include TDS, pH, temp, nitrate-N, chloride, TKN, ...

Conclusion to Characterization

With the completion of site-specific characterization, final monitoring and test plans will be prepared. This monitoring and test plans will be based on the results of the characterization effort which includes the generation of a site conceptual groundwater flow model that describes probable aquifer conditions, suprabasalt aquifer water level(s) and groundwater flow direction(s) (including seasonal variations), and discharge points for recharge water.

Preliminary Site-Specific Surface Water and Groundwater Monitoring Plan

Monitoring for the proposed testing is designed to meet four basic objectives. These are to identify: (1) changes in the natural system caused by factors other than those related to testing, (2) changes in the natural system caused by the testing (track the test performance), (3) potential problems caused by the testing that may require termination of the test and/or mitigation actions, and (4) events that effect test operations, such as a freezing event. To meet these objectives, the results of site-specific characterization will be used to identify monitoring locations to track:

- Source water quality and volume coming onto the test site

- Up-gradient groundwater water quality

- Groundwater level changes migrating into the test area in order to provide the information needed to differentiate the effects of testing from other effects on the test site.

- Down-gradient groundwater quality and levels, both near and distal to the test site

- Surface water discharge and quality changes

Monitoring data collected at these points during testing will be evaluated against the established baseline to identify testing effects on the surrounding environment, differentiate those effects from others in the environment, and identify when changes in test operations appear necessary.

Four basic types of monitoring points are currently proposed, source water, test site groundwater, distal groundwater, and surface water (e.g., springs). Considerations for each are summarized below:

- Source water monitoring will be at the point of diversion onto the site. Sampling frequency will be periodic. For water quality, sampling frequency will be based on an analysis of characterization data that identifies when contaminants (if any) are likely to be present in the source water. The results of source water quality monitoring will be used to determine if modifications to test operations are warranted. The volume of water delivered to the test site and leaving the test site (via a return line to the Canal) also will be monitored to keep track of the volume of water that infiltrated into the ground via the ponds. During testing different sampling frequencies may be tried to identify those that are most effective.

- Site groundwater monitoring, consisting of water quality and level data, will be at monitoring wells established immediately adjacent to the test site to identify immediate quantity and quality impacts from testing. Up-gradient monitoring will be a part of this so that site impacts can be differentiated from offsite events. Sampling frequency will be determined from characterization data and modified as more is learned during testing.

- Distal groundwater monitoring, consisting of water quality and level data, will be at monitoring wells more distal from the test site. This monitoring will be used to identify longer term quantity and quality impacts from testing. This includes the formation and migration of a groundwater mound and recharge water plume at, and away from, the test site, towards intended and unintended receptors. Up-gradient monitoring will be a part of this so that testing effects can be differentiated from offsite events. Sampling frequency will be determined from characterization data and modified as more is learned during testing.

- Surface water monitoring, most likely in spring creeks, will be done to identify the effects of recharge on spring flow. This monitoring will include the collection of both water quality and flow parameters. As with groundwater monitoring, surface water monitoring will need up-gradient monitoring information so that effects unrelated to test site operations/testing can be differentiated from those due to testing. This monitoring will likely include a combination of flow volume and water quality.

Four basic elements are needed for the monitoring plan. These are summarized below and will be developed in greater detail following the collection of site-specific characterization data. The four basic monitoring plan elements are:

1. Identification of monitoring points and sampling frequency
2. Description of sampling procedures, including:
    a. Equipment to be used
    b. Water level measuring techniques
    c. Stream gauging techniques
    d. Sampling equipment decontamination
    e. Well Purging
    f. Field parameters to be collected at both surface and groundwater sites
    g. Sample collection methods at both surface and groundwater sites
    h. Chain of custody tracking
    i. Sample handling protocols
    j. Field record keeping
    k. QA/QC
3. Sampling point maintenance
4. Data Reporting and Analysis, including:
    a. Record keeping
    b. Annual reporting, including review of previously collected data, reporting of unusual events, and guidelines for recommending changes to test operations as a result of data analysis

This monitoring plan outline will be expanded upon following the collection of site-specific hydrogeologic characterization data.

Preliminary Test Site Operation Plan

In addition to the monitoring plan, a test plan will need to be developed. The test plan should describe how the test site will be operated during testing. Elements included in the test plan will include: (1) site construction, (2) test operations, (3) mitigation activities, and (4) reporting. The test plan will be developed prior to the start of actual testing. However, completion of the plan is contingent on funding. Assuming funding for the project can be procured, construction planning elements would be completed in the Autumn of 2003.

The contents of each test plan element are outlined below:

1. Site construction information describes the site layout. Site construction planning will include:
    a. Test Site survey and layout
    b. Specifications for pits/basins/ponds used for infiltration
    c. Water supply design (including diversion from canals if appropriate)
    d. Monitoring points (both on and off site)
    e. Site access controls (fences, etc.)
2. Test Operations will describe how the site will be used during the test. The operations plan will also describe provisions for changing the test operation plan as new data and information is collected during the test. The test operation plan will include:
    a. Test timing, including timing of recharge and monitoring frequencies
    b. Quantities of water used
    c. Outside influences that effect test, including weather (probably freezing), river flooding, trip wires for identifying potential offsite impacts before they occur so they can be mitigated and or testing suspended to prevent worsening conditions
    d. Responsible parties for diversion and delivery of water, operation of test, monitoring, and data review
    e. Permissions required to access offsite monitoring points
3. Mitigation - As stated above, one of the objectives of monitoring is to identify likely unintended consequences of recharge before they occur. If the precursors to these consequences, such as changing water quality detrimental to aquatic habitat or groundwater levels rising to close to the surface in areas where shallow groundwater is not desired, can be detected soon enough via monitoring, recharge activities will be modified

and/or terminated to mitigate against these effects. The mitigation plan will describe what the undesirable consequences of the test are, how they will be detected, and how the testing will have to modified to mitigate against these undesirable effects.

4. Reporting - Data and observations collected during testing, including monitoring data, will be compiled into reports. The basic objective of these reports will be to describe what was done during the test, what was observed at the monitoring points, interpret the data collected, and recommend changes to testing, monitoring, and mitigation plans. We anticipate that these reports will be produced annually. However, in cases where monitoring reveals the presence of an undesired effect from testing, the operator will need to immediately report the monitoring information to WRD and implement any required mitigation actions. At the conclusion of testing a final report will be prepared that describes the project, data colleted during operation and monitoring, interpretations of who well the recharge project worked in achieving project goals, and recommendations for future operations.