FINAL REPORT

STUDY OF PHOSPHORUS SOURCES IN GROUNDWATER ENTERING LAKE STEILACOOM

Prepared for
City of Lakewood

September 2004

URS and Brown and Caldwell

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September 3, 2004

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Re: Final Report
Study of Phosphorus Sources in the Groundwater entering Lake Steilacoom

Dear Mr. Vigoren:

Please find enclosed two copies of the Final Report for the Study of Phosphorus Sources in the Groundwater Entering Lake Steilacoom. If you need additional copies or have any questions, please call me at (206) 438-2360.

Sincerely,

Susan Bailey
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Steven P. Wolfe, R.G., L.HG.
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Enclosure

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ACRONYMS

bgs	below ground surface
cfs	cubic feet per second
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
ft/day	feet per day
gpd/ft	gallons per day per foot
HFO	hydrous ferric oxide
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
msl	mean sea level
ORP	oxidation/reduction potential
QAPP	Quality Assurance Project Plan
SRP	soluble reactive phosphorus
TDP	total dissolved phosphorus
TMDL	total maximum daily load
TPCHD	Tacoma-Pierce County Health Department
USGS	U.S. Geological Survey

EXECUTIVE SUMMARY

Lake Steilacoom has a long history of problems with blue-green algae blooms. A lake restoration study completed in 1996 identified soluble reactive phosphorus (SRP) as the most likely factor triggering the algae growth. The restoration study found that Ponce de Leon Creek was the most important pathway of excessive SRP during the summer growing season, and suggested that groundwater emanating from a buried marsh was the main source of phosphorus to Ponce de Leon Creek. However, the study did not include sampling to verify this hypothesis.

To address this issue, the City of Lakewood applied for and received a grant from the Washington State Department of Ecology to identify the potential sources of phosphorus in the groundwater entering Lake Steilacoom. The City contracted with URS and Brown & Caldwell to conduct the study, which includes three basic components:

- Evaluate the pathway(s) by which groundwater reaches Lake Steilacoom
- Measure phosphorus concentrations in the groundwater and surface water along the key pathway(s)
- Identify potential human and/or natural phosphorus sources affecting the groundwater along these flow paths

SOURCES OF WATER TO LAKE STEILACOOM

Ponce de Leon Creek

There appears to be little direct groundwater inflow to Lake Steilacoom. However, groundwater is the primary source of water to Ponce de Leon Creek. A cluster of springs located approximately 150 feet west of the Lakewood Towne Center discharges groundwater to the creek on a year-round basis. During the winter and spring, when the water table is high, additional groundwater is captured by a dewatering system located beneath the Lakewood Towne Center. The dewatering system discharges to Ponce de Leon Creek.

Clover Creek

The other major surface water tributary to the lake, Clover Creek, does not appear to receive groundwater inflow within the study area. In fact, Clover Creek appears to lose water to the underlying aquifer during dry seasons of the year. There was no surface flow in Clover Creek in the fall months.

Aquifers

There are two primary aquifer zones in the study area. Aquifer Zone A is the shallowest aquifer system in the area. Aquifer Zone A consists of deposits of the Vashon Glaciation, with flow velocities on the order of 25 ft/day. Aquifer Zone C is comprised of a glacial sequence of stratified sand and gravel with discontinuous layers of silt and clay as well as intermittent layers

of till. Groundwater flow rates in this aquifer are on the order of about 7 ft/day. Regional and local groundwater flow in both the A and C aquifers is generally westerly to northwesterly.

Near-surface glacial deposits with relatively low permeability or low hydraulic conductivity appear to influence the groundwater occurrence and flow direction in the study area. These low permeability deposits concentrate groundwater flow to the surface at Ponce de Leon springs. A marsh and peat deposit are buried beneath the Lakewood Towne Center and approximately 1,000 feet east of Ponce de Leon Creek. Two stream channels, now filled with soil, approach the Towne Center, one from the east/northeast and one from the south. The southern channel may be an old overflow channel from Clover Creek. During the wet season, the southern channel may serve as an infiltration conduit for groundwater from Clover Creek. When the water table rises during the wet season, some of the groundwater is collected in the dewatering pipes beneath the Towne Center. Stormwater runoff from the Towne Center is also collected in the drainage system. The dewatering/drainage system ultimately discharges into Ponce de Leon Creek via a single 48-inch-diameter culvert located about 150 feet upstream of the Ponce de Leon springs.

PHOSPHORUS CONCENTRATIONS

Surface water and groundwater samples were collected at sources to Lake Steilacoom (Ponce de Leon Creek) and at various locations along the groundwater flow path upgradient of the creek. Flow rates were measured in the creek at the time of sampling. In addition, soil and peat samples were collected in and around the buried wetland and peat bog beneath the Lakewood Towne Center. Surface water samples also were collected from Clover Creek. The water samples were analyzed for various forms of phosphorus as well as pH, dissolved oxygen, and other parameters. The soil samples were analyzed for total phosphorus and other parameters relevant to phosphorus mobility. The key findings are:

- Surface water in Ponce de Leon Creek and groundwater along the main flow path upgradient of the creek contained higher phosphorus concentrations than Clover Creek.

- Phosphorus concentrations in groundwater near the eastern city limits were about the same or higher than those measured in Ponce de Leon Creek. Thus, phosphorus concentrations did not increase as groundwater flowed through the city en route to Ponce de Leon Creek.

- Phosphorus concentrations in the groundwater were about the same upgradient and downgradient of the buried marsh and peat deposit beneath Lakewood Towne Center.

- Phosphorus concentrations during the dry season appeared to be slightly higher than during the wet season.

- The peat deposit did not contain higher phosphorus concentrations than the soil samples collected for this study. Moreover, the peat had very low permeability. Groundwater flows preferentially around in more permeable aquifer materials.

PHOSPHORUS SOURCES

An initial screening identified potential phosphorus sources in the study area. Based on this initial review, point sources, agriculture, forest practices, recreation, and hydromodification were deemed unlikely to be significant sources of phosphorus to the groundwater entering Lake Steilacoom. Urban runoff, on-site wastewater treatment (i.e., septic systems), loss of the Atwood Marsh, and natural organic (peat) deposits, and mineral deposits were judged to warrant more detailed evaluation. The results are summarized below.

- **Urban runoff** does not appear to be the predominant source of phosphorus to the groundwater entering Lake Steilacoom because groundwater upgradient of the City and its numerous stormwater dry wells had similar or higher SRP than the downgradient groundwater entering the lake. There was no apparent relationship between dry wells, land use, and phosphorus concentrations in groundwater. Phosphorus concentrations in the groundwater entering the lake appeared to decrease, rather than increase, during the wet season when stormwater infiltration was occurring. However, it is possible that geochemical and/or soil conditions are masking phosphorus inputs from the dry wells.

- **Loss of the Atwood Marsh** does not appear to have contributed phosphorus to the lake. The soluble phosphorus concentrations observed upgradient of the former marsh were less than the minimum achievable effluent concentrations ("irreducible concentrations") for wetlands designed specifically for water quality treatment. Moreover, the algal blooms in the lake reportedly began before the marsh was covered.

- **Septic systems** are a potential source of phosphorus to the groundwater entering the lake. Septic systems were prevalent in the study area prior to sanitary sewer service in the early1980s. Geochemical modeling demonstrated that releases from these historic septic systems could account for phosphorus concentrations observed in the groundwater. In addition, active septic systems located in the eastern portion of the groundwater basin, upgradient of the City, could be contributing phosphorus.

- **Organic soils beneath the Lakewood Towne Center** do not appear to be significant sources of phosphorus to the groundwater entering Lake Steilacoom. The investigation indicated that groundwater preferentially flows around the lower permeability peat near the Lakewood Towne Center and not through it. In addition, groundwater samples collected from these borings contained concentrations of phosphorus that were less than those observed in Ponce de Leon Creek.

- **Mineral dissolution is** a potential source of phosphorus to the groundwater entering Lake Steilacoom. Geochemical modeling indicates that dissolution of phosphorus minerals in the basin rocks and soils could account for the phosphorus concentrations observed.

In summary, the results of this study suggest that loading of the groundwater by historic septic systems and/or soil minerals account for the predominate sources of phosphorus in Lake Steilacoom.

1.0 INTRODUCTION

This report presents the results of a study to identify the sources of phosphorus in the groundwater entering Lake Steilacoom in Lakewood, Washington (Figure 1-1). A 1996 study determined that phosphorus is the main cause of the blue-green algal blooms that have beset the lake for many years. The 1996 study suggested that groundwater is potentially the primary source of phosphorus entering the lake, but did not evaluate the potential sources of phosphorus to groundwater. The Washington State Department of Ecology (Ecology) plans to issue a total maximum daily load (TMDL) for phosphorus in the lake.

In 1999, the City of Lakewood received a Centennial Clean Water Fund Grant for a study to identify the sources of phosphorus in the groundwater entering Lake Steilacoom. The City contracted with URS and Brown and Caldwell to conduct the study.

1.1 PROJECT OBJECTIVES AND SCOPE

The objectives of the phosphorus sources study were to:

- Evaluate potential pathways by which groundwater reaches Lake Steilacoom
- Measure phosphorus concentrations in the water along those pathways
- Identify potential human or natural phosphorus sources affecting the groundwater

URS completed the following activities for the study:

- Compiled historical data and prepared a technical memorandum describing the Lake Steilacoom hydrogeology (URS 2001)
- Identified potential phosphorus sources by evaluating current and historic land uses, numerous site visits, review of scientific literature, and interviews with long-time Lakewood residents
- Evaluated the geology upgradient of the lake and the interaction of groundwater, surface water, and
- Drilled soil borings, installed monitoring wells, and sampled soil in multiple areas with differing land uses and potential phosphorus sources
- Completed four quarterly rounds of groundwater and surface water sampling
- Performed geochemical modeling to assess potential phosphorus sources and mobility

Figure 1-1
Study Area Location

Steilacoom Lake
Seeley Lake
Gravelly Lake
American
Ponce de Leon Creek
Clover Creek
Lakewood Towne Center
McCHORD AFB

Legend
Streets
Waterbodies
Watercourses
City Limits

0 1,000 2,000 Feet

BROWN AND CALDWELL

December 2003

2.0 STUDY AREA OVERVIEW

The study area includes Lake Steilacoom and the Ponce de Leon Creek basin in Lakewood, Washington. Lake Steilacoom is an artificial impoundment formed when Andrew Byrd dammed Chambers Creek in 1853 to operate a grist mill (Morgan 1919). The lake is shallow, with an average depth of about 10 feet (KCM 1996).

Clover Creek and Ponce de Leon Creek are the primary sources of inflow to the lake (Figure 1-1). Clover Creek drains portions of Pierce County, McChord Air Force Base, and parts of the city of Lakewood. The Clover Creek basin encompasses about 70 square miles.

Ponce de Leon Creek is fed primarily by groundwater. It originates in an area of groundwater discharge near the Lakewood Towne Center shopping mall. Survey maps drawn prior to construction of the Towne Center describe the original creek's headwater area as "Ponce de Leon Lake" (White n.d.). During the dry season, nearly all of the flow in the creek comes from a series of springs located about 150 feet west of Lakewood Towne Center. These springs appear to be natural, as they are shown on a 1908 timber cruise survey maps from the Pierce County Archives (Pierce County 1908). During the wet season when the water table is relatively high, the creek also receives groundwater discharge from beneath Lakewood Towne Center, where it is collected in a system of perforated pipes that discharge into the creek at Gravelly Lake Road.

The Ponce de Leon surface water drainage basin is relatively small (less than one square mile). However, based on the large volume of baseflow in the creek, the Ponce de Leon groundwater basin is inferred to be much larger.

Land use in the study area is now mostly residential, with some commercial and a small amount of industrial development. Approximately 35 percent of the Clover Creek/Lake Steilacoom subwatershed is urbanized with residential, commercial, industrial, and transportation uses (KCM 1996). Agriculture use accounts for approximately three percent, 19 percent is forested, and 43 percent supports vegetative cover other than forests or agriculture (e.g., school grounds and golf courses). The 175-acre Lakewood Towne Center and its associated parking lots cover the headwaters of Ponce de Leon Creek. Approximately 200 residences and a small park occupy the shoreline of Lake Steilacoom. Prior to development, the study area was an open prairie with gently rolling hills and small, isolated groups of trees including fir, oak, and larch (Northwest Magazine, 1889).

Lake Steilacoom has a long history of problems with dense algae blooms. An attendee at a July 26, 2001 public meeting in Lakewood recalled that treatment of the lake first began in 1949. KCM reported that the Lake Steilacoom Improvement Club began treating the lake with copper sulfate in the late 1950s (KCM 1996). Application of copper sulfate was discontinued in 1992, due to concerns about potential adverse effects of copper on fish and other aquatic life in the lake. The algal blooms are caused by elevated phosphorus concentrations in the lake water (KCM 1996).

3.0 GEOLOGY AND GEOMORPHOLOGY

URS evaluated the stratigraphy and geomorphology of the study area using soil boring and test pit logs obtained from Ecology, Pierce County, Robinson and Noble, and other sources. Numerous engineering consultants and well drilling companies produced the logs, and the level of detail varies significantly depending on their original intended use. Only those logs with entries approximating standard soil descriptions were used for this study. The elevation of the groundwater and stratigraphic units in many of the logs are uncertain, and the lithologic descriptions are often incomplete.

3.1 REGIONAL GEOLOGY

The study area is located in the elongated, glacially-formed Puget Sound Lowland bordered by the Cascade and Olympic Mountains. The area is underlain by a complex sequence of alternating glacial and interglacial Quaternary sediments (Jones 1999). The glacial sediments represent periods when the lowlands were invaded by the Cordilleran ice sheet and at least six advances of the ice sheet have been suggested (Borden and Troost 2001). The nonglacial sediments represent periods when the glaciers retreated and the area was free of ice. Alpine glaciers and their associated streams emanating from the adjacent Cascade and Olympic Mountains also affected the area. These unconsolidated Pleistocene glacial and interglacial deposits underlie central Pierce County and contain extensive aquifers. From oldest to youngest, the four recognized major glaciations and their resulting deposits are commonly referred to as the Orting, Stuck, Salmon Springs, and Fraser (Jones 1999). Relatively thin discontinuous nonglacial sediments were deposited during interglacial periods, the most recent and uppermost being the Kitsap Formation (Olympia beds) during the Olympia interglacial period. The generalized stratigraphic sequence and nomenclature in the southern Puget Sound Lowland is depicted in Table 3-1. Figure 3-1 depicts geological cross-section lines A-A' and B-B'. Figure 3-2 shows a northwest to southeast trending regional geologic cross-section.

3.2 STUDY AREA GEOLOGY

Limited boring logs and current and historical topographic maps were used to describe the stratigraphy and landforms of the study area. URS relied on its knowledge of the area, interpretation of topographical features, and in some cases, interpolation between existing data points.

In general, the shallow surficial deposits that intersect Lake Steilacoom and Ponce de Leon Creek are composed of loose to medium dense gravel and sand, recessional glacial outwash deposits (Steilacoom Gravel), and compact till (Vashon Till). These unconsolidated units resulted from the advance, retreat, and wasting of ice during the Vashon Stade of the Fraser glaciation and have not been significantly altered by more recent events. Figure 3-3 shows a west to east trending geological cross-section within the study area. A surficial geologic map of the study area is provided on Figure 3-4.

3.2.1 Stratigraphy

The surficial deposits between the surface and approximately 60 feet below the ground surface (bgs) are comprised of Vashon Drift dominated by advance and recessional outwash with discontinuous till and ice-contact deposits. Post-glacial stream deposits; relatively small, localized peat and/muck deposits; recently formed soils; and imported fill overlie the glacial deposits. The study area stratigraphic relationship from oldest to youngest deposits is summarized below.

Advance Outwash Gravel and Ablation Till

A deposit of less dense advance outwash gravel and ablation till overlies the dense ground moraine till in scattered locations and ranges from between a few inches to approximately 40 feet thick. Outwash gravel or proglacial outwash includes materials deposited by streams ahead of or underneath the advancing ice sheet; however, these types of deposits often are incorporated into the ground moraine as the ice advances. Ablation till includes a heterogeneous mixture of silt, sand, gravel, and cobbles that fall off of the melting ice and retreating glaciers.

Boring logs in the study area indicate that these deposits contain medium dense to dense, gray or brown sandy gravel with silt and/or cobbles in varying proportions. The unit generally underlies the till as a horizontally oriented layer, but in some areas it appears to follow the slope of the per-Vashon topography. In scattered locations the unit subtly grades into the underlying Kitsap Formation and/or overlying till. A significant amount of water is present in this unit in the study area.

Till

Till is a general term for material transported, overridden, and deposited by moving glaciers. Where the till is deposited and then overridden by ice it is referred to as ground moraine. Ridges and elongated hills composed of till are called moraines and drumlins. In the study area, till is composed of very dense, gray, gravelly, sandy silt with cobbles and clay or various combinations of these components. Piezometers placed within and above the till during previous investigations suggested that it is generally not saturated but may contain occasional small, coarse-grained lenses with perched groundwater. Other discontinuities within the till, such as joints and/or bedding can increase the permeability of the till by several orders of magnitude (Troost et al., 2002). The till generally is the lowermost unit described in most of the boring logs.

The upper surface of the dense till is gently undulating and ranges between 270 and 210 feet above mean sea level (msl). It ranges in depth between approximately 50 feet bgs to just a few feet bgs. Where present near the ground surface, till provides a relatively low permeability cover to the underlying aquifers. The gently undulating surface topography appears to reflect the upper surface of this unit in places that have not been filled and/or graded. The till rests both conformably and unconformably on the underlying advance outwash deposits and unconformably on the pre-Vashon topography.

Recessional Glacial Outwash Gravel

As the ice sheet receded, ice-dammed lakes formed and outwash was deposited over an extensive area of Pierce County. Glacial Lake Puyallup formed in a subglacial trough that comprises the present day Puyallup River valley. Episodic discharges from this lake formed a series of channels and outwash plains that cut westerly across the upland portions of the study area (Troost et al., 2002). These glacial outwash deposits are referred to as the Steilacoom gravel unit. This unit is easily distinguished in the existing boring logs by the brown color, low density, and well-rounded nature of the gravel and cobbles. The Steilacoom gravel unit is very permeable and readily drains surface water runoff. In many areas a thin veneer of recent alluvium, topsoil, or imported fill overlies the gravel.

Ice-contact deposits surround the kettle lakes in the study area including Lake Steilacoom (Troost et al., 2002). The deposit is similar to the recessional outwash deposit described above, except for a higher percentage of silt intermixed with granular sediments, and lenses and pods of till. This deposit is normally consolidated and associated with hummocks and kettles

Peat and Muck

An approximately 20-acre peat deposit ranging from a few inches to at least 20 feet thick underlies the central, east portion of the Lakewood Towne Center. Other peat deposits near the study area include one in Seeley Lake and a large deposit 2 miles to the east along the shore of Clover Creek (Walsh 1987, Rigg 1958).

Muck, a combination of decomposed peat, organic matter, and silt, is present in the peat deposit that is located 2 miles east of the study area (Rigg 1958). Dupont Muck (classified by the Soil Conservation Service after the type section near Dupont, Washington) is present in scattered locations throughout Pierce County (SCS 1959). Based on its presence in nearby areas, muck is probably associated with the peats in Seeley Lake and at the former headwaters of Ponce de Leon Creek underneath.

Recent Soils and Fill

Soils formed on the Steilacoom gravel in the Ponce de Leon Basin are classified as the Spana and Spanaway Series soils after a type section located near Spanaway, Washington (SCS 1959). These series consist of gravelly sandy loam. Fill materials and native soil observed by URS at the nearby Lakewood Towne Center consists of sandy, gravelly cobbles, and silty sand with gravel.

3.2.2 Geomorphology

The glacial plain in the study area is characterized by gently rolling hills that roughly mimic the undulating upper surface of buried till. As the last Pleistocene ice sheet advanced, it deposited low-lying ridges of till and pro-glacial outwash in the form of moraines and drumlins. Low areas between these hummocky till deposits were then filled in with outwash gravel deposits as the ice melted and retreated. Just outside the study area, to the north, southwest, and south, small groups of drumlins that approach 400 feet in elevation extend above the surrounding flatter plains (Figure 3-3).

Kettle lakes are found around the City of Lakewood. American Lake and Gravelly Lake, just south of the study area, are examples of kettles that formed when large blocks of ice broke off of the retreating glaciers and persisted while post glacial outwash streams deposited gravel around them. After the blocks of ice melted, the resulting depressions became lakes.

Smaller lakes such as Seeley Lake (also called Crawford Marsh), the former pond at the headwaters of Ponce de Leon Creek, and possibly a small portion of Lake Steilacoom, may have been formed by smaller pieces of buried ice or permafrost that eventually melted and left very shallow depressions. Peat deposits formed in the depressions at Seeley Lake and the small pond/bog at the former headwaters of Ponce de Leon Creek as a result of abundant water available for vegetation in these areas. At Ponce de Leon Springs the approximately oval-shaped peat deposit ranges from less than 1 foot to approximately 20 feet thick and pinches out laterally to the east (Earth Consultants 1987). Based on the thickness of the peat and peat accumulation rates in western Washington, the peat associated with the Ponce de Leon Spring was probably growing for about 10,000 years (Rigg 1958). Boring logs show that the peat is first encountered at depths ranging from eight to 15 feet bgs. The peat is underlain by sand and gravel with little or no fines.

Immediately north of Steilacoom Boulevard, approximately 1/2 mile north of Lakewood Towne Center, the land surface abruptly descends approximately 20 feet to the floodplain of Flett Creek. The Flett Creek Floodplain trends generally east to west and merges with the north end of Lake Steilacoom and the Chambers Creek basin. The presence of the creek and several wetlands on the floodplain suggests that till is close to the surface and covered with only a small amount of permeable soil or gravel. Borings drilled in this area, as well as the areas around the north and northwest sides of Lake Steilacoom, confirm that till and/or dense pro-glacial gravel deposits are close to the surface (Hart Crowser 1975 and 1982). The borings did not extend below 200 feet msl; therefore, strata and occurrence of groundwater below this depth have not been characterized. A small group of till drumlins and small kettle lakes is present just southwest of Lake Steilacoom.

3.2.3 Lake Steilacoom

Lake Steilacoom was formed when Andrew Byrd built a dam on Chambers Creek in 1853. Records describing the characteristics of the lake basin prior to 1853 are not available; however, the lake's shape and depth suggest that its natural form was quite different from its present state. The alignment and bottom of the southern two-thirds of the lake suggest that it may have been a continuation of Clover Creek or Ponce de Leon Creek, or it may have been a channel just downstream of the two creeks' former confluence. A similar channel extending due south from the Chambers Creek dam indicates that Chambers Creek once began at the narrowest part of the lake adjacent to Lake Steilacoom County Park. The widest portion of the lake just north of the bridge is shaped like a wide, shallow bowl. The shallow bowl shape suggests that a small pond or wetland may have been present between or next to the former creeks. KCM et al. (1996) reported that the lake inundated a wetland. The presence of the ice-contact around Lake Steilacoom may also suggest the presence of a pond or wetland since the ice-contact deposit has been commonly associated with kettles (Troost et al. 2002).

3.2.4 Ponce de Leon Creek

Ponce de Leon is the main source of flow to Lake Steilacoom during the dry season. The creek channel begins at Gravelly Lake Road about 1/2 mile upstream of the lake. Old maps indicate that prior to development, the Ponce de Leon Creek channel extended east from Gravelly Lake Road about 1/4 mile to a wetland area called Atwood Marsh. However, the marsh and upper reach of Ponce de Leon Creek were covered with fill, buildings, and/or pavement when the Villa Plaza Shopping center was built in the late 1950s.

A system of underground, perforated pipes was installed at Villa Plaza to collect groundwater during the wet season and convey it to Ponce de Leon Creek at Gravelly Lake Road. The system also collected stormwater runoff from the mall. In 2001, the mall was remodeled again, and renamed the Lakewood Towne Center. Recent additions to the drainage system include several subsurface sand filters designed to treat and infiltrate surface water into the ground. A review of as-built drawings for the new (2001) drainage system indicates that a large portion of the stormwater runoff from the Lakewood Towne Center is directed to sand filters for infiltration.

Ponce de Leon Creek is fed primarily by groundwater. The creek receives much of its flow from a series of perennial springs located about 150 feet west of Gravelly Lake Road. The springs are of natural origin. The springs are the sole source of baseflow in Ponce de Leon Creek in the dry season. When the water table rises during the wet season, groundwater is collected in the Lakewood Towne Center dewatering system and discharged into Ponce de Leon Creek. The dewatering system captures groundwater when the water table rises above approximately 245 feet msl.

The approximate size of the groundwater recharge area was calculated based on an estimated recharge rate for outwash soils and the annual groundwater input to Ponce de Leon Creek that was reported by KCM (KCM 1996). The former was obtained from a USGS groundwater study for central Thurston County (PGG 1999) that reported an outwash soil recharge rate of 35 inches per year for a site with an average rainfall of 51 inches per year. Based on this precipitation-recharge relationship, the recharge rate for outwash soils in the study area (assuming an average rainfall of 42.5 inches per year) is approximately 29 inches per year. Based on the groundwater and Ponce de Leon Creek input noted above and a recharge rate of 29 inches per year, the groundwater recharge area was estimated to be approximately 9 square miles. This indicates a large groundwater contribution to Ponce de Leon Creek.

Although groundwater comprises most of its flow, Ponce de Leon Creek does receive direct stormwater runoff from a relatively small area (about 200 acres) along Gravelly Lake Road and the western part of Lakewood Towne Center. Runoff from this area is collected in inlets and conveyed to the 48-inch-diameter culvert at Gravelly Lake Road, which also serves as the outfall for the Towne Center groundwater dewatering system (Figure 3-5). Dry wells also receive stormwater runoff in the Lakewood area.

Phosphorus loads in stormwater discharges to drywells are related to the volume of flow and the phosphorus concentration in the flow. It should be noted that because of the highly permeable soils that underlie most of the city, areas that are not covered by impervious surfaces generate very little runoff; most precipitation infiltrates through the surficial soil into the aquifer.

Moreover, runoff from impervious surfaces that flows onto pervious surfaces (e.g., roof downspouts draining onto lawn) likely produces very little runoff. Thus, most of the flow reaching drywells is from roofs and paved areas that are directly connected to the dry wells. Because of the very permeable soils noted above, the drywells probably receive relatively little runoff from fertilized areas (e.g., lawns, gardens).

Because it is fed primarily by groundwater, flows in Ponce de Leon Creek do not show much increase during storm events (KCM 1996). Rather, the flow appears to rise and fall relatively slowly, in response to seasonal changes in the water table elevation.

3.2.5 Clover Creek

Clover Creek discharges water supplied by a large (approximately 64 square miles) drainage basin in the eastern portion of Pierce County. The current stream may be a remnant of what was once a much larger meltwater channel that drained Lake Puyallup during the late Pleistocene epoch. Abandoned natural channel scars just north of the lower reach of the creek indicate a recent (several hundred years) southward migration of the creek from a point where it may have once joined Ponce de Leon Creek. Upstream of the study area, the creek has been rerouted through McChord Air Force Base and along several stretches near the town of Parkland.

Based on flow observations made by KCM (1996) and the present study, Clover Creek appears to be a losing stream along its lower reach (i.e., within the city of Lakewood). Groundwater elevation data recorded by Hart Crowser, Inc. in 1975 and Brown and Caldwell in 2002 suggest that seepage from Clover Creek recharges the shallow aquifer. Seepage from Clover Creek does not appear to migrate south because of the relatively impermeable till along the south shore of the creek. One boring drilled just south of the creek was dry (Hart Crowser 1975). Historic discharge data suggest that the flow volume in lower Clover Creek increases appreciably after heavy precipitation and runoff distinguishing its flow from Ponce de Leon Creek, which is primarily groundwater.

3.3 REGIONAL AND STUDY AREA HYDROGEOLOGY

3.3.1 Regional Hydrogeology

The aquifer systems in the Clover/Chambers Creek basin are recharged by local rainfall (Robinson & Noble 1997). Regional groundwater flow is generally westerly to northwesterly (Figure 3-6), and eventually emanates as springs that discharge to Puget Sound or to lakes and streams. The basin is underlain by two primary aquifer zones that are used for production (Aquifer Zones A and C) and two deeper aquifer zones (Aquifer Zone E and "deeper" undifferentiated systems) that are currently unused (Robinson & Noble 1997). The aquifer units are separated by aquitards. Aquifer Zones A and C, and confining layer B are described below.

Aquifer Zone A

Aquifer Zone A is the shallowest aquifer system in the area. It consists of deposits of the Vashon Glaciation (Vashon Recessional Outwash, Steilacoom Gravel, Vashon Till, and Vashon Advance Outwash). Groundwater in Aquifer Zone A in the Lakewood area is typically

encountered from approximately 25 feet to 50 feet below ground surface (bgs) (Robinson & Noble 1997). Because this aquifer zone consists of a variety of sediment types, local groundwater flow directions can be preferential. High permeability outwash sediments permit water to move easily while the till deposits restrict and re-direct groundwater flow. However, the regional groundwater flow is consistently north to northwest (Figure 3-6).

Water in Aquifer Zone A is often in direct hydraulic connection with local surface water bodies and it is the first to receive recharge from precipitation (Robinson & Noble 1997). Except for the low permeability Vashon Till, the units of Aquifer Zone A are generally permeable with average calculated transmissivities of approximately 150,000 gallons per day per foot (gpd/ft). Hydraulic conductivity values range from 1 to more than 4,000 feet per day (ft/day), with an average of 1,650 ft/day (Robinson & Noble 1997). Coupled with an estimated effective porosity of 35 percent and a hydraulic gradient of approximately 0.005 foot per foot (Robinson & Noble 1997), groundwater in Aquifer Zone A flows approximately 25 ft/day.

Aquifer Zone C

Aquifer Zone C is comprised of a glacial sequence of stratified sand and gravel with discontinuous layers of silt and clay as well as intermittent layers of till. This aquifer is approximately 200 feet thick and the elevation is typically between 200 feet msl and sea level (Robinson & Noble 1997). In the Lakewood area, it is generally encountered between 100 feet msl to 100 feet below sea level. The regional groundwater flow is consistently west to northwest (Figure 3-7).

Transmissivity values for the area range between 6,500 gpd/ft to 250,000 gpd/ft, with a mean value of 60,000 gpd/ft (Robinson & Noble 1997). Hydraulic conductivity values are typically between 1 and 2,000 ft/day, with a mean value of 300 ft/day. Coupled with an estimated effective porosity of 30 percent and a hydraulic gradient of approximately 0.007 foot per foot (Robinson & Noble 1997), groundwater in Aquifer Zone C flows approximately 7 ft/day.

Confining Layer B

Layer B is a fine-grained, low permeability unit that separates the shallow Aquifer Zone A from Aquifer C, the next aquifer unit. Layer B consists predominantly of the Kitsap Formation, a non-glacial deposit of clay, silt, and fine sand, with occasional gravel lenses (Robinson & Noble 1997). In the Lakewood area, confining layer B ranges in thickness from approximately 25 feet to 50 feet (Robinson & Noble 1997). Though regionally significant, layer B is absent in some areas. Most notably, the layer appears to be missing in parts of the McChord Air Force Base/Spanaway area and the South Tacoma Channel area (Figure 3-8). In these areas, there is increased potential for groundwater mixing between Aquifer Zones A and C.

3.3.2 Study Area Hydrogeology

Figures 3-9 through 3-12 illustrate the groundwater flow in Aquifer Zone A within the study area from groundwater measurements collected during the quarterly groundwater sampling. Although the groundwater elevations varied in different sampling events, the groundwater within Aquifer Zone A in the study area flowed consistently to the northwest, which is similar to the regional groundwater flow in Aquifer Zone A. Based on the potentiometric surfaces, the

horizontal hydraulic gradients within the study area appear to be similar to the regional gradients (Figures 3-6 and 3-9 through 3-12).

The following bullets summarize our current understanding of the Lakewood area hydrogeology:

- Lake Steilacoom is an artificial, shallow impoundment that appears to be supplied by water predominantly from Ponce de Leon Creek and Clover Creek. Ponce de Leon supplies nearly all of the inflow to the lake during the dry season.

- There is little direct groundwater inflow to the lake. This is supported by the results of other studies as well as this study. KCM performed a water budget analysis for Lake Steilacoom that involved measurement of flows into and out of the lake over a one-year period, and measurement of head differentials in piezometers installed through the bottom of the lake. Based on these studies, they estimated that direct groundwater input to the lake was about 2% of the total annual inflow (KCM 1996). Streamflow measurements during the sampling rounds did not indicate increased water flow downstream of the springs at sampling stations SW-2 and SW-3 (discussed in more detail in Section 6). Additional evidence for little direct groundwater flow into Lake Steilacoom is suggested by the lower portion of Clover Creek, which appears to be a losing reach, at least during portions of the year. Boring MS-7 was located south of Ponce de Leon Creek and west of the Lakewood Towne Center. The boring produced no groundwater even at depths below the elevation of water surface in Lake Steilacoom.

- Ponce de Leon Creek flows to the lake year-round and is fed predominantly by groundwater. Ponce de Leon Creek receives groundwater from a relatively large area from Aquifer Zone A (Section 3.3.1), although the boundaries of the groundwater recharge zone are unknown. In addition, Aquifer Zone A may receive inflow from deeper aquifer(s) in areas where the underlying confining layer is missing, such as the area east of the Lakewood city limits.

- Clover Creek begins several miles south and east of Lakewood. As noted above, the lower reach of Clover Creek, between the city limits and Lake Steilacoom, appears to be a losing stream. For example, in late fall 2002, water was flowing in the upper reaches of the stream, but was infiltrating into the ground within approximately 200 feet downstream of Pacific Highway Southwest.

- Groundwater generally flows west to northwest toward Lake Steilacoom from recharge areas in the eastern portion of Pierce County (Figures 3-6 and 3-7). Localized variations in shallow groundwater occurrence, flow direction, and gradient beneath Lakewood appear to be controlled by ridges and valleys in soils with low hydraulic conductivity and/or permeability (glacial till) that are present just below the ground surface.

- The upper aquifer (Aquifer Zone A - including shallow glacial till) is present above a confining unit, which separates shallow groundwater from the underlying Aquifer Zone C. Data suggest that the confining unit directly underlies Lake Steilacoom and

extends eastward to a point where it pinches out just east of Lakewood (Brown and Caldwell 1985).

- Groundwater discharges at a cluster of springs on the north bank of Ponce de Leon Creek just west of the Lakewood Towne Center.

- A wetland area named Atwood Marsh and small lake were present until the late 1950s in the current location of the Lakewood Towne Center, approximately 1/2 mile east of Lake Steilacoom. The wetland and underlying peat deposit are now buried beneath the mall buildings. A stream channel reportedly once extended between Lakeview and Atwood Marsh. Historical information indicates that this channel was filled in the first half of the 20th century (Pierce County 1900, USGS 1948). Another stream channel, which is now mostly filled with soil, formerly extended from Clover Creek and, to the south side of Atwood March in the current location of Lakewood City Hall (Pierce County 1900). This channel may have received overflows from Clover Creek during large flow events.

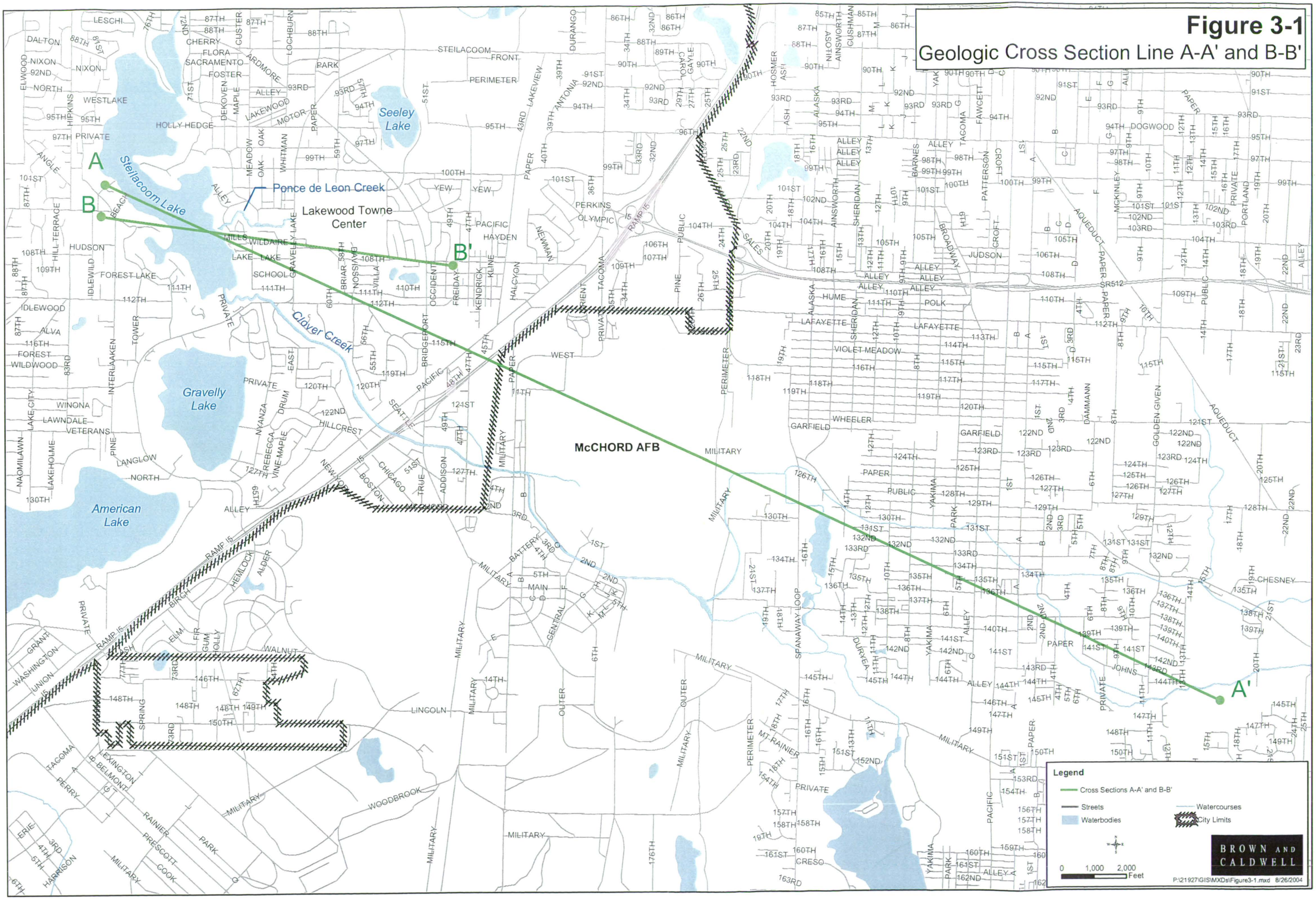
- A complex system of drainage and dewatering pipes (Figure 3-5) is present beneath Lakewood Towne Center. The system was originally designed (during construction of the first mall in the late 1950s and early 1960s) to capture groundwater entering the mall site at the points where the former stream channels entered Atwood Marsh (Nastansky, personal communication). The system also collects surface water runoff from the mall parking areas and roof drains. Some of the groundwater and some surface water runoff (during storm events) is collected by the system and discharged to Ponce de Leon Creek via a 48-inch diameter culvert, underneath the west side of Gravelly Lake Drive, just west of the Lakewood Towne Center. The elevations of the dewatering system pipes are higher than the elevation of the peat deposit; therefore, the dewatering system would not have altered groundwater flow through the peat.

- Recent additions to the stormwater collection system include several subsurface sand filters designed to treat and infiltrate surface water into the ground. A review of as-built drawings for the updated drainage system suggests that a large portion of the surface water from the mall now flows toward the sand filter infiltration basins. This will likely reduce the already small amount of surface water discharged directly to Ponce de Leon Creek via the outfall. The ratio of groundwater to surface water collected and discharged from the mall to the creek depends on precipitation and the depth of the groundwater table beneath the mall. However, the area served by the stormwater drainage system (~200 acres) is quite small compared to the estimated groundwater basin (roughly 9 to 18 square miles). The 1994-1995 lake restoration study found that Ponce de Leon Creek flows showed little response to storm events (KCM 1996). Thus, direct stormwater runoff (i.e., via storm sewers, ditches, or overland flow) probably comprises a fraction of the flow observed in Ponce de Leon Creek.

In summary, the available data indicate there is little direct groundwater inflow to the lake. Based on the URS study and the results of previous investigations, Lake Steilacoom appears to be fed by water predominantly from Clover and Ponce de Leon

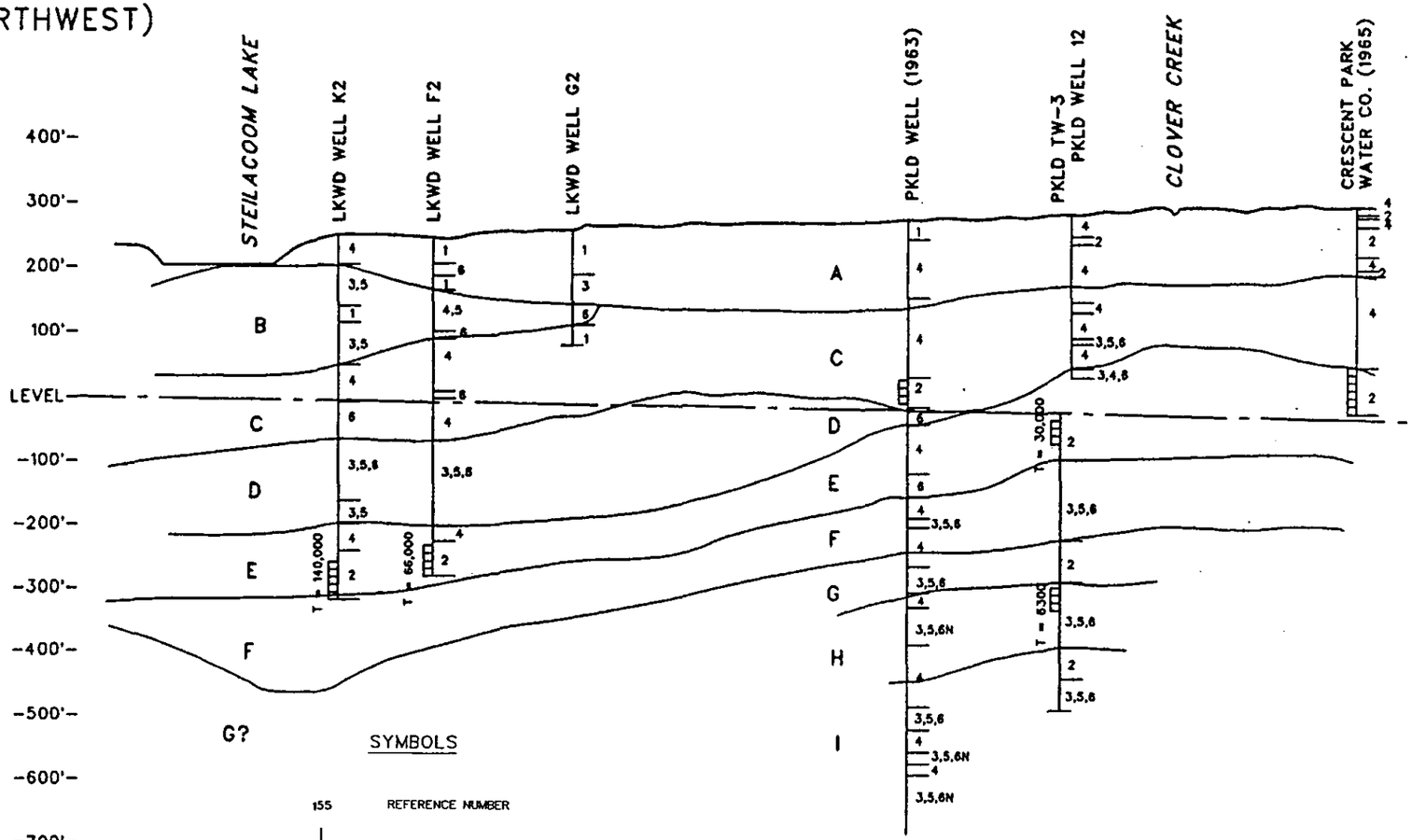
Creeks and rain falling directly on the lake. Groundwater is the primary source of flow in Ponce de Leon Creek. In contrast, Clover Creek loses flow to groundwater. During the dry season, nearly all of the discharge into Ponce de Leon Creek is from a series of springs located just west of the Towne Center. During the wet season when the water table is higher, flow from the springs is supplemented by groundwater collected in the Towne Center's dewatering system. The dewatering system discharges to Ponce de Leon Creek at a culvert approximately 150 feet upstream of the Ponce de Leon Creek springs. As noted above, the dewatering system also collects some stormwater runoff from the Towne Center; however, much of the surface water from the mall now drains to infiltration facilities.

Figure 3-1
Geologic Cross Section Line A-A' and B-B'



A
(NORTHWEST)

A'
(SOUTHEAST)



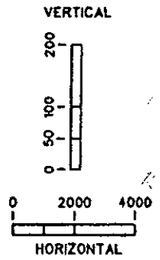
SYMBOLS

155 REFERENCE NUMBER

6.1 LITHOLOGY INTERVAL AND IDENTIFIER

SCREENED INTERVAL

TRANSMISSIVITY (GAL/DAY/FOOT)



Legend

LITHOLOGY

1 GRAVEL

2 SAND AND GRAVEL

3 SAND

4 CLAY, SILT, SAND, AND GRAVEL MIX (AS TILL)

5 SILT

6 CLAY

HYDROSTRATIGRAPHIC LAYERS

A - DEPOSITS ABOVE KITSAP FORMATION (MOSTLY OF VASHON GLACIATION)

B - NONGLACIAL DEPOSITS - MAINLY EQUIVALENT TO KITSAP FORMATION (CONFINING AQUITARD)

C - GLACIAL DEPOSITS - MAINLY EQUIVALENT TO SALMON SPRINGS DRIFT

D - NONGLACIAL DEPOSITS - MAINLY EQUIVALENT TO PUYALLUP FORMATION (CONFINING AQUITARD)

E - NONGLACIAL DEPOSITS - GEOLOGIC CORRELATION INDEFINITE, POSSIBLY STUCK DRIFT

F - NONGLACIAL DEPOSITS - GEOLOGIC CORRELATION INDEFINITE, POSSIBLY ALDERTON FORMATION

G - NONGLACIAL DEPOSITS - GEOLOGIC CORRELATION INDEFINITE, POSSIBLY ORTING DRIFT

NOTE:
AQUIFER A CONSISTS OF Qvr, Qvs, Qvt, AND Qva. SEE FIGURE 3-4 FOR UNIT DESCRIPTIONS.

Source: Robinson and Noble, 1997

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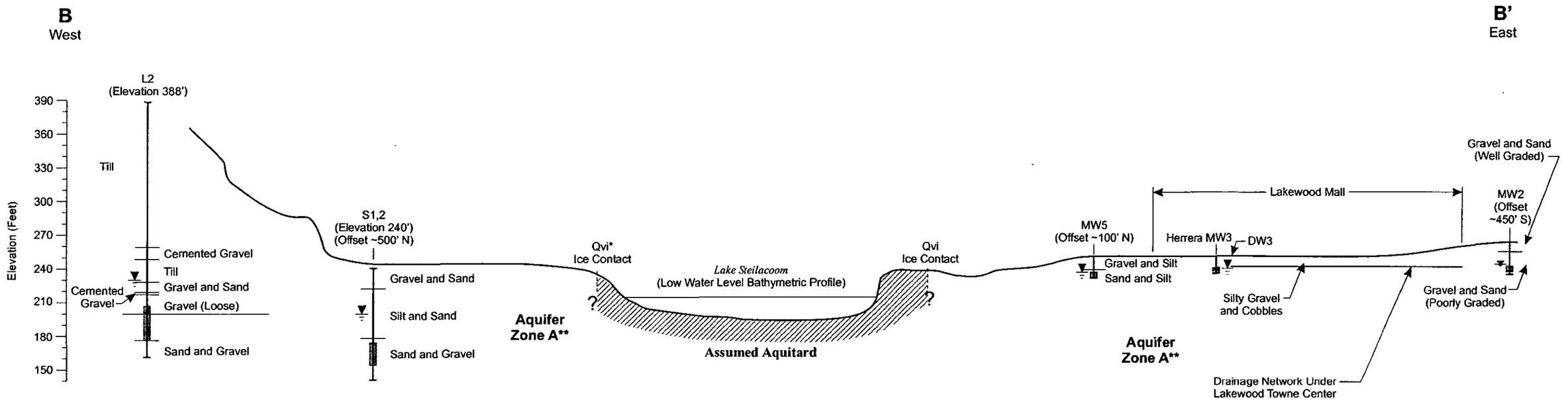
EDIT DATE: 08/31/04 AT: 15:35

Lake Steilacoom City of Lakewood	Project No. 33750346.00007	Regional Geologic Cross-Section A-A'	Figure 3-2
URS			



LEGEND

Aquifer Zone A** comprised of:

Qvr	Vashon Recessional Outwash
Qvs	Steilacoom Gravel
Qvt	Vashon Till
Qva	Vashon Advance Outwash

(See Figure 3-4 for unit descriptions)

* Ice contact (Qvi) from Geologic Map (Troost, Booth, Borden 2002, Draft) – Below surface orientation unknown

** Southeast Tacoma Mutual Water Company Wellhead Protection Plan (Robinson & Noble, Inc., June 1997)

0 900 1,800

Horizontal Scale in Feet
Vertical Exaggeration = 10x

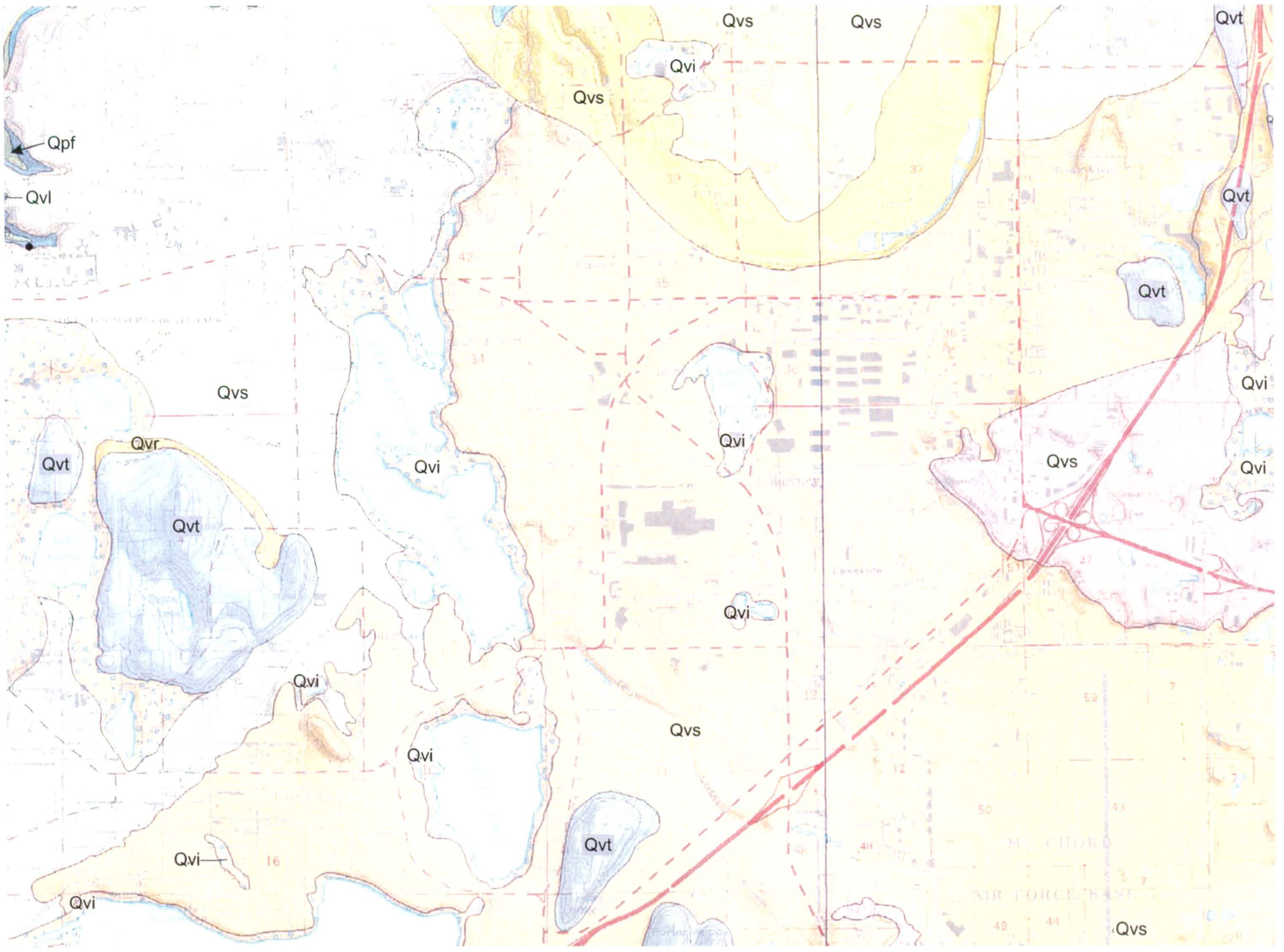
Job No. 33750346

Figure 3-3
Geologic Cross Section B-B'

URS

Lake Steilacoom
Steilacoom, Washington

33750346_07.CDR



DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)** Sand, silt, gravel, and cobbles, deposited by streams and running water. May include slide debris, locally derived. Gradational with and locally including sediment equivalent to units Qf, Qb, Qvr, and Qvs. Normally consolidated.

Qvr **Recessional outwash deposits** Stratified sand and gravel, moderately sorted to well sorted, and less common silty sand and silt. Present predominately as irregular upland bodies with no obvious channelized form. May include deposits of unit Qvs where separation not possible. Deposits less than about 1 m thick are commonly observed overlying till but are not mapped. Normally consolidated.

Qvs **Steilacoom Gravel** Openwork sandy gravel and cobbles, deposited by episodic discharges from Glacial Lake Puyallup. Poorly to well sorted. Normally consolidated. Locally subdivided by channels and then by relative age – higher number denotes younger channel-scouring event based on elevations of remnant surfaces. Numbering system is contiguous with adjacent Tacoma South and Puyallup quadrangles (Troost, in review).

Qvi **Ice-contact deposits** Deposits similar in texture to unit Qvr but locally containing a much higher percentage of silt intermixed with granular sediments, and lenses and pods of till. Commonly associated with kettles and hummocks. Normally consolidated.

Qvt **Till** Compact diamict containing subrounded to well-rounded clasts, glacially transported and deposited under the ice. Commonly fractured and has intercalated sand lenses. Upper few feet of unit is generally weathered and only medium dense. Generally forms an undulating surface and is a few meters to a few tens of meters thick. Also found sporadically within areas mapped as unit Qvi.

Qva **Advance outwash deposits** Compact well-bedded sand and gravel deposited by streams and rivers issuing from the front of the advancing ice sheet. Some turbidite facies present in lower part. Generally unoxidized. May grade upward into till. Silt lenses locally present in upper part and are common in lower part. Equivalent to the Esperance Sand Member of the Vashon Drift of Mullineaux et al. (1965) and in part to the Colvos Sand of Noble and Wallace (1966). Locally over 60 m (200 ft) thick; dense to very dense).

Qvlc **Lawton Clay** Stiff to hard, laminated to massive, silt, clayey silt, and silty clay deposited in proglacial or lowland lakes. May include deposits from the transition from nonglacial to glacial time; unequivocal evidence for glacial or nonglacial origin rarely present. Mapped deposits are assigned to this unit primarily on the basis of stratigraphic position, but only some localities have nearby absolute age control. Deposits of correlative age and texture may be included in unit Qpff, where evidence of age and/or depositional environment is absent. Locally may include fine-grained sediment of unit Qob or distal deposits of alpine glaciations where indistinguishable from Qvlc. Absent to over 30 m (100 ft) thick in map area, often present as channels in the subsurface.

Qpf **Sedimentary deposits of pre-Fraser glaciation age (Pleistocene)** Weakly oxidized to moderately oxidized sand and gravel, lacustrine sediments containing local peat layers, and moderately oxidized to strongly oxidized diamict composed of silty matrix and rounded gravel clasts. Very dense and hard.

Qpfn **Nonglacial deposits** Abundant organic debris or volcanic provenance indicates nonglacial origin. Encountered downstream of Garrison Springs above Chambers Bay.

Reference: Troost et al. (2002, draft)

Job No. 33750346

Figure 3-4
Geologic Map of Study Area

URS

Lake Steilacoom
Steilacoom, Washington

Figure 3-5
Lakewood Towne Center Property
Main Stormwater Dewatering System

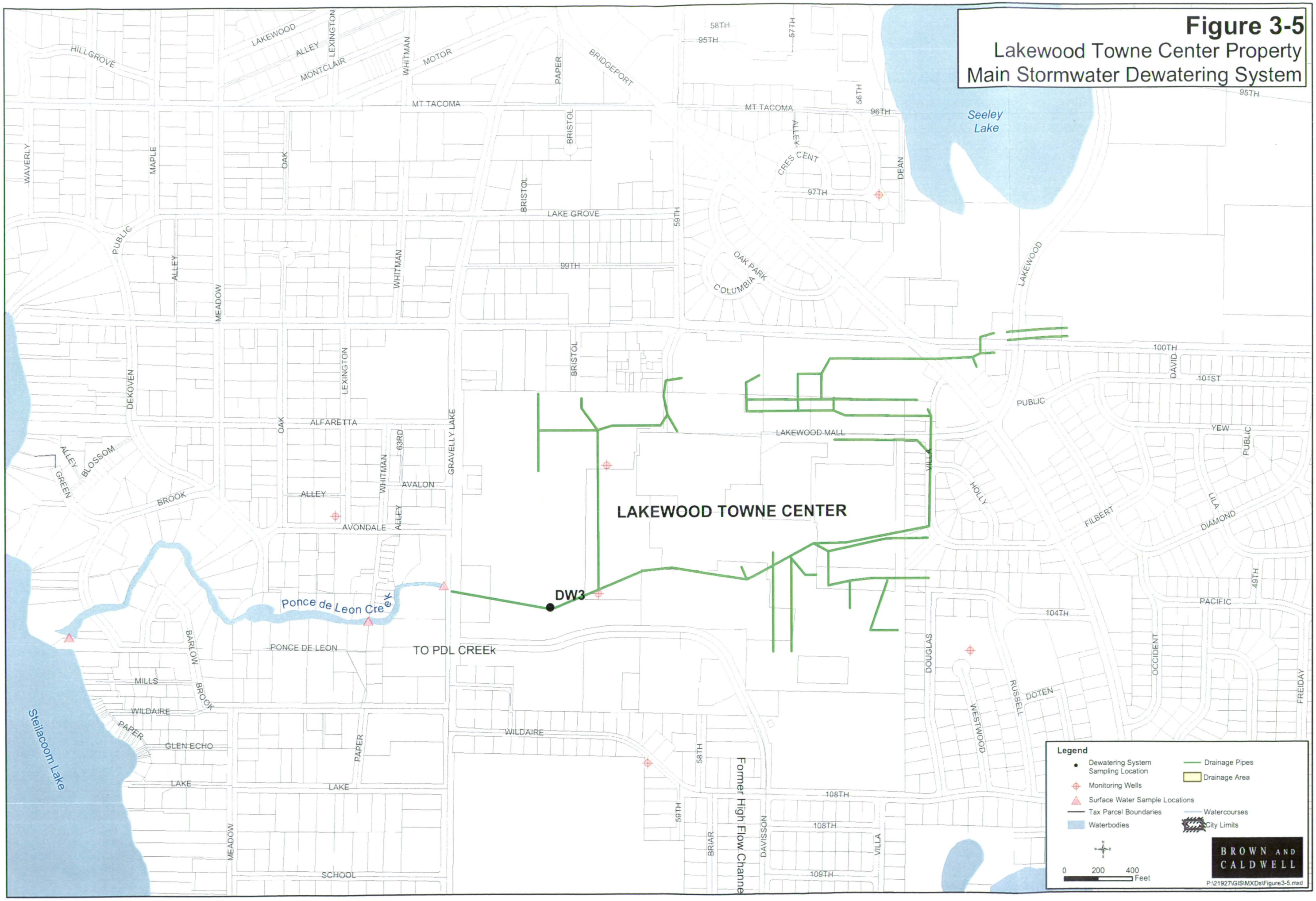


Figure 3-6
Regional Potentiometric Surface Map
Shallow Aquifer (Zone A)

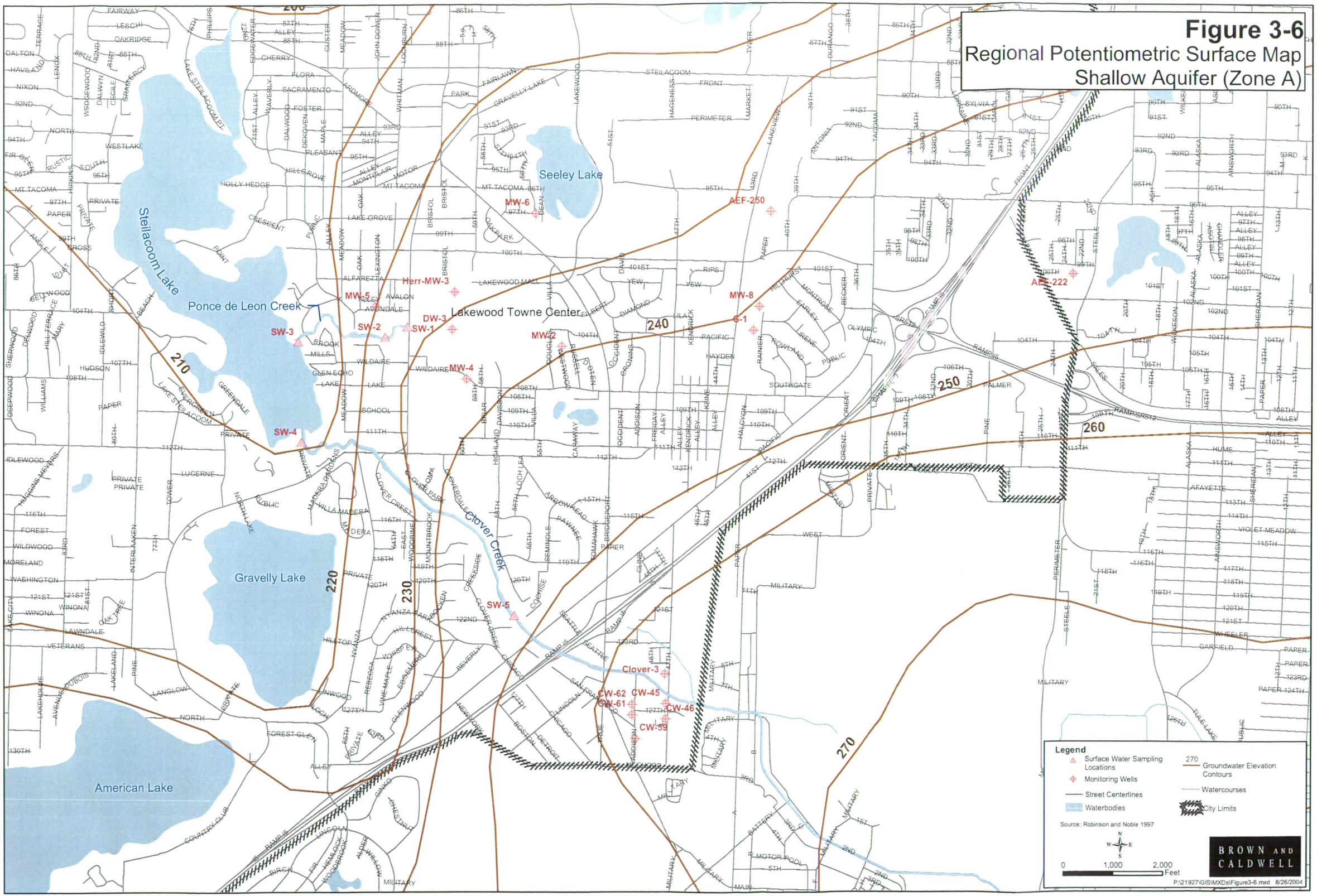


Figure 3-7
Regional Potentiometric Surface Map
Deeper Aquifer (Zone C)

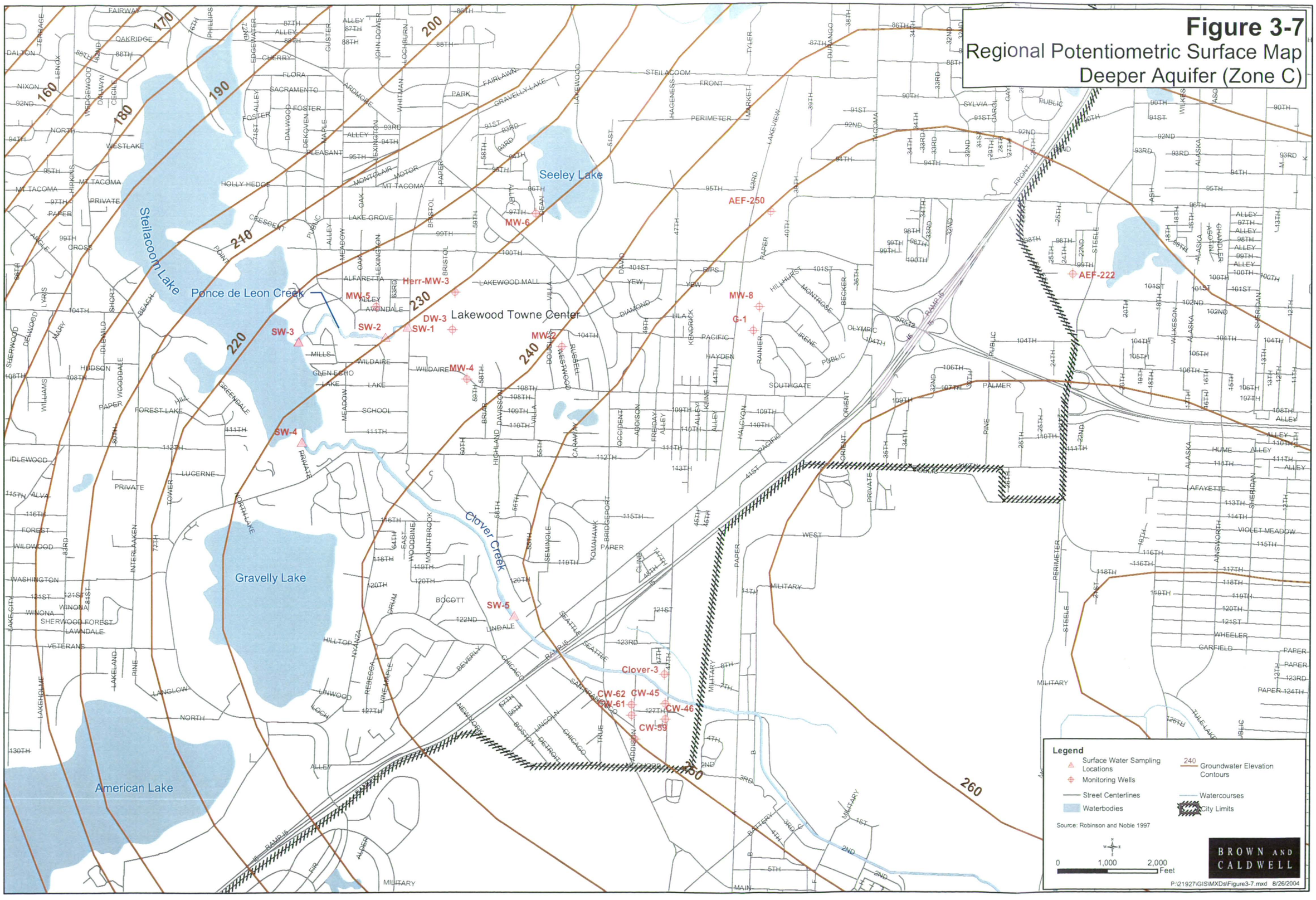


Figure 3-8
Generalized Area Where Aquitard (B Horizon) is Not Present

Seeley Lake
Steilacoom Lake
Ponce de Leon Creek
lakewood Towne Center
Gravelly Lake
Clover Creek
American Lake

MW-6
AEF-250
AEF-222
MW-8
G-1
Herr-MW-3
MW-5
DW-3
SW-1
SW-2
SW-3
MW-2
MW-4
SW-4
SW-5
Clover-3
CW-62
CW-61
CW-45
CW-46
CW-59

Legend
- Surface Water Sampling Locations
- Monitoring Wells
- Street Centerlines
- Waterbodies
- B Horizon Not Present
- Watercourses
- City Limits

Source: Robinson and Noble 1997

0 1,000 2,000 Feet

BROWN AND CALDWELL

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Figure 3-9
Groundwater Potentiometric Surface Map
August 2002

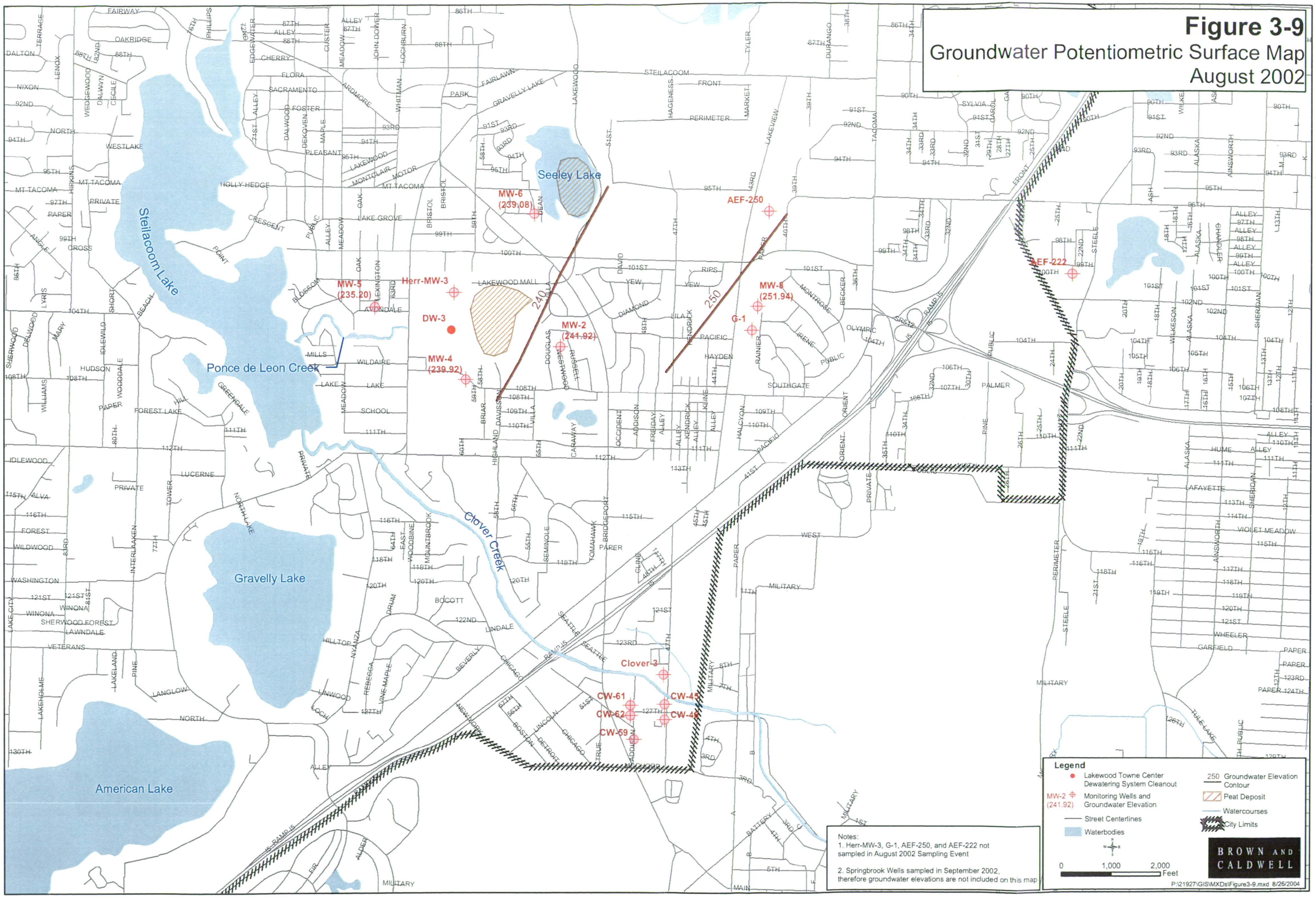

Figure 3-10
Potentiometric Surface Map
December 2002

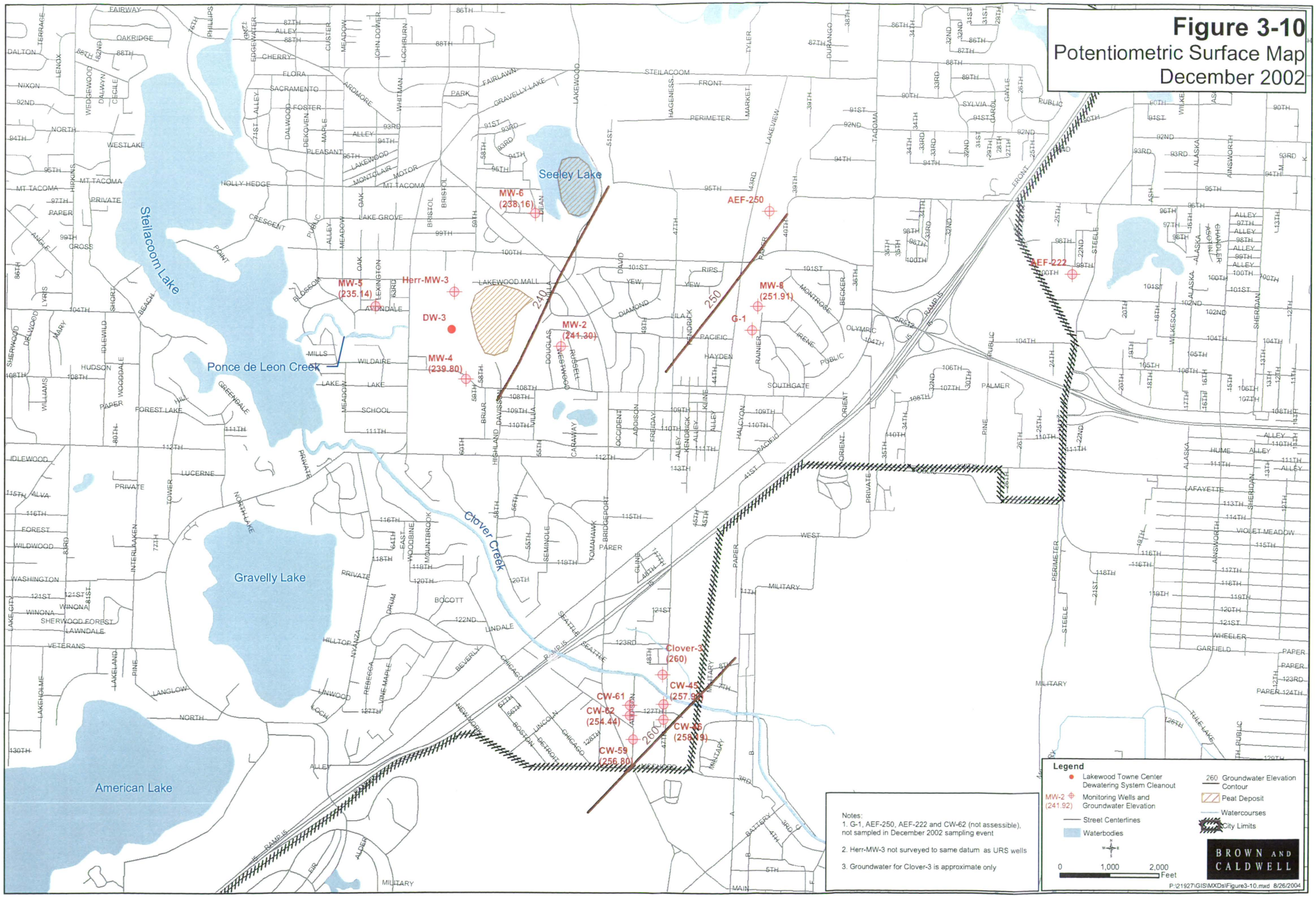

Figure 3-11
Potentiometric Surface Map
March 2003

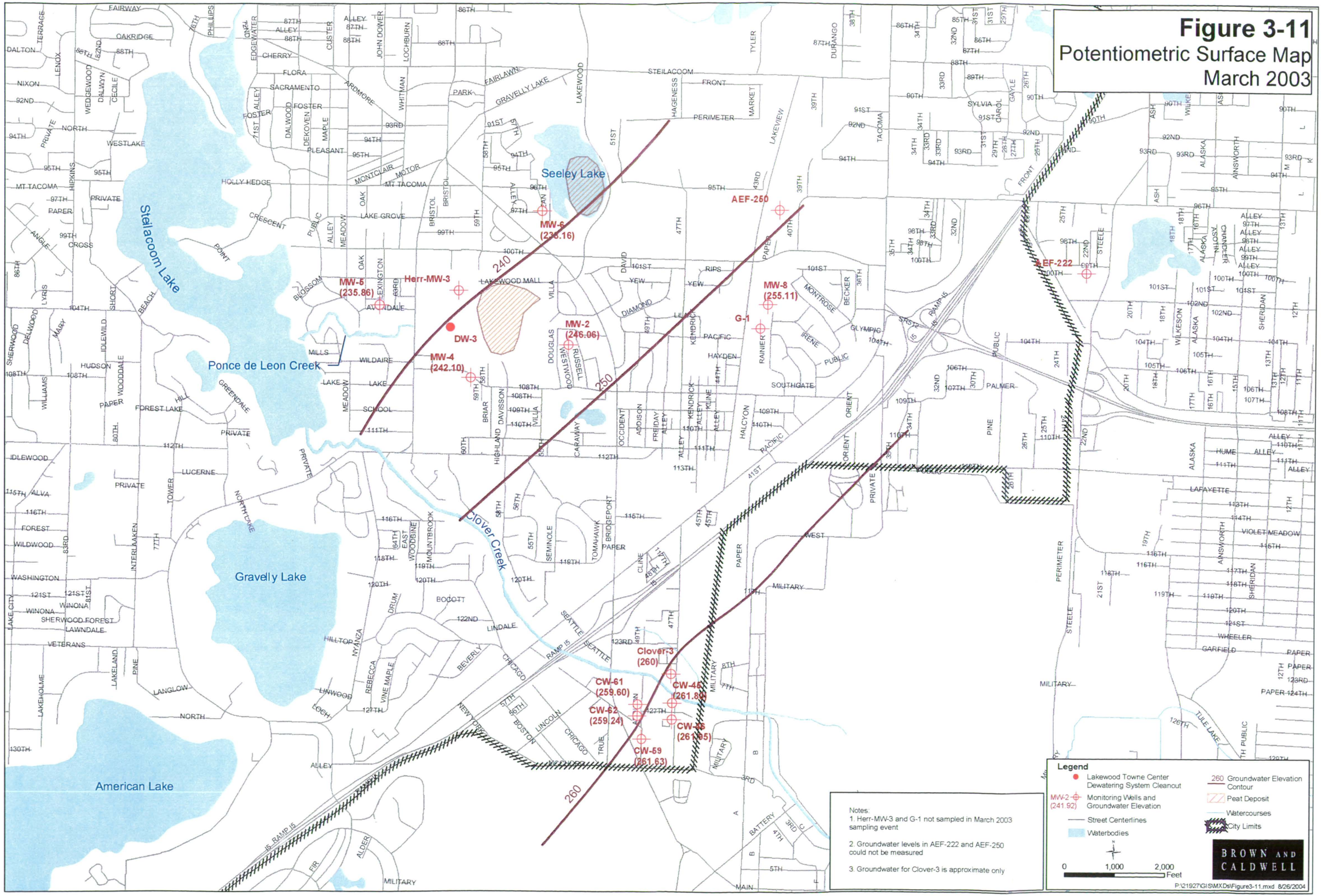

Figure 3-12
Potentiometric Surface Map
June 2003

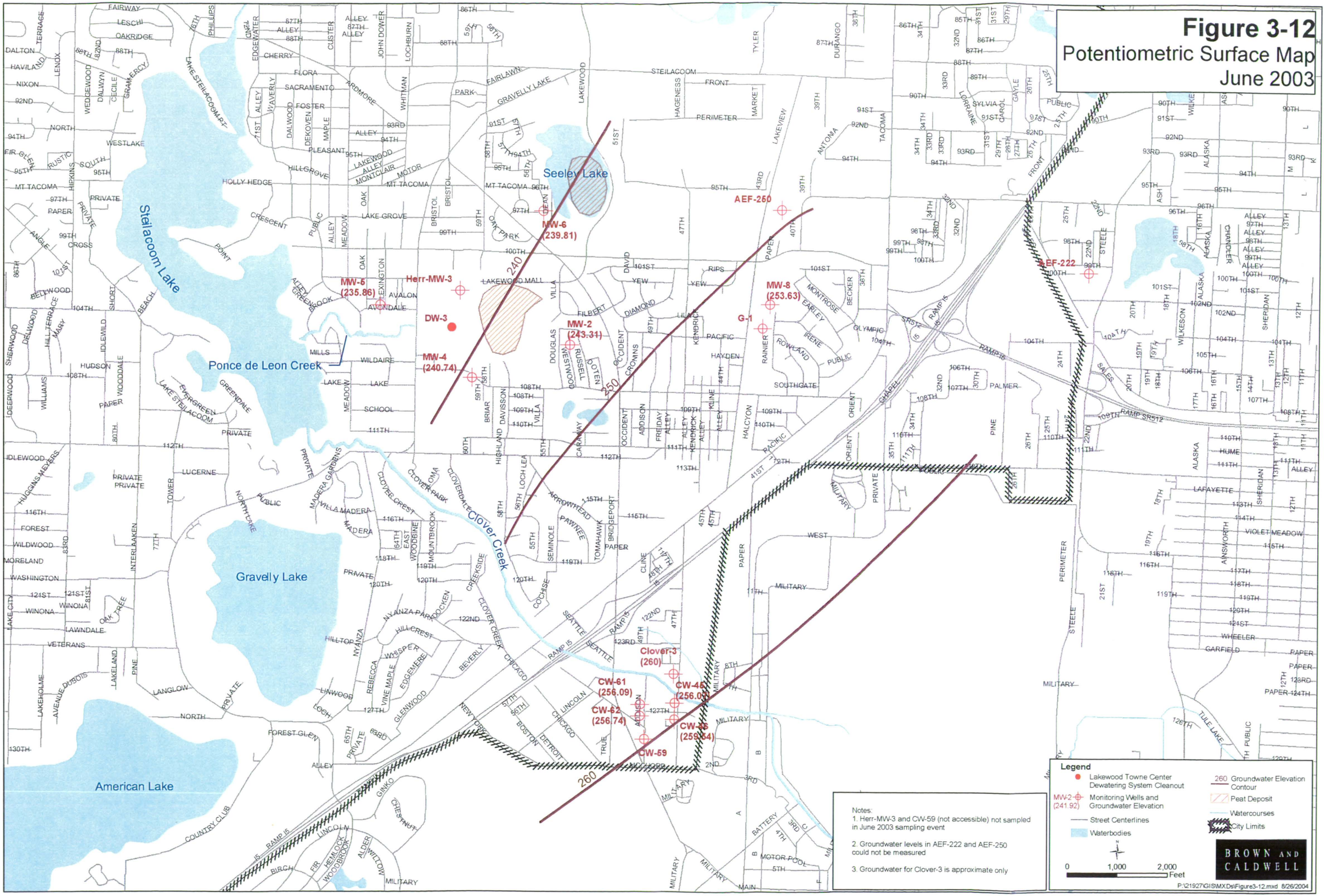

Table 3-1

Geologic Framework

Southern Puget Sound Lowland

Geologic Framework[1]						Hydrogeologic Framework	Robinson & Noble Aquifer Units[6]
Period	**Age (Ka)**	**Geologic/Climate Unit[2]**		**Stratigraphy**		**Name of Unit**	
Quaternary	10	Interglacial		Alluvium, Electron Mudflow, Osceoloa Mudflow, lahars, marine deposits[3]		Nisqually River aquifer, Green River aquifer, Puyallup River aquifer, Snoqualmie River aquifer, Skokomish River aquifer, Chehalis River aquifer	
		Fraser Glaciation		Alluvium			
			Vashon Stade	Vashon Drift	Steilacoom Gravels	Fraser aquifer	Aquifer Unit A
					Recessional Outwash		
					Moraine Deposits		
					Vashon Till[4]		
					Advance Outwash		
					Colvos Sand Member/Esperance/Lawton Clay[5]		
	20		Evans Creek Slide	Alluvium	Evans Creek Drift		
					Skokomish Gravels		
	60	Olympia Interglacial		Kitsap Formation		Confining Unit	Confining Unit B
			Upper Stade	Upper Salmon Springs Drift		Puget Aquifer	Aquifer Unit C
			Interstade	Sediments, Tephra			
	80	Salmon Springs Glaciation	Lower Stade	Lower Salmon Springs Drift			
		Puyallup Interglacial		Puyallup Formation			
	>100	Stuck Glaciation		Stuck Drift			
		Alderton Glaciation		Alderton Formation			
		Orting Glaciation		Orting Drift			
pre-Quaternary Rock Units						Basement Confining Unit	

Notes:

1 - Adapted from Jones (1999) and Borden and Troost (2001).

2 - Drift sequences are generally separated by unconformities

3 - Mudflows and lahars are part of alluvial valey aquifers where confined in channels and not principal unit in channel, otherwise, considered part of surficial semiconfining unit: marine deposits are considered part of aquifer system where saturated with freshwater.

4 - Vashon till makes up the surficial semiconfining unit where it outcrops at land surface or is covered by only a thin veneer of younger unsaturated deposits.

5 - From Borden and Troost (2001).

6 - From Robinson & Noble (1997).

Geologic units above Fraser Glaciation not present in study area.

4.0 PREVIOUS INVESTIGATIONS

The section summarizes historical phosphorus data for Lake Steilacoom, Ponce de Leon and Clover Creeks, stormwater, and groundwater.

4.1 PHOSPHORUS DATA FOR LAKE STEILACOOM

Surface water quality monitoring was performed monthly from May 1994 to April 1995 for the 1996 lake restoration study (KCM 1996). Sample analytes included total phosphorus and soluble reactive phosphorus (SRP). Water samples were collected at five stations in Lake Steilacoom and composited to obtain a representative sample. SRP includes only dissolved organic orthophosphate derived from naturally occurring minerals or the breakdown of more complex phosphorus compounds. It is the most mobile form of phosphorus through groundwater and may be desorbed from or adsorbed onto soil particles and released to or removed from groundwater. SRP is also the form of phosphorus most easily used by aquatic plants and the most likely factor triggering algae growth in Lake Steilacoom. Alternatively, total dissolved phosphorus (TDP) is organic, derived primarily from biological processes, and not as readily available to aquatic plants as SRP. Total phosphorus includes SRP, TDP, and undissolved particulate phosphates. In surface water, algae is commonly attributable to total phosphorus.

During the study period, the mean SRP concentration in the lake was 8 to 10 μg/L. All but one value (38 μg/L) were less than or equal to 10 μg/L. The total phosphorus concentrations in Lake Steilacoom ranged from 22 to 69 μg/L with a mean value of 45 μg/L. Using critical phosphorus loading models, it was concluded that total phosphorus concentrations at or below 20 μg/L in Lake Steilacoom would maintain non-eutrophic conditions (i.e., not cause nuisance algae blooms) (KCM 1996).

4.2 PHOSPHORUS DATA FOR PONCE DE LEON, CLOVER, AND CHAMBERS CREEKS

Water quality for the tributaries and outlet of Lake Steilacoom were monitored for the 1996 lake restoration study (KCM 1996). Grab samples were collected monthly from May 1994 to April 1995 near the mouths of Clover Creek and Ponce de Leon Creek, and just below the outlet structure at Chambers Creek dam. Phosphorus levels in Ponce de Leon Creek were consistently the highest and exhibited the smallest temporal variability of the three creeks. Total phosphorus concentrations in Ponce de Leon Creek were between 40 and 80 μg/L, with a mean of 51 μg/L, and SRP concentrations were between 36 and 52 μg/L, with a mean of 45 μg/L (Table 4-1). In Clover Creek, total phosphorus levels ranged from 22 to 32 μg/L (mean of 26 μg/L), and SRP levels ranged from 3 to 22 μg/L (mean of 15 μg/L). Clover Creek was not sampled for four months in the late summer and early fall of 1994 because of insufficient flow.

In addition to monthly monitoring, Clover and Ponce de Leon Creeks were sampled during storm events. Flow-integrated samples were collected over 3 hours to characterize nutrient loading during periods of high runoff. Clover Creek was monitored during two storm events. The phosphorus levels were not elevated during these events, but the storms were small in magnitude.

In Ponce de Leon Creek, phosphorus was measured during four storm events and found to be slightly elevated during storm conditions. The KCM report also provides total phosphorus data for Clover Creek just downstream of McChord Air Force Base. Of the ten samples collected between 1993 and 1995, seven samples were below the total phosphorus detection limit of 100 μg/L, two were at or near the detection limit (100 μg/L and 120 μg/L), and one sample exceeded the detection limit (330 μg/L).

In addition to the data provided in the lake restoration study, water quality data for Clover Creek and its tributaries were collected over a 16-month USGS study conducted during 1991 and 1992 (USGS 1996). Phosphorus concentrations at Station SW-5, located at South Tacoma Way, which is approximately 1.5 miles upstream of the mouth of Clover Creek, ranged from less than 10 to 120 μg/L total phosphorus and less than 10 to 60 μg/L SRP. The study compared early 1990s data with historical data collected during the 1960s and 1970s and found that phosphorus concentrations in the Clover Creek basin have not changed substantially over the past few decades.

Kuo (2004) collected samples from Ponce de Leon Creek on 14 occasions during 2001-2002 and reported an average soluble reactive phosphorus (SRP) concentration of 29 μg/L (range 14 to 47 μg/L). The report noted that SRP concentrations appeared to increase between November 2001 and early March 2002, reaching a peak of about 47 μg/L, and then leveled off to 29 μg/L. Kuo (2004) hypothesized that the initial increase in SRP was related to increased precipitation. However, weather data recorded at nearby McChord Air Force Base indicate a continued increase in cumulative precipitation from October 2001 through June 2002, which does not correspond with the SRP pattern. It should also be noted that the SRP concentrations reported for the first two rounds (November 2001) were considerably lower than any of the samples previously collected from Ponce de Leon Creek by KCM and other investigators, or subsequently measured during the present study.

4.3 PHOSPHORUS DATA FOR STORMWATER

Pierce County Surface Water Management collected four composite stormwater samples in 1994 at Lakewood Mall, now Lakewood Towne Center (KCM 1996). Stormwater total phosphorus levels ranged from 50 to 140 μg/L, and SRP levels ranged from non-detect (detection limit of 50 μg/L) to 110 μg/L. It is not clear whether the catch basins used for the stormwater sampling were isolated from the mall's dewatering system or if the samples were a mixture of storm and groundwater (KCM 1996).

4.4 HISTORICAL PHOSPHORUS DATA FOR GROUNDWATER

Sampling conducted by the U.S. Geological Survey during the 1974-1975 period (EPA, 1975) indicated that the dissolved orthophosphate concentration at the springs varied between 100 to 120 μg/L in the area of Ponce de Leon Springs. However, considering the age of the data, it is unknown how comparable these historical results are to the data collected during more recent studies, including the present study.

Limited groundwater quality monitoring was performed during the 1996 lake restoration study (KCM 1996). On two occasions, samples were collected from three land-based and three lake-based drive points. The total phosphorus concentrations ranged from 20 to 100 µg/L, with a mean of 50 µg/L. Generally, total phosphorus levels in groundwater increased from the south to the north end of the lake.

KCM also measured total and soluble phosphorus concentrations in water sampled from City of Lakewood production wells. Well I-1, 81 meters deep, had a total phosphorus concentration of 25 µg/L, all in the form of SRP. The total phosphorus concentration in the deep well, D-2 (153 meters deep), was 110 mg/L with 100 µg/L as SRP (KCM 1996).

Kuo (2004) analyzed samples of soil water collected from lysimeters installed at four locations along the lake shore during 2001-2002. The report does not describe the soils at each site, nor how the four sites were selected. As noted in Section 3, the surficial geology of the lakeshore area appears to be quite different from most of the rest of the basin. The phosphorus concentrations were highly variable, with mean SRP concentrations at the four sites ranging from 14 to 258 µg/L. The soil water samples were collected at a depth of about 2 inches below the ground surface, so the samples do not represent groundwater. Thus, Kuo's soil water results are not directly comparable to the groundwater or surface water results collected for the current study.

Table 4-1

Historic Surface Water Quality Data

Ponce de Leon and Clover Creeks

Sample Location	Ponce de Leon Creek				Clover Creek							
	SW-3 ~100 feet upstream of Lake Steilacoom				SW-4 (USGS 602; KCM Clover Ck) Gravelly Lake Drive Crossing*				SW-5 (USGS 500) South Tacoma Way Crossing			
Date	Flow (ft^3/S)	SRP (ug/L)	Total P (ug/L)	TDP (ug/L)	Flow (ft^3/S)	SRP (ug/L)	Total P (ug/L)	TDP (ug/L)	Flow (ft^3/S)	SRP (ug/L)	Total P (ug/L)	TDP (ug/L)
01/04/91									43	<10	20	
01/11/91					64	40	30		65	20	20	
01/12/91									92	30	30	
01/14/91									92	20	30	
01/23/91					76	20	30		68	10	20	
02/01/91									53	40	20	
02/03/91					104	30	80		87	30	70	
02/04/91					117	30	20		92	20	40	
02/06/91					104	30	40		85	30	30	
03/01/91					97	<10	30		80	10	30	
03/02/91					106	<10	30		88	<10	30	
03/03/91					141	10	30		115	20	30	
03/04/91									120	<10	30	
03/13/91									109	20	60	
06/11/91									35	<10	20	
06/26/91					29				30			
08/20/91									9.6	10	30	
08/27/91					13	<10	30		9.9	<10	40	
09/04/91					7.8	<10	20		7.5	10	20	
09/04/91					7.8	<10	20		7.7	<10	20	
09/04/91					7.8	<10	20		7.7	<10	20	
09/05/91					7.8							
10/16/91									11	60	110	
11/23/91									8.1	<10	40	
11/24/91					13	<10	20					
11/25/91									18	<10	40	
01/10/92									42	30	100	
01/15/92									16	10	60	
01/23/92									26	20	40	
01/23/92									39	30	80	
01/25/92					23	10	80		27	20	40	
01/28/92					46	30	10		50	30	120	
01/29/92									56	30	60	
01/31/92									80	30	80	
02/04/92					50	20	50		70	20	30	
02/19/92									65	20	50	
02/21/92					67	20	40		84	10	50	
02/27/92									50	20	20	
03/24/92					35	<10	<10		32	10	<10	
04/21/92					40	10	10		45	20	30	
04/24/92												
04/06/94		<5	40									
05/27/94	12	36	45		10	3	24					
07/12/94	7	48	46		7	12	24					
08/01/94	6	51	45		0	0	0					
09/01/94	3	49	50		0	0	0					
09/08/94		50										
09/22/94			80									
10/06/94	2	52	53		0	0	0					
10/28/94	5	48	66		0	0	0					
11/08/94		70	80									
12/02/94	12	49	43		6	14	22					
12/16/94		<10	50									
01/09/95	24	40	43		50	22	32					
02/06/95	21	45	40		45	20	25					
03/02/95	23	43	48		90	21	29					
03/30/95	18	44	46		60	7	15					
04/28/95	12	37	44		45	10	24					

Notes:

Samples from 4/6/94, 9/8/94, 9/22/94, 11/8/94, and 12/16/94 collected by Pierce County (KCM 1996).

Clover Creek data between 1/91 and 4/92 were collected by the USGS (USGS 1996).

*: KCM collected Clover Creek samples at the stream mouth, approximately 1,000 feet downstream of the Gravelly Lake Drive Bridge.

KCM flow measurements (except SW-3) are approximate (+/- feet3) because of channel variability.

ug/L - micrograms per liter

ft^3/S - cubic feet per second

5.0 FIELD ACTIVITIES

The scope of work for the phosphorus sources study included preparing a Quality Assurance Project Plan (QAPP) to describe the locations and rationale for sampling (sampling design) and data quality objectives. The City of Lakewood, URS, and Ecology worked together to develop the QAPP, which was submitted to the City of Lakewood on July 3, 2002 (URS 2002). The activities described in the QAPP were designed to be consistent with specific tasks outlined in the *Centennial Clean Water Fund Grant* issued to the City of Lakewood by Ecology. Specifically, URS was assigned Task 3, summarized in the grant as follows:

> *The City will use existing water quality data and additional sampling, as needed, to fill data gaps. New test wells will be drilled at strategic locations in an attempt to identify the sources of the phosphorus entering the lake by way of groundwater.*

The 1996 lake restoration study completed by KCM concluded that direct groundwater inflow to the lake was relatively small, but groundwater appeared to comprise most of the flow in Ponce de Leon Creek. The study also concluded that the lower reach of Clover Creek is a losing stream and therefore is not a groundwater discharge pathway. Therefore, the QAPP outlined a sampling strategy that focused on the groundwater entering Ponce de Leon Creek and the interaction of groundwater and surface water in Clover Creek. The key objectives of the sampling were to evaluate the pathways by which groundwater enters Lake Steilacoom, measure phosphorus concentrations along the pathways, and identify potential sources of phosphorus that could account for the observed patterns. The following field activities were completed as described in the QAPP:

- January 2002 – Direct-push soil borings and groundwater sampling in and around the peat deposit beneath the Lakewood Towne Center
- February 2002 – Preliminary surface water sampling at Ponce de Leon Creek
- August 2002 – Soil borings, soil sampling, and installation of groundwater monitoring wells
- August/September and December 2002, and March and June 2003 – Four quarterly surface water sampling in Ponce de Leon and Clover Creeks
- August/September and December 2002, and March and June 2003 – Four quarterly rounds of groundwater sampling and analysis

Figure 5-1 shows the groundwater and surface water sampling locations. Groundwater monitoring wells sampled for this study include those installed by URS between Lake Steilacoom and the city of Lakeview, wells installed by McChord Air Force Base in the Springbrook neighborhood of Lakewood, and one well installed by Herrera Consultants on the Lakewood Towne Center property for a separate investigation (Figure 5-1). In addition, water from a Lakewood Water District supply well was sampled, as well as two Tacoma-Pierce County Health Department (TPCHD) monitoring wells. The TPCHD wells were added to serve as

upgradient sampling locations after data from Rounds 1 and 2 indicated elevated phosphorus concentrations in well MW-8, the easternmost sampling point originally identified. Well MW-8 is located upgradient of the Lakewood Towne Center and the former Atwood Marsh.

Descriptions of field procedures are provided in Appendix A.

Laboratory analyses conducted by URS focused on the following forms of phosphorus:

- **Soluble reactive phosphorus** includes only dissolved inorganic orthophosphate (PO_4), derived from naturally-occurring minerals or the breakdown of more complex phosphorus compounds. SRP may be desorbed from or adsorbed to soil particles and released to or removed from groundwater, depending on conditions in the aquifer (Lazoff, personal communication). SRP is the form of phosphorus that disperses throughout the water column in a lake and is most easily used by aquatic plants and algae. In the past, naturally-occurring orthophosphates (commonly called rock phosphate) were used as fertilizers, but, in too many cases, soil conditions were not correct for converting the rock phosphate to SRP (Vitosh 1997). Current fertilizers contain orthophosphates bonded with calcium, ammonia, or other elements to form what are commonly referred to as superphosphates. Once applied, different superphosphate formulations revert to orthophosphates (including SRP) in soil at different rates depending on environmental conditions (Vitosh 1997).

- **Total dissolved phosphorus** includes SRP, dissolved organic phosphates, and dissolved polyphosphates (Lazoff, personal communication). Dissolved organic phosphates are derived primarily from biological processes. Although certain organic phosphates (e.g., manure) have been applied as fertilizers for centuries, the organic forms of phosphorus in the manure are not as readily available to plants as the inorganic forms that are also present (Rehm et al. 2002). Polyphosphates are very large molecules and are the type of phosphorus used in degreasers, detergents and liquid fertilizers. Polyphosphates from liquid fertilizers convert to orthophosphates by hydrolysis (taking on water) at various rates, depending on environmental conditions (Vitosh 1997). Other potential sources of phosphorus include wastewater from historic use of septic systems (Lakewood area served by sanitary sewer system by approximately 1980) and leakage from municipal sewer systems.

- **Total Phosphorus** (Total P) includes all of the above dissolved forms in addition to particulate phosphates that have not dissolved prior to entering the system being sampled. Particulate phosphates are derived from many sources including dead vegetation, manure, and algae. In stream water, the concentration of total P, which is over and above the total dissolved phosphorus (TDP) concentration, is usually attributable to algae (Lazoff, personal communication).

It should be noted that superphosphates are also sometimes called polyphosphates. However, the existing body of literature appears to limit superphosphates to fertilizers, whereas polyphosphates can be associated with fertilizers, detergents, and many other materials.

5.1 PEAT AND ASSOCIATED GROUNDWATER SAMPLING

In January 2002, URS advanced soil borings and collected soil and groundwater samples from the former Atwood Marsh peat deposit. URS conducted the peat sampling in January 2002, between the time when the former Lakewood Mall was demolished and the beginning of construction activities for the current Lakewood Towne Center buildings. Within the short window of opportunity when mall buildings were not present, URS was able to drill and sample 10 direct-push soil borings in and around the peat deposit in the locations shown on Figure 5-2. This sampling effort was conducted because reports from previous investigations suggested that muck and peat deposits beneath the Towne Center are a potentially important phosphorus source located just upgradient of Ponce de Leon Creek and Lake Steilacoom (KCM 1996).

To the extent practicable, sampling locations were selected to be laterally and vertically representative of the peat deposit. Peat was collected from several different depths and groundwater was collected from directly above and below the deposit at five locations. Eight peat samples were analyzed for total phosphorus and five groundwater samples were analyzed for TDP, SRP, metals, and other nutrients. One of the peat samples was subjected to special extraction analyses, to measure specific forms of phosphorus, for potential use in geochemical modeling of the study area.

The extractions performed on sample PD-4 included the following: ammonium chloride (NH_4Cl), which removes loosely bound phosphorus; a sodium hydroxide (NaOH) and citrate-bicarbonate-dithionate buffer (CBD), which extracts exchangeable phosphorus from soils containing iron and aluminum oxides and hydrates (Delgado and Torrent 2000); and hydrochloric acid (HCl), which removes mineral-bound phases such as apatite. The sequential extractions were primarily used to understand the amount of hydrous ferric oxide (HFO) that might be available to immobilize groundwater phosphorus.

Peat encountered in the borings was mostly dry at the time of drilling and generally appeared to have a very low permeability. Because the peat samples did not drain water, it was not possible to collect groundwater samples from the internal part of the deposit.

5.2 PRELIMINARY SURFACE WATER SAMPLING IN PONCE DE LEON CREEK

URS collected surface water samples and measured flow volumes at several locations in Ponce de Leon Creek in February 2002. The sample locations included the culvert beneath Gravelly Lake Drive (SW-1), a point just downstream of the springs (SW-2), and a small bridge approximately 100 feet east of the stream mouth (SW-3) (Figure 5-1). Historic surface water quality data are shown in Table 4-1.

5.3 SOIL BORINGS AND MONITORING WELL INSTALLATION

On August 28 and 29, 2002, URS installed five monitoring wells (MW-2, MW-4, MW-5, MW-6, and MW-8) in the locations shown on Figure 5-1. In the QAPP, URS proposed installing eight monitoring wells and two screened drive points along Ponce de Leon Creek. However, as described below, not all of the wells could be installed as planned.

5.3.1 Deviations from QAPP

The following deviations from the QAPP occurred because of conditions encountered in the field:

- Proposed well MW-3 was not installed because the owners of the Lakewood Towne Center (MBK Northwest) requested that no wells be installed on their property until all construction activities for the new mall were complete. The well location was originally proposed to measure phosphorus concentrations downgradient of the buried peat deposit and upgradient of stormwater drainage collection piping beneath the mall parking areas.

- Two proposed drive points (MW-9 and MW-10) could not be installed next to Ponce de Leon Creek because of refusal within the upper 2 to 3 inches of soil during the attempted installation. However, well points along the creek would be redundant because groundwater entering the creek can be sampled at the springs (SW-2).

- Monitoring well MW-6 was moved approximately 200 feet northwest of the proposed location because of property access and buried utility issues. The different location chosen for MW-6 was still consistent with the goal for the well, which was to evaluate groundwater quality downgradient of Seeley Lake.

- Monitoring well MW-7 was not installed because groundwater was not encountered in the boring prior to encountering drilling refusal. The soil boring at this location (MS-7) extended 40 feet below the ground surface (218 feet msl), which is below the elevation of the water surface in Lake Steilacoom.

- A well was not installed at proposed location MW-1 because groundwater was not encountered prior to drilling refusal. Boring MS-1 was drilled to 30 feet bgs (234 feet msl), which is below the depth of groundwater that is just downgradient of MS-1, around the Atwood Marsh peat deposit.

- The QAPP indicated that three soil samples from each boring would be submitted for laboratory analysis. However, the majority of samples retrieved from the borings consisted of cobbles and coarse gravel, which are not suitable for analysis. Thus, fewer soil samples were analyzed. One sample each was submitted for analysis from locations MW-5 and MW-6. Two samples were submitted from every other boring where a monitoring well was installed. URS attempted to retrieve split-spoon soil samples every 5 feet unless large cobbles or boulders were obviously present at the bottom of the boring.

- The groundwater monitoring program was expanded to include two additional monitoring wells (i.e., locations not specified in the QAPP) during Rounds 3 and 4, when Rounds 1 and 2 indicated elevated phosphorus concentrations upgradient of MW-8.

- DW-3 (cleanout from the Lakewood Towne Center dewatering system) was sampled to measure phosphorus concentrations in the water discharged to Ponce de Leon Creek.

5.4 GROUNDWATER SAMPLING

URS completed four quarterly groundwater monitoring rounds conducted during August 2002, December 2002, March 2003 and June 2003. The locations sampled were selected to evaluate phosphorus concentrations along the pathways by which groundwater and surface water reach Lake Steilacoom. The sampling locations are shown on Figure 5-1 and summarized below:

- **MW-2, MW-4, MW-5, MW-6, and MW-8** were installed by URS specifically for the phosphorus sources study. All of these wells were sampled during all four quarterly monitoring rounds.

- **Springbrook wells CW-45, CW-46, CW-59, CW-61 and CW-62** were installed by McChord Air Force Base as part of a chlorinated solvent investigation. They were included in the phosphorus sources investigation to monitor groundwater conditions near the eastern boundary of the city of Lakewood. The wells were sampled during the four quarterly monitoring rounds except for well CW-62, which was inaccessible During Round 2 because a car was parked above the well monument and the car owner could not be located. In addition, well CW-59 was not accessible during Round 4.

- **WS1** is a residential tap located in the neighborhood north of Ponce de Leon Creek. Groundwater from this tap is representative of a mixture of water from several different water supply wells that are screened in multiple aquifers. Given these conditions, groundwater analytical data from this location are not directly comparable to data from the other wells. The objective for sampling WS1 was to obtain a general indication of phosphorus concentrations in the deeper aquifers. In the QAPP, URS proposed sampling this tap during one event only.

- **HERR-MW3** was installed by Herrera Consultants as part of an ongoing investigation in the northwest corner of the Lakewood Towne Center property. The purpose for groundwater sampling in this location was to measure potential phosphorus contributions from a strip mall area that formerly contained several septic systems. This well was sampled three times for TDP and SRP. In the QAPP, URS proposed sampling the well during all four quarterly monitoring rounds, but access to the well was limited by the need to coordinate monitoring with the ongoing investigation being conducted by Herrera Consultants.

- **G1** is a Lakewood Water District supply well, which was originally thought to be screened in the Aquifer Zone C. URS added this well to the phosphorus sources study during the second monitoring round to evaluate Aquifer Zone C as a potential phosphorus source to the shallow aquifer. Some evidence suggests that deep aquifer groundwater might be upwelling upgradient of Lakewood in locations where the

aquitard beneath the shallow Vashon Drift aquifer is absent. However, recently-obtained information suggests that this well is screened in the lower portion of Aquifer Zone A (Burt Clothier, personal communication).

- **AEF-250 and AEF-222** were installed in 1985 as part of the TPCHD Chambers/Clover Management Plan. The plan was initiated in 1994 in response to groundwater concerns related to population growth including resource consumption, public health and safety, and groundwater quality. URS added these wells during the monitoring Rounds 3 and 4. Based on review of the results for Rounds 1 and 2, AEF-222 was added because it is upgradient of MW-8, which exhibited elevated phosphorus concentrations in Rounds 1 and 2. AEF-250 was added to help evaluate whether stormwater drainage from the Ward Lake area appeared to be contributing to the elevated phosphorus concentrations observed at MW-6 and MW-8. The wells are screened in Aquifer Zone A at approximately 257-267 feet msl (AEF-222) and 233-243 feet msl (AEF-250).

- **Clover 3** was installed by Brown and Caldwell as part of a separate groundwater investigation. It was added to the list of monitoring wells to fill in gaps for upgradient sampling locations.

5.4.1 Purging and Sampling

Purging was performed prior to sample collection to removed the stagnant water in the well and ensure that a representative groundwater sample was obtained from the surrounding formation. Most groundwater purging and sampling was conducted using a peristaltic pump fitted with polyethylene tubing. The mall dewatering system cleanout (DW-3) although sampled with a peristaltic pump in the same manner as monitoring wells, was not purged because it consists of 48-inch diameter pipe designed to direct groundwater toward Ponce de Leon Creek. Purging would not affect the quality of the sample from this pipe. Sampling methods used for the Springbrook wells varied because of limitations due to the depth to groundwater. Whenever possible, a peristaltic pump was used to maintain consistency with the overall sampling design. However, where the depth to water was too great for peristalsis, either a bailer or impeller pump was used to purge and sample the well. At supply well G-1, water was retrieved from a spigot at the well-head, upstream of the chlorine treatment system. A detailed description of groundwater sampling techniques is provided in Appendix A.

5.5 SURFACE WATER SAMPLING

URS collected surface water samples and measured flow rates at five locations on Ponce de Leon and Clover Creeks. The sample locations on Ponce de Leon Creek included the culvert beneath Gravelly Lake Drive (SW-1), a point just downstream of the springs (SW-2), and a small bridge approximately 100 feet east of the stream mouth (SW-3) (Figure 5-1). The Clover Creek samples were from locations previously used by the USGS, including the crossings at Gravelly Lake Drive (SW-4) and Tacoma Way South/Bridgeport Way (SW-5) (USGS 1996).

Instantaneous flow measurements were made at the time of sample collection in Ponce de Leon Creek. Flows were measured using a Model FP101 – FP201 Global Flow Probe at various points across the channel. Given the small size and uniformity of the channel, these measurement are expected to be reasonably accurate (+/- 15 - 25%). However, stream gauges were not installed. The Clover Creek channel at SW-4 contained substantial vegetation and debris that precluded flow measurement. Therefore, the only flow data for Clover Creek were obtained from flow measurements collected near the USGS gauge near SW-5 (+/- 15 - 25%). The results of the flow measurements are discussed in Section 6.

On February 19, 2002, URS collected samples from locations SW-1 and SW-3 to compare the surface water in Ponce de Leon Creek to groundwater that had been collected from around the peat deposit one month earlier. On August 29 and September 3, 2002, the Ponce de Leon Creek and Clover Creek sample stations were included in the first quarterly monitoring round for the phosphorus sources study. On December 3 and 4, 2002, URS collected samples at three locations on Ponce de Leon Creek and one location on Clover Creek as part of the second quarterly monitoring event. Only upstream sample station SW-5 on Clover Creek was sampled in December, because the stream was dry at downstream location SW-4 near the lake. Surface water samples were collected from all five locations during the March 2003 and June 2003 sampling efforts.

The sampling locations are shown on Figure 5-1 and summarized below:

- **Lakewood Mall cleanouts (DW-1 and DW-3)** in the mall dewatering system, were sampled to measure phosphorus concentrations in the water that is discharged to Ponce de Leon Creek. In the QAPP, URS proposed sampling three dewatering locations (DW-1, DW-2, and DW-3). Phosphorus concentrations in the pipe water were compared to phosphorus concentrations that were measured in groundwater from the peat. Due to ongoing construction at the Lakewood Towne Center, location DW-2 was never found. DW-3 was the only location sampled during August 2002. During the December 2002 sampling event, the entire dewatering system was dry. In March 2003, DW-1 and DW-3 were sampled. During the final sampling round in June 2003, only DW-3 was sampled.

- **SW-1, SW-2 and SW-3** were used to measure phosphorus concentrations over the length of the Ponce de Leon Creek channel. The was data was used to see if groundwater feeding the stream via the Lakewood Mall dewatering system or groundwater entering along the creek banks contributes significantly to the flow and/or phosphorus concentration.

- **SW-4 and SW-5** were used to measure the phosphorus concentrations downstream and upstream, respectively, in the Lakewood reach of Clover Creek. The data was compared to the data collected by McChord AFB for the Clover Creek reach upstream of Lakewood Towne Center. Because Clover Creek is a losing stream in its lower reach, with the lost water most likely flowing northwest toward Ponce de Leon Creek, leakage from Clover Creek could contribute phosphorus to the groundwater entering Ponce de Leon Creek.

Figure 5-1
Groundwater and Surface Water Sampling Locations

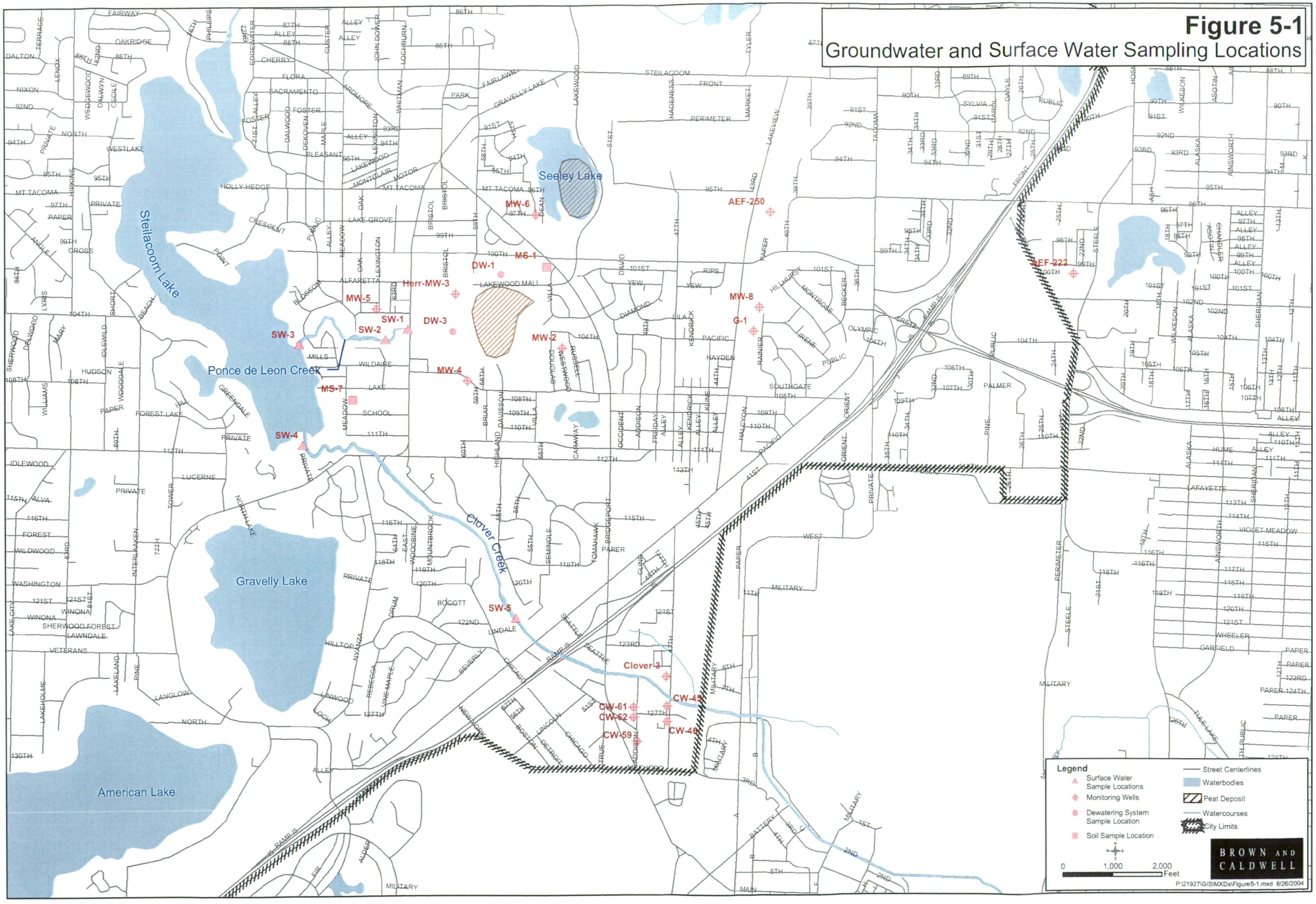

Figure 5-2
Atwood Marsh Peat Deposit
Soil Boring Locations

LAKEWOOD TOWNE CENTER

PD-1
PD-2
PD-3
PD-4
PD-5
PD-6
PD-7
PD-8
PD-9
PD-10

Ponce De Leon Creek

OAK
BRISTOL
LAKE GROVE
97TH
DEAN
ALLEY
WHITMAN
99TH
59TH
OAK PARK
COLUMBIA
BRIDGEPORT
LAKEWOOD
MEADOW
LEXINGTON
100TH
DAVID
101ST
PUBLIC
ALFARETTA
LAKEWOOD MALL
YEW
63RD
VILLA
BROOK
AVALON
HOLLY
FILBERT
DIAMOND
AVONDALE
LILA
49TH
PACIFIC
104TH
BARLOW
PONCE DE LEON
DOUGLAS
MILLS
WESTWOOD
RUSSELL
DOTEN
OCCIDENT
WILDAIRE
GLEN ECHO
PAPER
58TH
LAKE
CRONINS
108TH
59TH
BRIAR
DAVISSON
109TH
MEADOW
SCHOOL
GRAVELLY LAKE
110TH
CARAWAY
111TH
60TH

Legend

- Peat Deposit Boring
- Peat Deposit
- Tax Parcel Boundaries
- Watercourses
- Waterbodies
- City Limits

0 200 400 Feet

BROWN AND CALDWELL

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6.0 SAMPLING RESULTS

This section summarizes the field observations and laboratory analyses performed for this phosphorus source study.

6.1 ANALYTICAL DESCRIPTION AND DATA QUALITY OBJECTIVES

Groundwater, surface water, peat, and soil samples were submitted to Aquatic Research Inc., an Ecology accredited laboratory, located in Seattle, Washington for analysis as described in the QAPP. Samples were analyzed for one or more of the following:

- Total Phosphorus, TDP, and SRP by EPA Method 365.1 or Standard Method (SM 18) 4500-PF
- Dissolved Metals (aluminum, iron, potassium, magnesium, manganese, sodium, and calcium) by EPA 200.7
- Chloride by EPA Method 325.3
- Fluoride by EPA Method 340.2
- Bromide by Standard Method SM18 4500-PF
- Nitrate or Nitrate+Nitrite by EPA 353.2
- Nitrite by EPA Method 354.1
- Sulfate by EPA Method 375.4
- Alkalinity by EPA Method 310.1
- Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC) by EPA Method 415.2

Analytical results are summarized in Tables 6-1 through 6-5. Aquatic Research Inc. provided summary analytical reports containing sample results and quality control results. URS reviewed the reports to assess whether:

- The data were consistent and complete
- Results for QC samples were included
- Acceptance criteria for QC results were achieved
- Methods and protocols specified in the QAPP were followed

The summary data quality reviews were based on method performance criteria and QC criteria as documented in Table 5-1 of the QAPP (URS 2002). Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike

duplicate results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. Additionally, compliance with field procedures, like field filtering of TDP, SRP, and dissolved metals were also considered. Data qualifiers were assigned based on guidance in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002 as well as professional judgment of the reviewer. Data quality review reports and copies of the laboratory reports are provided in Appendix B. Assigned data qualifiers are included with numerical results in Tables 6-1 to 6-5.

The data review indicated that generally data were usable without qualification. The following exceptions were noted:

- Results for nitrate, nitrite, and/or DOC for the push probe groundwater samples collected in January 2002 (PD2-G, PD4-G, PD5-G, PD8-G, and PD9-G) were qualified as estimated based on holding time exceedance.

- The laboratory duplicate percent differences associated with specialized extracts NaOH and HCl for bound phosphorus on peat sample PD4-14 were above the QAPP criteria. The relative percent difference for total phosphorus in the parent and field duplicate samples collected at PD2-18 was above the QAPP limits. The associated sample results for PD4-14 and PD2-18 were qualified as estimated.

- The surface water samples (SW-1 and SW-3) collected in February 2002 were not field filtered for TDP and SRP. The samples were delivered to the laboratory on the day collected and filtration was performed at the laboratory. Since the surface water samples did not likely contain significant iron or manganese to bind phosphorus, the effect of the delayed filtration was performed at the laboratory. Since the surface water samples did not likely contain significant iron or manganese to bind phosphorus, the effect of the delayed filtration was considered minimal and the data were not qualified. KCM (1996) found that the iron to phosphorus ratio in Ponce de Leon Creek was about 0.9, and noted that the ratio should be greater than 3 for iron to effectively precipitate phosphorus under aerobic conditions.

- The results for nitrate+nitrite, fluoride, and DOC performed for groundwater samples MW-2, MW-4, MW-5, MW-6, MW-8, and DW-3 collected in August 2002 were qualified as estimated based on holding time exceedance.

- The SRP result for one groundwater sample (CW-61) collected in December 2002 was qualified as an estimated value due to an out-of-range matrix spike recovery.

- The result for nitrate+nitrite performed for groundwater sample WS-G1 collected in January 2003 was qualified as estimated based on holding time exceedance.

- The nitrate+nitrite result for groundwater sample WS-G1 collected in March 2003 was qualified as an estimated value due to an out-of-range matrix spike recovery.

- One groundwater sample (Herr MW-3) collected in May 2003 and one collected (AEF-222) in June 2003 were not field filtered for TDP and SRP. The field

representative requested the samples be filtered at the laboratory. The results for TDP and SRP detected in these samples were qualified as estimated based on the potential that delayed filtration may have affected the sample results.

The laboratory substituted method EPA 365.1 for methods 365.2 and SM 18-4500P-F for measurement of total phosphorus, TDP, and SRP in most samples. Dissolved metals analysis was performed by method EPA 200.7 rather than EPA 6010. Fluoride and TOC analyses were performed by methods EPA 340.2 and EPA 415.1 instead of EPA 340.1 and EPA 415.2. The methods substituted are comparable in analytical principles and considered minor adjustments to the methods listed in the QAPP. The project objectives are unaffected by the substitutions.

Water samples for TDP, SRP, and dissolved metals were generally field-filtered at the time of sample collection. There were two exceptions as noted in the data review reports and briefly summarized above. Results for these samples were qualified based on reviewer judgment and the type of samples.

Peat and soil samples submitted to the laboratory were prepared for analysis after removing rocks, gravel, and sticks. The samples were then extracted to collect an aqueous solution for phosphorus analysis. Samples submitted for analysis for total phosphorus were prepared using a Kjeldahl digestion. The resulting solution was diluted and analyzed for phosphorus by SM18-4500PF. Due to the dilution of the extract, analytical interferences to phosphorus are likely minimal.

The sequential analysis conducted on sample PD4-14 to assess the geochemical nature of phosphorus was performed as follows: the sample was extracted with laboratory water (target analyte free). The solid and water extract was centrifuged to separate the water for analysis. Total phosphorus was measured by SM18 4500-PF after each chemical addition. The order was ammonium chloride (measures total phosphorus), followed by CBD (measures iron-bound phosphorus only), followed by NaOH solution (measures soluble aluminum hydroxides and may have included some iron bound phosphorus), and HCL to measure calcium (mineral) bound phosphorus. Each analysis was performed at approximately a 100 to 1 dilution to minimize interferences from other matrix constituents.

No data were rejected and all were considered usable for the project objectives, although some results are considered estimated. The analytical results are discussed in the following sections.

6.2 PEAT SAMPLES

The peat deposit is located below the groundwater table beneath the approximate center of the Lakewood Towne Center property. It ranges from a few inches to approximately 10 feet thick and is buried beneath approximately 10 feet of fill (in locations that were drilled). The peat varies from wet, dark brown/black organic clay on the deposit's outer surface, to a dry, brick-red or greenish sphagnum-like material from just below the outer surface to the deposit's inner core. The color variation from black on the outer part of the deposit to green and red on the inside indicates a gradation from oxidizing conditions around the deposit surface to reducing conditions from just below the deposit's outer surface to its core. All of the red and green peat samples turned black almost immediately upon exposure to air. The variation in moisture content of the

material suggests that groundwater flow is retarded by the peat. Thus, groundwater flow follows a less resistant path around the peat deposit.

These characteristics indicate that the peat has little potential to release phosphorus to groundwater or influence the local geochemistry to promote phosphorus transport. First, groundwater appears to primarily contact only the outer surface of the deposit due to the peat's relatively low permeability. Therefore phosphorus released from the peat would come from the outer surface only, which is a relatively small area. Furthermore, dissolved oxygen concentrations and oxygen reduction potential (ORP) values in the groundwater around the peat, as well as the color of the deposit's outer surface, indicated oxidizing conditions.

Total phosphorus concentrations in the eight peat samples ranged from 125 mg/kg to 611 mg/kg (Table 6-1). Another peat sample collected in August 2002, south of the main deposit (MS4-5), contained a total phosphorus concentration of 993 mg/kg (Table 6-2). Laboratory Analytical Reports are presented in Appendix C. The average total phosphorus concentration was 340 mg/kg, which is lower than many other peat deposits in Western Washington, as reported by Rigg in 1958, and similar to or lower than concentrations measured in surrounding soil (Rigg 1958). The deposits measured by Rigg contained concentrations from 500 to 15,200 mg/kg of phosphorus by dry mass (Rigg 1958).

6.3 PEAT DEPOSIT GROUNDWATER SAMPLES

Samples of groundwater from locations in direct contact with the peat (PD2-G, PD4-G, and PD5-G) contained TDP concentrations ranging from 7 µg/L to 34 µg/L, with a mean concentration of 17 µg/L (Table 6-1). Soluble reactive phosphorus concentrations in these samples ranged from 3 µg/L to 11 µg/L, with a mean concentration of 7 µg/L (Table 6-1). When compared on a general level, SRP concentrations in the water that is in contact with the peat deposit are approximately half the concentration of TDP.

Conversely, groundwater samples collected from the periphery of the peat deposit (PD8 and PD9) contained TDP at concentrations of 20 µg/L and 24 µg/L, with SRP concentrations essentially equal to the TDP concentrations in both cases (Table 6-1). However, the groundwater samples in contact with and around the peat deposit contained less phosphorus than samples from Ponce de Leon Creek, suggesting that the peat deposit is not a significant phosphorus source to the creek.

In addition, the lateral distribution of TDP/SRP concentrations in groundwater around the peat shows an increase away from the southernmost and central borings (PD2 and PD5), with the highest concentrations outside the east and west boundaries of the peat deposit. One possible explanation for this distribution is that SRP in groundwater underneath the Lakewood Towne Center is potentially being diluted from an influx of water with a lower SRP concentration from a point south of PD2 and PD5.

Anions and cations were also analyzed from three of the peat deposit groundwater samples although the samples from PD8 and PD9 were not analyzed for cations and anions (Table 6-1). The results in Table 6-1 suggest that, except for the sulfate and calcium concentrations, cation and anion concentrations above and below the peat deposit are largely similar. The sulfate

concentration below the peat deposit was 6.38 mg/L while the concentration above the peat deposit was 49.5 mg/L. Additionally, the calcium concentration below the peat deposit was 11.2 mg/L while the concentration above the peat deposit was 29.6 mg/L.

The peat sample collected from PD4 at 14 feet bgs was analyzed after different extractions. The rationale for this analysis was that adsorbed phosphate on the surface of minerals can be a reservoir of phosphate even though phosphate minerals are not present. The concentration of adsorbed phosphate typically exceeds the dissolved phosphate concentration. Exchangeable phosphate is loosely bound on the surfaces of minerals, while extractable phosphate includes exchangeable phosphate plus phosphate that is more tightly bound on metal oxide minerals. The more tightly bound phosphate would be released into the groundwater if the adsorbing minerals dissolve under reducing conditions. As shown on Table 4-1, extractable phosphorus concentrations ranged from less than 10 mg/kg (NH_4Cl extraction) to 148 mg/kg (NaOH =CBD [iron + aluminum] extraction). Total phosphorus for this sample was 429 mg/kg.

6.4 PRELIMINARY SAMPLING OF PONCE DE LEON CREEK

6.4.1 Discharge Volume

In February 2002, water in Ponce de Leon Creek was flowing at a rate of approximately 12 cfs at the Gravelly Lake Drive culvert (SW-1) and 30 cfs at the stream mouth (SW-3) (Table 6-3). URS' observations of the entire length of the creek indicated that the majority of increase in flow was attributable to discharge from the springs, which are between 50 and 200 feet downstream of SW-1.

6.4.2 Physical Water Quality Parameters

URS measured physical water quality parameters (temperature, pH, conductivity, and dissolved oxygen) at each sample location. The parameters measured in February 2002 were essentially equal at locations SW-1 and SW-3 (Table 6-3).

In February, URS compared the parameters measured at SW-1 to those measured in groundwater from peat deposit borings (Tables 6-1 and 6-3). The creek's water quality was similar to water at location PD8, which is east of the mall and the peat deposit.

6.4.3 Analytical Results

SRP concentrations in the February 2002 Ponce de Leon Creek samples were 30 μg/L at the culvert beneath Gravelly Lake Drive, where the creek first "daylights" (SW-1), and were 37 μg/L at the stream mouth (SW-3) (Table 6-3). The SRP values were essentially equal to the TDP values at both sample locations. Total phosphorus (dissolved and particulate) showed a slight increase between the outfall and the stream mouth. This increase was likely due to entrainment of particulate soil and/or plant detritus from the stream channel.

URS compared the phosphorus concentrations in Ponce de Leon Creek in February 2002 to the concentrations measured in groundwater around the peat deposit in January. The concentrations

in the creek water were most similar to the concentrations at locations PD8 and PD9, which are east (upgradient) and west (downgradient) of the peat deposit, respectively.

6.5 SOIL BORING/WELL INSTALLATION OBSERVATIONS

Brief descriptions of the soil encountered at each drilling location are provided below. Soil samples consisting primarily of cobbles and course gravel were not analyzed. Soil boring and monitoring well construction logs are included in Appendix D.

- **Boring MS-1** was drilled to evaluate the buried stream channel, which approaches the east/northeast boundary of the former Atwood Marsh. Soil from the ground surface to the maximum depth drilled (30 feet bgs or 234 feet msl) consists of very dry, dense, sandy, silty coarse gravel and cobbles. Although early maps suggest that the former channel approached the marsh in this location, the density and composition of the soil encountered are more similar to glacial till than imported materials that would have been used to fill a channel. Because groundwater was not encountered in boring MS-1, no soil samples were collected and no monitoring well was installed.

- **Boring MW-2** was drilled and well MW-2 was installed to evaluate groundwater quality upgradient of the Lakewood Towne Center. It is located in a residential neighborhood with numerous stormwater dry wells. In Lakewood, dry wells are widely used to infiltrate stormwater. Each dry well consists of an approximately 3-foot-diameter by 10-foot-deep basin with an opening at the bottom where runoff infiltrates into the surrounding soil. There are approximately 14 dry wells located within 800 feet of Well MW-2. This location was selected to evaluate if dry wells may potentially impact the phosphorous concentrations in the groundwater.

  Soil in location MW-2 consists of medium-dense, silty, sandy coarse gravel. Groundwater is present at a depth of approximately 21 feet bgs (242 feet msl). However, unlike other drilling locations where groundwater was encountered, groundwater recharge to MW-2 was very slow.

  Two soil samples were collected at depths of 5 and 15 feet bgs with total phosphorus concentrations of 720 and 391 mg/kg, respectively (Table 6-2).

- **Boring MS-4** was drilled and Well MW-4 was installed in the former Clover Creek high-flow channel, which approached Atwood Marsh from the south (Figure 5-1). Soils encountered from the ground surface to approximately 6 feet bgs included mostly sandy gravel mixed with small pieces of peat. Groundwater was encountered at approximately 6 feet bgs (239 feet msl). The presence of mixed gravel and peat indicates that the material used to fill the former channel may have been scraped from the nearby mall site prior to or during construction in the 1950s. A homeowner, who lived next to the mall site during the construction period, told URS staff that large volumes of soil were pushed toward the south side of the property at that time.

Two soil samples were collected at depths of 5 and 6 feet bgs with total phosphorus concentrations of 993 and 483 mg/kg, respectively (Table 6-2).

- **Boring MS-5** was drilled and Well MW-5 was installed in the residential neighborhood just north of the springs along Ponce de Leon Creek to evaluate potential phosphorus input from dry wells.

  Soils encountered in the boring included silty, sandy, coarse gravel and gravelly sand. Unlike other drilling locations, the soil in this location does not appear to contain large cobbles. Groundwater was encountered at an elevation of 235 feet msl, approximately equal to the elevation of Ponce de Leon Creek at the springs (SW-2).

  One soil sample was collected at a depth of 10 feet bgs and the total phosphorus concentration was 532 mg/kg (Table 6-2).

- **Boring MS-6** was drilled and well MW-6 was installed to evaluate the potential phosphorus input to groundwater from Seeley Lake. MW-6 is just downgradient of the southern end of the lake, where lake water lost to the shallow aquifer would be expected to enter the main groundwater flow path. Soil encountered in the boring included sandy, fine to coarse gravel with cobbles. Groundwater was encountered at an elevation of 239 feet msl.

  One soil sample was collected at a depth of 28 feet bgs and the total phosphorus concentration was 270 mg/kg (Table 6-2).

- **Boring MS-7** was drilled to evaluate groundwater flow direction and potential phosphorus sources in the residential neighborhood south of Ponce de Leon Creek. Residences in this neighborhood are surrounded by relatively large, heavily vegetated lots. MS-7 was advanced to 40 feet below the ground surface (218 feet msl) prior to encountering refusal due to either a large rock or dense till layer. Soil samples retrieved from the boring, from the ground surface to the final depth drilled, consisted of a very dense, dry, silty, sandy, gravelly cobbles. Although the boring extended below the surface water elevation of the lake, no groundwater was encountered, so a monitoring well was not installed.

  Although a well was not installed, the drilling data for MS-7 are important in understanding the study area hydrogeology. The dry boring (to an elevation below the elevation of Lake Steilacoom) is additional evidence for the presence of till and/or other soils with low permeability acting as aquitards, which influence groundwater flow in the vicinity of the Lakewood Towne Center. These units could also be responsible for the upwelling of springs at Ponce de Leon Creek, for separating the lower reach of Clover Creek from groundwater in the Ponce de Leon Creek drainage basin, and for preventing groundwater flow directly to the southeastern shore of Lake Steilacoom.

  No soil samples were collected from boring MS-7 and there was no groundwater present.

- **Boring MS-8 was drilled and well MW-8** was installed near the western boundary of the Lakeview Village Housing tract (also called the Southgate Addition), hydraulically upgradient of downtown Lakewood and the Lakewood Towne Center. Lakeview Village was constructed in the 1950s in a large, subtle depression that appears, in a 1941 aerial photograph, to be a former wetland. An existing small pond, which appears to be a remnant of the former wetland, is located approximately 300 feet northwest of MW-8. MW-8 was drilled and installed in an apparent former stream channel, which flowed westward from the buried wetland in Lakeview to the Atwood Marsh, according to late nineteenth century maps. Based on the topography at the well location, the well may be located in the former stream channel at the discharge point of the former wetland.

  Soil encountered in the boring for MW-8 consisted predominantly of sandy gravel with some cobbles, but was different from other borings in that the gravel matrix contained a substantial quantity of white, clayey silt. The occurrence of the white material at depths up to 20 feet bgs suggests that it is natural and not imported fill. The material was originally thought to be a diatomaceous deposit related to the former lake. However, observation of the soil using a petrographic microscope showed that it is a very fine, silica-rich silt, which does not appear to contain diatoms. In addition, laboratory analysis of the white clayey silt found phosphorus concentrations similar to those of other soils in the area.

  Two soil samples were collected at depths of 10 and 20 feet bgs and total phosphorus concentration were 343 and 347 mg/kg, respectively (Table 6-2).

6.6 SOIL ANALYTICAL RESULTS

Analytical results for soil samples collected from the well borings indicated total phosphorus concentrations ranging from 270 mg/kg at MS6 to 720 mg/kg at MS2, with a mean concentration of 445 mg/kg. Peaty gravel from MS4, not included in this mean, contained total phosphorus at a concentration of 993 mg/kg. The peaty gravel sample was not included in the peat mean because the soil at MS4 was moved from the peat deposit in the 1950s. The white silty soil at MS8 contained concentrations ranging from 343 mg/kg to 374 mg/kg.

6.7 GROUNDWATER ANALYTICAL RESULTS

Analytical data for the four rounds of groundwater sampling are presented in Tables 6-4 and 6-5. Figures 6-1 and 6-2 show SRP and TDP concentrations for each sampling location.

6.7.1 Physical Water Quality Parameters

URS measured pH, temperature, specific conductance, ORP, turbidity, and dissolved oxygen using an in-line flow-through cell during purging and sampling. Final sets of water quality parameters recorded after purging and just prior to sampling at each well are shown on Tables 6-4 and 6-5. Groundwater and surface water sampling data sheets are provided in Appendix E.

Physical water quality parameters measured at monitoring well MW-8 indicate different localized groundwater conditions from those observed at the other monitoring locations. In August, the dissolved oxygen (0.1.34 mg/L) was much lower than at other wells, and the ORP was in the negative range (Table 6-4). This suggests the presence of organic material in the aquifer near MW-8. Specific conductance (210 µs/cm) was approximately twice that of other samples and the pH, although within a normal range, was the highest measured. Factors potentially affecting these parameters at MW-8 might include the former wetland environment in this location, and/or elevated concentrations of chloride sulfate, alkalinity, calcium, and potassium in the water.

6.7.2 Analytical Laboratory Results

Monitoring Round 1 – August 2002

The first round of groundwater samples was collected in August 2002. Little rain had fallen in the study area since approximately the beginning of April 2002 (weather data from McChord Air Force Base rain gauge). Aquatic Research, Inc., of Seattle, Washington, analyzed all of the groundwater samples from MW-2 through MW-8 for dissolved metals (aluminum, iron, potassium, magnesium, manganese, sodium, and calcium), chlorine, fluorine, nitrate/nitrite, sulfate, alkalinity, TDP, SRP, total organic carbon, and dissolved organic carbon. Samples collected at the Springbrook wells, HERR-MW3, and the first water supply sample from the residential tap were analyzed for TDP and SRP only.

The Round 1 analytical results showed that phosphorus concentrations at locations MW-5, MW-6, MW-8 were similar to phosphorus concentrations in Ponce de Leon Creek, and were about twice as high as the concentrations measured in monitoring wells MW-2 and MW-4 and Clover Creek. Along the Ponce de Leon Creek flow path and the mall dewatering system, TDP concentrations ranged from 26 µg/L to 41 µg/L and SRP concentrations ranged from 31 µg/L to 43 µg/L. At MW-2, MW-4 and Clover Creek, TDP concentrations ranged from 8 µg/L to 18 µg/L and SRP concentrations ranged from 13 µg/L to 14 µg/L (Figures 6-1 and 6-2).

At residential tap WS1-G, phosphorus concentrations were approximately twice as high as the concentrations measured in Ponce de Leon Creek. The TDP concentration was 73 µg/L and the SRP concentration was 76 µg/L.

The highest phosphorus concentrations observed during Round 1 were in samples collected from monitoring wells CW-59, CW-61, and CW-62 in the Springbrook neighborhood, with SRP concentrations ranging from 84 µg/L to 390 µg/L, respectively. At well CW-59, the total phosphorus concentration was 1,930 µg/L. In contrast, phosphorus concentrations at the nearby wells CW-45 and CW-46 were similar to phosphorus concentrations observed along the main groundwater flow path leading to Ponce de Leon Creek.

In addition to being relatively high in comparison to all other wells monitored, the Round 1 phosphorus concentrations at CW-61 and CW-62 were significantly different from previous measurements at the same wells.

Monitoring Round 2 – December 2002 and January 2003

After an exceptionally dry summer and fall, the second round of groundwater samples was collected in December 2002 and January 2003. Groundwater elevations were similar to those measured during Round 1. Phosphorus concentrations at MW-5, MW-6, and MW-8 were slightly higher than the concentrations observed in Round 1, but were still similar to concentrations in Ponce de Leon Creek. At monitoring well MW-2, the SRP concentration was similar to the Round 1 concentration, but the TDP concentration was approximately twice as high. Both the TDP and SRP concentrations in this location were less than half the concentrations in Ponce de Leon Creek. At MW-4, TDP and SRP were approximately three times as high as the Round 1 concentrations and were similar to concentrations observed at MW-5, MW-6, and MW-8 and in Ponce de Leon Creek. MW-4 is located in the buried high-flow channel from Clover Creek. Clover Creek was dry during the Round 2 sampling. It is possible that the observed increase in phosphorus concentrations at MW-4 may be attributable to a decrease in dilution by flows from Clover Creek. TDP and SRP concentrations measured at HERR-MW3 were approximately equal to the concentrations measured at MW-6, MW-8 and in Ponce de Leon Creek.

The results of sample analyses from the Springbrook wells during Round 2 were anomalous to Round 1. Groundwater from wells CW-45 and CW-46 contained phosphorus concentrations similar to concentrations measured at MW-2 through MW-8 and Ponce de Leon Creek. Samples from wells CW-59 and CW-61, however, showed significant changes from Round 1. For example, the SRP concentration at CW-59 decreased from 390 µg/L to 166 µg/L, while the concentration at CW-61 increased from 84 µg/L to 331 µg/L (Figure 6-1).

In January 2003, URS sampled Lakewood Water District well G-1, which is screened at a depth of approximately 150 feet bgs. This well was added to the study to evaluate phosphorus concentrations in Aquifer Zone C based on a report indicating that the well was screened in Aquifer Zone C (Robinson & Noble 1997). However, more recent information indicates that well G-1 is screened in the lower section of Aquifer Zone A (Burt Clothier, personal communication). Similar to MW-8, nearly all of the phosphorus in the sample from G-1 was attributable to SRP. However, the SRP concentration (32 µg/L) was lower than the Round 2 measurement at MW-8.

Monitoring Round 3 – March 2003

Seasonal rainfall fell between January and March 2003, when Round 3 of the sampling was completed (weather data from McChord Air Force Base rain gauge). Groundwater elevations were approximately three feet higher during Round 3 than they were in Round 2. Phosphorus concentrations at MW-5, MW-6, and MW-8 were similar to the concentrations reported in December 2002 (Figures 6-1 and 6-2). At monitoring well location MW-2, the TDP and SRP concentrations were similar to the Round 2 concentrations. Both the TDP and SRP concentrations in this location remained less than half the concentrations in Ponce de Leon Creek. At MW-4, TDP and SRP were similar to the Round 2 concentrations and were similar to concentrations observed at MW-5, MW-6, and MW-8 and in Ponce de Leon Creek.

Groundwater from CW-45 and CW-46 contained phosphorus concentrations similar to concentrations measured at MW-4, MW-5, MW-6, MW-8, and HERR-MW-3. The samples from wells CW-59 and CW-62, however, indicated significant changes from previous sampling rounds. The SRP concentration at CW-59 decreased from 180 µg/L in Round 2 to 54 µg/L in Round 3, while the SRP at CW-62 decreased from 352 µg/L in Round 2 to 23 µg/L in Round 3. The SRP concentration at CW-61 increased from 331 µg/L to 350 µg/L.

Lakewood Water District well G-1 sample had a TDP concentration of 30 µg/L, while SRP was 29 µg/L (Figures 6-1 and 6-2). These results were similar those reported for Round 2.

The TPCHD wells AEF-250 and AEF-222 were added to the sampling program for Round 3 because they are further to the east and may provide data regarding potential sources of phosphorus upgradient of the City. Well AEF-222, the easternmost upgradient well sampled in this study, contained TDP and SRP concentrations that were considerably higher than in wells along the main groundwater flow path and in Ponce de Leon Creek. Phosphorus concentrations in AEF-250 were less than half those measured in well MW-5, MW-6, and MW-8 and in Ponce de Leon Creek.

Monitoring Round 4 – June 2003

Weather conditions at the study site were relatively dry when the fourth round of groundwater sampling was completed in June 2003. No appreciable rain had fallen since approximately the end of April 2003 (weather data from McChord Air Force Base rain gauge). Groundwater elevations were approximately two feet lower in June 2003 compared to the elevations measured during Round 3 of groundwater sampling in March 2003. Phosphorus concentrations at MW-5, MW-6, and MW-8 were similar to the Round 3 concentrations and similar to concentrations in Ponce de Leon Creek (Figure 6-1). At monitoring well location MW-2, the TDP and SRP concentrations were similar to the Round 3 concentrations. Both the TDP and SRP concentrations in this location remained less than half the concentrations in Ponce de Leon Creek. At MW-4, TDP and SRP were similar to the concentrations reported in Round 3 and were similar to concentrations observed at MW-5, MW-6,and MW-8 and in Ponce de Leon Creek.

Groundwater from wells CW-45 and CW-46 contained phosphorus concentrations similar to concentrations measured at MW-4, MW-5, MW-6, MW-8, and HERR-MW-3 and Ponce de Leon Creek. The samples from wells CW-61 and CW-62 contained similar concentrations of TDP and SRP to the results from Round 3. Well CW-59 was inaccessible during Round 4.

In Round 4, Lakewood Water District well G-1 contained a TDP concentration of 33 µg/L while SRP was 35 µg/L. These results were similar those reported in Round 3.

The TPCHD well AEF-222 contained higher concentrations of TDP and SRP than wells MW-5, MW-6, and MW-8 and in Ponce de Leon Creek. AEF-250 had lower concentrations. These results are similar to the Round 3 results.

6.8 SURFACE WATER SAMPLING AT PONCE DE LEON CREEK

6.8.1 Physical Water Quality Parameters

URS measured temperature, pH, conductivity, oxidation-reduction potential (ORP), and dissolved oxygen at each sample location. ORP measurements provide an indication of a reducing or oxidizing environment. These conditions are important because the solubility of phosphorus is related to the ORP. Furthermore, the ORP has a significant effect on the presence of iron and aluminum hydroxides, which adsorb phosphorus. Under reducing conditions, hydroxides are not present resulting in an absence of compounds to adsorb and bind phosphorus. The parameters measured in February 2002 were essentially equal at locations SW-1 and SW-3. In August, the measurements were similar at locations SW-2 and SW-3 (Table 6-3). Both pH and ORP at SW-1 were slightly elevated above the measurements at the other two locations.

Temperature measurements in December were slightly lower. Specific conductance and pH measurements were similar to previous measurements at most sample locations. Dissolved oxygen and ORP measurements were different, but this variation may have been due to instrument error.

The results of the measurements collected in March and June 2003 were similar to those reported in earlier rounds of sampling and did not show appreciable differences except for the notable differences observed in the water quality parameters measured in SW-1 (Gravelly Lake Drive Outfall) in December 2002 compared with the data measured during the other sampling rounds. However, the December measurements were collected after a short storm event that may have influenced the field measurements.

6.8.2 Flow Rates and Results of Laboratory Analysis

Preliminary Sampling – February 2002

In February 2002, Ponce de Leon Creek was flowing at a rate of approximately 12 cfs at the Gravelly Lake Drive culvert (SW-1) and 30 cfs at the stream mouth (SW-3) (Table 6-3 and Figure 6-3). URS' observations of the entire length of the creek indicated that the majority of the increase in flow was attributable to discharge from the springs, which are about 150 feet downstream of SW-1.

SRP concentrations in the February 2002 Ponce de Leon Creek samples were 30 μg/L at the culvert beneath Gravelly Lake Drive, where the creek first "daylights" (location SW-1), and were 37 μg/L at the stream mouth (location SW-3). The SRP values were essentially equal to the TDP values at both sample locations. Total phosphorus (dissolved and particulate) showed a slight increase between the outfall and the stream mouth.

Round 1 Sampling – August 2002

On August 29, 2002, approximately 0.1 cfs of water was being discharged from the Gravelly Lake Drive culvert (SW-1), while 8 cfs was measured just downstream of the springs at SW-2 and at the stream mouth at SW-3 (Table 6-3 and Figure 6-3). Considering that little appreciable precipitation events had occurred since August 5, 2002 (0.13 inches measured at the McChord

Air Force Base rain gauge), the water in the creek and the water discharging from the culvert can be attributed to groundwater.

In August 2002, SRP concentrations in Ponce de Leon Creek ranged from 38 µg/L at SW-1 to 43 µg/L at both SW-2 and SW-3, and were slightly higher than the concentrations measured in February (Table 6-3 and Figure 6-1). All three of the August 29, 2002 samples had similar phosphorus concentrations, nearly all in the form of SRP. Based on the similar flow volumes (8 cfs at both locations) and phosphorus concentrations at SW-2 and SW-3, nearly all of the phosphorus in the creek was coming from the groundwater discharged by the springs. Also, the TDP and SRP concentrations observed in the SW-1 sample were similar to the concentrations observed in samples collected in February from the periphery of the peat deposit (URS 2003) and in samples from MW-5, MW-6, and MW-8 collected in August (Table 6-4). These data suggest that the water discharged at SW-1 in August originated north and east of the Lakewood Towne Center property, and not from the peat deposit or the former Clover Creek channel, which enters the mall from the south.

Round 2 Sampling – December 2002-January 2003

The second quarterly monitoring round of the phosphorus sources study on December 3 and 4, 2002 coincided with the first measurable precipitation events that had occurred in a relatively long dry period preceding the sampling event. On December 3, no water was present in the Lakewood Towne Center dewatering system pipes, and there was no visible discharge from the Gravelly Lake Drive culvert (SW-1). The flow volumes at locations SW-2 and SW-3 were approximately 6 cfs and 8 cfs respectively, indicating that all of the water in Ponce de Leon Creek was from the springs (Table 6-3 and Figure 6-3).

On the morning of December 4, after intermittent rainfall throughout the previous evening, URS observed Ponce de Leon Creek to evaluate the effect of stormwater runoff on discharge volumes at the Gravelly Lake Drive culvert. The ground surface at the base of the SW-1 culvert was damp, but no water was flowing from the pipe. Between approximately 7:00 am and 9:00 am, continuous precipitation generated surface runoff along Gravelly Lake Drive. Approximately 15 minutes after the rain began, runoff from drains along Gravelly Lake Drive began entering the culvert and continued until approximately 9:30 am. However, discharge from the outfall was too low to obtain an accurate flow measurement, and all of the water seeped into the ground before reaching the flowing portion of Ponce de Leon Creek near SW-2. Subsequent observations of the culvert and streambed throughout the day indicated similar conditions.

December 2002 analytical results for samples from SW-2 and SW-3 were very similar to the August results (Table 6-3 and Figure 6-1). As observed during previous sampling rounds, the phosphorus concentrations in Ponce de Leon Creek were approximately equal to the concentrations measured at MW-5, MW-6,and MW-8 leading to the Ponce de Leon Creek springs.

URS measured phosphorus concentrations at SW-1 on December 4, 2002 during a short storm event. The SW-1 sample contained total phosphorus at a concentration of 109 µg/L and SRP at a concentration of 71 µg/L. However, the flow rate at the time of sampling was very low (<0.1 cfs) and the entire flow volume infiltrated into the creek bed within about 50 feet of SW-1,

before entering the flowing reach of the creek. Thus, the phosphorus load at SW-1 was very low, despite the relatively high phosphorus concentrations.

Round 3 Sampling – March 2003

In March 2003, water in Ponce de Leon Creek was flowing at a rate of approximately 6.3 cfs at the Gravelly Lake Drive culvert (SW-1), 23 cfs at SW-2, and 19 cfs at the stream mouth (SW-3) (Table 6-3 and Figure 6-3). URS' observations of the entire length of the creek indicated that most of the increase in flow observed at SW-2 was attributable to the springs.

In March 2003, SRP concentrations in Ponce de Leon Creek ranged from 28 µg/L at locations SW-1 and SW-2 to 33 µg/L at location SW-3, and were slightly lower than the concentrations measured in December 2002 (Table 6-3 and Figure 6-1). The March 2003 samples had phosphorus concentrations similar to the concentrations measured in August 2002. Based on the similar flow volumes (23 cfs and 19 cfs at SW-2 and SW-3, respectively) and phosphorus concentrations between SW-2 and SW-3, the majority of the phosphorus in Ponce de Leon Creek appeared to originate from the groundwater discharged by the springs.

Round 4 Sampling – June 2003

In June 2003 0.74 cfs was measured flowing at SW-1, 16 cfs at SW-2, and 17 cfs at SW-3. In June 2003, SRP concentrations in Ponce de Leon Creek ranged from 31 µg/L at SW-2 to 33 µg/L at locations SW-1 and SW-3, although the concentrations were similar at all three locations. In addition, the results were similar to those reported during the March 2003 sampling event (Table 6-3 and Figure 6-1). Based on the similar flow volumes (16 cfs and 17 cfs at SW-2 and SW-3, respectively) and phosphorus concentrations between SW-2 and SW-3, the majority of the phosphorus in Ponce de Leon Creek appeared to originate from the groundwater discharged by the springs (Table 6-3 and Figure 6-3).

6.9 SURFACE WATER SAMPLING AT CLOVER CREEK

6.9.1 Physical Water Quality Parameters

The water quality parameters measured at SW-4 and SW-5 are shown on Table 6-3. The measurements at both locations were similar during all four quarterly sampling rounds.

6.9.2 Flow Rates and Results of Laboratory Analysis

Round 1 Sampling – August 2002-September 2002

During the first quarterly monitoring round, in August 2002, URS attempted to measure discharge rates at the two Clover Creek sampling locations, SW-4 and SW-5. However, both channel locations were full of rocks, debris, and vegetation, making it difficult to obtain accurate flow measurements. In lieu of measuring each location, URS obtained flow data for Clover Creek from the USGS telemetric gauging station located next to SW-5.

On September 3, 2002, the discharge volume at location SW-5 was 2.3 cfs (USGS 2002). At both sample stations (SW-4 and SW-5) the water level appeared to be within a foot of the high water mark on nearby bridge supports, but the flow velocity was low (Table 6-3 and Figure 6-4).

Total phosphorus and SRP concentrations at SW-4 and SW-5 were approximately equal in September 2002. Total phosphorus in the creek ranged from 25 µg/L to 28 µg/L and SRP was 14 µg/L. Overall, TDP and SRP concentrations measured in Clover Creek in August 2002 were approximately half of the concentrations measured in Ponce de Leon Creek. SRP accounted for approximately half of the total phosphorus in Clover Creek, whereas nearly all of the phosphorus in Ponce de Leon Creek was SRP (Table 6-3 and Figure 6-1).

Round 2 Sampling – December 2002-January 2003

On December 3, 2002, the discharge volume in Clover Creek was low. At SW-5, the discharge rate was approximately 0.5 cfs with surface flow disappearing approximately 200 feet downstream of the sample station. At SW-4, the stream channel was completely dry (Table 6-3 and Figure 6-4). These observations indicate that Clover Creek loses water in its lower reach and infiltrates the channel bed.

In December 2002, the phosphorus concentrations at SW-5 were approximately the same as the concentrations measured in September (Table 6-3 and Figure 6-1). Observations of Clover Creek throughout December indicated that surface flow did not reappear in the lower reach of the creek until the end of the month.

Round 3 Sampling – March 2003

The stream flow for SW-4 and SW-5 during March 2003 was recorded by the USGS system as 1.6 cfs (Table 6-3 and Figure 6-4). Phosphorus concentrations at SW-4 and SW-5 during the March 2003 sampling events were approximately the same as the concentrations reported for the two previous rounds of sampling. Overall, TDP and SRP concentrations measured in Clover Creek in March 2003 were approximately half of the concentrations measured in Ponce de Leon Creek. SRP accounted for approximately half of the total phosphorus in Clover Creek, whereas nearly all of the phosphorus in Ponce de Leon Creek was SRP (Table 6-3 and Figure 6-1).

Round 4 Sampling – June 2003

The stream flow for SW-4 and SW-5 during June 2003 was recorded by the USGS system as 0.56 cfs (Table 6-3 and Figure 6-4). Phosphorus concentrations at SW-4 and SW-5 during the June 2003 sampling events were approximately the same as the concentrations reported for the three two previous rounds of sampling. Overall, TDP and SRP concentrations measured in Clover Creek in June 2003 were approximately half of the concentrations measured in Ponce de Leon Creek. SRP accounted for approximately half of the total phosphorus in Clover Creek, whereas nearly all of the phosphorus in Ponce de Leon Creek was SRP (Table 6-3 and Figure 6-1).

6.10 SUMMARY OF GROUNDWATER AND SURFACE WATER SAMPLING

The following bullets summarize the key sampling results.

- Surface water in Ponce de Leon Creek and groundwater at MW-5, MW-6, and MW-8 upgradient of the creek contained higher SRP and TDP concentrations than Clover Creek.

- TDP and SRP concentrations in groundwater near the eastern city limits (well AEF 222 and the Springbrook area wells) were about the same or higher than those measured in Ponce de Leon Creek. Thus, phosphorus concentrations did not appear to increase as groundwater flowed beneath the city en route to Ponce de Leon Creek.

- TDP and SRP concentrations in the groundwater were about the same upgradient and downgradient of the buried marsh and peat deposit beneath Lakewood Towne Center.

- TDP and SRP concentrations during the dry season appeared to be slightly higher than during the wet season.

- The peat deposit did not contain higher phosphorus concentrations than the soil samples collected for this study. Moreover, the peat had very low permeability, indicating that groundwater flows preferentially around the peat.

- During Rounds 1, 2 and 4, nearly all of the flow observed in Ponce de Leon Creek discharged from the springs located just west of Gravelly Lake Road. During Round 3 when the water table was high, the Lakewood Towne Center dewatering system accounted for about one-quarter of the discharge in the creek, while the springs accounted for three quarters. Thus, the springs were the primary source of flow to Ponce de Leon Creek.

- Clover Creek flows were considerably lower than those measured in Ponce de Leon Creek during all four sampling rounds. Clover Creek appeared to lose flow to groundwater infiltration throughout the year. Lower Clover Creek was dry during the December 2003 sampling round.

- The highest phosphorus concentrations observed during this study were in samples collected from several of the wells located in the Springbrook area near the eastern city limits. However, the phosphorus concentrations in these wells ranged significantly from round to round.

Figure 6-1
SRP Concentrations in Groundwater and Surface Samples

SW-3	
Rnd	[SRP]
1	43
2	43
3	33
4	33

MW-5	
Rnd	[SRP]
1	31
2	34
3	32
4	32

DW-3	
Rnd	[SRP]
1	40
2	NS
3	28
4	22

Herr-MW-3	
Rnd	[SRP]
1	NS
2	51
3	47
4	45

MW-6	
Rnd	[SRP]
1	42
2	43
3	42
4	39

AEF-250	
Rnd	[SRP]
1	NS
2	NS
3	19
4	21

MW-8	
Rnd	[SRP]
1	43
2	45
3	45
4	42

MW-2	
Rnd	[SRP]
1	14
2	15
3	18
4	20

AEF-222	
Rnd	[SRP]
1	NS
2	NS
3	89
4	76

G-1	
Rnd	[SRP]
1	NS
2	32
3	29
4	35

SW-2	
Rnd	[SRP]
1	43
2	35
3	28
4	31

SW-1	
Rnd	[SRP]
1	38
2	71
3	28
4	23

MW-4	
Rnd	[SRP]
1	13
2	34
3	32
4	36

SW-4	
Rnd	[SRP]
1	14
2	NS
3	11
4	14

Clover-3	
Rnd	[SRP]
1	NS
2	NS
3	33
4	37

CW-45	
Rnd	[SRP]
1	40
2	40
3	38
4	39

SW-5	
Rnd	[SRP]
1	14
2	5
3	14
4	8

CW-62	
Rnd	[SRP]
1	352
2	NS
3	23
4	35

CW-61	
Rnd	[SRP]
1	84
2	331
3	350
4	348

CW-46	
Rnd	[SRP]
1	51
2	48
3	43
4	45

CW-59	
Rnd	[SRP]
1	390
2	166
3	52
4	NS

Seeley Lake
Stellacoom Lake
Ponce de Leon Creek
Lakewood Towne Center
Clover Creek
Gravelly Lake
American Lake

Legend

- Surface Water Sampling Location
- Monitoring Wells
- Street Centerlines
- Waterbodies
- Rnd = Round
- [SRP] = Soluble Reactive Phosphorus Concentration, ug/L
- NS = Not Sampled
- Watercourses
- City Limits

0 1,000 2,000 Feet

BROWN AND CALDWELL

December 2003

Figure 6-2
TDP Concentrations in Groundwater and Surface Samples

SW-3	
Rnd	[TDP]
1	41
2	45
3	34
4	35

MW-5	
Rnd	[TDP]
1	26
2	35
3	34
4	26

DW-3	
Rnd	[TDP]
1	38
2	NS
3	28
4	15

Herr-MW-3	
Rnd	[TDP]
1	NS
2	56
3	51
4	44

MW-6	
Rnd	[TDP]
1	40
2	46
3	44
4	40

AEF-250	
Rnd	[TDP]
1	NS
2	NS
3	20
4	19

MW-8	
Rnd	[TDP]
1	40
2	50
3	48
4	43

MW-2	
Rnd	[TDP]
1	8
2	17
3	17
4	16

AEF-222	
Rnd	[TDP]
1	NS
2	NS
3	82
4	81

SW-2	
Rnd	[TDP]
1	41
2	37
3	29
4	32

SW-1	
Rnd	[TDP]
1	36
2	94
3	27
4	20

MW-4	
Rnd	[TDP]
1	9
2	34
3	33
4	35

G-1	
Rnd	[TDP]
1	NS
2	33
3	30
4	33

SW-4	
Rnd	[TDP]
1	18
2	NS
3	13
4	19

Clover-3	
Rnd	[TDP]
1	NS
2	NS
3	35
4	44

CW-45	
Rnd	[TDP]
1	41
2	47
3	42
4	42

SW-5	
Rnd	[TDP]
1	17
2	9
3	17
4	13

CW-62	
Rnd	[TDP]
1	360
2	NS
3	26
4	33

CW-46	
Rnd	[TDP]
1	48
2	53
3	47
4	40

CW-61	
Rnd	[TDP]
1	84
2	330
3	350
4	349

CW-59	
Rnd	[TDP]
1	390
2	180
3	54
4	NS

Steilacoom Lake
Seeley Lake
Ponce de Leon Creek
Lakewood Towne Center
Gravelly Lake
Clover Creek
American Lake

Legend

- Surface Water Sampling Location
- Monitoring Wells
- Street Centerlines
- Waterbodies
- Rnd = Round
- [TDP] = Total Dissolved Phosphorus Concentration, ug/L
- NS = Not Sampled
- Watercourses
- City Limits

N

0 1,000 2,000 Feet

BROWN AND CALDWELL

December 2003

Figure 6-3
Stream Flow in Ponce de Leon Creek

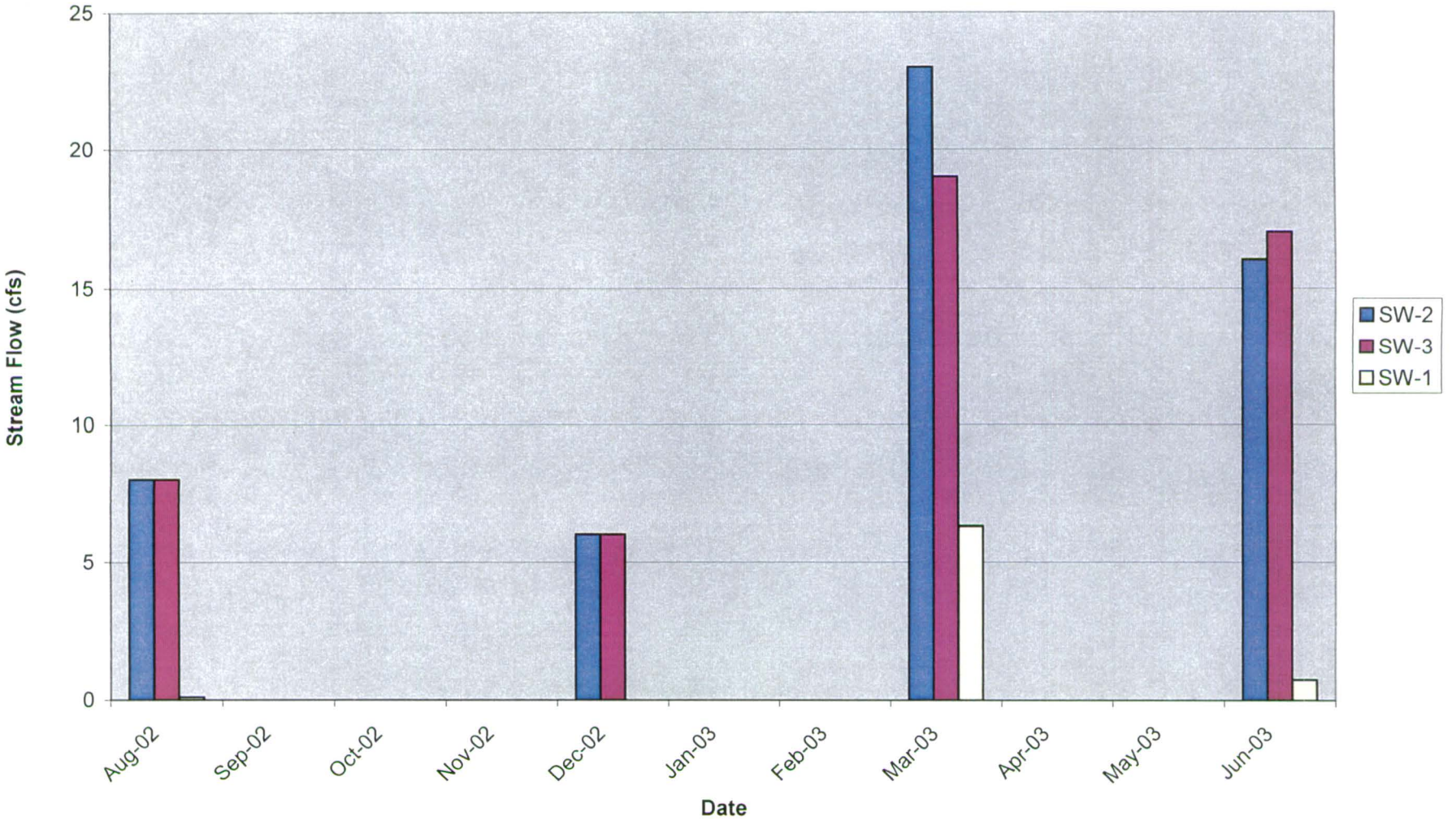


Figure 6-4
Stream Flow in Clover Creek

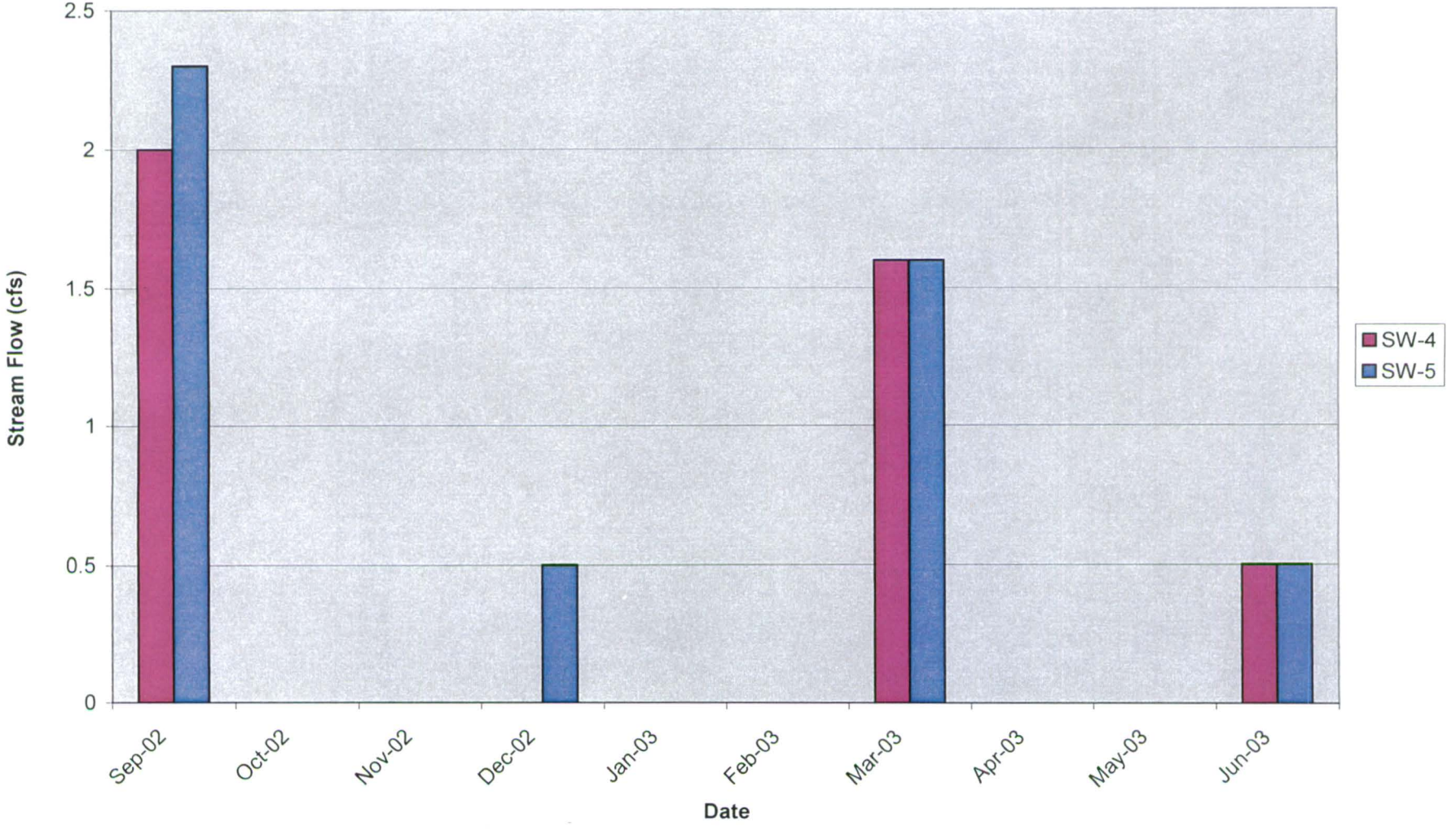


Table 6-3
Phosphorus Sources Study Surface Water Sampling Data

	Dewatering System										Ponce de Leon Creek									Clover Creek							
	DW-1	DW-3				SW-1					SW-2				SW-3					SW-4[a]				SW-5[b]			
	NE Mall Parking Lot	SW Mall Parking Lot				Gravelly Lake Drive Outfall					Springs				Stream Mouth					Gravelly Lake Drive Crossing				South Tacoma Way Crossing			
	3/4/03	8/29/02	12/3/02	3/4/03	6/19/03	2/19/02	8/29/02	12/4/02[c]	3/4/03	6/23/03	8/29/02	12/3/02	3/4/03	6/23/03	2/19/02	8/29/02	12/3/02	3/4/03	6/23/03	9/3/02	12/3/02	3/5/03	6/23/03	9/3/02	12/3/02	3/5/03	6/23/03
Analyte	Round 1	Round 1	Round 2	Round 3	Round 4	Initial	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Initial	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Flow (cfs)	trickle	0.1 est.	0	nm	nm	12	0.1 est.	0	6.3	0.74	8	6	23	16	30	8	6	19	17	2[d]	0	1.6	0.56	2.3[e]	0.5	1.6	0.56
TDP (ug/L)	34	38	nm	28	15	31	36	94	27	20	41	37	29	32	38	41	45	34	35	18	nm	13	19	17	9	17	13
SRP (ug/L)	33	40	nm	28	22	30	38	71	28	23	43	35	28	31	37	43	43	33	33	14	nm	11	14	14	5	14	8
Total P (ug/L)	nm	nm	nm	nm	nm	34	4	109	30	22	40	37	30	35	49	43	47	35	36	28	nm	27	17	25	21	32	16
Temperature °C	12.1	16.2	nm	11.7	nm	10.9	14.9	8.8	11.2	12.15	12.7	12.2	11.5	12.84	10.3	14.5	11.9	11.4	12.40	15.1	nm	8.6	14.2	15.0	6.3	8.5	14.2
pH	6.61	6.09	nm	6.51	nm	5.49	7.20	7.55	6.68	6.69	6.73	6.05	6.70	6.58	6.02	6.88	6.99	6.81	8.37	7.68	nm	6.77	7.07	7.56	6.49	6.79	7.33
Sp. Cond. (us/cm)	137	125	nm	129	nm	128	125	38	129	114	119	135	127	108	137	119	129	130	114	132	nm	139	122	128	149	140	124
DO (mg/L)	8.8	6.0	nm	10.9	nm	8.7	10.4	11.1	9.4	9.6	10.6	8.3	10.5	9.4	7.9	11.7	9.0	10.0	10.9	10.7	nm	11.1	10.7	10.2	9.7	11.6	10.2
ORP (mV)	265	145	nm	245	nm	nm	208	58	227	107	170	216	244	143	nm	158	86	239	66	112	nm	283	131	146	59	288	115

Notes:

a. Sample location SW-4 also identified as USGS 602 and KCM Clover Ck during previous studies.

b. Sample location SW-5 also identified as USGS 500 during previous studies.

c. Little water discharging from culvert. Water infiltrated soil a short distance from the culvert. Therefore, sample probably does not represent flow in the creek.

d. Assumed flow rate based on USGS data for upstream location. Visual observation suggests slightly higher flow.

e. Measurement from USGS time series record

nm: not measured

ug/L - micrograms per liter

mg/L - milligrams per liter

mV - millivolts

us/cm - microsemiens per centimeter

°C - degrees celsius

cfs - cubic feet per second

Table 6-4
Phosphorus Sources Study
Groundwater Sampling Data

	Sample Location																													
	MW-2				MW-4				MW-5				Herr-MW3[a]			MW-6				MW-8				G-1			AEF-250		AEF-222		WS1[b]
	Neighborhood just east of Lakeview Towne Center				Former high flow channel, south of Lakeview Towne Center				North of springs on PDL Creek				Northwest corner of Lakewood Towne Center			Downgradient of Seeley Lake				Lakeview (shallow aquifer)				Lakeview (Salmon Springs aquifer)			Upgradient of Lakeview Industrial Park		I-5 and SR 512 east of Lakeview		Residential tap water from deep aquifers
	8/29/02	12/4/02	3/5/03	6/19/03	8/29/02	12/3/02	3/4/03	6/19/03	8/29/02	12/3/02	3/4/03	6/19/03	11/20/02	2/20/03	5/21/03	8/29/02	12/3/02	3/4/03	6/20/03	8/29/02	12/4/02	3/4/03	6/19/03	1/27/03	3/4/03	6/19/03	3/4/03	6/19/03	3/4/03	6/19/03	9/3/02
Analyte	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3	Round 4	Round 3	Round 4	Round 1
TDP (ug/L)	8	17	17	16	9	34	33	35	26	35	34	26	56	51	44J	40	46	44	40	40	50	48	43	33	30	33	20	19	82	81J	73
SRP (ug/L)	14	15	18	20	13	34	32	36	31	34	32	32	51	47	45J	42	43	42	39	43	45	45	42	32	29	35	19	21	89	76J	76
TOC (mg/L)	<0.250	nm	nm	nm	0.380	nm	nm	nm	0.235	nm	nm	nm	nm	nm	nm	0.364	nm	nm	nm	0.239	nm	nm	nm	0.028	nm	nm	nm	nm	nm	nm	nm
DOC (mg/L)	0.757J	nm	nm	nm	0.536J	nm	nm	nm	1.69J	nm	nm	nm	nm	nm	nm	0.876J	nm	nm	nm	1.36J	nm	nm	nm	na	nm	nm	nm	nm	nm	nm	nm
NO_2/NO_3 (mg/L)	1.57J	nm	nm	nm	0.657J	nm	nm	nm	1.64J	nm	nm	nm	nm	nm	nm	2.98J	nm	nm	nm	1.14J	nm	0.29	nm	0.59	1.28J	nm	1.91	nm	2.49	nm	nm
Chloride (mg/L)	5.9	nm	nm	nm	4.7	nm	nm	nm	4.9	nm	nm	nm	nm	nm	nm	5.6	nm	nm	nm	10.5	nm	3.4	nm	4.70	5.30	nm	3.10	nm	3.90	nm	nm
Sulfate (mg/L)	6.71	nm	nm	nm	5.04	nm	nm	nm	5.37	nm	nm	nm	nm	nm	nm	6.63	nm	nm	nm	23.4	nm	16.6	nm	8.66	10.7	nm	10.4	nm	10.1	nm	nm
$CaCo_3$ (mg/L)	49.4	nm	nm	nm	44.5	nm	nm	nm	40.5	nm	nm	nm	nm	nm	nm	38.3	nm	nm	nm	65.7	nm	33.7	nm	69.8	67.5	nm	53.5	nm	48.6	nm	nm
Fluoride (mg/L)	<0.100UJ	nm	nm	nm	<0.100UJ	nm	nm	nm	<0.100UJ	nm	nm	nm	nm	nm	nm	<0.100UJ	nm	nm	nm	0.145J	nm	nm	nm	0.12	nm	nm	nm	nm	nm	nm	nm
Aluminium (mg/L)	<0.100	nm	nm	nm	<0.100	nm	nm	nm	<0.100	nm	nm	nm	nm	nm	nm	<0.100	nm	nm	<0.100	<0.100	nm	<0.100	nm	<0.100	<0.100	nm	<0.100	nm	<0.100	nm	nm
Calcium (mg/L)	12	nm	nm	nm	10.9	nm	nm	nm	10.8	nm	nm	nm	nm	nm	nm	11.4	nm	nm	10.3	19.0	nm	11.6	nm	15.3	14.7	nm	13.4	nm	12.5	nm	nm
Iron (mg/L)	<0.020	nm	nm	nm	<0.020	nm	nm	nm	<0.020	nm	nm	nm	nm	nm	nm	<0.020	nm	nm	<0.020	<0.020	nm	<0.020	nm	<0.020	<0.020	nm	<0.020	nm	<0.020	nm	nm
Magnesium (mg/L)	4.40	nm	nm	nm	3.67	nm	nm	nm	4.06	nm	nm	nm	nm	nm	nm	4.54	nm	nm	3.99	5.32	nm	3.38	nm	9.34	8.32	nm	6.25	nm	4.06	nm	nm
Manganese (mg/L)	0.074	nm	nm	nm	0.059	nm	nm	nm	<0.005	nm	nm	nm	nm	nm	nm	<0.005	nm	nm	<0.005	0.032	nm	<0.005	nm	<0.005	<0.005	nm	<0.005	nm	<0.005	nm	nm
Potassium (mg/L)	1.84	nm	nm	nm	1.66	nm	nm	nm	1.30	nm	nm	nm	nm	nm	nm	1.49	nm	nm	1.10	4.07	nm	1.69	nm	2.2	1.9	nm	2.2	nm	1.23	nm	nm
Sodium (mg/L)	7.12	nm	nm	nm	5.78	nm	nm	nm	4.77	nm	nm	nm	nm	nm	nm	5.92	nm	nm	5.73	12.3	nm	4.63	nm	5.87	5.55	nm	5.02	nm	6.76	nm	nm
Reference Elevation	263.22	263.22	263.22	263.22	239.22	239.22	239.22	239.22	250.62	250.620	250.620	250.620	nm	nm	nm	263.67	263.67	263.67	263.67	269.33	269.33	269.33	269.33	nm	nm	nm	unk.	unk.	unk.	unk.	nm
Depth to Groundwater	21.30	21.92	17.16	19.91	6.30	6.42	4.12	5.48	15.42	15.48	14.76	14.76	nm	nm	nm	24.59	25.51	22.30	23.86	17.39	17.42	14.22	15.70	nm	nm	nm	23.42	26.50	35.46	39.48	nm
Groundwater Elevation	241.92	241.30	246.06	243.31	239.92	239.80	242.10	240.74	235.20	235.14	235.86	235.86	nm	nm	nm	239.08	238.16	241.37	239.81	251.94	251.91	255.11	253.63	nm	nm	nm	nm	nm	nm	nm	nm
Temperature (°C)	12.46	11.71	11.5	12.5	14.12	12.39	11.71	12.4	13.31	12.00	11.91	12.43	12.9	nm	12.3	13.84	13.01	13.01	12.4	15.2	13.91	12.63	13.15	nm	12.37	11.80	12.36	13.18	11.51	12.63	21.70
pH	6.18	6.34	6.30	6.18	5.72	6.04	6.21	6.07	6.06	6.14	6.25	6.17	6.15	nm	6.38	5.93	6.10	6.30	6.20	7.16	6.36	6.85	6.41	nm	6.85	6.8	6.87	7.38	6.04	6.58	6.88
Sp. Conduct. (us/cm)	134	120	122	112	118	124	129	105	119	127	124	109	146	nm	134.2	130	172	140	120	210	93	138	138	nm	191	159	175	142	175	127	147
DO (mg/L)	7.02	8.83	8.46	7.66	4.62	7.81[c]	7.03	8.11	9.43	9.04	8.54	8.11	5.74	nm	7.5	9.18	9.78	8.12	9.11	1.34	7.39	2.11	6.04	nm	9.09	2.12	6.68	6.91	8.89	9.56	6.12
ORP (mV)	160.4	210	283	177.2	320.6	79.6[c]	256	173	180.4	152	245	170	nm	nm	nm	230.2	67[c]	245	132	-179.6	61.9	216	137.7	nm	383	81	215	131.6	214	156.9	166.6

Notes:

a. Herrera Consultants measured water quality parameters at HERR-MW-3. HERR-MW3 not surveyed to same datum as wells installed by URS.

b. WS-1 was a tap water sample representing up to 29 drinking water supply wells.

c. Readings indicate possible instrument error.

na: Insufficient volume of water to complete analysis.

nm: not measured.

J: Estimated value

U: Compound was analyzed for but not detected above the reporting limit.

Table 6-5
Phosphorus Sources Study
Groundwater Sampling Data
Springbrook Neighborhood Wells

	CW-37	CW-39	CW-45				CW-46				CW-53	CW-54	Clover 3		CW-59[a]			CW-61					CW-62				
	1,200 ft. SE of park	900 ft. SE of park	400 ft. east of park				200 ft. south of CW-45				100 ft. north of CW-45	500 ft. north of CW-45	600 ft. north of CW-45		150 ft. south of SW corner of park			30 ft. west of NW corner of park					300 ft. north of NW corner of park (bank of Clover Creek; creek bottom at ~266 ft msl)				
	6/19/01	6/19/01	9/23/02	12/5/02	3/5/03	6/18/03	9/23/02	12/5/02	3/5/03	6/18/03	6/19/01	6/19/01	3/5/03	6/20/03	9/24/02	12/5/02	3/5/03	6/19/01	9/24/02	12/5/02	3/5/03	6/18/03	6/19/01	9/24/02	12/5/02[b]	3/5/03	6/18/03
Analyte	Historical	Historical	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Historical	Historical	Round 3	Round 4	Round 1	Round 2	Round 3	Historical	Round 1	Round 2	Round 3	Round 4	Historical	Round 1	Round 2	Round 3	Round 4
TDP (ug/L)	nm	nm	41	47	42	42	48	53	47	40	nm	nm	35	44	390	180	54	nm	84	330	350	349	nm	360	nm	26	33
SRP (ug/L)	13	12	40	40	38	39	51	48	43	45	43	24	33	37	390	166	52	279	84	331	350	348	8	352	nm	23	35
Total P (ug/L)	nm	nm	45	nm	nm	nm	117	nm	nm	nm	nm	nm	nm	nm	1930	nm	nm	nm	75	nm	nm	nm	nm	388	nm	nm	nm
Reference Elevation	293.77	292.80	288.99	288.99	288.99	288.99	257.94	257.94	257.94	257.94	289.01	282.94	nm	nm	285.01	285.01	285.01	286.24	286.24	286.24	286.24	286.24	273.50	273.50	273.50	273.50	273.50
Depth to Groundwater	27.34	28.97	30.22	31.00	27.19	29.92	30.50	30.25	26.49	28.90	30.05	12.98	nm	nm	27.80	28.21	23.38	29.59	28.11	31.80	27.00	29.50	17.48	20.09	nm	14.04	17.41
Groundwater Elevation	266.43	263.83	258.77	257.99	261.8	259.07	257.94	258.19	261.95	259.54	258.96	258.96	~260	~260	257.21	256.8	261.63	256.65	258.13	254.44	259.24	256.74	256.02	253.41	nm	259.6	256.09
Temperature (°C)	13.42	13.8	13.24	11.47	10.7	13.61	13.24	10.51	10.77	13.46	12.53	13.34	9.39	12.37	12.59	11.96	10.36	15.14	13.18	12.78	11.39	12.5	14.35	13.48	nm	8.96	11.14
pH	6.5	6.25	7.28	6.81	7	6.74	7.05	6.68	6.79	6.96	6.75	7.02	6.52	6.37	7.02	6.94	6.58	8.13	6.92	6.91	7.26	7.36	6.71	6.81	nm	6.4	6.14
Sp. Conduct. (us/cm)	203	109	212	879	228	192	178	203	188	192	185	156	160	123	204	208	132	189	202	182	173	146	194	194	nm	137	118
DO (mg/L)	4.9	3.8	2.2	2.31	2.41	1.79	3.33	3.57	4.24	3	5.6	7.1	4.03	5.19	3.5	3.82	6.46	1.5	3.1	2.81	6.72	3.18	3.7	1.81	nm	5.56	6.48
ORP (mV)	465	473	386	207	293	115.9	387	195	289	119.7	389	310	287	152.8	361	304	287	84	374	389	289	119.5	203	100	nm	291	160.8

Notes:

a. Water removed from well during both sampling rounds was very turbid, which may influence total P and water quality parameter measurements. This well was inaccessible during the June 2003 sampling.

b. Access to this well was obstructed by broken-down vehicle. Sampling team could not locate owner.

nm: not measured

ug/L - micrograms per liter

mg/L - milligrams per liter

°C - degrees celsius

us/cm - microsemiens per centimeter

mV - millivolts

7.0 POTENTIAL SOURCES OF PHOSPHORUS TO THE GROUNDWATER ENTERING LAKE STEILACOOM

Potential phosphorus sources were evaluated through a three-step process:

- Delineate the key groundwater flow path(s) to Lake Steilacoom
- Measure phosphorus concentrations at various locations along and adjacent to the groundwater flow path(s)
- Identify potential phosphorus sources along the key groundwater flow paths, and evaluate each potential source in light of the observed spatial and temporal variations in groundwater phosphorus concentrations

7.1 GROUNDWATER FLOW PATHS

As discussed in Section 3.3, Lake Steilacoom is bounded by an aquitard. There appears to be little direct groundwater inflow to Lake Steilacoom. Groundwater is the primary source of flow in Ponce de Leon Creek, however, and Ponce de Leon is the main source of flow to the lake during the dry season . Much of Ponce de Leon Creek flow comes from springs located a short distance west of the Lakewood Towne Center upgradient of Lake Steilacoom. During the summer months, these springs supply virtually all of the flow to Ponce de Leon Creek.

In contrast, Clover Creek loses flow via infiltration throughout the year, and often has no surface flow in the later summer and fall. The seepage occurs because the groundwater table elevation is consistently lower than the creek channel elevation. While there may be some subsurface contribution to Lake Steilacoom through the Clover Creek alluvium, this is expected to be minor. Ponce de Leon Creek appears to be the primary pathway by which groundwater enters Lake Steilacoom. No comparison to rainfall contribution has been made.

The available groundwater elevation data indicates that groundwater flows into Ponce de Leon is from the Aquifer A areas east and southeast of the city (Figure 3-6). The main groundwater flow direction in Aquifer Zone A within the study area is from the east/southeast to the west/northwest.

Aquifer A within Lakewood is recharged from numerous dry wells and direct infiltration through pervious areas. In addition, it is possible that the groundwater from the deeper Aquifers C and E aquifers may communicate with Aquifer A in locations where the low-permeability aquitards (i.e., the B and D layers) are thin or absent. One such area is located just east of the city limits (Figure 3-8).

7.2 PHOSPHORUS CONCENTRATIONS ALONG FLOW PATH

Phosphorus concentrations were measured at various locations in the study area (Figures 6-1and 6-2). The key findings include:

- SRP concentrations in the groundwater-fed Ponce de Leon Creek were about the same as those measured upgradient of the Lakewood Towne Center. There was no apparent increase in phosphorus concentrations between the farthest upgradient monitoring locations near the eastern city limits and the groundwater discharge into Ponce de Leon Creek.

- Groundwater samples collected from Ponce de Leon Creek during the wet season (Rounds 3 and 4) had lower SRP concentrations than the dry season (Rounds 1 and 2, and preliminary (February 2002) samples. This suggests that phosphorus concentrations were diluted by recharge water containing relatively low phosphorus concentrations.

- SRP concentrations in groundwater in the Springbrook area near the eastern City limits were highly variable. Very high concentrations were observed in some wells, while other nearby wells had concentrations similar to those observed in Ponce de Leon Creek.

- Clover Creek had much lower SRP concentrations than did Ponce de Leon Creek or the groundwater upgradient of Ponce de Leon Creek. As noted above, Clover Creek "loses" flow via seepage to groundwater; thus, there is probably little groundwater discharge entering Lake Steilacoom via the Clover Creek channel.

7.3 POTENTIAL PHOSPHORUS SOURCES

Pollutant sources can generally be categorized as either point (emanating from a discrete location, such as a wastewater treatment plant outfall) or non-point (emanating for multiple small or diffuse sources, such as urban runoff). Review of Ecology's NPDES permit database and existing and historic land use information did not identify any potential point sources along the main groundwater flow path within the city. Thus, the observed phosphorus very likely comes from non-point sources.

Ecology's non-point source management plan for the state defines the following general categories of non-point pollution sources:

- Agriculture
- Forest practices
- Recreation
- Hydromodification
- Urban areas
- Loss of aquatic ecosystems

In addition to these anthropogenic sources, natural organic and mineral soil deposits can be important sources of phosphorus in some situations (Woodward-Clyde 1998).

URS and Brown and Caldwell reviewed the available information on existing and historic land uses, hydrology, wastewater treatment systems, and soils in order to identify which of these potential categories might be important sources of phosphorus to the groundwater entering Lake Steilacoom. The results of this initial screening are summarized as follows:

- Agriculture and forest practices are minor land uses within the area upgradient of Lake Steilacoom. Agriculture and forest lands account for about 0.5% and 19%, respectively, of the entire Clover Creek-Lake Steilacoom watershed (Pierce County 1997). There is little commercial forestry within the watershed. Moreover, the agricultural and forest land uses that do exist are concentrated in the eastern portion of the basin, far from the lake. As shown in Figure 7-1, neither of these land uses occurs along the main groundwater flow path within the City of Lakewood. Therefore, agricultural and forest practices are very unlikely to be significant sources of phosphorus to the groundwater flowing to Lake Steilacoom.

- Recreational activities (boating, marinas) are very unlikely to contribute significant phosphorus to the groundwater entering the lake, as there is little water-based recreation in the basin, and none along the main groundwater flow path within the City of Lakewood.

- Hydromodification has clearly affected Lake Steilacoom. The lake itself is an artificial impoundment, and its main tributaries (Clover and Ponce de Leon Creeks) have been subject to substantial channel alterations during the past 100 years. Streambank erosion (due to altered basin hydrology) could have affected some of the upper reaches of Clover Creek. However, these hydromodifications are unlikely to be significant sources of phosphorus for the groundwater entering the lake. Streambank erosion could be a source of suspended phosphorus in Clover Creek, but suspended phosphorus particles are quickly filtered out as water seeps through the ground; thus, suspended phosphorus in Clover Creek seepage is very unlikely to reach the lake via groundwater transport. Ponce de Leon Creek is fed primarily by groundwater discharges that are caused by local hydrogeologic conditions rather than hydromodification of surface water channels. Because it is fed primarily by groundwater, Ponce de Leon Creek does not show a rapid response to storm events (KCM 1996), and shows little evidence of channel erosion.

- Urban areas could contribute phosphorus to the groundwater entering the lake via infiltration of stormwater runoff. There are numerous stormwater infiltration "dry wells" throughout the basin, including many along the main groundwater flow path. In addition, historic and active on-site septic systems are potential sources.

- Loss of aquatic ecosystems—specifically, loss of the Atwood Marsh beneath the Lakewood Towne Center—has been mentioned as a potential cause of the elevated phosphorus concentrations found in the groundwater-fed Ponce de Leon Creek (Templeton 2003). Natural wetlands often function as pollutant traps or sinks, and

constructed wetlands are commonly used for stormwater quality treatment. Wetland filling can reduce or eliminate this water quality treatment function.

- The Lake Steilacoom basin contains organic deposits that have the potential to contribute phosphorus to the groundwater entering the lake. KCM (1996) hypothesized that muck soils were the primary source of the phosphorus in the groundwater entering Ponce de Leon Creek. Phosphorus is also a constituent of several minerals commonly found in soils derived from volcanic deposits and igneous rocks.

Based on this initial review, agriculture, forest practices, recreation, and hydromodification were deemed very unlikely to be significant sources of phosphorus to the groundwater entering Lake Steilacoom. Urban runoff, on-site wastewater treatment (septic systems), loss of the Atwood Marsh, and natural organic and mineral deposits were judged to warrant more detailed evaluation. These more detailed evaluations are described in Sections 7.3.1 through 7.3.4 below.

7.3.1 Urban Stormwater Runoff

Stormwater runoff from developed areas often contains elevated phosphorus concentrations. Typical sources include soil erosion, excessive fertilizer use, pet waste, urban wildlife (e.g., geese and ducks) waste, certain cleaning products, and decomposing leaves (Caraco and Brown 2001). In addition, precipitation itself can contain appreciable phosphorus concentrations. For example, precipitation samples collected for the American Lake Phase I Restoration Study had a mean phosphorus concentration of 37 μg/L (KCM 1993).

Urban runoff typically contains phosphorus in both suspended particulate and dissolved forms. Phosphorus in suspended or particulate form is not expected to move very far through the ground due to physical filtering and settling (Woodward-Clyde 1998). Dissolved phosphorus is strongly retained in most soils due to a variety of attenuation processes including adsorption on iron and aluminum hydroxides and chemical precipitation reactions. Because of these removal mechanisms, infiltration can be an effective "Best Management Practice" for removing phosphorus from stormwater runoff (Caraco 2001). However, infiltration may be less effective for phosphorus removal in areas where the soils are excessively permeable and have low clay or organic matter content (Ecology 2001).

Adolfson Associates Inc. conducted a preliminary evaluation of the potential impacts of dry wells on groundwater quality in the general vicinity of the Lake Steilacoom study area. Their report stated that "ortho-phosphorus levels in the groundwater were slightly higher than the drywell samples..." (Adolfson 1989). Therefore, phosphorus was dropped as a parameter of concern for Adolfson's subsequent, more detailed study of drywell impacts, which was completed in 1995 (Personal communication with Lisa Adolfson, February 2002).

A recent study in the American Lake basin just south of Lake Steilacoom involved sampling of several large stormwater outfalls. Total phosphorus concentrations in the stormwater samples ranged from 10 to 80 μg/L (Woodward-Clyde 1998). Most of the American Lake basin is covered by very permeable soils similar to those of the Lake Steilacoom basin.

Much of the Clover Creek/Lake Steilacoom basin is covered with very permeable soils. In these areas, most stormwater runoff is infiltrated via "dry wells," which are basically open-bottom concrete catchbasins. There are approximately 800 dry wells located within the Clover Creek-Lake Steilacoom basin (KCM 1996). About half of these are located within the City of Lakewood on or near the main groundwater flow path to Ponce de Leon Creek (Figure 7-2).

Phosphorus concentrations at the farthest upgradient monitoring locations near the eastern City limits were about the same or higher than those measured at the downgradient locations where groundwater discharges into Ponce de Leon Creek, despite the numerous dry wells in the area. Moreover, there was no apparent relationship between SRP concentrations and proximity to dry wells (Figure 7-3).

Phosphorus concentrations in stormwater often vary depending on the local land use activities. For example, single-family residential areas may have more fertilizer use, and thus higher phosphorus concentrations, than commercial or industrial areas with little landscaping. SRP concentrations were similar along the groundwater flow path through the city, however. There was no apparent relationship between groundwater phosphorus concentrations and land uses near the monitoring locations (Figure 7-4).

The lack of a clear relationship between land use and groundwater phosphorus concentrations could be attributable to soil permeability and/or geochemical conditions. As noted in Section 3.2 above, because of the highly permeable soils, areas that are not covered by impervious surfaces generate little runoff; most precipitation infiltrates through the surficial soil into the aquifer. In areas where impervious surfaces discharge onto pervious surfaces (e.g., roof downspouts draining onto lawns), much of the runoff probably infiltrates before reaching the dry wells. Thus, the flow reaching drywells is predominantly from paved areas and roofs that are directly connected to the dry wells, with relatively little runoff from adjacent fertilized areas (e.g., lawns, gardens). Waschbusch et al. (1997) found that geometric mean total phosphorus concentrations in lawn runoff were two to eight times the concentrations measured in runoff from residential feeder streets. They estimated that lawns contributed about 69-75% of the dissolved phosphorus loads in the basins studied, while streets, driveways, parking lots, and roofs contributed 15-21%, 6-8%, 0-1%, and 1-4%, respectively. Moreover, they found that about 50% of the particulate phosphorus in "street dirt" samples was in the relatively coarse (>250 um) size fraction.

It is also possible that groundwater phosphorus concentrations are controlled primarily by geochemical conditions, such as adsorption on ferric hydroxides and mineral dissolution. Geochemical conditions are discussed in Section 7.4 below.

If stormwater was a significant source, phosphorus concentrations might be expected to increase during the wet season when stormwater infiltration is occurring. This trend was not observed in the present study, however. Samples collected from Ponce de Leon Creek during the wet season (Round 3) had slightly lower SRP concentrations than the dry season (Rounds 1 and 2) samples (Figure 6-1).

The results of the present study are consistent with those of a phosphorus source study in the American Lake basin (Woodward-Clyde 1998). American Lake is about two miles south of Lake Steilacoom. Most of the American Lake basin is covered by permeable outwash soils

similar to those of the Lake Steilacoom basin. The Tillicum area on the eastern shore of American Lake is densely developed with numerous dry wells and septic systems, while the area upgradient of Tillicum (Fort Lewis) is served by storm and sanitary sewers. Groundwater phosphorus concentrations were similar in monitoring wells upgradient and downgradient of Tillicum. Stormwater samples collected during the American Lake study contained 0.01 to 80 μg/L total phosphorus. The report concluded that dry wells were not a key phosphorus source in the American Lake basin (Woodward-Clyde 1998).

As noted above, it is possible that geochemical conditions are masking the effects of dry wells. Consequently, urban stormwater infiltration cannot be ruled out as a source for the phosphorus observed in the groundwater entering the city.

A wetland known as Atwood Marsh was formerly present in the current location of the Lakewood Towne Center, just east of Ponce de Leon Creek (Figure 1-1). In the 1950s, the wetland was covered with fill and a shopping center was built over it. As noted above, natural wetlands often function as pollutant traps or sinks, and constructed wetlands are commonly used for stormwater quality treatment.

A recent report hypothesized that Atwood Marsh functioned to reduce phosphorus loadings entering Lake Steilacoom. The report suggested that covering of the marsh (by the Villa Plaza Shopping Center, now the Lakewood Towne Center) eliminated this water quality treatment function and allowed more phosphorus to reach Ponce de Leon Creek and Lake Steilacoom (Templeton 2003).

The results of this study and other available data do not support this hypothesis. Wetlands—even constructed wetlands designed specifically for water quality treatment—appear to have a finite capacity to remove dissolved phosphorus (Caraco 2001). According to the National BMP Database, the "irreducible" soluble phosphorus concentration for discharges from water quality wetlands ranges from 60 to 120 μg/L (Winer 2000). The "irreducible" concentration is the minimum achievable effluent concentration for a properly designed and constructed water quality wetland. The soluble phosphorus concentrations measured in the groundwater upgradient of the Atwood Marsh ranged from 42 to 45 μg/L – well below the "irreducible" phosphorus concentrations cited above. Thus, it is unlikely that Atwood Marsh would have reduced soluble phosphorus concentrations in the groundwater flowing into it.

The Templeton report also suggested that the mall drainage system "eliminated biofiltration" and increased phosphorus delivery to the creek and the lake. However, the mall dewatering system is generally above the water table during the dry season, so it has no effect on groundwater flow during those months. During the summer and fall dry season, nearly all of the flow in Ponce de Leon Creek is from a series of natural springs located about 150 feet west of the Lakewood Towne Center. Moreover, soluble phosphorus concentrations in Ponce de Leon Creek decreased during the wet season. If the mall dewatering system was delivering high phosphorus loadings to the creek, wet season concentrations would increase, not decrease.

Algal blooms in the lake began in the early 1950s (perhaps earlier), before the Atwood Marsh was covered or the mall dewatering system was installed.

7.3.2 On-Site Wastewater Treatment Systems

Effluent from on-site wastewater treatment (septic) systems typically contains high phosphorus concentrations. A study conducted during 1991–1994 by TPCHD reported an average phosphorus concentration of 70 μg/L in "typical" septic tank effluent, and an average concentration of 30 μg/L at a depth of about three feet below the drainfields. The septic systems included in the TPCHD study were located in permeable soils similar to those found in the Clover Creek-Lake Steilacoom basin. It should be noted that typical phosphorus concentrations could have declined since the TPCHD study, because phosphorus was effectively eliminated from laundry detergents in 1994.

Phosphorus from septic systems is generally strongly retained in soils. Jones and Lee (1977) and Alhazar, Harkin, and Chesters (1989) reported that phosphorus concentrations are typically reduced by about 99% within 30 feet of a single, isolated septic system. Harmon et al. (1996) found greater than 98% removal of phosphorus within 300 feet downgradient of a 44-year commercial (elementary school) septic system in a shallow, very permeable sand aquifer. Stollenwerk (1996) reported that phosphate from an historic sewage plume was attenuated by aquifer sediment (after) 800 m.

The surficial soils covering much of the Clover Creek/Lake Steilacoom basin are permeable and have relatively low organic matter and clay contents. Consequently, they could have less phosphorus removal capacity than other soils and more potential for phosphorus transport.

The area surrounding Lake Steilacoom has been served by sanitary sewers since the early 1980s (KCM 1996). There are few active on-site septic systems within the City of Lakewood on or near the groundwater flow path to Lake Steilacoom. As noted in Section 7.2, phosphorus concentrations in the upgradient wells (i.e., near the city limits) were high. There are approximately 13,000 septic systems located in the eastern portion of the Clover Creek surface water basin, about 4 to 12 miles east of the Lakewood city limits (Pierce County 1997). These active septic systems could potentially contribute phosphorus to the underlying aquifers, and some of the groundwater from these areas could eventually flow into Ponce de Leon Creek. In addition, residual phosphorus from historic septic systems in the Lakewood portion of the study area could still be influencing groundwater quality.

Geochemical modeling was performed to assess whether historic septic systems formerly present in Lakewood or active systems in the eastern portion of the Clover Creek/ Lake Steilacoom basin could be sources of phosphorus to the groundwater entering the lake. Section 7.4 describes the modeling approach and results.

In December 2003, TPCHD initiated a groundwater monitoring study that encompasses the area east and southeast of the City of Lakewood. Groundwater samples will be analyzed for phosphorus as well as major anions and cations (Ray Hanowell, personal communication). The results may help determine whether septic systems east of Lakewood are a significant contributor to the groundwater entering Lake Steilacoom.

7.3.3 Organic Deposits

The Phase I Lake Restoration Study for Lake Steilacoom (KCM 1996) suggested that the primary source of the phosphorus in Ponce de Leon Creek may be the organic deposits buried beneath the Lakewood Mall. Peat and muck (a combination of decomposed peat, organic matter, and silt) are known to be present at various depths and locations in the Clover Creek/Lake Steilacoom basin.

Peat deposits in western Washington contain total phosphorus concentrations ranging from 500 to 15,200 mg/kg (Rigg 1958). Studies conducted in northern Europe found that the discharge from peat dewatering can contain high phosphorus levels.

In January 2002, soil borings were drilled and soil and groundwater samples were collected from various locations within the Lakewood Towne Center. The samples were collected to evaluate the potential for the former Atwood Marsh and underlying peat deposit to contribute phosphorus to the groundwater entering Ponce de Leon Creek and Lake Steilacoom. The samples were collected during a brief period when many of the old mall buildings had been removed prior to construction of the Towne Center.

Peat samples were collected from laterally and vertically representative areas of the deposit and analyzed for total phosphorus. The peat samples collected from the interior of the deposit were dry, indicated that the peat deposit has very low permeability. Oxidizing conditions were observed at the outer surface of the peat while reducing conditions were observed on the interior to the core of the peat. The low permeability suggests that groundwater flows preferentially around the deposit, through the more permeable soils.

Groundwater samples were collected from saturated areas adjacent to the peat. The samples were analyzed for soluble phosphorus. Analyses of peat samples indicated a mean total phosphorus concentration of 340 mg/kg, which is lower than many of the peat deposits in Western Washington (Rigg 1958) and similar to or lower than concentrations measured in the surrounding soil as part of this investigation. Samples from groundwater from locations in direct contact with the peat deposit contained a mean TDP concentration of 17 μg/L, approximately half of which was represented by SRP (mean of 7 μg/L). Conversely, groundwater samples collected from the periphery of the peat deposit contained TDP as high as 24 μg/L with SRP concentrations essentially equal to the TDP.

Overall, the groundwater samples in contact with and around the peat deposit contained less phosphorus than the samples from Ponce de Leon Creek, which suggests that the peat deposit is not a significant source of phosphorus to the groundwater. This is not surprising, since primary groundwater appears to flow around rather than through the peat due to its relatively low permeability.

Deposits of muck and other organic materials are known to be present at various locations and depths in the study area. A recent phosphorus source study conducted for the neighboring American Lake watershed (characterized by similar geology and soils) found that elevated groundwater phosphorus concentrations had little apparent relationship to land use (Woodward-Clyde 1998). The study concluded that muck soils and other phosphorus-rich material in the

basin were the primary source of phosphorus in groundwater. However, the current study did not "bracket" any known organic deposits aside from the Atwood Marsh deposit noted above.

In summary, the groundwater monitoring results suggest that the organic deposits around Atwood Marsh are not a source of phosphorus to the groundwater entering Lake Steilacoom. However, geochemical modeling indicates that phosphorus-bearing minerals could be an important phosphorus source, as discussed in Section 7.4 below.

7.4 GEOCHEMICAL MODELING OF GROUNDWATER PHOSPHORUS SOURCES

Geochemical modeling was performed to evaluate whether the phosphorus concentrations observed in the study area groundwater could be attributed to septic system drainfields or to natural processes such as the dissolution of phosphate-bearing minerals below the water table. The results of the modeling are discussed below.

7.4.1 Model Setup

The USGS-supported software PHREEQC (Parkhurst and Appelo 1999) was used to model a 3-km flow path within the City of Lakewood. This flow path was selected to approximate the distance between the Springbrook area (where phosphorus concentrations as high as 400 μg/L have been reported) and Lake Steilacoom. Because PHREEQC can only simulate 1-D transport, transverse dispersion is not included in model predictions. Assuming that the correct chemical and hydrologic properties of the saturated zone are used, this implies that predicted concentrations are *upper* estimates of actual, *in situ* values downgradient of a single, isolated septic system drainfield.

Two numerical column experiments were set up as shown on Figure 7-5. The columns were discretized into thirty 100-meter grid cells and the initial chemical and hydrologic properties shown in Table 7-1 were applied. The initial chemical concentrations in the groundwater corresponded to average values reported in URS and Brown and Caldwell (2004). The exception was dissolved phosphorus, which was initially set to 1 μg/L (a value lower than measurements), so that the effects of different phosphorus sources could be examined. Also, the minerals ferrihydrite, gibbsite, and amorphous silica were used to buffer groundwater concentrations of iron, aluminum, and silicon, respectively.

At the beginning of each experiment, groundwater was added to the top of each column to maintain a constant flow rate of 25 ft/day for 75 years (flow rate from URS and Brown and Caldwell 2004). The following scenarios were examined:

1) In the first column (Scenario 1), a single, isolated septic source was assumed to be active for the period 1930-1980. This scenario was designed to simulate phosphorus plumes from decommissioned septic systems in the City of Lakewood (decommissioning occurred around 1980 [KCM 1996]). Phosphorus was added at the top of the column at a concentration of 5,000 μg/L for the first 50 years of the simulation. This concentration approximates the upper limit of groundwater concentrations measured below active sewage drainfields (Robertson and Harman 1999). For the remaining 25 years (1980-2004), a background concentration of

1 μg/L was used for the influent. Precipitation and dissolution of secondary phosphate minerals (in this case, strengite) were also allowed to occur near the discharge source (the presence of secondary minerals has been documented by Zanini et al. 1998). Precipitation and dissolution were modeled as kinetic (time-dependent) processes using the reaction rates reported by Parkhurst et al. (2003).

2) In the second column (Scenario 2), background groundwater dissolved phosphorus concentrations were applied for the entire 75-year simulation period (1930-2004). This scenario was designed to simulate dissolved groundwater phosphorus concentrations in the presence of natural sources. In order to achieve this objective, hydroxyapatite was assumed to be present in the saturated soil. The model then allowed the mineral to dissolve or precipitate over time using the reaction rates reported in Palandri and Kharaki (2004). Although a calcium-bearing phosphate minerals were identified in sample PD-4 at a concentration of 10 mg/kg, the HCl sequential extraction can underestimate actual concentrations (Ruban et al. 1999). Consequently, an additional column experiment was run using 50 mg/kg phosphorus as hydroxyapatite.

The HFO concentration used in this study was 0.2%, a value derived from the numerical modeling of a sewage plume in other glacial deposits (Parkhurst et al. 2003). This concentration is similar to the measured concentration of HFO (0.4% by weight) for sample PD-4 (URS and Brown and Caldwell 2004). Also, all of the column experiments were assumed to contain dissolved oxygen at a concentration of 4 mg/L. The relatively oxidizing conditions are consistent with field data from the study area and groundwater analyzed from the vicinity of other septic systems (Robertson et al. 1998). Oxidizing conditions can occur where organic carbon and reduced species are attenuated in the vadose zone (Robertson and Harman 1999). Finally, the effect of using a groundwater velocity of 5 ft/day was examined (results not shown). It was found that lower velocities caused the predicted distance traveled by the phosphorus plumes for Scenario 1 to be less. For Scenario 2, the distance to reach a steady-state concentration was similarly reduced.

7.4.2 Results of Column Experiments

Scenario 1: Septic System Loads (1930-1980) and Background (1980-2004)

Figure 7-6 shows current (2004) predicted dissolved groundwater phosphorus concentrations downgradient of a single, isolated septic system drainfield after 50 years of operation and 25 years of recovery. Dissolved phosphorus concentrations between 100 and 500 meters are approximately 100 μg/L, and are controlled by the relative rates of strengite dissolution and groundwater flow. At greater distances, concentrations are less, and are controlled by equilibrium partitioning of phosphorus between HFO and groundwater (the reason that strengite is not controlling concentrations at these distances is that dissolved phosphorus concentrations were never high enough to precipitate the mineral during active septic system use).

As shown on Figure 7-6, the maximum downgradient extent of the phosphorus plume is approximately 1 km. This result is consistent with Stollenwerk (1996), which states, "Phosphate in the sewage plume is attenuated by aquifer sediment (after) 800 m." Although this result

implies that historical releases could affect current dissolved phosphorus concentrations even after 25 years, a single, isolated septic system located more than 1 km upgradient of Lake Steilacoom would likely be only an insignificant contributor to the current phosphorus mass loading of the lake.

Considering that the total number of former septic systems in the City of Lakewood may have been as high as 2,000, it is possible that phosphorus plumes from multiple septic systems interacted along the same groundwater flow path. In this case, the effect on dissolved phosphorus concentrations in the aquifer would be additive. For example, if another system was located 500 meters downgradient of the modeled drainfield shown on Figure 7-6, then the distance that strengite was precipitated during active septic system use would extend to 1,000 meters. This implies that after the septic system use was discontinued for 25 years, there would be a relatively uniform dissolved phosphorus plume with a concentration of 100 μg/L for this distance.

The primary uncertainty in this geochemical model analysis is the magnitude of the relatively uniform dissolved phosphorus concentration in the presence of strengite. Factors such as mineral dissolution rates and groundwater flow rates could cause dissolved phosphorus concentrations to lie either in the range of monitoring wells CW or monitoring wells MW, SW, and AEF. For example, if dissolution was a faster process, or groundwater flow rates were slower, then dissolved phosphorus concentrations would be less. Without mineralogical data confirming the presence of secondary phosphorus minerals, it is possible that septic systems could be responsible for observed concentrations using geochemical models

Scenario 2: Aquifer Soil Mineral Dissolution (1930-2004)

Figure 7-7 shows current (2004) predicted dissolved groundwater phosphorus concentrations within the modeled column of soil where the influent phosphorus concentration is 1 μg/L and hydroxyapatite dissolution is allowed to occur within the aquifer. As shown on Figure 7-7, there is an initial increase in dissolved phosphorus concentration as the inflowing groundwater accumulates dissolving hydroxyapatite, but a uniform, steady-state phosphorus concentration of approximately 36 μg/L is eventually reached. The relative magnitude and consistency of the phosphorus concentrations for the case where there is 10 mg/kg phosphorus as hydroxyapatite is consistent with monitoring data from the MW, SW, and AEF wells. The relative magnitude and consistency of the phosphorus concentrations for the case where there is 50 mg/kg of phosphorus as hydroxyapatite is consistent with monitoring data from the CW wells.

7.4.3 Conclusions of Geochemical Modeling

The additional geochemical modeling presented in Figure 7-6 suggests that historical septic systems could have contributed to the current dissolved phosphorus groundwater concentrations. The modeling also shows that dissolution of phosphorus-bearing minerals in the aquifer could account for the observed magnitude and consistency of phosphorus concentrations in the monitoring well samples.

Figure 7-1
Current Land Use in the Study Area

Figure 7-2
Dry Wells in Study Area

Steilacoom Lake
Seeley Lake
Lakewood Towne Center
Ponce de Leon Creek
Gravelly Lake
Clover Creek
American Lake

Legend
- Dry Wells
- Street Centerlines
- Waterbodies
- Infiltration Trench
- Watercourses
- City Limits

N

0 1,000 2,000 Feet

BROWN AND CALDWELL

December 2003

Figure 7-3. Soluble Reactive Phosphorus Concentration vs. Number of Nearby Dry Wells

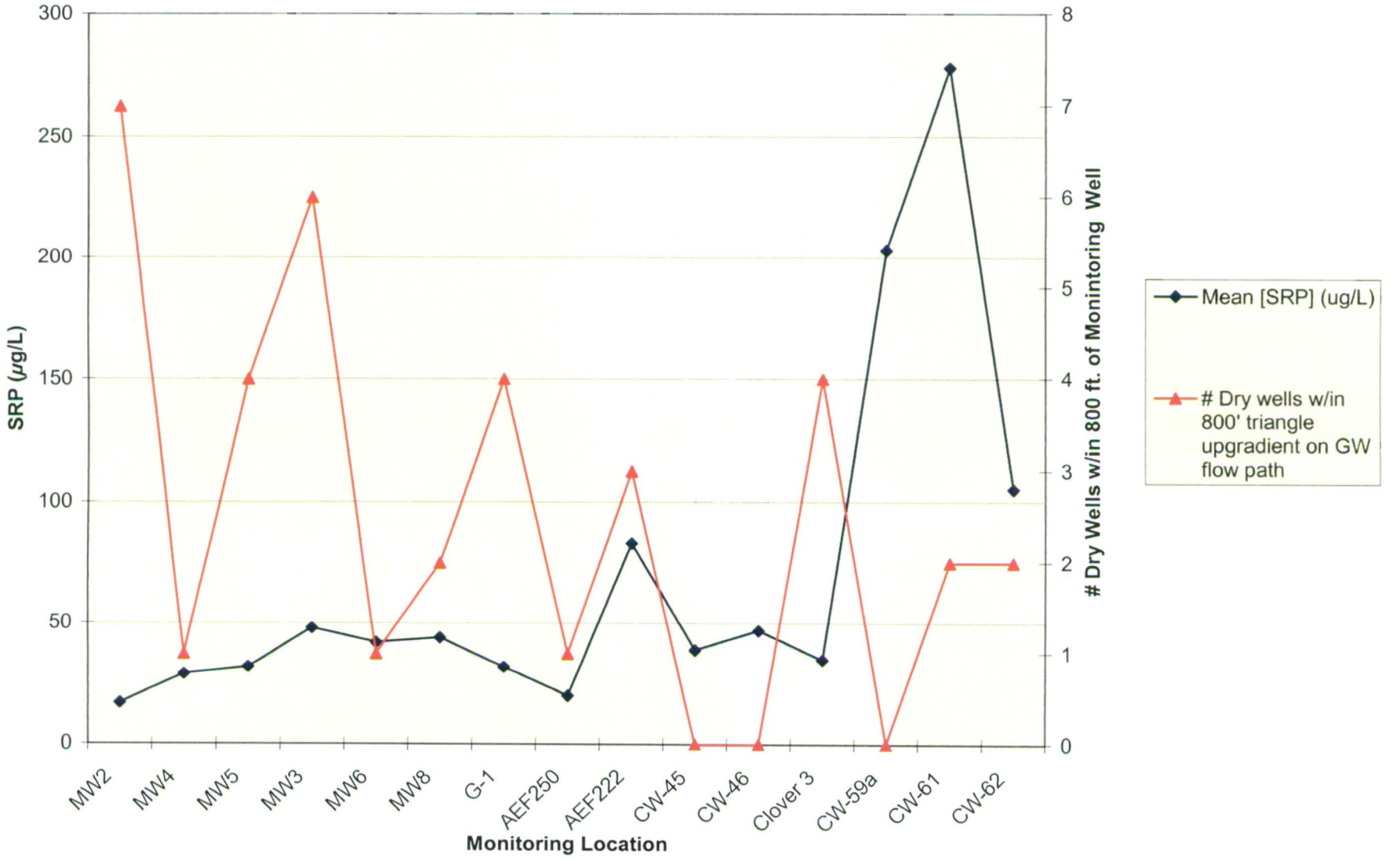
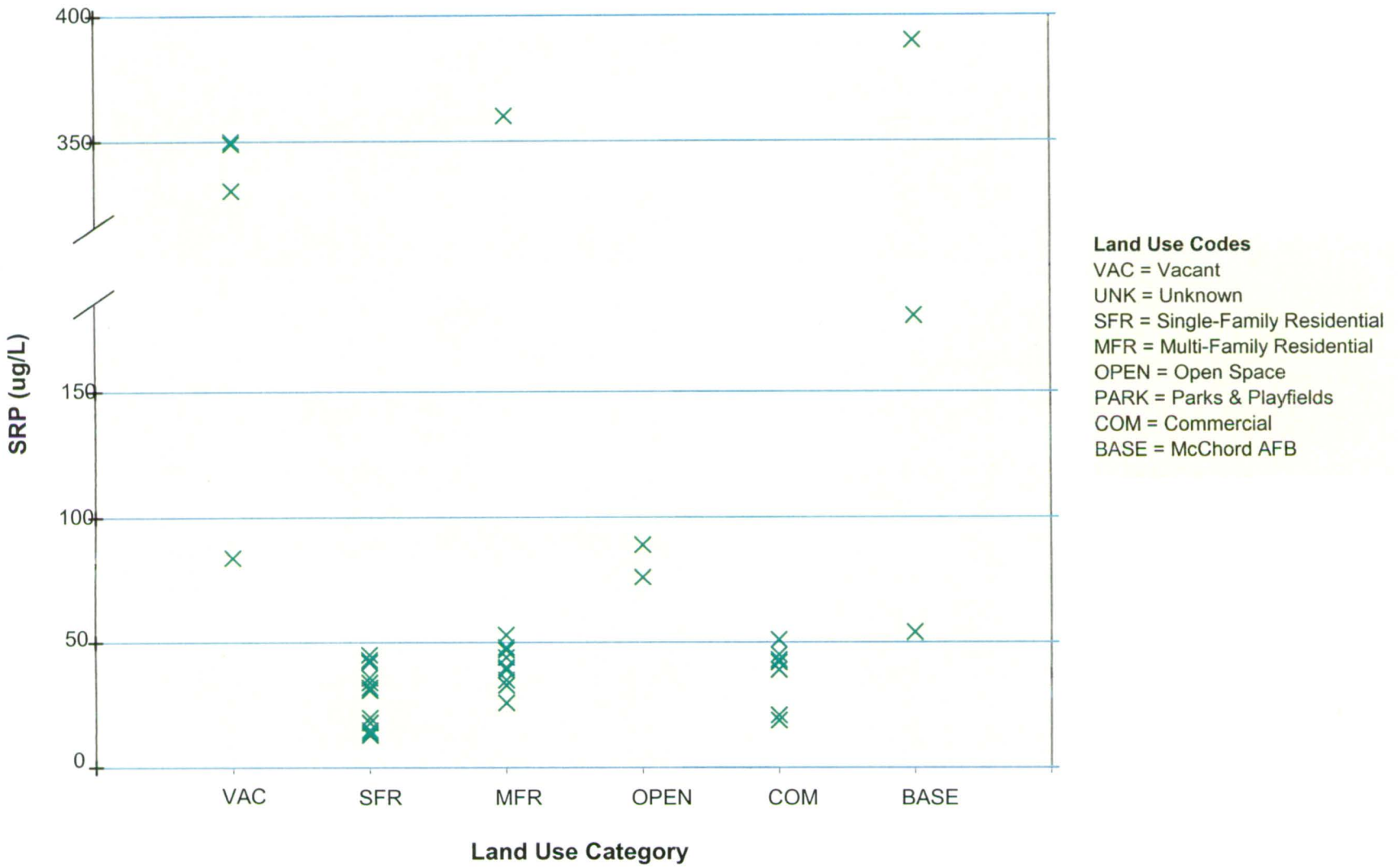


Figure 7-4. SRP Concentration vs. Dominant Land Use Near Monitoring Well

(90 deg., 800-foot triangle upgradient from well)



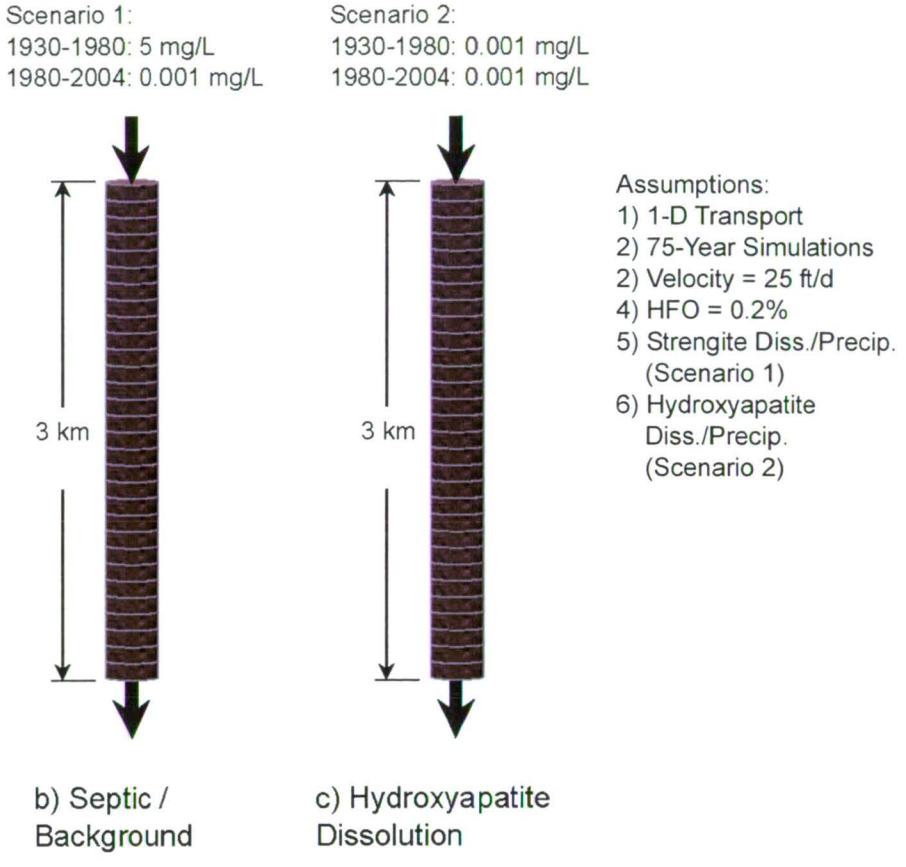


Figure 7-5

Conceptualized PHREEQC Numerical Column Experiments

Figure 7-6
Conceptualized Dissolved Phosphorus Concentration (Scenario 1)

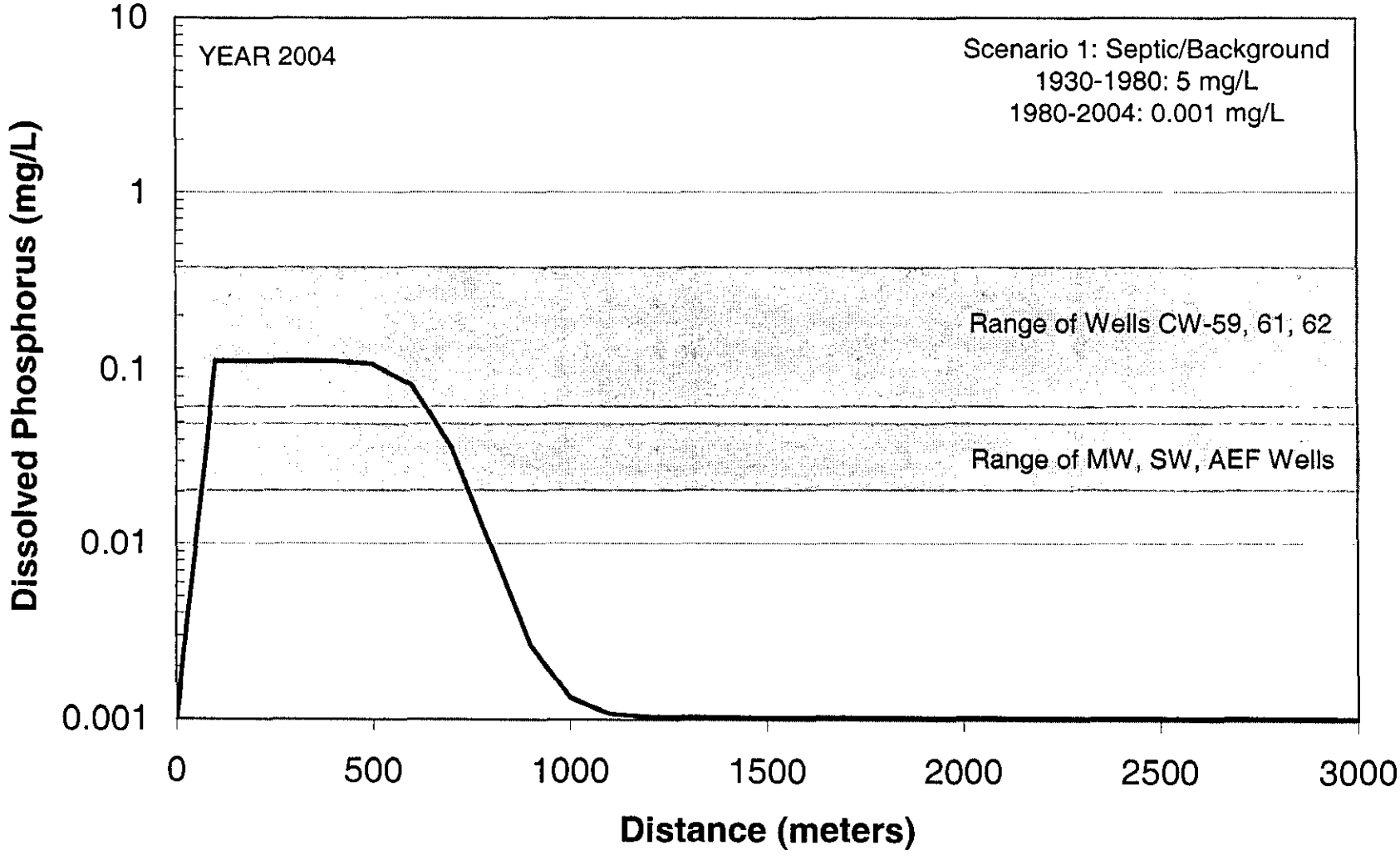


Figure 7-7

Conceptualized Dissolved Phosphorus Concentration (Scenario 2)

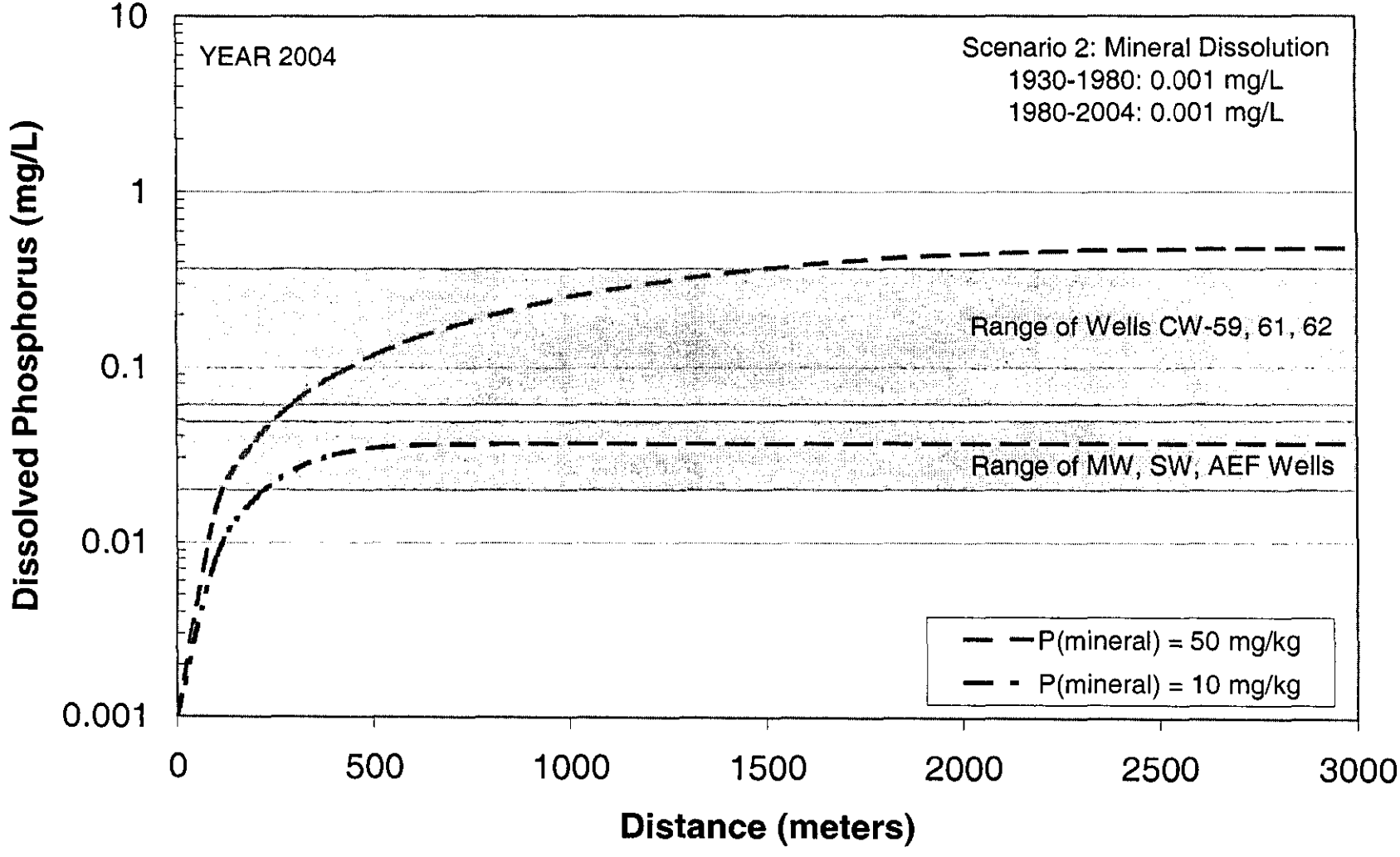


Table 7-1
PHREEQC Initial Groundwater Composition

Parameter	Value	Units	Comments
Temperature	14	deg. C	
pH	6 to 6.5		
Eh	915	mV	
Al	1	mg/L	$Al(OH)_3$(am) buffered
C	7	mg/L	
Ca	11	mg/L	
Cl	6	mg/L	Charge-balanced
DOC	3	mg/L	
K	1	mg/L	
Mg	5	mg/L	
N	1	mg/L	As nitrate
Na	1	mg/L	
S	2	mg/L	As sulfate
Si	18	mg/L	SiO_2(am) buffered
Fe	20	ug/L	Ferrihydrite buffered
Mn	5	ug/L	
P	1	ug/L	
Se	30	ug/L	

Notes:
Eh - oxidation/reduction potential
(am) - amorphous form

8.0 CONCLUSIONS

This study was conducted to identify the likely sources of phosphorus to the groundwater entering Lake Steilacoom. No attempt was made to sample shoreline surface runoff directly into the lake.

8.1 KEY FINDINGS

The general direction of groundwater flow is from the east/southeast toward the west/northwest. There is little, if any, direct groundwater inflow to the lake is restricted geologically; however, upgradient groundwater is intercepted by upper Ponce de Leon Creek and is conveyed to the lake as surface flow.

No potential point sources of phosphorus were identified along the groundwater flow path in the study area. Therefore, the phosphorus in the groundwater entering Lake Steilacoom is from non-point sources.

Based on review of the monitoring, hydrogeology, and land use data, several potential non-point sources—urban stormwater, septic systems, soils, and loss of aquatic ecosystems (Atwood Marsh)—were deemed worthy of detailed evaluation. The results are summarized below.

- **Urban runoff** into Ponce de Leon and Clover Creek does not appear to be a major source of phosphorus to the groundwater entering Lake Steilacoom. This conclusion is based on the following observations:
  - Groundwater upgradient of the city and its numerous stormwater dry wells had similar or higher SRP than the downgradient groundwater entering the lake.
  - There was no apparent relationship between dry wells, land use, and phosphorus concentrations in groundwater.
  - Because of the highly permeable soils, most of the runoff entering the dry wells is from streets, driveways, parking lots and roofs, rather than lawns or other fertilized areas. Runoff from the paved areas is expected to have lower phosphorus concentrations than runoff from lawns and other fertilized areas (Waschbusch et al. 1997)
  - Phosphorus concentrations in the groundwater entering the lake did not appear to increase during the wet season when stormwater infiltration was occurring.
  - A recent study of the nearby American Lake basin, which has very similar soils to Lake Steilacoom, found that groundwater phosphorus concentrations in an area served by storm and sanitary sewers and with no known current or historic phosphorus sources, were similar to those in monitoring wells located downgradient of numerous dry wells. Stormwater samples collected for that

study contained 10 to 80 μg/L total phosphorus. Therefore, the study concluded that dry wells were not a key phosphorus source (Woodward-Clyde 1998).

  - However, it is possible that geochemical and soil conditions may have masked the effects of stormwater dry wells; thus, dry wells cannot be ruled out based on the existing data.

- **Historic septic systems** within the city of Lakewood could be a potential source of phosphorus to the groundwater entering the lake. Geochemical modeling demonstrates that historical releases from septic systems could affect the current dissolved phosphorus concentrations observed in the groundwater, given that there may have been as many as 2,000 septic systems in the study area before the sanitary sewers were completed in the early 1980. It is also possible that the septic systems located in the eastern portion of the basin (south and east of the city) historically contributed phosphorus to the groundwater which is now entering the lake.

- **Loss of the Atwood Marsh** does not appear to have contributed to the elevated phosphorus concentrations in the downgradient groundwater. Wetlands have limited capacity to remove dissolved phosphorus. The SRP concentrations observed upgradient of the former marsh were less than the minimum achievable effluent concentrations ("irreducible concentrations") for wetlands designed specifically for water quality treatment. It should also be noted that the algal blooms in the lake reportedly began before the marsh was covered. Thus, it is unlikely that the Atwood Marsh would have reduced dissolved phosphorus concentrations in the groundwater entering Lake Steilacoom.

- **Organic soils** do not appear to be significant sources of phosphorus to the groundwater entering Lake Steilacoom. This conclusion is based on the following observations:

  - Soil samples around Lakewood Towne Center near the underlying peat deposit indicated that preferential groundwater flowed around the peat. Groundwater samples collected from these borings contained concentrations of phosphorus that were less than those observed in Ponce de Leon Creek.

  - Peat samples collected from the soil borings contained a mean phosphorus concentration of 340 mg/kg, which is lower than many of the peat deposits in Western Washington and similar to or lower than concentrations measured in the surrounding soil as part of this investigation.

- **Mineral Dissolution** is a potential source of phosphorus to the groundwater entering Lake Steilacoom. This conclusion is based on the following observations:

  - Phosphorus at appreciable concentrations in the subsurface soil samples collected during this study.

- Geochemical modeling indicated that the phosphorus minerals in the basin rocks and soils are unstable and dissolution could account for the phosphorus concentrations observed in the groundwater samples.

- Geochemical modeling indicated that adsorption on iron hydroxides appears to be the primary mechanism controlling phosphorus transport in the groundwater.

In summary, the results of this study suggest that either historic septic systems and/or naturally occurring minerals could account for phosphorus concentrations observed in the groundwater entering Lake Steilacoom. One source is historical and the other widely distributed. Neither source is amenable to source control.

8.2 STUDY LIMITATIONS

This study was limited in several respects. Sampling or characterization of the runoff from Steilacoom Lake shoreline land use was not included. Second, the project budget did not allow for groundwater monitoring throughout the entire groundwater basin upgradient of Ponce de Leon Creek and Lake Steilacoom. The monitoring effort focused on the lower portion of the basin between Lake Steilacoom to the Lakewood city limits. Aside from AEF 222, the study did not include any monitoring wells upgradient (east/southeast) of the city. Additional monitoring wells east and southeast of the city would provide more information on potential sources, such as septic systems, in the eastern portion of the basin.

Fourth, the project budget provided for four rounds of sampling over a one-year period. Thus, the study results cannot be used to assess year-to-year variations or long-term trends.

Third, the study did not include monitoring of phosphorus concentrations or potentiometric surface elevations in wells tapping the deeper aquifers. This would help determine if groundwater from the deeper aquifers is a potential source of phosphorus to Aquifer A and thus to Ponce de Leon Creek and Lake Steilacoom. Monitoring of the deeper layers might be especially useful in the area east and southeast of the city, where the aquitard layer B is missing.

Fourth, the study did not include extensive sampling and analysis to assess mineralogy. Such information could help refine the assessment of potential phosphorus contributions from soil minerals and historic septic systems.

Finally, because the basin is mostly developed, it was not possible to monitor true "background" areas (i.e., undeveloped, upgradient areas with hydrogeologic and geochemical conditions similar to those found within the City.

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APPENDIX A

Description of Field Activities

APPENDIX A
DESCRIPTION OF FIELD ACTIVITIES

A.1 DIRECT PUSH DRILLING

URS and Cascade used a direct-push drilling rig to collect peat and groundwater samples from in and around the Atwood Marsh peat deposit beneath Lakewood Mall. This "early action" sampling was done to take advantage of the one-week time period between demolition of existing structures and construction of new foundations, when it was possible to sample areas that were inaccessible at other times. The specific direct-push method that was used consisted of driving a polyethylene-lined, extrusion spoon sampler directly to the desired sample depths without rotational drilling. The polyethylene tubes were extruded from the sample spoon and set-aside for logging and sample collection. Sample jars for analysis were filled after the boring was complete. This method allowed for drilling a large number of borings very quickly without getting in the way of construction activities.

To retrieve an adequate volume of soil for laboratory analysis, Cascade used a 1-inch-diameter by 2-foot-long extrusion spoon. With full recovery, one spoonful of soil provided ample material for analysis of all parameters. While the driller drove the sampling device, the on-site geologist recorded the sampler descent rate on the boring log form as a qualitative means of comparing the density of the different soil types encountered. Hammer blow counts were not used to assign densities based on American Society for Testing and Materials (ASTM) D1586-67 for a standard penetration test. When the sample spoon was removed from the boring, the geologist described the soil on a log form, photographed the soil, and labeled the tube. After finishing all of the borings, the geologist transferred the necessary quantity to laboratory-provided sample jars. Selected samples were submitted to the laboratory for analysis based on depth, and the composition of material. URS attempted to analyze all of the different types of peat encountered and peat from different depths in the deposit.

A.2 SOIL SAMPLING

Soil samples were collected from an air rotary boring by retracting the drilling bit from the drill casing and driving a split-spoon sampler through the casing and to the desired depth. In these borings, unlike in the direct-push borings, the split spoon was attached to drilling rod and driven with a 140-pound downhole hammer with a 36-inch drop (or equivalent). The sampling tools met specifications for geotechnical sampling according to ASTM standards. While the sampler was driven, the on-site geologist recorded blow counts on the well drilling log.

The onsite geologist logged each split spoon of sample material. The log for each sample included depth, estimated density based on blow-counts, color, soil type, and moisture content. In addition, any unusual features such as odor or unusual solid constituents were noted on the soil boring log form.

After logging the sample, soil for laboratory analysis was transferred directly to clean, laboratory-provided, glass jars. Large pieces of gravel and non-native debris were removed from the sample material and noted on the boring log.

A.3 SURFACE WATER SAMPLING

URS collected the surface water samples beginning at the downstream location in each creek and walking (or driving) to upstream stations for subsequent samples. This was done to prevent contamination of downstream samples by any sediment disturbed by the sampling crew. Water was withdrawn from the stream using a battery-operated peristaltic pump fitted with polyethylene tubing. The pump intake was suspended in the thalweg of the stream, 1 to 2 inches below the stream surface and/or well above the bottom substrate. Water was pumped directly from the stream to the sample bottles, except in the case of sample water for total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP), which was filtered through an in-line 0.45-micron nitrocellulose filter.

Water quality parameters were measured immediately after filling the bottles at each location. The water quality parameters were measured by placing the sonde of a YSI 600XLM® water quality meter directly into the stream (SW-1 through SW-3 and SW-5) or pumping the water through a flow through cell (SW-4). The parameters measured included temperature, pH, oxidation/reduction potential (ORP), specific conductance, dissolved oxygen, and turbidity.

Stream discharge was measured after sampling by first measuring the cross section of the creek at each sample station and then measuring the flow rate throughout the cross section using a Model FP101 – FP201 Global Flow Probe. The cross section in square feet times the average velocity in feet per second (measured at several points in the channel) resulted in a cubic feet per second flow measurement. At location SW-5, the stream discharge was extremely difficult to measure because the stream channel is full of boulders and debris, and blackberry bushes overhang the channel's banks. After reviewing the data, URS' flow measurement at SW-5 may be inaccurate and was, therefore, substituted with United States Geotechnical Survey (USGS) flow data from the nearby gauging station, if the USGS data were available for the sampling period.

A.4 GROUNDWATER SAMPLING

A.4.1 Measuring Static Water Levels

URS field personnel measured static water levels in the monitoring wells using an electronic water level indicator. The measurements for all wells were collected in an approximately 1-hour-long period prior to beginning sampling to obtain a "snapshot" of the whole study area. The well cap was removed, and approximately 5 minutes were allowed to elapse to allow time for the water level to stabilize. Measurements of the depth to groundwater were accurate to the nearest hundredth of a foot (0.01 foot). The groundwater depth, time, and ambient weather conditions were recorded on the same form used for water sampling.

A.4.2 Physical Water Quality Parameters

Water quality parameters, including pH, temperature, specific conductance, ORP, turbidity, and dissolved oxygen were measured during purging and sampling using a YSI 600XLM® Water Quality Monitoring System. The YSI meter is factory calibrated, but URS checked the calibration two times per sampling day using a standardized formazin solution. The meter probe

assembly was fitted to an in-line flow-through cell attached to the pump discharge hose to minimize atmospheric influence on the measurements.

A.4.3 Purging and Sampling

Each well was purged and sampled using a peristaltic pump fitted with polyethylene tubing. The mall dewatering system cleanout (DW-3) was not purged because it consists of 48-inch diameter pipe designed to direct groundwater toward Ponce de Leon Creek. The purpose of purging is to remove stagnant and/or stratified water and ensure that fresh formation water, representative of the surrounding groundwater, is sampled. Purging details, including time, purge volume, and water quality parameters, were recorded on a well sampling form. All equipment used for purging and sampling was decontaminated prior to use at each location.

A low-flow purging technique was employed. This included placing the pump intake at the approximate center of the well screen and withdrawing groundwater at a rate of approximately 200 to 300 milliliters per minute for approximately 20 minutes or until measured parameters of the discharge water stabilized. Groundwater quality parameters were measured continuously and recorded every 5 minutes during purging to ensure stabilization. Generally three or more consecutive measurements of pH within 0.2 pH units, conductivity within 10 percent, and temperature within 1 degree Celsius (°C) indicate adequate stability. A final set of water quality parameters was recorded after purging and just prior to sampling.

A.4.4 Groundwater Sampling

Immediately after purging, field personnel collected a sample directly from the pump discharge using the following procedures:

- One sample bottle was filled at a time, taking care not to agitate or overfill the bottle.
- Samples selected for analysis of TDP, SRP, and dissolved metals were filtered using an in-line, high-volume, 0.45-micron nitrocellulose filter. Each disposable filter was purged with the sample water for approximately 1 minute prior to filling the bottles. The purpose for filtering is to obtain representative measurements of the analytes that would be mobilized in the aquifer. Without filtering, fines from the aquifer matrix would bias the sample result to indicate higher levels of dissolved and soluble reactive phosphorus.
- Filled bottles were labeled and immediately placed into a cooler with sufficient ice to maintain the temperature at or below 4 °C. URS hand-delivered all samples to Aquatic Research, Inc. in Seattle, Washington, within the required holding times for analysis.

APPENDIX B

Data Quality Review Reports

URS

Memo

Century Square
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Seattle, Washington 98101
206.438.2700 Telephone
206.438.2699 Fax

To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 26, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Springbrook Groundwater Samples June 2001: Case File Number FWC001-03 33750346		

This memo is a summary data quality review of six groundwater samples collected on June 19, 2001. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Soluble reactive phosphorus (SRP) by Standard Methods SM18 4500-PF

A chain-of-custody was not submitted with the laboratory report; therefore, it is not known whether the samples were filtered by the laboratory or in the field. It is unclear whether the samples were received at the appropriate temperature. In addition, the date sampled is based on the date presented in the laboratory report and cannot be verified against the chain-of-custody. The samples were analyzed in general accordance with method SM18 4500-PF as referenced in *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, 1992.

The following samples are associated with AR case file number FWC001-03:

Sample ID	Requested Analyses
CW-62	SRP
CW-54	SRP
CW-61	SRP
CW-53	SRP
CW-37	SRP
CW-39	SRP

This summary data review is based on method performance criteria and QC criteria as documented in the Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Summary Data Quality Review
Lake Steilacoom – Springbrook Groundwater Samples
June 2001

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Sample – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Acceptable
7. A field duplicate was not submitted with the samples.
8. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

Overall Assessment of Data

The completeness of AR case file number FWC001-03 is 100% for analytical results; however, documentation is incomplete due to the loss of the chain-of-custody. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
CW-62	None	
CW-54	None	
CW-61	None	
CW-53	None	
CW-37	None	
CW-39	None	

URS

Memo

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To:	Galen Davis, Project Manager	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	September 30, 2002 Revised July 26, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Lakewood Mall Groundwater Samples January 2002: Case File Number URS002-01 33750346		

This memo is a summary data quality review of six groundwater samples collected on January 14 and 15, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington. Groundwater samples were analyzed for one or more of the following analyses:

- Dissolved metals (aluminum, iron, potassium, magnesium, manganese, sodium, and calcium) by EPA SW846 Method 200.7
- Conventionals (Chloride by EPA Method 325.3, Fluoride by EPA Method 340.2, Bromide by Standard Method SM18 4500-PF, Nitrate by EPA Method 353.2, Nitrite by EPA Method 354.1, Sulfate by EPA Method 375.4, Alkalinity by EPA Method 310.1)
- Total organic carbon (TOC) and dissolved organic carbon (DOC) by EPA Method 415.2
- Total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for dissolved metals, TDP, and SRP analyses were filtered in the field. The analyses were performed in general accordance with methods specified in EPA's *Test Methods for Evaluating Solid Waste (SW-846)*, January 1995 and associated revisions, *Methods for Chemical Analysis of Water and Wastes*, March 1983, and *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, 1992.

The following samples are associated with AR case file number URS002-01:

Sample ID	Matrix	Requested Analyses
PD2-G	water	TDP, SRP, conventionals, dissolved metals
PD5-G	water	TDP, SRP, TOC, DOC, dissolved metals, conventionals
PD4-G	water	TDP, SRP, TOC, DOC, dissolved metals
PD8-G	water	TDP, SRP, TOC, DOC
PD9-G	water	TDP, SRP, TOC, DOC
PD19-G	water	TDP, SRP

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. Discrepancies were recorded by AR on COCs and addressed with URS personnel prior to sample analyses. The cooler temperatures were not recorded as part of the check-in procedure; therefore it is not known whether the coolers were received within the

acceptable temperature range of 4C +/- 2C. Samples were delivered to the laboratory the same day collected. No data were qualified.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. The data review conducted on these data included a review of summarized results and QA/QC data per the requirements set forth in the QAPP. Hold times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Inorganic Analyses

Samples were analyzed for the parameters identified in the introduction to this report.

1. Holding Times – Acceptable

   Nitrate by EPA 353.2 – The holding time for analysis of nitrate by EPA Method 353.2 is 48 hours from collection to analysis. The samples were analyzed 8 days past the holding time. The nitrate/nitrite results in the associated samples were qualified as estimated and flagged with a "J".

   Nitrite by EPA 354.1 – The holding time for analysis of nitrite by EPA Method 354.1 is 48 hours from collection to analysis. The samples were analyzed 1 day past the holding time. The nitrite results in the associated samples were qualified as estimated and flagged with a "J".

   DOC by EPA 415.1 – The holding time for analysis of DOC by EPA Method 415.1 is 48 hours from collection to analysis if unpreserved. The samples were analyzed 12 and 13 days past the holding time. There is no indication that the samples were preserved in the field upon filtration or upon receipt at the laboratory; therefore, DOC results in the associated samples were qualified as estimated and flagged with a "J".

2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Acceptable

   One field duplicate was collected during this sampling event. The relative percent differences (RPDs) are acceptable as indicated in the following table.

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
PD9-G/PD19-G	SRP	0.024	0.024	0
	TDP	0.024	0.023	4

7. Reporting Limits – Acceptable with the exceptions listed below

   The reporting limits meet those specified in the QAPP (Table 5-1) with the exception of the water reporting limits for dissolved aluminum and bromide. The dissolved aluminum reporting limit specified in the QAPP was 0.02 mg/L and the reporting limit obtained was 0.1 mg/L. The bromide reporting limit specified in the QAPP was 0.05 mg/L and the reporting limit obtained was 0.1 mg/L. The elevated reporting limits do not affect data usability.

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1, dissolved metals by EPA 200.7, and fluoride by EPA 340.2. The QAPP specified EPA 365.2/SM18 4500 PF, EPA 6010, and EPA 340.1, respectively. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-01 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
PD2-G	nitrate nitrite	1.42 J 0.003 J
PD5-G	nitrate nitrite DOC	1.51 J 0.011 J 6.75 J
PD4-G	DOC	5.82 J
PD8-G	DOC	2.36 J
PD9-G	DOC	0.421 J
PD19-G	None	

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To:	Galen Davis, Project Manager	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	September 30, 2002 Revised July 26, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Lakewood Mall Peat Samples January 2002: Case File Number URS002-01B 33750346		

This memo is a summary data quality review of eight soil samples collected on January 14, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington. Soil samples were analyzed for the following analysis:

- Total phosphorus by Standard Methods SM18 4500-PF

The analyses were performed in general accordance with methods specified in *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, 1992 and modified for a solid matrix.

The following samples are associated with AR case file number URS002-01B:

Sample ID	Matrix	Requested Analyses
PD2-18	soil	total phosphorus
PD2-20	soil	total phosphorus
PD2-24	soil	total phosphorus
PD4-14	soil	total phosphorus
PD4-20	soil	total phosphorus
PD3-16	soil	total phosphorus
PD3-20	soil	total phosphorus
PD5-14	soil	total phosphorus
FLD-DUP	soil	total phosphorus

Sample PD4-14 was additionally analyzed for loosely bound phosphorus; Fe + Al bound phosphorus, total Fe + Al bound phosphorus, and Ca bound phosphorus using extraction methods described in Table 5-1 of the QAPP.

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. Discrepancies were recorded by AR on COCs and addressed with URS personnel prior to sample analyses. The cooler temperatures were not recorded as part of the check-in procedure, therefore it is not known whether the coolers were received within the acceptable temperature range of 4C +/- 2C. No data were qualified.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. The data review conducted on these data included a review of summarized results and QA/QC data per the requirements set forth in the QAPP. Hold times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Inorganic Analyses

Samples were analyzed for the parameters identified in the introduction to this report.

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable with the exceptions listed below

   The laboratory duplicate relative percent differences (RPDs) were greater than 20% during the analysis of Fe + Al bound phosphorus (NAOH) at 28.29%, total Fe + Al bound phosphorus at 21.28%, and Ca bound phosphorus at 22.95%. The sample results (PD4-14) were qualified as estimated and flagged with a "J".
5. Matrix Spike (MS) – Matrix spike samples were not performed
6. Field Duplicates – Acceptable

   One field duplicate was collected during this sampling event. The relative percent difference (RPD) is greater than the control limit of 20%. The total phosphorus results in the primary and duplicate sample are qualified as estimated and flagged with a "J".

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
PD2-18/FLD-DUP	total phosphorus	234	343	38

7. Reporting Limits – Acceptable

Overall Assessment of Data

The completeness of AR case file number URS002-01B is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
PD2-18	total phosphorus	234 J
PD2-20	none	
PD2-24	none	
PD4-14	Fe + Al bound P (NAOH) Tot. Fe + Al bound P Ca bound P	121 J 148 J 11 J
PD4-20	none	
PD3-16	none	
PD3-20	none	
PD5-14	none	
FLD-DUP	total phosphorus	343 J

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To:	Galen Davis, Project Manager	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	September 30, 2002 Revised July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Ponce de Leon Creek Surface Water Samples February 2002: Case File Number URS002-02 33750346		

This memo is a summary data quality review of two surface water samples collected on February 19, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington. Surface water samples were analyzed for following analyses:

- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for TDP and SRP were filtered by the laboratory. As these samples were surface water samples, it is unlikely that iron or manganese concentrations were high enough to result in binding of phosphorus prior to filtration. The results are judged unaffected by the delay in filtration.

The analyses were performed in general accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983. The following samples are associated with AR case file number URS002-02:

Sample ID	Requested Analyses
SW-1-21902	total phosphorus, TDP, and SRP
SW-3-21902	total phosphorus, TDP, and SRP

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. Discrepancies were recorded by AR on COCs and addressed with URS personnel prior to sample analyses. The cooler temperatures were not recorded as part of the check-in procedure; therefore it is not known whether the coolers were received within the acceptable temperature range of 4C +/- 2°C. Samples were delivered to the laboratory the same day collected. No data were qualified.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. The data review conducted on these data included a review of summarized results and QA/QC data per the requirements set forth in the QAPP. Hold times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data

qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Inorganic Analyses

Samples were analyzed for the parameters identified in the introduction to this report.

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – A field duplicate was not submitted with these samples
7. Reporting Limits – Acceptable

The QAPP specifies method EPA 365.2 be used for analysis of total phosphorus and TDP, the laboratory analyzed these parameters using method EPA 365.1. The QAPP specifies method SM18 4500-PF be used for analysis of SRP, the laboratory analyzed this parameter using method EPA 365.1.

Overall Assessment of Data

The completeness of AR case file number URS002-02 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
SW-1-21902	none	
SW-3-21902	none	

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To:	Galen Davis, Project Manager	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	September 30, 2002 Revised July 26, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Monitoring Well Soil Samples August 2002: Case File Number URS002-03 33750346		

This memo is a summary data quality review of eight soil samples collected on August 22 and 23, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington. Soil samples were analyzed for the following analyses:

- Total phosphorus by EPA Method 365.1

The analyses were performed in general accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983, modified for solid matrices.

The following samples are associated with AR case file number URS002-03:

Sample ID	Requested Analyses
MS2-5	total phosphorus
MS2-15	total phosphorus
MS5-10	total phosphorus
MS4-5	total phosphorus
MS4-6	total phosphorus
MS6-28	total phosphorus
MS8-10	total phosphorus
MS8-20	total phosphorus

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. Discrepancies were recorded by AR on COCs and addressed with URS personnel prior to sample analyses. The cooler temperatures were not recorded as part of the check-in procedure, therefore it is not known whether the coolers were received within the acceptable temperature range of 4C +/- 2C. No data were qualified.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. The data review conducted on these data included a review of summarized results and QA/QC data per the requirements set forth in the QAPP. Hold times, method blanks,

laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Inorganic Analyses

Samples were analyzed for the parameters identified in the introduction to this report.

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable with the exceptions listed below

   Total Phosphorus by EPA 353.2 – The matrix spike percent recovery was flagged "OR" by the laboratory to indicate a "recovery not calculable due to spike sample out of range or spike too low relative to sample concentration". Steve Lazoff of AR stated that the sample required a dilution; therefore, the matrix spike was diluted out and was not calculated. The duplicate and laboratory control samples were within the control limits; therefore, no data were qualified.
6. Field Duplicates – A field duplicate was not submitted with these sample
7. Reporting Limits – Acceptable

The QAPP specifies method EPA 365.2 be used for analysis of total phosphorus, the laboratory analyzed this parameter using method EPA 365.1. The method variance does not affect data usability.

Overall Assessment of Data

The completeness of AR case file number URS002-03 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
MS2-5	none	
MS2-15	none	
MS5-10	none	
MS4-5	none	
MS4-6	none	
MS6-28	none	
MS8-10	none	
MS8-20	none	

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To:	Galen Davis, Project Manager	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	September 30, 2002 Revised July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Groundwater and Surface Water Samples – Round One August and September 2002: Case File Number URS002-04,05 33750346		

This memo is a summary data quality review of five groundwater samples, seven surface water samples, and one surface water field duplicate collected on August 28 through 29 and September 3, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Dissolved metals (aluminum, iron, potassium, magnesium, manganese, sodium, and calcium) by EPA SW846 Method 200.7
- Conventionals (chloride by EPA Method 325.3, fluoride by EPA Method 340.2, bromide by Standard Method SM18 4500-PF, nitrate + nitrite by EPA Method 353.2, sulfate by EPA Method 375.4, and alkalinity by EPA Method 310.1)
- Total organic carbon (TOC) and dissolved organic carbon (DOC) by EPA Method 415.2
- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for TDP, SRP, and DOC analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. Bromide was not analyzed due to lack of sample volume. The analyses were performed in general accordance with methods specified in EPA's *Test Methods for Evaluating Solid Waste (SW-846)*, January 1995 and associated revisions, *Methods for Chemical Analysis of Water and Wastes*, March 1983, and *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, 1992.

The following samples are associated with AR case file numbers URS002-04,05:

Sample ID	Requested Analyses
MW2-G1	dissolved metals, conventionals, TDP/SRP, TOC/DOC
MW4-G1	dissolved metals, conventionals, TDP/SRP, TOC/DOC
MW5-G1	dissolved metals, conventionals, TDP/SRP, TOC/DOC
MW6-G1	dissolved metals, conventionals, TDP/SRP, TOC/DOC
MW8-G1	dissolved metals, conventionals, TDP/SRP, TOC/DOC
DW3-G1	dissolved metals, conventionals, TDP/SRP, TOC/DOC
SW1-G1	TDP/SRP and total phosphorus
SW2-G1	TDP/SRP and total phosphorus
SW3-G1	TDP/SRP and total phosphorus
SW13-G1	TDP/SRP and total phosphorus
SW4-G1	TDP/SRP and total phosphorus

Sample ID	Requested Analyses
SW5-G1	TDP/SRP and total phosphorus
WS1-G1	TDP/SRP and total phosphorus

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. Discrepancies were recorded by AR on COCs and addressed with URS prior to analyses. The cooler temperatures were not recorded as part of the check-in procedure, therefore it is not known whether the coolers were received within the acceptable temperature range of 4 ± 2 °C. Samples were submitted to the laboratory within 24 hours of collection. No data were qualified.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Inorganic Analyses

Samples were analyzed for the parameters identified in the introduction to this report.

1. Holding Times – Acceptable with the exceptions listed below

   Nitrate/Nitrite by EPA 353.2 – The holding time for analysis of nitrate/nitrite by EPA Method 353.2 is 48 hours from collection to analysis. The samples were analyzed 19 days past the holding time. The nitrate/nitrite results in the associated samples were qualified as estimated and flagged with a "J".

   Fluoride by EPA 340.2 – The holding time for analysis of fluoride by EPA Method 340.2 is 28 days from collection to analysis. The samples were analyzed 6 days past the holding time. The fluoride results in the associated samples were qualified as estimated and flagged with a "J".

   DOC by EPA 415.1 – The holding time for analysis of DOC by EPA Method 415.1 is 48 hours from collection to analysis if unpreserved. The samples were analyzed 12 and 13 days past the holding time. There is no indication that the samples were preserved in the field upon filtration or upon receipt at the laboratory; therefore, DOC results in the associated samples were qualified as estimated and flagged with a "J".

2. Blanks – Acceptable

3. Laboratory Control Samples (LCS) – Acceptable

4. Laboratory Duplicates – Acceptable

5. Matrix Spike (MS) – Acceptable with the exceptions listed below

   Nitrate/Nitrite by EPA 353.2 – The matrix spike percent recovery was flagged "OR" by the laboratory to indicate a "recovery not calculable due to spike sample out of range or spike too low relative to sample concentration". It is not possible to tell from the summary page if the spike concentration was greater than the spike added. The samples analyzed for nitrate/nitrite were previously qualified based on holding times. No additional qualifiers were added due to the MS data.

6. Field Duplicates – Acceptable

One field duplicate was collected during this sampling event. The relative percent differences (RPDs) are acceptable as indicated in the following table:

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
SW3-G1/SW13-G1	Total Phosphorus	0.043	0.042	2
	TDP	0.043	0.043	0
	SRP	0.041	0.041	0

7. Reporting Limits – Acceptable

The reporting limits meet those specified in the QAPP (Table 5-1) with the exception of dissolved iron, dissolved manganese, and dissolved aluminum. The dissolved iron reporting limit specified in the QAPP was 0.08 mg/L and the reporting limit obtained was 0.1 mg/L. The dissolved manganese reporting limit specified in the QAPP was 0.0043 mg/L and the reporting limit obtained was 0.005 mg/L. The dissolved aluminum reporting limit specified in the QAPP was 0.02 mg/L and the reporting limit obtained was 0.100 mg/L. The elevated reporting limits do not impact project objectives.

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1, dissolved metals by EPA 200.7, fluoride by EPA 340.2. The QAPP specified EPA 365.2/SM18 4500 PF, EPA 6010, and EPA 340.1, respectively. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-04,05 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
MW2-G1	nitrate/nitrite fluoride DOC	1.57 J 0.100 UJ 0.757 J
MW4-G1	nitrate/nitrite fluoride DOC	0.657 J 0.100 UJ 0.536 J
MW5-G1	nitrate/nitrite fluoride DOC	1.64 J 0.100 UJ 1.69 J
MW6-G1	nitrate/nitrite fluoride DOC	2.98 J 0.100 UJ 0.876 J
MW8-G1	nitrate/nitrite fluoride DOC	1.14 J 0.145 J 1.36 J
DW3-G1	nitrate/nitrite fluoride DOC	1.27 J 0.100 UJ 0.663 J
SW1-G1	None	
SW2-G1	None	
SW3-G1	None	
SW13-G1	None	
SW4-G1	None	
SW5-G1	None	
WS1-G1	None	

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Springbrook Groundwater Samples – Round One September 2002: Case File Number URS002-06 33750346		

This memo is a summary data quality review of five groundwater samples and one field duplicate collected on September 23 and 24, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for TDP and SRP analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. The analyses were performed in general accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following samples are associated with AR case file number URS002-06:

Sample ID	Requested Analyses
CW-45-1	TDP/SRP/total phosphorus
CW-46-1	TDP/SRP/total phosphorus
CW-59-1	TDP/SRP/total phosphorus
CW-62-1	TDP/SRP/total phosphorus
CW-162-1	TDP/SRP/total phosphorus
CW-61-1	TDP/SRP/total phosphorus

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. Samples were submitted to the laboratory the day of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were

reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Acceptable

   One field duplicate was collected during this sampling event. The relative percent differences (RPDs) are acceptable as indicated in the following table.

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
CW-62-1/CW-162-1	Total Phosphorus	0.388	0.392	1
	TDP	0.360	0.357	1
	SRP	0.352	0.344	2

7. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1. The QAPP specified EPA 365.2 / SM18 4500-PF. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-06 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
CW-45-1	None	
CW-46-1	None	
CW-59-1	None	
CW-62-1	None	
CW-162-1	None	
CW-61-1	None	

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Herr MW-3 – Round One November 2002: Case File Number URS002-07 33750346		

This memo is a summary data quality review of one groundwater sample collected on November 20, 2002. The sample was submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for TDP and SRP analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. The analyses were performed in general accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following sample is associated with AR case file number URS002-07:

Sample ID	Requested Analyses
HERR-MW-3-G2	TDP/SRP/total phosphorus

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. Samples were submitted within 24 hours of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Field duplicates were not collected with this sampling event
7. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

The QAPP specifies method EPA 365.2 be used for analysis of total phosphorus and TDP, the laboratory analyzed these parameters using method EPA 365.1. The QAPP specifies method SM18 4500 pf be used for analysis of SRP, the laboratory analyzed this parameter using method EPA 365.1. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-07 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
HERR-MW-3-G2	None	

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Groundwater and Surface Water Samples – Round Two December 2002: Case File Number URS002-08 33750346		

This memo is a summary data quality review of five groundwater samples, one groundwater field duplicate, four surface water samples, and one surface water field duplicate collected on December 3 and 4, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for TDP and SRP analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. The analyses were performed in accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following samples are associated with AR case file number URS002-08:

Sample ID	Requested Analyses
SW5-G2	TDP/SRP/total phosphorus
SW2-G2	TDP/SRP/total phosphorus
SW3-G2	TDP/SRP/total phosphorus
SW13-G2	TDP/SRP/total phosphorus
MW5-G2	TDP/SRP
MW4-G2	TDP/SRP
MW6-G2	TDP/SRP
MW2-G2	TDP/SRP
MW8-G2	TDP/SRP
SW1-G2	TDP/SRP/total phosphorus
MW18-G2	TDP/SRP

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. The samples were submitted within 24 hours of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality*

Assurance Project Plan (QAPP), Section 5, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Acceptable

   Two field duplicates were collected during this sampling event. The relative percent differences (RPDs) are acceptable as indicated in the following table:

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
SW3-G2/SW13-G2	Total Phosphorus	0.047	0.048	2
	TDP	0.045	0.045	0
	SRP	0.043	0.044	2
MW8-G2/MW18-G2	TDP	0.050	0.051	2
	SRP	0.045	0.048	6

7. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

The QAPP specifies method EPA 365.2 be used for analysis of total phosphorus and TDP, the laboratory analyzed these parameters using method EPA 365.1. The QAPP specifies method SM18 4500-PF be used for analysis of SRP, the laboratory analyzed this parameter using method EPA 365.1. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-08 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
SW5-G2	None	
SW2-G2	None	
SW3-G2	None	
SW13-G2	None	
MW5-G2	None	
MW4-G2	None	
MW6-G2	None	
MW2-G2	None	
MW8-G2	None	
SW1-G2	None	
MW18-G2	None	

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Springbrook Groundwater Samples – Round Two December 2002: Case File Number URS002-09 33750346		

This memo is a summary data quality review of four groundwater samples collected on December 5, 2002. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for TDP and SRP analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. The analyses were performed in accordance with methods specified in *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following samples are associated with AR case file number URS002-09:

Sample ID	Requested Analyses
CW45-G2	TDP/SRP
CW46-G2	TDP/SRP
CW59-G2	TDP/SRP
CW61-G2	TDP/SRP

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. Samples were submitted to the laboratory within 24 hours of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable except as listed below

   SRP by EPA 365.1 – The matrix spike percent recovery was flagged "OR" by the laboratory to indicate a "recovery not calculable due to spike sample out of range or spike too low relative to sample concentration". The laboratory did not provide spike concentration information, so it is not possible to determine if the concentration of the sample was at least four times greater than the spike concentration. The SRP result in the parent sample (CW61-G2) was qualified as estimated and flagged with a "J".
6. Field Duplicates – Field duplicates were not collected with this sampling event
7. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

The QAPP specifies method EPA 365.2 be used for analysis of TDP, the laboratory analyzed this parameter using method EPA 365.1. The QAPP specifies method SM18 4500-PF be used for analysis of SRP, the laboratory analyzed this parameter using method EPA 365.1. The sample results do not require qualification based on these discrepancies.

Overall Assessment of Data

The completeness of AR case file number URS002-09 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
CW45-G2	None	
CW46-G2	None	
CW59-G2	None	
CW61-G2	SRP	0.331 J

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – WS-G1 January 2003: Case File Number URS002-10 33750346		

This memo is a summary data quality review of one groundwater sample collected on January 27, 2003. The sample was submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Dissolved metals (aluminum, iron, potassium, magnesium, manganese, sodium, and calcium) by EPA Method 200.7
- Conventionals (Chloride by EPA Method 325.3, Fluoride by EPA Method 340.2, Bromide by Standard Methods SM18 4500, Nitrate + Nitrite by EPA Method 353.2, Sulfate by EPA Method 375.4, Alkalinity by EPA Method 310.1)
- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for dissolved metals, TDP, and SRP analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. The analyses were performed in general accordance with methods specified in EPA's *Test Methods for Evaluating Solid Waste (SW-846)*, January 1995 and associated revisions, *Methods for Chemical Analysis of Water and Wastes*, March 1983, and *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, 1992.

The following sample is associated with AR case file number URS002-10:

Sample ID	Requested Analyses
WS-G1 WELL	dissolved metals, conventionals, total phosphorus, TDP, SRP

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. Samples were delivered to the laboratory the same day they were collected.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing

summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable

   Nitrate/Nitrite by EPA 353.2 – The holding time for analysis of nitrate/nitrite by EPA Method 353.2 is 48 hours from collection to analysis. The sample was analyzed 1 day past the holding time. The nitrate/nitrite result in the associated sample was qualified as estimated and flagged with a "J".

2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Field duplicates were not collected during this sampling event
7. Reporting Limits – Acceptable with the exceptions listed below

   The reporting limits met those specified in the QAPP (Table 5-1) with the exception of bromide (QAPP limit 0.05mg/L, reporting limit 0.1 mg/L) and dissolved manganese (QAPP limit 0.0043 mg/L, reporting limit 0.005 mg/L). Elevated reporting limits do not affect data usability.

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1, dissolved metals by EPA 200.7, and fluoride by EPA 340.2. The QAPP specified EPA 365.2/SM18 4500-PF, EPA 6010, and EPA 340.1, respectively. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-10 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
WS-G1 WELL	nitrate + nitrite	0.591 J

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Herr MW-3 – Round Two February 2003: Case File Number URS002-11 33750346		

This memo is a summary data quality review of one groundwater sample collected on February 20, 2003. The sample was submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

The sample was filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter for TDP and SRP analyses. The analyses were performed in accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following sample is associated with AR case file number URS002-11:

Sample ID	Requested Analyses
HERRMW3-G3	TDP/SRP/total phosphorus

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. The samples were submitted to the laboratory within 24 hours of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Field duplicates were not collected with this sampling event
7. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

The QAPP specifies method EPA 365.2 be used for analysis of total phosphorus and TDP, the laboratory analyzed these parameters using method EPA 365.1. The QAPP specifies method SM18 4500-PF be used for analysis of SRP, the laboratory analyzed this parameter using method EPA 365.1. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-11 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
HERRMW3-G3	None	

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To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Groundwater and Surface Water Samples – Round 3 March 2003: Case File Number URS002-12 and 13 33750346		

This memo is a summary data quality review of sixteen groundwater samples, two groundwater field duplicates, and five surface water samples collected on March 4 and 5, 2003. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Dissolved metals (aluminum, iron, potassium, magnesium, manganese, sodium, and calcium) by EPA Method 200.7
- Conventionals (Chloride by EPA Method 325.3, Fluoride by EPA Method 340.2, Bromide by Standard Method SM18 4500-PF, Nitrate + Nitrite by EPA Method 353.2, Sulfate by EPA Method 375.4, Alkalinity by EPA Method 310.1)
- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

All samples submitted for dissolved metals, TDP, and SRP analyses were filtered in the field using a 0.045 micron, high-volume, nitrocellulose filter. The analyses were performed in accordance with methods specified in EPA's *Test Methods for Evaluating Solid Waste (SW-846)*, January 1995 and associated revisions, *Methods for Chemical Analysis of Water and Wastes*, March 1983, and *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, 1992.

The following samples are associated with AR case file number URS002-12:

Sample ID	Requested Analyses
MW-AEF250-G3	dissolved metals, conventionals, TDP, SRP
MW-AEF222-G3	dissolved metals, conventionals, TDP, SRP
MW8-G3	dissolved metals, conventionals, TDP, SRP
DW1-G3	TDP, SRP
DW3-G3	TDP, SRP
WSG1-G3	dissolved metals, conventionals, TDP, SRP
SW3-G3	TDP, SRP, total phosphorus
SW2-G3	TDP, SRP, total phosphorus
SW1-G3	TDP, SRP, total phosphorus

Sample ID	Requested Analyses
MW6-G3	dissolved metals, TDP, SRP
MW16-G3	dissolved metals, TDP, SRP
MW5-G3	TDP, SRP
MW4-G3	TDP, SRP

The following samples are associated with AR case file number URS002-13:

Sample ID	Requested Analyses
MW-2-G3	TDP, SRP
SW4-G3	TDP, SRP, total phosphorus
SW5-G3	TDP, SRP, total phosphorus
CW62-G3	TDP, SRP
CW61-G3	TDP, SRP
CW59-G3	TDP, SRP
CW70-G3	TDP, SRP
CW45-G3	TDP, SRP
CW46-G3	TDP, SRP
CLOVERMW3-G3	TDP, SRP

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. Samples were submitted to the laboratory within 24 hours of collection.

Samples MW-AEF250-G3, MW-AEF222-G3, MW8-G3, and WSG1-G3 were not analyzed for fluoride and bromide due to lack of sample. The COC indicated that these analytes should be analyzed only if enough sample volume remained. No sample results require qualification.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable with the exceptions listed below

   Nitrate + Nitrite by EPA Method 353.2 – The matrix spike percent recovery was flagged "OR" by the laboratory to indicate a "recovery not calculable due to spike sample out of range or spike too low relative to sample concentration". The laboratory did not provide spike concentration information, so it is not possible to determine if the concentration of the sample was at least four times greater than the spike

concentration. The nitrate + nitrite result in the parent sample (WSG1-G3) was qualified as estimated and flagged with a "J".

6. Field Duplicates – Acceptable

Two field duplicates were collected during this sampling event. The relative percent differences (RPDs) are acceptable as indicated in the following table.

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
MW6-G3/MW16-G3	SRP	0.042	0.043	2
	TDP	0.044	0.044	0
	calcium	10.3	10.5	2
	magnesium	3.99	3.95	1
	potassium	1.10	1.18	7
	sodium	5.73	5.75	<1
CW59-G3/CW70-GW	TDP	0.054	0.055	2
	SRP	0.052	0.053	2

3. Reporting Limits – Acceptable with the exceptions listed below

The reporting limits met those specified in the QAPP (Table 5-1) with the exception of dissolved aluminum (QAPP limit 0.02 mg/L, reporting limit 0.1 mg/L), dissolved manganese (QAPP limit 0.0043 mg/L, reporting limit 0.005 mg/L), and dissolved potassium (QAPP limit 0.3 mg/L, reporting limit 1.0 mg/L). The elevated reporting limits do not affect data usability.

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1, dissolved metals by EPA 200.7, fluoride by EPA 340.2. The QAPP specified EPA 365.2 / SM18 4500-PF, EPA 6010, and EPA 340.1, respectively. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file numbers URS002-12 and URS002-13 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
MW-AEF250-G3	None	
MW-AEF222-G3	None	
MW8-G3	None	
DW1-G3	None	
DW3-G3	None	
WSG1-G3	Nitrate + Nitrite	1.28 J
SW3-G3	None	
SW2-G3	None	
SW1-G3	None	
MW6-G3	None	
MW16-G3	None	
MW5-G3	None	
MW4-G3	None	
MW-2-G3	None	
SW4-G3	None	
SW5-G3	None	
CW62-G3	None	
CW61-G3	None	
CW59-G3	None	
CW70-G3	None	
CW45-G3	None	
CW46-G3	None	
CLOVERMW3-G3	None	

URS

Memo

Century Square
1501 4th Avenue, Suite 1400
Seattle, Washington 98101
206.438.2700 Telephone
206.438.2699 Fax

To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Herr MW-3 – Round Three May 2003: Case File Number URS002-14 33750346		

This memo is a summary data quality review of one groundwater sample collected on May 21, 2003. The sample was submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total phosphorus, total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) by EPA Method 365.1

It was not indicated on the COC that the sample was filtered in the field. There was a note indicating that the dissolved phosphorus analysis should be filtered by the laboratory; however, the laboratory did not indicate whether any of the samples were filtered in the laboratory. The TDP and SRP results were qualified as estimated and flagged with a "J" due to this discrepancy. The analyses were performed in general accordance with methods specified in EPA's *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following sample is associated with AR case file number URS002-14:

Sample ID	Requested Analyses
HERRMW3-G4	TDP/SRP/total P

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperature was not recorded as part of the check-in procedure. Samples were delivered to the laboratory the day of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Field duplicates were not collected with this sampling event
7. Reporting Limits – Acceptable

   The reporting limits meet those specified in the QAPP (Table 5-1).

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1. The QAPP specified EPA 365.2/SM18 4500-PF. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file number URS002-14 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
HERRMW3-G4	TDP	0.044 J
	SRP	0.045 J

URS

Memo

Century Square
1501 4th Avenue, Suite 1400
Seattle, Washington 98101
206.438.2700 Telephone
206.438.2699 Fax

To:	File	**Info:**	Final
From:	Crystal Neirby, Staff Scientist	**Date:**	July 27, 2004
RE:	Summary Data Quality Review Steilacoom Lake – Groundwater and Surface Water Samples – Round 4 June 2003: Case File Number URS002-15 and 16 33750346		

This memo is a summary data quality review of fourteen groundwater samples, five surface water samples, and one surface water field duplicate collected on June 18-20 and 23, 2003. The samples were submitted to Aquatic Research Inc. (AR), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Seattle, Washington, for the following analyses:

- Total phosphorus, total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP) by EPA Method 365.1

The COC for the surface water samples (case file number URS002-16) indicated that the samples were filtered in the field for TDP and SRP analyses. It was not indicated on the COC for URS002-15 that the samples were filtered in the field; however, there was a note for sample AEF222-G4 that the laboratory needed to filter this sample indicating that the other samples were field filtered. The laboratory did not indicate whether sample AEF222-G4 was filtered in the laboratory. The TDP and SRP results were qualified as estimated and flagged with a "J". The analyses were performed in accordance with methods specified in *Methods for Chemical Analysis of Water and Wastes*, March 1983.

The following samples are associated with AR case file number URS002-15:

Sample ID	Requested Analyses
CW45-G4	TDP, SRP
CW46-G4	TDP, SRP
CW59-G4	TDP, SRP
CW62-G4	TDP, SRP
WSG1-G4	TDP, SRP
MW8-G4	TDP, SRP
AEF250-G4	TDP, SRP
AEF222-G4	TDP, SRP
MW2-G4	TDP, SRP
MW4-G4	TDP, SRP
DW3-G4	TDP, SRP
MW5-G4	TDP, SRP
MW6-G4	TDP, SRP
CLOVERMW3-G4	TDP, SRP

The following samples are associated with AR case file number URS002-16:

Sample ID	Requested Analyses
SW3-G4	TDP, SRP, total phosphorus
SW13-G4	TDP, SRP, total phosphorus
SW1-G4	TDP, SRP, total phosphorus
SW2-G4	TDP, SRP, total phosphorus
SW4-G4	TDP, SRP, total phosphorus
SW5-G4	TDP, SRP, total phosphorus

Upon receipt by AR, the sample jar information was compared to the chain-of-custody. The cooler temperatures were not recorded as part of the check-in procedure. Samples were delivered to the laboratory the day of collection.

This summary data review is based on method performance criteria and QC criteria as documented in the *Study of Natural Phosphorus Sources in the Groundwater Entering Ponce de Leon Creek and Lake Steilacoom, Quality Assurance Project Plan (QAPP), Section 5*, July 2002. The laboratory provided a standard report containing summarized sample results and associated QA/QC data. This report summarizes URS' review of results and QA/QC data per the requirements set forth in the QAPP. Sample holding times, method blanks, laboratory control sample results, laboratory duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, and reporting limits were reviewed to assess compliance with applicable methods and the QAPP. If data qualification was required, data were qualified based on the definitions and use of qualifying flags outlined in the EPA document *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, July 2002.

Performance Criteria

Analytical results were reviewed with respect to the following performance criteria:

1. Holding Times – Acceptable
2. Blanks – Acceptable
3. Laboratory Control Samples – Acceptable
4. Laboratory Duplicates – Acceptable
5. Matrix Spike (MS) – Acceptable
6. Field Duplicates – Acceptable

   One field duplicate was collected during this sampling event. The relative percent differences (RPDs) are acceptable as indicated in the following table.

SAMPLE ID/ DUPLICATE ID	ANALYTE	PRIMARY RESULT (µg/L)	DUPLICATE RESULT (µg/L)	RELATIVE PERCENT DIFFERENCE
SW3-G4/SW13-G4	total phosphorus	0.036	0.038	5
	TDP	0.035	0.035	0
	SRP	0.033	0.035	6

7. Reporting Limits – Acceptable

The laboratory performed total phosphorus and TDP/SRP by EPA 365.1. The QAPP specified EPA 365.2 / SM18 4500-PF. The change in methods does not affect the validity of the results or their use for project objectives.

Overall Assessment of Data

The completeness of AR case file numbers URS002-15 and URS002-16 is 100%. The usefulness of this data is based on USEPA guidance documents and the QAPP referenced in the introduction to this report. Upon consideration of the information presented above, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values. A summary of the data qualifiers applied to the results for all samples associated with this review is included below.

Data Qualifier Definitions:

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Sample ID	Qualified Analyte	Qualified Result
CW45-G4	None	
CW46-G4	None	
CW59-G4	None	
CW62-G4	None	
WSG1-G4	None	
MW8-G4	None	
AEF250-G4	None	
AEF222-G4	TDP SRP	0.081 J 0.076 J
MW2-G4	None	
MW4-G4	None	
DW3-G4	None	
MW5-G4	None	
MW6-G4	None	
CLOVERMW3-G4	None	
SW3-G4	None	
SW13-G4	None	
SW1-G4	None	
SW2-G4	None	
SW4-G4	None	
SW5-G4	None	

APPENDIX C

Chain of Custody Forms and Laboratory Analytical Results

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: FWC001-03 PAGE 1
REPORT DATE: 06/25/01_
DATE SAMPLED: 06/19/01_ DATE RECEIVED: 06/19/01_
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM FOSTER WHEELER

CASE NARRATIVE

Six water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	SRP (mg/l)
CW-62	0.008
CW-54	0.024
CW-61	0.279
CW-53	0.043
CW-37	0.013
CW-39	0.012

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: FWC001-03 PAGE 2
REPORT DATE: 06/25/01_
DATE SAMPLED: 06/19/01_ DATE RECEIVED: 06/19/01_
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM FOSTER WHEELER

QA/QC DATA

QC PARAMETER	SRP

	(mg/l)
METHOD	SM18 4500PF
DATE ANALYZED	06/21/01_
DETECTION LIMIT	0.001
DUPLICATE	
SAMPLE ID	CW-39
ORIGINAL	0.012
DUPLICATE	0.012
RPD	3.06%
SPIKE SAMPLE	
SAMPLE ID	CW-39
ORIGINAL	0.012
SPIKED SAMPLE	0.033
SPIKE ADDED	0.020
% RECOVERY	108.88%
QC CHECK	
FOUND	0.027
TRUE	0.027
% RECOVERY	98.58%
BLANK	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES
FOR WATER RESOURCES

February 18, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report and invoice for water and soil samples received for laboratory analysis on 01/15/02. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

soil/gw samples for Peat Deposit

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
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AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

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CASE FILE NUMBER:	**URS002-01**	**PAGE 1**	
REPORT DATE:	**02/08/02**		
DATE SAMPLED:	**01/14,15/02**	**DATE RECEIVED:**	**01/15/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

Six water samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA CONVENTIONALS

SAMPLE ID	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaCO3/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
PD2-G	4.4	6.38	42.9	<0.100	<0.100
PD5-G	3.7	49.5	73.0	<0.100	<0.100
PD4-G	4.7			<0.100	<0.100

SAMPLE ID	TOC (mg/l)	DOC (mg/l)	NITRATE (mg/l)	NITRITE (mg/l)	SRP (mg/l)	TOT DIS-P (mg/l)
PD2-G			1.42	0.003	0.007	0.012
PD5-G	78.9	6.75	1.51	0.011	0.003	0.007
PD4-G	11.5	5.82			0.011	0.034
PD8-G	3.53	2.36			0.019	0.020
PD9-G	0.661	0.421			0.024	0.024
PD19-G					0.024	0.023

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-01 PAGE 2

REPORT DATE: 02/08/02

DATE SAMPLED: 01/14,15/02 DATE RECEIVED: 01/15/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

SAMPLE DATA TOTAL METALS

SAMPLE ID	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
PD2-G	<0.100	11.2	0.184	3.48	0.141	2.04	6.17
PD5-G	<0.100	29.6	1.60	4.53	0.827	2.53	14.0
PD4-G	<0.100	43.5	1.15	8.43	2.16	3.38	13.0

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LABORATORY & CONSULTING SERVICES

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CASE FILE NUMBER:	**URS002-01**	**PAGE 3**	
REPORT DATE:	**02/08/02**		
DATE SAMPLED:	**01/14,15/02**	**DATE RECEIVED:**	**01/15/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
METHOD	EPA 325.3	EPA 375.4	EPA 310.1	EPA 340.2	SM184500BRB
DATE ANALYZED	01/18/02	01/28/02	01/23/02	01/24/02	02/07/02
DETECTION LIMIT	0.50	1.00	1.00	0.100	0.100
DUPLICATE					
SAMPLE ID	BATCH	BATCH	BATCH	PD5-G	PD2-G
ORIGINAL	2.3	3.66	42.0	<0.100	<0.100
DUPLICATE	2.3	3.70	41.9	<0.100	<0.100
RPD	NC	1.04%	0.24%	NC	NC
SPIKE SAMPLE					
SAMPLE ID	BATCH	BATCH		PD5-G	PD2-G
ORIGINAL	2.3	3.66		<0.100	<0.100
SPIKED SAMPLE	12.3	14.4		1.07	0.223
SPIKE ADDED	10.0	10.0		1.00	0.250
% RECOVERY	99.97%	107.01%	NA	106.74%	89.20%
QC CHECK					
FOUND	30.4	19.6		0.915	
TRUE	30.0	20.0		1.00	
% RECOVERY	101.30%	97.76%	NA	91.53%	NA
BLANK	<0.50	<1.00	<1.00	<0.100	<0.100

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-01

REPORT DATE: 02/08/02

DATE SAMPLED: 01/14,15/02 **DATE RECEIVED:** 01/15/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	TOC (mg/l)	DOC (mg/l)	NITRATE (mg/l)	NITRITE (mg/l)	SRP (mg/l)	TOT DIS-P (mg/l)
METHOD	EPA 415.2	EPA 415.2	EPA 353.2	EPA354.1	EPA 365.1	EPA 365.1
DATE ANALYZED	01/29/02	01/29/02	01/24/02	01/17/02	01/16/02	01/22/02
DETECTION LIMIT	0.250	0.250	0.010	0.002	0.001	0.002
DUPLICATE						
SAMPLE ID		BATCH	BATCH	PD5-G	PD19-G	PD19-G
ORIGINAL		5.61	0.201	0.011	0.024	0.023
DUPLICATE		5.48	0.204	0.011	0.025	0.023
RPD	NA	2.42%	1.55%	0.00%	2.26%	0.43%
SPIKE SAMPLE						
SAMPLE ID		BATCH	BATCH	PD5-G	PD19-G	PD19-G
ORIGINAL		5.61	0.201	0.011	0.024	0.023
SPIKED SAMPLE		10.2	0.423	0.051	0.043	0.074
SPIKE ADDED		4.50	0.200	0.040	0.020	0.050
% RECOVERY	NA	102.64%	111.07%	100.00%	93.47%	100.84%
QC CHECK						
FOUND	1.88	1.88	0.461	0.040	0.028	0.093
TRUE	2.00	2.00	0.433	0.040	0.027	0.091
% RECOVERY	94.00%	94.00%	106.47%	100.00%	102.20%	102.44%
BLANK	<0.250	<0.250	<0.010	<0.002	<0.001	<0.002

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
C = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
R = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

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CASE FILE NUMBER:	**URS002-01**	**PAGE 5**	
REPORT DATE:	**02/18/02**		
DATE SAMPLED:	**01/14,15/02**	**DATE RECEIVED:**	**01/15/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA **TOTAL METALS**

QC PARAMETER	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
METHOD	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
DATE ANALYZED	01/22/02	01/22/02	01/22/02	01/22/02	01/22/02	01/22/02	01/22/02
DETECTION LIMIT	0.100	0.100	0.020	0.100	0.005	1.00	0.300
DUPLICATE							
SAMPLE ID	PD5-G	PD5-G	PD5-G	PD5-G	PD5-G	PD5-G	PD5-G
ORIGINAL	<0.100	29.6	1.60	4.53	0.827	2.53	14.0
DUPLICATE	<0.100	29.7	1.60	4.56	0.774	2.33	13.8
RPD	NC	0.34%	0.00%	0.66%	6.62%	8.23%	1.44%
SPIKE SAMPLE							
SAMPLE ID	PD5-G	PD5-G	PD5-G	PD5-G	PD5-G	PD5-G	PD5-G
ORIGINAL	<0.100	29.6	1.60	4.53	0.827	2.53	14.0
SPIKED SAMPLE	0.954	56.2	2.68	29.6	1.76	27.6	41.5
SPIKE ADDED	1.00	25.0	1.00	25.0	1.00	25.0	25.0
% RECOVERY	95.40%	106.40%	108.00%	100.28%	93.30%	100.28%	110.00%
QC CHECK							
FOUND	0.976	50.9	0.931	47.9	0.927	46.1	53.0
TRUE	1.00	50.0	1.00	50.0	1.00	50.0	50.0
% RECOVERY	97.60%	101.76%	93.08%	95.82%	92.65%	92.20%	106.00%
BLANK	<0.100	<0.100	<0.020	<0.100	<0.005	<1.00	<0.300

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-01B**		**PAGE 1**
REPORT DATE:	**02/18/02**		
DATE SAMPLED:	**01/15/02**	**DATE RECEIVED:**	**01/15/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SEDIMENT SAMPLES FROM URS / LAKE STEILACOOM

CASE NARRATIVE

Nine sediment samples were received by the laboratory in good condition . The samples were and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA - SEDIMENTS(DRY WT. BASIS)

SAMPLE ID	% SOLIDS	TOTAL-P (mg/kg)	LOOSLY BOUND P (NH4CL) (mg/kg)	FE+AL BOUND P (NAOH) (mg/kg)	FE+AL BOUND P (CBD) (mg/kg)	TOT. FE+AL BOUND P (NAOH+CBD) (mg/kg)	CA BOUND P (HCL) (mg/kg)
PD2-18	25.67%	234					
PD2-20	20.94%	125					
PC2-24	19.05%	128					
PD4-14	23.70%	429	<10.0	121	27.5	148	11.0
PD4-20	19.37%	169					
PD3-16	31.40%	611					
PD3-20	26.23%	299					
PD5-14	30.76%	136					
FLD-DUP	29.96%	343					

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-01B**	**PAGE 2**	
REPORT DATE:	**02/18/02**		
DATE SAMPLED:	**01/15/02**	**DATE RECEIVED:**	**01/15/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SEDIMENT SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA- SEDIMENTS

QC PARAMETER	% SOLIDS	TOTAL-P (mg/kg)	LOOSLY BOUND P (NH4CL) (mg/kg)	FE+AL BOUND P (NAOH) (mg/kg)	FE+AL BOUND P (CBD) (mg/kg)	TOT. FE+AL BOUND P (NAOH+CBD) (mg/kg)	CA BOUND P (HCL) (mg/kg)
METHOD	SM18 2540B	SM18 4500PF	SM18 4500PF	SM18 4500PF	SM18 4500PF	SM18 4500PF	SM18 4500PF
DATE PREPARED	01/28/02	02/04/02	02/08/02	02/08/02	02/08/02	02/08/02	02/08/02
DATE ANALYZED	1.00%	5.00	10.0	10.0	10.0	10.0	10.0
DETECTION LIMIT							
DUPLICATE							
	FLD-DUP	PD2-20	PD4-14	PD4-14	PD4-14	PD4-14	PD4-14
SAMPLE ID	29.96%	125	<10.0	121	27.5	148	11.0
ORIGINAL	33.54%	123	<10.0	90.9	28.9	120	13.8
DUPLICATE	11.28%	1.61%	NC	28.29%	5.00%	21.28%	22.95%
RPD							
SPIKE SAMPLE							
SAMPLE ID							
ORIGINAL							
SPIKED SAMPLE							
SPIKE ADDED	NA	NA	NA	NA	NA	NA	NA
% RECOVERY							
QC CHECK (mg/l)							
FOUND		0.903	0.072	0.072	0.072	0.072	0.072
TRUE		0.915	0.070	0.070	0.070	0.070	0.070
% RECOVERY	NA	98.69%	102.73%	102.73%	102.73%	102.73%	102.73%
BLANK	NA	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0

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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002-01

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS

SAMPLING DATE: 1/14/02 – 1/15/02

SAMPLERS: Galen C. Davis

PROJECT ID: LK. Stellacoom P Sources

CASE FILE NO.:

DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	Total Phosphorus	Hold bottle for future ++	Total Dissolved Phosph	Soluble React. Phosph.	TOC	DOC	Conventionals #	Metals #,##	CBD + NaOH + HCl ext.	BOTT #	NOTES
PD2-18 (soil)	1/14/02 0930	x	x								2	
PD2-20 (soil)	1/14/02 0940	x	x								2	
PD2-24 (soil)	1/14/02 0950	x	x								2	
PD4-14 (soil)	1/14/02 1110	x	x							X	2	
PD4-20 (soil)	1/14/02 1150	x	x								2	
PD3-16 (soil)	1/14/02 1020	x	x								2	
PD3-20 (soil)	1/14/02 1035	x	x								2	
PD5-14 (soil)	1/14/02 1320	x	x								2	
PD2-G (water)	1/14/02 0950	*	*	X	X			x	x		3	TP/SRP/Metals
PD5-G (water)	1/14/02 1325			x	x	x	x	x	x		3	field-filtered
PD4-G (water)	1/14/02 1130			x	x	x	x		x		3	w/ 0.045 µ nitro
PD8-G (water)	1/15/02 0930			x	x	x	x				2	cellulose filter
PD9-G (water)	1/15/02 1030			x	x	x	x		*		2	↓
PD19-G (water)	1/15/02 1200			x	x				*		1	
Fld-Dup	1/14/02 0930	X										

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen C. Davis	1/15/02 1400	[illegible]	1/15/01
Signature	Galen Davis		Tony Meadows	1400
Affiliation	URS		ART	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): ** Al, Ca, Fe, K, Mg, Mn, Na, Cl, Fl, Br, * NO_2 NO_3-N, SO_4, Alkalinity

+ +1 soil Jar from each soil sample hold for extractions (CBD, NaOH, HCl) we will call to discuss w/ Steve L.

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

June 17, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report for water samples received for laboratory analysis on 02/19/02.

Please let me know if you have any questions regarding this data report.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

Initial Surface sampling @ SW-1 and SW-3 2/02

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-02**	**PAGE 1**	
REPORT DATE:	**03/07/02**		
DATE SAMPLED:	**02/19/02**	**DATE RECEIVED:**	**02/19/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Two water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
SW-1-21902	0.034	0.031	0.030
SW-3-21902	0.049	0.038	0.037

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-02**	**PAGE 2**
REPORT DATE:	**03/07/02**	
DATE SAMPLED:	**02/19/02**	**DATE RECEIVED: 02/19/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	02/20/02	02/20/02	02/20/02
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	SW-3-21902		SW-3-21902
ORIGINAL	0.049		0.037
DUPLICATE	0.053		0.037
RPD	6.99%	NA	0.10%
SPIKE SAMPLE			
SAMPLE ID	SW-3-21902		SW-3-21902
ORIGINAL	0.049		0.037
SPIKED SAMPLE	0.095		0.058
SPIKE ADDED	0.050		0.020
% RECOVERY	91.33%	NA	102.72%
QC CHECK			
FOUND	0.093	0.093	0.029
TRUE	0.092	0.092	0.027
% RECOVERY	100.67%	100.67%	105.64%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS

PROJECT ID: PDL CREEK

SAMPLING DATE: 2/19/02

CASE FILE NO.:

SAMPLERS: Galen Davis 206-438-2079

DATA RECORDED BY:

SAMPLE INFORMATION

PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	Total Phosphorus	Tot. Dissolv. Phosphorus	Sol. Reac. Phosphorus	BOTT #	NOTES
SW-1-21902	2/19/02 1030	X	X	X	2	
SW-3-21902	2/19/02 1115	X	X	X	2	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	2/19/02	Olga Apalaryan	2/19/02
Signature	Galen Davis	1350	Olga Apalaryan	13:50
Affiliation	URS		ARI	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): Please Filter the Total Dissolved P and the SRP samples

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

September 23, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a revised data report and invoice for soil samples received for laboratory analysis on 08/27/02. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

RECEIVED
SEP 27 2002
URS ACCOUNTING

soil samples from MW installation (DRY WEIGHT)

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-03	PAGE 1	
REPORT DATE:	09/19/02		
DATE SAMPLED:	08/22,23/02	DATE RECEIVED:	08/27/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SOIL SAMPLES FROM URS

CASE NARRATIVE

Eight soil samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA -DRY WEIGHT BASIS

SAMPLE ID	TOTAL-P (mg/kg)
MS2-5	720
MS2-15	391
MS5-10	532
MS4-5	993
MS4-6	483
MS6-28	270
MS8-10	343
MS8-20	374

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-03	PAGE 2	
REPORT DATE:	09/19/02		
DATE SAMPLED:	08/27/02	DATE RECEIVED:	08/27/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SOIL SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/kg)
METHOD	EPA 365.1
DATE ANALYZED	09/12/02
DETECTION LIMIT	5.00
DUPLICATE	
SAMPLE ID	MS8-20
ORIGINAL	374
DUPLICATE	423
RPD	12.33%
SPIKE SAMPLE	
SAMPLE ID	MS8-20
ORIGINAL	
SPIKED SAMPLE	
SPIKE ADDED	
% RECOVERY	OR
QC CHECK (mg/l)	
FOUND	0.917
TRUE	0.916
% RECOVERY	100.11%
BLANK	<5.00

RPD = RELATIVE PERCENT DIFFERENCE
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OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

URS002.

CHAIN-OF-CUSTODY RECORD

CLIENT: URS Corp Contact: Galen Davis (206) 438 2000
SAMPLING DATE: 8/22/02 - 8/23/02
SAMPLERS: Galen Davis

SHEET 1 OF 1
PROJECT ID: Lake Stevens
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Total Phosphorus	BOTT #	NOTES
MS2-5	8/22/02 1030	X		
MS2-15	8/22/02 1035	X		
MS5-10	8/23/02 0830	X		
MS4-5	8/22/02 0845	X		
MS4-6	8/22/02 0846	X		
MS6-28	8/23/02 1020	X		
MS8-10	8/22/02 1315	X		
MS8-20	8/22/02 1400	X		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	8/22/02 1453	Steve Nielsen	8/23/02 14:53
Signature				
Affiliation	URS Corp		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

September 20, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report and invoice for ~~water~~ soil samples received for laboratory analysis on 08/27/02. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

RECEIVED
SEP 27 2002
URS ACCOUNTING

Soil samples from soil borings where MWs were installed.

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-03**	**PAGE 1**	
REPORT DATE:	**09/19/02**		
DATE SAMPLED:	**08/22,23/02**	**DATE RECEIVED:**	**08/27/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Eight water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)
MS2-5	3.14
MS2-15	1.71
MS5-10	2.36
MS4-5	3.97
MS4-6	2.13
MS6-28	1.43
MS8-10	1.80
MS8-20	1.75

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-03**	**PAGE 2**	
REPORT DATE:	**09/19/02**		
DATE SAMPLED:	**08/27/02**	**DATE RECEIVED:**	**08/27/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)
METHOD	EPA 365.1
DATE ANALYZED	09/12/02
DETECTION LIMIT	0.002
DUPLICATE	
SAMPLE ID	MS8-20
ORIGINAL	1.75
DUPLICATE	1.93
RPD	9.74%
SPIKE SAMPLE	
SAMPLE ID	MS8-20
ORIGINAL	
SPIKED SAMPLE	
SPIKE ADDED	
% RECOVERY	OR
QC CHECK	
FOUND	0.099
TRUE	0.091
% RECOVERY	108.31%
BLANK	<0.002

RPD = RELATIVE PERCENT DIFFERENCE.
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OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.01

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS Corp Contact: Galen Davis (206) 438-2081
SAMPLING DATE: 8/22/02 - 8/23/02
SAMPLERS: Galen Davis

SHEET 1 OF 1
PROJECT ID: Lake Skilacoom
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	Total Phosphorus	BOTT #	NOTES
MS2-5	8/22/02 1030	X		
MS2-15	8/22/02 1035	X		
MS5-10	8/23/02 0830	X		
MS4-5	8/22/02 0845	X		
MS4-6	8/22/02 0846	X		
MS6-28	8/23/02 1030	X		
MS8-10	8/22/02 1315	X		
MS8-20	8/22/02 1400	X		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	8/27/02 1453	Shawn Nielsen	8/27/02 14:53
Signature				
Affiliation	URS Corp		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

October 1, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report and invoice for ~~soil~~ water samples received for laboratory analysis on 08/30,09/04/02. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

1ST Round
8/29/02
9/3/02

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-04,05 **PAGE 1**
REPORT DATE: 10/01/02
DATE SAMPLED: 08/28-09/03/02 **DATE RECEIVED:** 08/30,09/04/02
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

Thirteen water samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. DOC results were greater than TOC, possibly from contamination from filtration. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA CONVENTIONALS

SAMPLE ID	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
MW2-G1	5.9	6.71	49.4	<0.100	NO SAMPLE
MW4-G1	4.7	5.04	44.5	<0.100	NO SAMPLE
MW5-G1	4.9	5.37	40.5	<0.100	NO SAMPLE
MW6-G1	5.6	6.63	38.3	<0.100	NO SAMPLE
MW8-G1	10.5	23.4	65.7	0.145	NO SAMPLE
DW3-G1	4.5	4.99	45.9	<0.100	NO SAMPLE

SAMPLE ID	TOC (mg/l)	DOC (mg/l)	NO3+NO2 (mg/l)	TOTAL-P (mg/l)	SRP (mg/l)	TOT DIS-P (mg/l)
MW2-G1	<0.250	0.757	1.57		0.014	0.008
MW4-G1	0.380	0.536	0.657		0.013	0.009
MW5-G1	0.235	1.69	1.64		0.031	0.026
MW6-G1	0.364	0.876	2.98		0.042	0.040
MW8-G1	0.239	1.36	1.14		0.043	0.040
DW3-G1	0.411	0.663	1.27		0.040	0.038
SW1-G1				0.040	0.038	0.036
SW2-G1				0.040	0.043	0.041
SW3-G1				0.043	0.043	0.041
SW13-G1				0.042	0.043	0.041
SW4-G1				0.028	0.014	0.018
SW5-G1				0.025	0.014	0.017
WS1-G1				0.077	0.076	0.073

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-04,05 PAGE 2

REPORT DATE: 10/01/02

DATE SAMPLED: 08/28-09/03/02 DATE RECEIVED: 08/30,09/04/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

SAMPLE DATA TOTAL METALS

SAMPLE ID	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
MW2-G1	<0.100	12.0	<0.020	4.40	0.074	1.84	7.12
MW4-G1	<0.100	10.9	<0.020	3.67	0.059	1.66	5.78
MW5-G1	<0.100	10.8	<0.020	4.06	<0.005	1.30	4.77
MW6-G1	<0.100	11.4	<0.020	4.54	<0.005	1.49	5.92
MW8-G1	<0.100	19.0	<0.020	5.32	0.032	4.07	12.3
DW3-G1	<0.100	11.9	<0.020	4.34	<0.005	1.39	5.23

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-04,05 **PAGE 3**

REPORT DATE: 10/01/02

DATE SAMPLED: 08/28-09/03/02 **DATE RECEIVED:** 08/30,09/04/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
METHOD	EPA 325.3	EPA 375.4	EPA 310.1	EPA 340.2	SM184500BRB
DATE ANALYZED	09/11/02	09/19/02	08/31/02	10/01/02	
DETECTION LIMIT	0.50	1.00	1.00	0.100	0.100
DUPLICATE					
SAMPLE ID	BATCH	BATCH	DW3-G1	BATCH	
ORIGINAL	1.6	6.57	45.9	<0.100	
DUPLICATE	1.6	6.63	47.3	<0.100	
RPD	NC	0.88%	2.90%	NC	NA
SPIKE SAMPLE					
SAMPLE ID	BATCH	BATCH		BATCH	
ORIGINAL	1.6	6.57		<0.100	
SPIKED SAMPLE	11.8	17.6		1.11	
SPIKE ADDED	10.0	10.0		1.00	
% RECOVERY	101.97%	109.82%	NA	111.08%	NA
QC CHECK					
FOUND	29.8	9.38		1.99	
TRUE	30.0	10.0		2.00	
% RECOVERY	99.30%	93.81%	NA	99.70%	NA
BLANK	<0.50	<1.00	<1.00	<0.100	NA

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-04,05 **PAGE 4**

REPORT DATE: 10/01/02

DATE SAMPLED: 08/28-09/03/02 **DATE RECEIVED:** 08/30,09/04/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	TOC (mg/l)	DOC (mg/l)	NO3+NO2 (mg/l)	TOTAL-P (mg/l)	SRP (mg/l)	TOT DIS-P (mg/l)
METHOD	EPA 415.2	EPA 415.2	EPA 353.2	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	09/13/02	09/13/02	09/17/02	09/23/02	08/30,09/05/02	09/23/02
DETECTION LIMIT	0.250	0.250	0.010	0.002	0.001	0.002
DUPLICATE						
SAMPLE ID	DW3-G1		DW3-G1	SW13-G1	MW2-G1	WS1-G1
ORIGINAL	0.411		1.27	0.042	0.014	0.073
DUPLICATE	0.369		1.25	0.041	0.014	0.074
RPD	10.57%	NA	1.60%	1.44%	0.30%	1.35%
SPIKE SAMPLE						
SAMPLE ID	DW3-G1		DW3-G1	SW13-G1	MW2-G1	WS1-G1
ORIGINAL	0.411			0.042	0.014	0.073
SPIKED SAMPLE	10.1			0.095	0.030	0.122
SPIKE ADDED	9.00			0.050	0.020	0.050
% RECOVERY	107.89%	NA	OR	107.04%	79.89%	99.66%
QC CHECK						
FOUND	4.07	4.07	0.425	0.089	0.027	0.089
TRUE	4.00	4.00	0.433	0.092	0.027	0.092
% RECOVERY	101.75%	101.75%	98.24%	96.74%	99.35%	96.74%
BLANK	<0.250	<0.250	<0.010	<0.002	<0.001	<0.002

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OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-04,05 PAGE 5

REPORT DATE: 10/01/02

DATE SAMPLED: 08/28-09/03/02 DATE RECEIVED: 08/30,09/04/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA **TOTAL METALS**

QC PARAMETER	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
METHOD	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
DATE ANALYZED	09/17/02	09/17/02	09/17/02	09/17/02	09/17/02	09/17/02	09/17/02
DETECTION LIMIT	0.100	0.100	0.020	0.100	0.005	1.00	0.300
DUPLICATE							
SAMPLE ID	MW8-G1	MW8-G1	MW8-G1	MW8-G1	MW8-G1	MW8-G1	MW8-G1
ORIGINAL	<0.100	19.0	<0.020	5.32	0.032	4.07	12.3
DUPLICATE	<0.100	20.4	<0.020	4.89	0.029	3.73	11.7
RPD	NC	7.11%	NC	8.42%	9.84%	8.72%	5.00%
SPIKE SAMPLE							
SAMPLE ID	MW8-G1	MW8-G1	MW8-G1	MW8-G1	MW8-G1	MW8-G1	MW8-G1
ORIGINAL	<0.100	19.0	<0.020	5.32	0.032	4.07	12.3
SPIKED SAMPLE	1.03	42.8	0.892	23.0	0.98	49.9	29.6
SPIKE ADDED	1.00	20.0	1.00	20.0	1.00	40.0	20.0
% RECOVERY	102.90%	119.00%	89.20%	88.40%	94.60%	114.58%	86.50%
QC CHECK							
FOUND	0.986	49.1	0.911	52.8	0.973	52.3	51.0
TRUE	1.00	50.0	1.00	50.0	1.00	50.0	50.0
% RECOVERY	98.60%	98.20%	91.10%	105.60%	97.30%	104.60%	102.06%
BLANK	<0.100	<0.100	<0.020	<0.100	<0.005	<1.00	<0.300

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OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

VIKS002-04

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS Corp. Cont: Galen 206-438-2079
SAMPLING DATE: 8/28/02 — 8/29/02
SAMPLERS: Galen Davis

SHEET 1 OF 1
PROJECT ID: Lk. Steil. P Study
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION Lake Steilacoom Phosphorus Study

SAMPLE ID	DATE/TIME COLLECTED	Dis. Metals **	Nutrients **	TDP/SRP	TOC	DOC	Total Phosphorus	BOTT #	NOTES
MW2-G1	8/27/02 0945	X	X	X	X	X		5	
MW4-G1	8/28/02 1610	X	X	X	X	X		5	
MW5-G1	8/29/02 1215	X	X	X	X	X		5	
MW6-G1	8/28/02 1456	X	X	X	X	X		5	
MW8-G1	8/26/02 1325	X	X	X	X	X		5	
DW3-G1	8/29/02 1315	X	X	X	X	X		5	
SW1-G1	8/29/02 1625			X			X	2	
SW2-G1	8/29/02 1549			X			X	2	
SW3-G1	8/29/02 1500			X			X	2	
SW13-G1	8/29/02 1600			X			X	2	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis		Susan Nielsen	8/30/02
Signature	Galen C. Davis			8:35 am
Affiliation	URS CORP			

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): * Diss Metals: Al, Fe, K, Mg, Mn, Na, Ca
** Nutrients: Cl, Ft, Br, NO_2+NO_3, SO_4, Alkalinity
TDP + SRP were Field-Filtered / DOC Field Filtered

⇒ SO_4 Alk Cl F Br are low priority if not enough sample

URS002.03

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS CORP Contact: Galen Davis 206 438-2079
SAMPLING DATE: 7/3/02
SAMPLERS: Galen C. Davis

SHEET 1 OF 1
PROJECT ID:
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION Lake Steilacoom Phosphorus Study

SAMPLE ID	DATE/TIME COLLECTED	Total Phosphorus	Total dissolved P	Soluble Reactive P	BOTT #	NOTES
SW4-G1	7/3/02 1130	X	X	X	2	
SW5-G1	7/3/02 1200	X	X	X	2	
WS1-G1	7/3/02 1004	X	X	X	2	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen C. Davis	7/3/02 1036	Shawn Wilson	7/3/02 1036
Signature	Galen Davis		[signature]	
Affiliation	URS CORP		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):
TDP/SRP was Field Filtered
Please Report along w/ samples submitted on 7/30/02

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-06	PAGE 1	
REPORT DATE:	10/11/02		
DATE SAMPLED:	09/23,24/02	DATE RECEIVED:	09/24/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Six water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
CW-45-1	0.045	0.041	0.040
CW-46-1	0.117	0.048	0.051
CW-59-1	1.93	0.039	0.039
CW-62-1	0.388	0.360	0.352
CW-162-1	0.392	0.357	0.344
CW-61-1	0.075	0.084	0.084

Springbrook
1ST Round
9/23,24/02

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-06	PAGE 2
REPORT DATE:	10/11/02	
DATE SAMPLED:	09/24/02	DATE RECEIVED: 09/24/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	10/04/02	10/04/02	09/25/02
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	CW-61-1		CW-61-1
ORIGINAL	0.075		0.084
DUPLICATE	0.073		0.083
RPD	2.80%	NA	1.74%
SPIKE SAMPLE			
SAMPLE ID	CW-61-1		CW-61-1
ORIGINAL	0.075		0.084
SPIKED SAMPLE	0.127		0.102
SPIKE ADDED	0.050		0.020
% RECOVERY	104.38%	NA	87.85%
QC CHECK			
FOUND	0.092	0.092	0.027
TRUE	0.092	0.092	0.027
% RECOVERY	99.53%	99.53%	99.45%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.06

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS CORP
SAMPLING DATE: 9/23 - 9/24/02
SAMPLERS: Galen Davis

SHEET 1 OF 1
PROJECT ID: CK Steilacoom P Study
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Total PhoS	Tot Diss. P	SRP	BOTT #	NOTES
CW-45-1	9/23/02 1000	X	X	X	2	
CW-46-1	9/23/02 1100	X	X	X	2	
CW-59-1	9/24/02 0630	X	X	X	2	
CW-62-1	9/24/02 0700	X	X	X	2	
CW-162-1	9/24/02 0911	X	X	X	2	
CW-61-1	9/24/02 0550	X	X	X	2	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen C. Davis	9/24/02 1107	Shawn Wiesen	9/24/02 1107
Signature	Galen C. Davis			
Affiliation	URS CORP		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

TDP/SRP was field-filtered

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

December 17, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

~~Dear Galen~~:

Please find enclosed two data reports and an invoice for water samples received for laboratory analysis on 12/04,06/02. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

2ND ROUND

*DW-3/SW-4/CW-62
NOT SAMPLED
NO FLOW

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-08	PAGE 1	
REPORT DATE:	12/13/02		
DATE SAMPLED:	12/03,04/02	DATE RECEIVED:	12/04/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Eleven water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
SW5-G2	0.021	0.009	0.005
SW2-G2	0.037	0.037	0.035
SW3-G2	0.047	0.045	0.043
SW13-G2	0.048	0.045	0.044
MW5-G2		0.035	0.034
MW4-G2		0.034	0.034
MW6-G2		0.046	0.043
MW2-G2		0.017	0.015
MW8-G2		0.050	0.045
SW1-G2	0.109	0.094	0.071
MW18-G2		0.051	0.048

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-08**	**PAGE 2**	
REPORT DATE:	**12/13/02**		
DATE SAMPLED:	**12/04/02**	**DATE RECEIVED:**	**12/04/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	12/09/02	12/09/02	12/04/02
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	BATCH	BATCH	MW18-G2
ORIGINAL	0.057	0.330	0.048
DUPLICATE	0.058	0.327	0.049
RPD	1.79%	0.90%	2.08%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	MW18-G2
ORIGINAL	0.057	0.330	0.048
SPIKED SAMPLE	0.112	0.375	0.067
SPIKE ADDED	0.050	0.050	0.020
% RECOVERY	110.50%	91.28%	93.03%
QC CHECK			
FOUND	0.093	0.093	0.027
TRUE	0.092	0.092	0.027
% RECOVERY	100.75%	100.75%	99.45%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.08

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS Corp.

PROJECT ID:

SAMPLING DATE: 12/3/02 & 12/4/02

CASE FILE NO.:

SAMPLERS: Graham C. Davis

DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	Total Dissv. P	Sol. Reac. P	Total P	BOTT #	NOTES
SW5-G2	12/3/02 1100	X	X	X	2	TDP/SRP
SW2-G2	12/3/02 0930	X	X	X	2	Samples
SW3-G2	12/3/02 0900	X	X	X	2	Field ;
SW13-G2	12/3/02 0830	X	X	X	2	Filtered
MW5-G2	12/3/02 1255	X	X		1	
MW4-G2	12/3/02 1545	X	X		1	
MW6-G2	12/3/02 1415	X	X		1	
MW2-G2	12/4/02 0930	X	X		1	
MW8-G2	12/4/02 1045	X	X		1	
SW1-G2	12/4/02 0730	X	X	X	2	
MW18-G2	12/4/02 1100	X	X		1	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Graham Davis	12/4/02	Sharon Nielsen	12/4/02
Signature	Graham Davis			14:15
Affiliation	URS CORP		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-09**	**PAGE 1**	
REPORT DATE:	**12/16/02**		
DATE SAMPLED:	**12/05/02**	**DATE RECEIVED:**	**12/06/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Four water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOT DIS-P (mg/l)	SRP (mg/l)
CW45-G2	0.047	0.040
CW46-G2	0.053	0.048
CW59-G2	0.180	0.166
CW61-G2	0.330	0.331

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-09	PAGE 2
REPORT DATE:	12/16/02	
DATE SAMPLED:	12/06/02	DATE RECEIVED: 12/06/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1
DATE ANALYZED	12/09/02	12/06/02
DETECTION LIMIT	0.002	0.001
DUPLICATE		
SAMPLE ID	CW61-G2	CW61-G2
ORIGINAL	0.330	0.331
DUPLICATE	0.327	0.335
RPD	0.90%	1.25%
SPIKE SAMPLE		
SAMPLE ID	CW61-G2	CW61-G2
ORIGINAL	0.330	
SPIKED SAMPLE	0.375	
SPIKE ADDED	0.050	
% RECOVERY	91.28%	OR
QC CHECK		
FOUND	0.093	0.028
TRUE	0.092	0.027
% RECOVERY	100.75%	101.94%
BLANK	<0.002	<0.001

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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002-C

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS Corp

PROJECT ID: IK. Skil. P Study

SAMPLING DATE: 12/6/02

CASE FILE NO.:

SAMPLERS: Madhu C. Davis

DATA RECORDED BY: Mc D

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Tot. Dis. P	PARAMETERS: Sol. Reac. P	BOTT #	NOTES
CW45-G2	12/5/02 0900	X	X	1	
CW46-G2	12/5/02 1035	X	X	1	Samples were Field-Filtered
CW59-G2	12/5/02 1350	X	X	1	
CW61-G2	12/5/02 1230	X	X	1	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Madhu C. Davis	12/6/02 0840	Olga Apalaryan	12-6-02
Signature	Galen Davis			08:50
Affiliation	URS			

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

December 10, 2002

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report and invoice for water samples received for laboratory analysis on 11/20/02. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

HERR MW-3
1ST sampled
11/20/02

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-07**	**PAGE 1**	
REPORT DATE:	**12/10/02**		
DATE SAMPLED:	**11/20/02**	**DATE RECEIVED:**	**11/20/02**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

One water sample was received by the laboratory in good condition . The sample was analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
HERR-MW-3-G2	0.059	0.056	0.051

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PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-07 **PAGE 2**

REPORT DATE: 12/10/02

DATE SAMPLED: 11/20/02 **DATE RECEIVED:** 11/20/02

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	12/02/02	12/02/02	11/21/02
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	BATCH		BATCH
ORIGINAL	0.097		0.003
DUPLICATE	0.101		0.003
RPD	4.72%	NA	5.91%
SPIKE SAMPLE			
SAMPLE ID	BATCH		BATCH
ORIGINAL	0.097		0.003
SPIKED SAMPLE	0.149		0.025
SPIKE ADDED	0.050		0.020
% RECOVERY	104.53%	NA	107.84%
QC CHECK			
FOUND	0.096	0.096	0.027
TRUE	0.092	0.092	0.027
% RECOVERY	104.59%	104.59%	98.22%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.G

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS
SAMPLING DATE: 11/20/02
SAMPLERS: Galen Davis

SHEET ____ OF ____
PROJECT ID:
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	TDP/SRP	Total P	BOTT #	NOTES
Herr-MW3-G2	11/20/02 0930	X	X	2	TDP/SRP Field-Filtered

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	11/20/02 1600	Sharon Nicksa	11/20/02 1600
Signature				
Affiliation			ARI	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

February 19, 2003

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report and an invoice for water samples received for laboratory analysis on 01/27/03. Please submit the invoice for payment.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

WELL G1
Sampled 1/27/03

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-10 **PAGE 1**
REPORT DATE: 02/17/03
DATE SAMPLED: 01/27/03 **DATE RECEIVED:** 01/27/03
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

One water sample was delivered to the laboratory in good condition. The sample was analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA CONVENTIONALS

SAMPLE ID	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
WS-G1 WELL	4.7	8.66	69.8	0.120	0.101

SAMPLE ID	NO3+NO2 (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	TOT DIS-P (mg/l)
WS-G1 WELL	0.591	0.028	0.033	0.032

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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-10 PAGE 2

REPORT DATE: 02/17/03

DATE SAMPLED: 01/27/03 DATE RECEIVED: 01/27/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

SAMPLE DATA TOTAL METALS

SAMPLE ID	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
WS-G1 WELL	<0.100	15.3	<0.020	9.34	<0.005	2.20	5.87

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PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-10 **PAGE 3**

REPORT DATE: 02/17/03

DATE SAMPLED: 01/27/03 **DATE RECEIVED:** 01/27/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
METHOD	EPA 325.3	EPA 375.4	EPA 310.1	EPA 340.2	SM184500BRB
DATE ANALYZED	02/11/03	02/10/03	02/06/03	02/14/03	02/14/03
DETECTION LIMIT	0.50	1.00	1.00	0.100	0.100
DUPLICATE					
SAMPLE ID	WS-G1 WELL	BATCH	WS-G1 WELL		
ORIGINAL	4.7	1.47	69.8		
DUPLICATE	4.8	1.49	69.6		
RPD	2.11%	1.28%	0.29%	NA	NA
SPIKE SAMPLE					
SAMPLE ID	WS-G1 WELL	BATCH			
ORIGINAL	4.7	1.47			
SPIKED SAMPLE	14.6	10.8			
SPIKE ADDED	10.0	10.0			
% RECOVERY	98.97%	93.68%	NA	NA	NA
QC CHECK					
FOUND	27.9	19.8		1.02	0.227
TRUE	30.0	20.0		1.00	0.250
% RECOVERY	92.97%	99.20%	NA	102.25%	90.80%
BLANK	<0.50	<1.00	<1.00	<0.100	<0.100

RPD = RELATIVE PERCENT DIFFERENCE.
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OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-10 **PAGE 4**

REPORT DATE: 02/17/03

DATE SAMPLED: 01/27/03 **DATE RECEIVED:** 01/27/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	NO3+NO2 (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	TOT DIS-P (mg/l)
METHOD	EPA 353.2	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	01/30/03	01/27/03	02/03/03	02/03/03
DETECTION LIMIT	0.010	0.001	0.002	0.002
DUPLICATE				
SAMPLE ID	BATCH	WS-G1 WELL	BATCH	
ORIGINAL	0.708	0.028	0.054	
DUPLICATE	0.731	0.028	0.053	
RPD	3.21%	0.19%	0.75%	NA
SPIKE SAMPLE				
SAMPLE ID	BATCH	WS-G1 WELL	BATCH	
ORIGINAL	0.708	0.028	0.054	
SPIKED SAMPLE	0.922	0.051	0.104	
SPIKE ADDED	0.200	0.020	0.050	
% RECOVERY	107.18%	112.19%	100.48%	NA
QC CHECK				
FOUND	0.433	0.028	0.093	0.093
TRUE	0.433	0.027	0.092	0.092
% RECOVERY	99.97%	105.49%	101.19%	101.19%
BLANK	<0.010	<0.001	<0.002	<0.002

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-10 **PAGE 5**

REPORT DATE: 02/18/03

DATE SAMPLED: 01/27/03 **DATE RECEIVED:** 01/27/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA **DISSOLVED METALS**

QC PARAMETER	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
METHOD	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
DATE ANALYZED	02/17/03	02/17/03	02/17/03	02/17/03	02/17/03	02/17/03	02/17/03
DETECTION LIMIT	0.100	0.100	0.020	0.100	0.005	1.00	0.300
DUPLICATE							
SAMPLE ID	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL
ORIGINAL	<0.100	15.3	<0.020	9.34	<0.005	2.20	5.87
DUPLICATE	<0.100	16.1	<0.020	9.57	<0.005	2.22	5.76
RPD	NC	5.10%	NC	2.43%	NC	0.90%	1.89%
SPIKE SAMPLE							
SAMPLE ID	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL	WS-G1 WELL
ORIGINAL	<0.100	15.3	<0.020	9.34	<0.005	2.20	5.87
SPIKED SAMPLE	0.917	24.8	0.993	19.2	0.978	19.6	13.7
SPIKE ADDED	1.00	10.0	1.00	10.0	1.00	20.0	10.0
% RECOVERY	91.70%	95.00%	99.30%	98.60%	97.80%	87.00%	78.30%
QC CHECK							
FOUND	0.992	24.5	1.07	25.7	0.976	23.1	25.7
TRUE	1.00	25.0	1.00	25.0	1.00	25.0	25.0
% RECOVERY	99.20%	98.00%	107.00%	102.80%	97.60%	92.40%	102.80%
BLANK	<0.100	<0.100	<0.020	<0.100	<0.005	<1.00	<0.300

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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002-10

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS Corp
SAMPLING DATE: 1/27/03
SAMPLERS: Galen Davis

SHEET 1 OF 1
PROJECT ID: Lk. Steil. P Study
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Total P	Total Diss. P	SRP	Conventionals	Dissolved Metals	BOTT #	NOTES
WS-G1 well		X	X	X	X	X	5	1 Bottle extra unfiltered water TDP/SRP Diss Metals Field-Filtered

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen C. Davis	1/27/03	Shawn Nielsen	1/27/03
Signature	Galen Davis	1100	[signature]	1100
Affiliation	URS		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):
Metals = Al, Ca, Fe, K, Mg, Mn, Na

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

March 26, 2003

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

~~Dear Galen~~:

Please find enclosed two data reports for water samples received for laboratory analysis on 03/05,06/03.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

3rd Round Data

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-12 **PAGE 1**

REPORT DATE: 03/26/03

DATE SAMPLED: 03/04/03 **DATE RECEIVED:** 03/05/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

Thirteen water samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. DOC results were greater than TOC, possibly from contamination from filtration. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA CONVENTIONALS

SAMPLE ID	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
MW-AEF250-G3	3.10	10.4	53.5	NO SAMPLE	NO SAMPLE
MW-AEF222-G3	3.90	10.1	48.6	NO SAMPLE	NO SAMPLE
MW8-G3	3.40	16.6	33.7	NO SAMPLE	NO SAMPLE
WSG1-G3	5.30	10.7	67.5	NO SAMPLE	NO SAMPLE

SAMPLE ID	NO3+NO2 (mg/l)	TOTAL-P (mg/l)	SRP (mg/l)	TOT DIS-P (mg/l)
MW-AEF250-G3	1.91		0.019	0.020
MW-AEF222-G3	2.49		0.089	0.082
MW8-G3	0.287		0.045	0.048
DW1-G3			0.033	0.034
DW3-G3			0.028	0.028
WSG1-G3	1.28		0.029	0.030
SW3-G3		0.035	0.033	0.034
SW2-G3		0.030	0.028	0.029
SW1-G3		0.030	0.028	0.027
MW6-G3			0.042	0.044
MW16-G3			0.043	0.044
MW5-G3			0.032	0.034
MW4-G3			0.032	0.033

Field Dups

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-12 PAGE 2

REPORT DATE: 03/26/03

DATE SAMPLED: 03/04/03 DATE RECEIVED: 03/05/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

SAMPLE DATA DISSOLVED METALS

SAMPLE ID	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
MW-AEF250-G3	<0.100	13.4	<0.020	6.25	<0.005	2.20	5.02
MW-AEF222-G3	<0.100	12.5	<0.020	4.06	<0.005	1.23	6.76
MW8-G3	<0.100	11.6	<0.020	3.38	<0.005	1.69	4.63
WSG1-G3	<0.100	14.7	<0.020	8.32	<0.005	1.90	5.55
MW6-G3	<0.100	10.3	<0.020	3.99	<0.005	1.10	5.73
MW16-G3	<0.100	10.5	<0.020	3.95	<0.005	1.18	5.75

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-12 **PAGE 3**

REPORT DATE: 03/26/03

DATE SAMPLED: 03/04/03 **DATE RECEIVED:** 03/05/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	CHLORIDE (mg/l)	SULFATE (mg/l)	ALKALINITY (mg CaC03/l)	FLUORIDE (mg/l)	BROMIDE (mg/l)
METHOD	EPA 325.3	EPA 375.4	EPA 310.1	EPA 340.2	SM184500BRB
DATE ANALYZED	03/07/03	03/13/03	03/17/03		
DETECTION LIMIT	0.50	1.00	1.00	0.100	0.100
DUPLICATE					
SAMPLE ID	BATCH	BATCH	BATCH		
ORIGINAL	20.1	9.34	23.5		
DUPLICATE	20.3	9.70	23.6		
RPD	0.99%	3.72%	0.42%		
SPIKE SAMPLE					
SAMPLE ID	BATCH	BATCH			
ORIGINAL	20.1	9.34			
SPIKED SAMPLE	29.5	19.9			
SPIKE ADDED	10.0	10.0			
% RECOVERY	93.97%	105.38%	NA		
QC CHECK					
FOUND	29.5	9.50			
TRUE	30.0	10.0			
% RECOVERY	98.30%	94.99%	NA		
BLANK	<0.50	<1.00	<1.00		

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-12 **PAGE 4**

REPORT DATE: 03/26/03

DATE SAMPLED: 03/04/03 **DATE RECEIVED:** 03/05/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA

QC PARAMETER	NO3+NO2 (mg/l)	TOTAL-P (mg/l)	SRP (mg/l)	TOT DIS-P (mg/l)
METHOD	EPA 353.2	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	03/05/03	03/19/03	03/05/03	03/19/03
DETECTION LIMIT	0.010	0.002	0.001	0.002
DUPLICATE				
SAMPLE ID	WSG1-G3	BATCH	MW4-G3	MW4-G3
ORIGINAL	1.28	0.148	0.032	0.033
DUPLICATE	1.30	0.142	0.033	0.036
RPD	1.29%	4.42%	1.46%	10.27%
SPIKE SAMPLE				
SAMPLE ID	WSG1-G3	BATCH	MW4-G3	MW4-G3
ORIGINAL		0.148	0.032	0.033
SPIKED SAMPLE		0.198	0.050	0.083
SPIKE ADDED		0.050	0.020	0.050
% RECOVERY	OR	100.05%	88.67%	100.44%
QC CHECK				
FOUND	0.439	0.092	0.026	0.092
TRUE	0.433	0.092	0.027	0.092
% RECOVERY	101.45%	99.91%	96.88%	99.91%
BLANK	<0.010	<0.002	<0.001	<0.002

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-12 **PAGE 5**

REPORT DATE: 03/26/03

DATE SAMPLED: 03/04/03 **DATE RECEIVED:** 03/05/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS / LAKE STEILACOOM

QA/QC DATA **TOTAL METALS**

QC PARAMETER	ALUMINUM (mg/l)	CALCIUM (mg/l)	IRON (mg/l)	MAGNESIUM (mg/l)	MANGANESE (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)
METHOD	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
DATE ANALYZED	03/12/03	03/12/03	03/12/03	03/12/03	03/12/03	03/12/03	03/12/03
DETECTION LIMIT	0.100	0.100	0.020	0.100	0.005	1.00	0.300
DUPLICATE							
SAMPLE ID	MW16-G3	MW16-G3	MW16-G3	MW16-G3	MW16-G3	MW16-G3	MW16-G3
ORIGINAL	<0.100	10.5	<0.020	3.95	<0.005	1.18	5.75
DUPLICATE	<0.100	9.44	<0.020	3.47	<0.005	<1.00	5.36
RPD	NC	10.63%	NC	12.94%	NC	NC	7.02%
SPIKE SAMPLE							
SAMPLE ID	MW16-G3	MW16-G3	MW8-G1	MW16-G3	MW8-G1	MW16-G3	MW16-G3
ORIGINAL	<0.100	10.5	<0.020	3.95	<0.005	1.18	5.75
SPIKED SAMPLE	0.865	37.9	0.921	27.9	0.854	23.8	51.4
SPIKE ADDED	1.00	25.0	1.00	25.0	1.00	25.0	50.0
% RECOVERY	86.50%	109.60%	92.10%	95.80%	85.40%	90.37%	91.30%
QC CHECK							
FOUND	0.954	50.2	0.911	48.0	0.973	22.7	25.0
TRUE	1.00	50.0	1.00	50.0	1.00	25.0	25.0
% RECOVERY	95.40%	100.40%	91.10%	95.92%	97.30%	90.80%	99.96%
BLANK	<0.100	<0.100	<0.020	<0.100	<0.005	<1.00	<0.300

RPD = RELATIVE PERCENT DIFFERENCE
NA = NOT APPLICABLE OR NOT AVAILABLE
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.12

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS

PROJECT ID: LK. Steil. P Study

SAMPLING DATE: 3/4/03

CASE FILE NO.:

SAMPLERS: Galen Davis

DATA RECORDED BY: GCD

Dist# 3375034600006

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	TDP	SRP	Total P	Diss. Metals*	Nutrients**	BOTT #	NOTES
AN-AEF250-G3	3/4/03 0830	X	X		X	X		
-AEF222-G3	0930	X	X		X	X		
NW8-G3	1030	X	X		X	X		
DW1-G3	1200	X	X					TDP SRP
DW3-G3	1230	X	X					Diss. Metals
WSG1-G3	1100	X	X		X	X		were field
W3-G3	1300	X	X	X				Filtered
SW2-G3	1410	X	X	X				
W1-G3	1440	X	X	X				
MW6-G3	1525	X	X		X			
W16-G3	1800	X	X		X			
MW5-G3	1615	X	X					
MW4-G3	1730	X	X					

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	3/5/03 0915	Shawn Nielsen	3/5/03
Signature	Galen Davis			0915
Affiliation	URS		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

Dissolved Metals = Al, Ca, Fe, K, Mg, Mn, Na

Nutrients = Cl, Fl, Br, NO_2, NO_3, SO_4, Alkalinity

only if enough water is available

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-13	PAGE 1	
REPORT DATE:	03/25/03		
DATE SAMPLED:	03/05/03	DATE RECEIVED:	03/06/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Ten water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
MW2-G3	[redacted]	0.017	0.018
SW4-G3	0.027	0.013	0.011
SW5-G3	0.032	0.017	0.014
CW62-G3	[redacted]	0.026	0.023
CW61-G3	[redacted]	0.350	0.350
CW59-G3	[redacted]	0.054	0.052
CW70-G3	[redacted]	0.055	0.053
CW45-G3	[redacted]	0.042	0.038
CW46-G3	[redacted]	0.047	0.043
CLOVERMW3-G3	[redacted]	0.035	0.033

F14 Dup

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**URS002-13**	**PAGE 2**	
REPORT DATE:	**03/25/03**		
DATE SAMPLED:	**03/06/03**	**DATE RECEIVED:**	**03/06/03**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	03/19/03	03/19/03	03/06/03
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	SW5-G3	BATCH	CLOVERMW3-G3
ORIGINAL	0.032	0.033	0.033
DUPLICATE	0.031	0.036	0.033
RPD	2.65%	10.27%	0.18%
SPIKE SAMPLE			
SAMPLE ID	SW5-G3	BATCH	CLOVERMW3-G3
ORIGINAL	0.032	0.033	0.033
SPIKED SAMPLE	0.080	0.083	0.050
SPIKE ADDED	0.050	0.050	0.020
% RECOVERY	97.18%	100.44%	84.37%
QC CHECK			
FOUND	0.092	0.092	0.026
TRUE	0.092	0.092	0.027
% RECOVERY	99.91%	99.91%	97.63%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.13

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS

PROJECT ID:

SAMPLING DATE: 3/5/03

CASE FILE NO.:

SAMPLERS: Galen Davis

DATA RECORDED BY: Galen Davis

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: TDP	SRP	Total Phosph	BOTT #	NOTES
MW2-G3	3/5/03 1220	X	X			
SW4-G3	3/5/03 1240	X	X	X		TDP + SRP
SW5-G3	3/5/03 1300	X	X	X		Field Filtered
WG2-G3	3/5/03 1415	X	X			
W61-G3	3/5/03 1520	X	X			
W59-G3	3/5/03 1600	X	X			
W70-G3	3/5/03 1530	X	X			
W45-G3	3/5/03 1645	X	X			
W46-G3	3/5/03 1740	X	X			
lower MW3-G3	3/5/03 1840	X	X			

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	3/6/03 0900	Shawn Nielsen	3/6/03
Signature	Galen Davis			0900
Affiliation	URS		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS
SAMPLING DATE: 3/4/03
SAMPLERS: Galen Davis
DO# 33750346 00006

PROJECT ID: LK. Stev. P Study
CASE FILE NO.:
DATA RECORDED BY: GCD

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	TDP	SRP	Total P	Diss. Metals **	Nutrients ***	BOTT #	NOTES
MW-AEF250-G3	3/4/03 0830	X	X		X	X		
MW-AEF222-G3	0930	X	X		X	X		
MW8-G3	1030	X	X		X	X		
DW1-G3	1200	X	X					TDP SRP
DW3-G3	1230	X	X					Diss. Metals
WSG1-G3	1100	X	X		X	X		were field
SW3-G3	1300	X	X	X				Filtered
SW2-G3	1410	X	X	X				
SW1-G3	1440	X	X	X				
MW6-G3	1525	X	X		X			
MW16-G3	1800	X	X		X			
MW5-G3	1615	X	X					
MW4-G3	1730	X	X					

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen Davis	3/5/03 0915	Shawn Nielsen	3/5/03
Signature	Galen Davis			0915
Affiliation	URS		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

* Dissolved Metals = Al, Ca, Fe, K, Mg, Mn, Na
** Nutrients = Cl, Fl, Br, NO_2, NO_3, SO_4, Alkalinity
*** only if enough water is available

AQUATIC RESEARCH
CONSULTING AND LABORATORY SERVICES FOR WATER RESOURCES

March 13, 2003

Galen Davis
URS Corp
1501 4th Ave. Suite 1400
Seattle, WA 98101

Dear Galen:

Please find enclosed a data report for water samples received for laboratory analysis on 02/20/03.

Please let me know if you have any questions regarding this data report or invoice.

Sincerely,
AQUATIC RESEARCH INCORPORATED

Steven Lazoff
Laboratory Director

AQUATIC RESEARCH, INC.
3927 AURORA AVENUE, N.
SEATTLE, WA 98103
PHONE: (206) 632-2715
FAX: (206) 632-2417

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-11	PAGE 1	
REPORT DATE:	03/12/03		
DATE SAMPLED:	02/20/03	DATE RECEIVED:	02/20/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

One water sample was received by the laboratory in good condition . The sample was analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
HERRMWG3	0.052	0.051	0.047

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-11 **PAGE 2**

REPORT DATE: 03/12/03

DATE SAMPLED: 02/20/03 **DATE RECEIVED:** 02/20/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	03/06/03	03/06/03	02/20/03
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	BATCH		BATCH
ORIGINAL	0.032		0.048
DUPLICATE	0.031		0.050
RPD	2.44%	NA	4.12%
SPIKE SAMPLE			
SAMPLE ID	BATCH		BATCH
ORIGINAL	0.032		0.048
SPIKED SAMPLE	0.084		0.068
SPIKE ADDED	0.050		0.020
% RECOVERY	104.61%	NA	98.44%
QC CHECK			
FOUND	0.094	0.094	0.026
TRUE	0.092	0.092	0.027
% RECOVERY	101.78%	101.78%	96.39%
BLANK	<0.002	<0.002	<0.001

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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

URS002.

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS
SAMPLING DATE: 2/20/03
SAMPLERS: Galen Davis

PROJECT ID:
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Total P	Tot. Diss. P	SRP	BOTT #	NOTES
HesrMW3-G3	2/20/03	X	X	X	2	TDP/SRP was field filtered?

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Galen C. Davis		Shawn Nielsen	2/20/03
Signature	Galen Davis			1105
Affiliation	URS		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): Send invoice separate from Lab Data Package

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-15	PAGE 1	
REPORT DATE:	07/16/03		
DATE SAMPLED:	06/18-20/03	DATE RECEIVED:	06/20/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Fourteen water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOT DIS-P (mg/l)	SRP (mg/l)
CW45-G4	0.042	0.039
CW46-G4	0.040	0.045
~~CW59-G4~~ CW61-G4	0.349	0.348
CW62-G4	0.033	0.035
WSG1-G4	0.033	0.035
MW8-G4	0.043	0.042
AEF250-G4	0.019	0.021
AEF222-G4	0.081	0.076
MW2-G4	0.016	0.020
MW4-G4	0.035	0.036
DW3-G4	0.015	0.022
MW5-G4	0.026	0.032
MW6-G4	0.040	0.039
CLOVER MW3-G4	0.044	0.037

4TH Round Data
June, 2003

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-15	PAGE 2	
REPORT DATE:	07/16/03		
DATE SAMPLED:	06/20/03	DATE RECEIVED:	06/20/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1
DATE ANALYZED	07/12/03	06/20/03
DETECTION LIMIT	0.002	0.001
DUPLICATE		
SAMPLE ID	CLOVER MW3-G4	CLOVER MW3-G4
ORIGINAL	0.044	0.037
DUPLICATE	0.038	0.036
RPD	14.95%	4.13%
SPIKE SAMPLE		
SAMPLE ID	CLOVER MW3-G4	CLOVER MW3-G4
ORIGINAL	0.044	0.037
SPIKED SAMPLE	0.094	0.056
SPIKE ADDED	0.050	0.020
% RECOVERY	101.37%	92.29%
QC CHECK		
FOUND	0.096	0.027
TRUE	0.092	0.027
% RECOVERY	104.10%	100.28%
BLANK	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-16	PAGE 1	
REPORT DATE:	07/16/03		
DATE SAMPLED:	06/23/03	DATE RECEIVED:	06/24/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

Six water samples were received by the laboratory in good condition . The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
SW3-G4	0.036	0.035	0.033
SW13-G4	0.038	0.035	0.035
SW1-G4	0.022	0.020	0.023
SW2-G4	0.035	0.032	0.031
SW4-G4	0.017	0.019	0.014
SW5-G4	0.016	0.013	0.008

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-16	PAGE 2	
REPORT DATE:	07/16/03		
DATE SAMPLED:	06/24/03	DATE RECEIVED:	06/24/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	07/12/03	07/12/03	06/24/03
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	SW5-G4	BATCH	SW5-G4
ORIGINAL	0.016	0.044	0.008
DUPLICATE	0.014	0.038	0.008
RPD	9.47%	14.95%	1.47%
SPIKE SAMPLE			
SAMPLE ID	SW5-G4	BATCH	SW5-G4
ORIGINAL	0.016	0.044	0.008
SPIKED SAMPLE	0.066	0.094	0.028
SPIKE ADDED	0.050	0.050	0.020
% RECOVERY	99.70%	101.37%	99.59%
QC CHECK			
FOUND	0.096	0.096	0.027
TRUE	0.092	0.092	0.027
% RECOVERY	104.10%	104.10%	99.89%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	URS002-14	PAGE 1	
REPORT DATE:	06/11/03		
DATE SAMPLED:	05/21/03	DATE RECEIVED:	05/21/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

CASE NARRATIVE

One water sample was received by the laboratory in good condition . The sample was analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows, while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
HERRMW3-G4	0.045	0.044	0.045

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: URS002-14 **PAGE 2**

REPORT DATE: 06/11/03

DATE SAMPLED: 05/21/03 **DATE RECEIVED:** 05/21/03

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM URS

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOT DIS-P (mg/l)	SRP (mg/l)
METHOD	EPA 365.1	EPA 365.1	EPA 365.1
DATE ANALYZED	06/02/03	06/02/03	05/21/03
DETECTION LIMIT	0.002	0.002	0.001
DUPLICATE			
SAMPLE ID	BATCH		BATCH
ORIGINAL	0.004		0.028
DUPLICATE	0.004		0.029
RPD	11.76%	NA	6.20%
SPIKE SAMPLE			
SAMPLE ID	BATCH		BATCH
ORIGINAL	0.004		0.028
SPIKED SAMPLE	0.055		0.047
SPIKE ADDED	0.050		0.020
% RECOVERY	101.72%	NA	96.85%
QC CHECK			
FOUND	0.091	0.091	0.027
TRUE	0.092	0.092	0.027
% RECOVERY	99.18%	99.18%	100.24%
BLANK	<0.002	<0.002	<0.001

RPD = RELATIVE PERCENT DIFFERENCE.
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NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff

Laboratory Director

URS002-1

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS

PROJECT ID:

SAMPLING DATE: 5-21-03

CASE FILE NO.:

SAMPLERS: J. RAPP (206) 438-2281

DATA RECORDED BY:

SAMPLE INFORMATION FAX → 438-2699

John Rapp

PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	Total P	Dissolved P	SRP	BOTT #	NOTES
HERRMW3-64	5-21-03 0940	X	X	X		Dissolved P needs to be Filtered

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	John Rapp	5-21-03	Shawn Nigus	5/21/03
Signature	John Rapp	1115	[signature]	1115
Affiliation	URS CORP		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): * NEW CONTACT PERSON (SEE PSOUG)

Aquatic Research Incorporated

3927 Aurora Ave N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: URS

PROJECT ID: 33750346

SAMPLING DATE: 6/18, 6/19, 6/20/2003

CASE FILE NO

SAMPLERS: J. RAPP

DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Total Dis. P	PARAMETERS: SRP	BOTT #	NOTES
CW45-G4	6/18 1245	X	X	2	
CW46-G4	6/18 1345	X	X	2	
CW59-G4	6/18 1445	X	X	2	
CW62-G4	6/18 1545	X	X	2	
WSG1-G4	6/19 945	X	X	2	
MW8-G4	6/19 1045	X	X	2	
AEF250-G4	6/19 1130	X	X	1	
AEF222-G4	6/19 1215	X	X	1	NEEDS TO BE FILTERED
MW2-G4	6/19 1330	X	X	1	
MW4-G4	6/19 1430	X	X	1	
DW3-G4	6/19 1450	X	X	1	
MW5-G4	6/19 1530	X	X	1	
MW6-G4	6/20 945	X	X	1	
Clover MW3-G4	6/20 1045	X	X	1	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	JOHN RAPP	6/20/2003 1200	SHANNON NELSON	6/20/03 1200
Signature	John Rapp			
Affiliation	URS		ARI	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: URS
SAMPLING DATE: 6-23-03
SAMPLERS: J. RAPP

SHEET 1 OF 1
PROJECT ID: 33750346
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	Total P	TDP	SRP	BOTT #	NOTES
SW3-G4	6/23 1015	X	X	X	2	
SW13-G4	6/23 1045	X	X	X	2	
SW1-G4	6/23 1100	X	X	X	2	
SW2-G4	6/23 1130	X	X	X	2	
SW4-G4	6/23 1200	X	X	X	2	
SW5-G4	6/23 1300	X	X	X	2	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	John Rapp	6/24	Shawn Nielson	6/24/03
Signature	John Rapp		[illegible]	0840
Affiliation	URS		ARI	

Special instructions (sample handling, turnaround time, etc.): All TDP and SRP have been field filtered

APPENDIX D

Boring Logs

Project: Lake Steilacoom Phosphorus Study Project Location: Lakewood, Washington Project Number: 33750346	**Log of Boring MS-1** Sheet 1 of 1

Date(s) Drilled and Installed	8/22/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	30 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	NA
Size and Type of Well Casing	NA	Screen Perforation	NA	Surface Elevation	264.10
Seal or Backfill	Bentonite Chips	Location			

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0						GW	Coarse GRAVEL with cobbles and some fine to coarse sand and silt (dense) (brown) (dry)		
260	5		1	6-10-8 18						
	10		2							Sampler refusal due to cobble
250	15		3	10-10-8 18				Same as above, increasing cobbles		No samples attempted below 15' because of cobbles
240	20									
	25							Same as above		
	30							Boring was terminated at 30' bgs due to refusal. Groundwater was not encountered. Boring was backfilled with bentonite chips.		
230	35									
	40									

ENV_SEA_WELL_2 T:\ONEWORLD\337503-1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/4/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring MW-2

Sheet 1 of 1

Date(s) Drilled and Installed	8/22/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	30 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	263.22
Size and Type of Well Casing	NA	Screen Perforation	NA	Surface Elevation	263.67
Seal or Backfill	Bentonite Chips	Location			

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0						GW	Brown, fine to coarse, well rounded GRAVEL with little sand/silt (loose) (dry)		Flush mount locking monument –Concrete
260										–Bentonite chips
	5		1	4-5-5 10				Grading more coarse		
	10		2	4-6-7 13			GW/ GP	Brown, coarse GRAVEL with little sand/silt, some cobbles (medium dense) (slightly moist)		
250										
	15		3	6-7-9 16			GW/ GP	Brown, coarse GRAVEL with some coarse sand (medium dense) (moist)		
	20		4	7-8-8 16				Same as above (wet)	21.30 ft ▼	21.30 ft on 8/29/02 22 ft ATD
240										–0.010-in screen
	25		5							Sampler refusal due to cobble
										–10-20 silica sand
	30							Boring was completed to 30' bgs. Groundwater was encountered at 21.3' bgs. Boring was completed as monitoring well.		**Ecology Well No. AHG-215**
230										
	35									
	40									

ENV_SEA_WELL_2 T:\ONEWORLD\33750346 LAKE STEILACOOM\LAKESTE.GPJ URSSEA3B.GLB URSSEA3.GDT 8/31/04

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring MW-4

Sheet 1 of 1

Date(s) Drilled and Installed	8/22/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	13 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	246.22
Size and Type of Well Casing	NA	Screen Perforation	NA	Surface Elevation	246.64
Seal or Backfill	Bentonite Chips	Location			

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0						GW	Brown, coarse GRAVEL with some fine sand and little silt (dry to moist)		Flush mount locking monument
								Grading more coarse		-Concrete
								Grading brown/black PEAT mixed with cobbles, peat is moderately fibrous (wet)		-Bentonite chips
	5		1	7-8-15			GM	Brown/black coarse GRAVEL with fine to coarse sand and peat matrix (wet) 6.3 ft ▼		6.3 ft ATD
240				23						-0.010-in screen
	10		2	7-10-15						
				25						-10-20 silica sand
								Boring was completed to 13' bgs. Groundwater was encountered at 6.3' bgs. Boring was completed as monitoring well.		**Ecology Well No. AHG-214**
	15									
230										
	20									
	25									
220										
	30									
	35									
210										
	40									

ENV_SEA_WELL_2 T:\ONEWORLD\33750346 LAKE STEILACOOM\LAKESTE.GPJ URSSEA3B.GLB URSSEA3.GDT 8/31/04

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring MW-5

Sheet 1 of 1

Date(s) Drilled and Installed	8/22/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	20 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	250.62
Size and Type of Well Casing	NA	Screen Perforation	NA	Surface Elevation	250.96
Seal or Backfill	Bentonite Chips	Location			

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
250	0						GM	Brown, silty, sandy, fine to coarse GRAVEL (loose) (moist to dry)		Flush mount locking monument –Concrete –Bentonite chips
	5		1	2-4-2 6				Same as above		
240	10		2	2-2-3 5				Same as above		–10-20 silica sand
							SP			
	15		3	5-6-5 11				Gray, fine, to coarse, gravelly SAND with little silt (medium dense) (wet) ▽		–0.010-in screen 16 ft at time of drilling
230	20							Boring was completed to 20' bgs. Groundwater was encountered at 16' bgs Boring was completed as monitoring well.		**Ecology Well No. AHG-217**
	25									
220	30									
	35									
210	40									

ENV_SEA_WELL_2 T:\ONEWORLD\33750346 LAKE STEILACOOM\LAKESTE.GPJ URSSEA3B.GLB URSSEA3.GDT 8/31/04

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring MW-6

Sheet 1 of 1

Date(s) Drilled and Installed	8/22/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	30 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	263.67
Size and Type of Well Casing	NA	Screen Perforation	NA	Surface Elevation	264.03
Seal or Backfill	Bentonite Chips	Location			

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0							Asphalt		Flush mount locking monument
							GW	Brown, sandy, fine to coarse GRAVEL with cobbles (loose) (dry)		–Concrete
260										–Bentonite chips
	5		1	4-4-3 7						
	10		2	6-8-10 18			GW/ GM	Brown, silty, sandy, fine to coarse GRAVEL with cobbles (dense) (dry)		
250										
	15		3	10-10-11 21				Same as above		
	20		4					Same as above		Sampler refusal due to cobble
240									▽	–0.010-in screen
	25		5	10-8-11 19				Same as above (wet)		Water was encountered at 24'-25' during drilling
										–10-20 silica sand
	30							Boring was completed to 30' bgs. Groundwater was encountered at 24'-25' bgs. Boring was completed as monitoring well.		Ecology Well No. AHG-218
230										
	35									
	40									

ENV_SEA_WELL_2 T:\ONEWORLD\33750346 LAKE STEILACOOM\LAKESTE.GPJ URSSEA3B.GLB URSSEA3.GDT 8/31/04

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring MW-7

Sheet 1 of 1

Date(s) Drilled and Installed	8/23/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	40 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	NA
Size and Type of Well Casing	NA	Screen Perforation	NA	Surface Elevation	258.60
Seal or Backfill	Bentonite Chips	Location			

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0						GW	Brown, coarse GRAVEL with some cobbles, little sand and silt (loose) (dry)		
	5		1	4-10-10 20			GW/ GP	Coarse GRAVEL with fine to coarse sand and cobbles (medium dense)		
250	10		2	10-15-10 25				Same as above		
	15		3	10-11-11 22				Same as above		
240	20		4					Same as above		Sampler refusal due to cobble No samples attempted below 20' bgs
	25							Same as above		
230	30									
	35									
220	40							Boring was completed to 40' bgs due to refusal. Groundwater was not encountered. Boring was backfilled with bentonite chips.		

ENV_SEA_WELL_2 T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/4/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring MW-8

Sheet 1 of 1

Date(s) Drilled and Installed	8/22/02	Logged By	Galen Davis	Checked By	
Drilling Method	Hollow Stem Auger	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	25 feet
Sampling Method	Dames & Moore	Hammer Data	150#/30"	Top of Casing Elevation	269.33
Size and Type of Well Casing	2" Sch 40 PVC	Screen Perforation	0.10-inch	Surface Elevation	N/M
Seal or Backfill	Bentonite Chips	Location			

Depth, feet	SAMPLES Type	Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
0						GW	Brown, coarse GRAVEL with little fine to coarse SAND (dense) (dry)		Flush mount locking monument -Concrete -Bentonite chips
5		1	5-8-9 17				Same as above, grading more fine, increasing sand		
10		2	6-10-11 21				Brown, sandy, fine to coarse GRAVEL with some cobbles (medium dense) (moist)		
15		3					Same as above		Sampler refusal due to cobble -0.010-in screen
20		4	5-5-2 7			GM	White, fine to coarse, silty, sandy GRAVEL (loose/soft) (wet) ▽ White/gray, coarse GRAVEL with white silt/fine to coarse sand matrix (medium dense) (wet)		-10-20 silica sand
25		5	10-10-11 21				Boring completed to 25' bgs. Groundwater was encountered between 15' and 20' bgs. Boring was completed as monitoring well. Nearby resident indicated white silty gravel is present at the surface in many areas around the drilling location.		**Ecology Well No. AHG-216**
30									
35									
40									

URS

ENV_SEA_WELL_2 T:\ONEWORLD\33750346 LAKE STEILACOOM\LAKESTE.GPJ URSSEA3B.GLB URSSEA3.GDT 8/31/04

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD1

Sheet 1 of 1

Date(s) Drilled	1/14/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	21 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	6 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	40' W of NW corner of Target Store		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Gray, gravelly, cobbely, fine to coarse SAND (dry) (dense) cobbles: andesitic, cherts, metam. (imported Steilacoom gravels)	0745
			1					Increasing silt	
	5		2					Less dense (wet)	6 ft ▼ water color tan in sampler little recovery
			3						
240	10		4						
			5						
			6						
	15		7					Increasing fine gravel and fine to medium sand	
			8					Mostly sand at bottom	
230	20								0920 no sample submitted
								Boring was completed to 20' bgs. Groundwater was encountered at 6' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD2

Sheet 1 of 1

Date(s) Drilled	1/14/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	27 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	6 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	50' N of center of north Gottschalks		

Elevation, feet	Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0					SM	Gray, gravelly, cobbley, fine to coarse SAND with silt (dense) (dry) (imported Steilacoom gravel)	0930 No sample
	5						Asphalt layer, very old, degraded	
						SM	Brown, gravelly, fine to coarse SAND with silt (medium dense) (wet at 6')	
							6 ft ▼	
240	10							
	15					PT	Brown, tan, black sphagnum peat with 4" thick brick red layer near top (medium stiff)	
230	20	Bag 18-20						
		Bag 20-22					6" thick reddish layer like sawdust at 21'	
		Bag 22-24						0950 Water Sample 23'-27'
	25	Bag 25				SW	Gray, fine to medium SAND (wet) (medium dense)	
							Boring was completed to 27' bgs. Groundwater was encountered at 6' bgs.	
220	30							
	35							
210	40							

ENV W/O WELL T:\ONEWORLD\337503-1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD3

Sheet 1 of 1

Date(s) Drilled	1/14/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	21 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	6 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	100' SW of S corner of theater building		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Gray, gravelly, cobbely, fine to coarse SAND (dry) (very dense) (fill)	
	5						SP	Asphalt layer 6 ft ▼	
240	10						PT	Brown/black, fine PEAT (plastic) (moist) (medium stiff) grades to light brown sphagnum at 13'	
	15		PD3-16 Bag 16-18 PD3-20 Bag 18-20						
230	20						SW	Gray, fine to coarse SAND with little silt (wet) (loose)	No water sample
								Boring was completed to 21' bgs. Groundwater was encountered at 6' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD4

Sheet 1 of 1

Date(s) Drilled	1/14/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	22 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	7 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	30' S of center of S wall of theater building		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Gray brown, gravelly, cobbely, fine to coarse SAND (dry) (dense) (fill)	
	5							Same as above (wet)	
								7 ft ▼	
240	10								1130 Water Sample 12'-16'
	15		PD4-14				PT	PEAT, fibrous at top with matted grasses, some fine twigs	1110
								Some brick red, granular, sawdust-like black streaks (moist to dry)	
230	20		PD4-20				SW	Gray, fine to coarse SAND (medium dense) (wet)	1150
	25							Boring was completed to 22' bgs. Groundwater was encountered at 7' bgs.	
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503-1\LAKESITE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD5

Sheet 1 of 1

Date(s) Drilled	1/14/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	18 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	5 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	Near inside corner of Target and standing wall		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Tan, gravelly, cobbley, fine to coarse SAND with some silt (dry) (dense) (fill)	
	5							5 ft ▼ Same as above (wet) (native?)	
240	10								1325 Water Sample 10'-14'
							PT	Dark brown PEAT (plastic clay like) grading tan grasses with sterns, little brick-red layers of grainy sawdust material (dry)	1320
	15		PD5-14				SW	Gray, fine to coarse SAND (wet) (medium dense)	
230	20							Boring was completed to 18' bgs. Groundwater was encountered at 5' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD6

Sheet 1 of 1

Date(s) Drilled	1/14/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	18 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	6 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	Toward west end current construction trailer site		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Tan and gray, gravelly, cobbley, fine to coarse SAND (dry) (dense) (fill) gravel well rounded classic Steilacoom gravel	Near refusal many times
	5							6 ft ▼ Same as above (wet) (native?)	
240	10								
	15								No samples submitted for analysis
230	20							Boring was completed to 18' bgs. Groundwater was encountered at 6'-7' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\33750\3-1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD7

Sheet 1 of 1

Date(s) Drilled	1/15/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	20 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	7 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	West end of construction site		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Tan, gravelly, cobbley, fine to coarse SAND (dry) (dense) (very clean, little fines)	Near refusal little recovery
	5							Same as above (wet) 7 ft ▼	
240	10								
	15								No samples submitted for analysis
230	20							Boring was completed to 20' bgs. Groundwater was encountered at 7' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503-1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD8

Sheet 1 of 1

Date(s) Drilled	**1/15/02**	Logged By	**Galen Davis**	Checked By	
Drilling Method	**Direct Push**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**20 feet**
Drill Rig Type	**Direct Push**	Drill Bit Size/Type		Ground Surface Elevation	**250.00**
Groundwater Level	**4 ft**	Sampling Method	**1" x 2' Poly-Lined Push-Out**	Hammer Data	**Auto**
Borehole Backfill		Location	**55' E of Target, approximate center of wall**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SM	Asphalt Gray/brown fine to coarse SAND with little gravel (dry) (loose), more silt encountered than at other locations	0820
									4 ft ▼
	5							Same as above (wet)	0830 Water Sample 5'-9'
240	10								
	15							Same as above	
230	20		Bag 18-20					Boring was completed to 20' bgs. Groundwater was encountered at 4' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD9

Sheet 1 of 1

Date(s) Drilled	1/15/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	16 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	6 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location	West end of construction site, ~20' N of PD7		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Gray/tan, gravelly SAND (dry) (dense) (fill)	
	5							Same as above (native?) 6 ft ▼	Water Sample 6'-10'
240	10								
	15							Boring was completed to 16' bgs. Groundwater was encountered at 6' bgs.	
230	20								
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project: Lake Steilacoom Phosphorus Study
Project Location: Lakewood, Washington
Project Number: 33750346

Log of Boring PD10

Sheet 1 of 1

Date(s) Drilled	1/15/02	Logged By	Galen Davis	Checked By	
Drilling Method	Direct Push	Drilling Contractor	Cascade Drilling	Total Depth of Borehole	18 feet
Drill Rig Type	Direct Push	Drill Bit Size/Type		Ground Surface Elevation	250.00
Groundwater Level	6 ft	Sampling Method	1" x 2' Poly-Lined Push-Out	Hammer Data	Auto
Borehole Backfill		Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
250	0						SP	Tan, gravelly, cobbley, fine to coarse SAND with little silt (dry) (dense)	
	5							Same as above (more loose) (increasing moisture) 6 ft ▼	
240	10							Same as above (wet) (medium dense)	
	15								No samples submitted for analysis
230	20							Boring was completed to 18' bgs. Groundwater was encountered at 6' bgs.	
	25								
220	30								
	35								
210	40								

ENV W/O WELL T:\ONEWORLD\337503~1\LAKESTE.GPJ URSSEA3.GLB URSSEA3.GDT 9/5/03

URS

Project No: 2331.0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

Location: Site SS-34N, On-base

Log of Borehole: CW-50

Total Depth 60

Depth-to-Water 41'

Engineer: D Seaver

Soil Boring Log

Depth	Elevation (NGVD)	Symbol	Description	OVM (ppm)
0	292.1		Ground Surface	
0–40			*Sandy GRAVEL (GW)* Mod dense, brown, well-graded gravels and cobbles w/ minor amount of sand, dry. Well rounded to sub-rounded gravels and cobbles. (Qvr)	0.0
40–45			*Gravelly SAND (SW)* Less dense, brown, well-graded sand w/ gravels, wet. Well-rounded. (Qvr)	0.0
41			Water at approximately 41' bgs	
45–60			*Sandy GRAVEL (GW)* Dense, grey, gravel w/ coarse sand, wet, rounded. (Qvr) Qva?	0.0
60	230		End of Borehole	0.0

Well Completion Diagram

Elevation (NGVD) 292.1

Well Data

Drill Method: H/S Auger

Drill Date: 6/5/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100 195th, STE 200 Bothell WA 98011

Datum (NGVD): 291.37 (PVC)

Northing 665353

Easting 1503921

Project No: 2331 0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

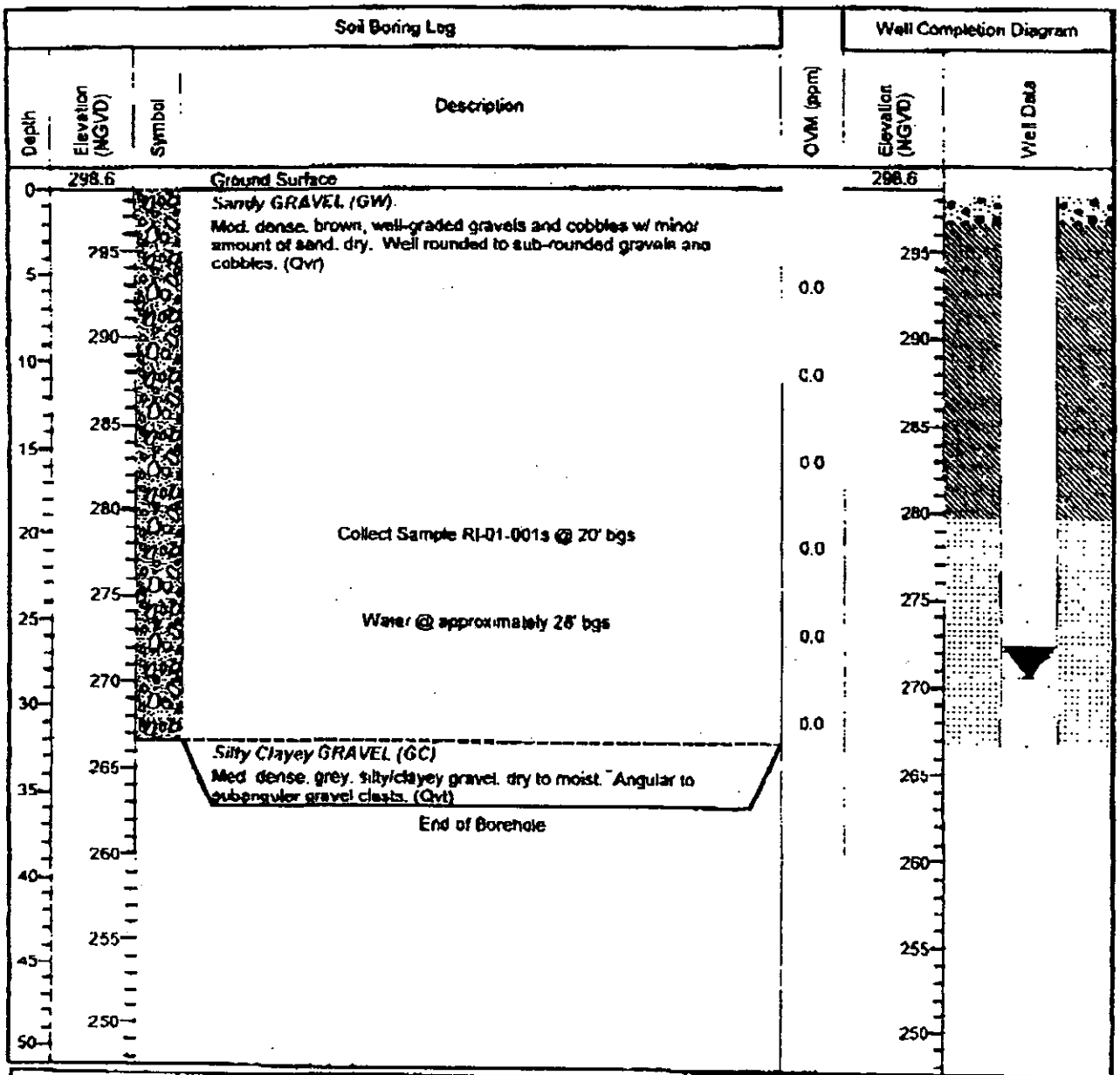
Location: Site SS-34N, On-base

Log of Borehole: CW-51

Total Depth 32'

Depth-to-Water 28'

Engineer: D. Seever



Drill Method: H/S Auger

Drill Date: 6/5/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100 195th, STE 200 Bothell WA 98011

Datum (NGVD): 298.10 (PVC)

Northing 665136

Easting 1503770

Project No: 2331 0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

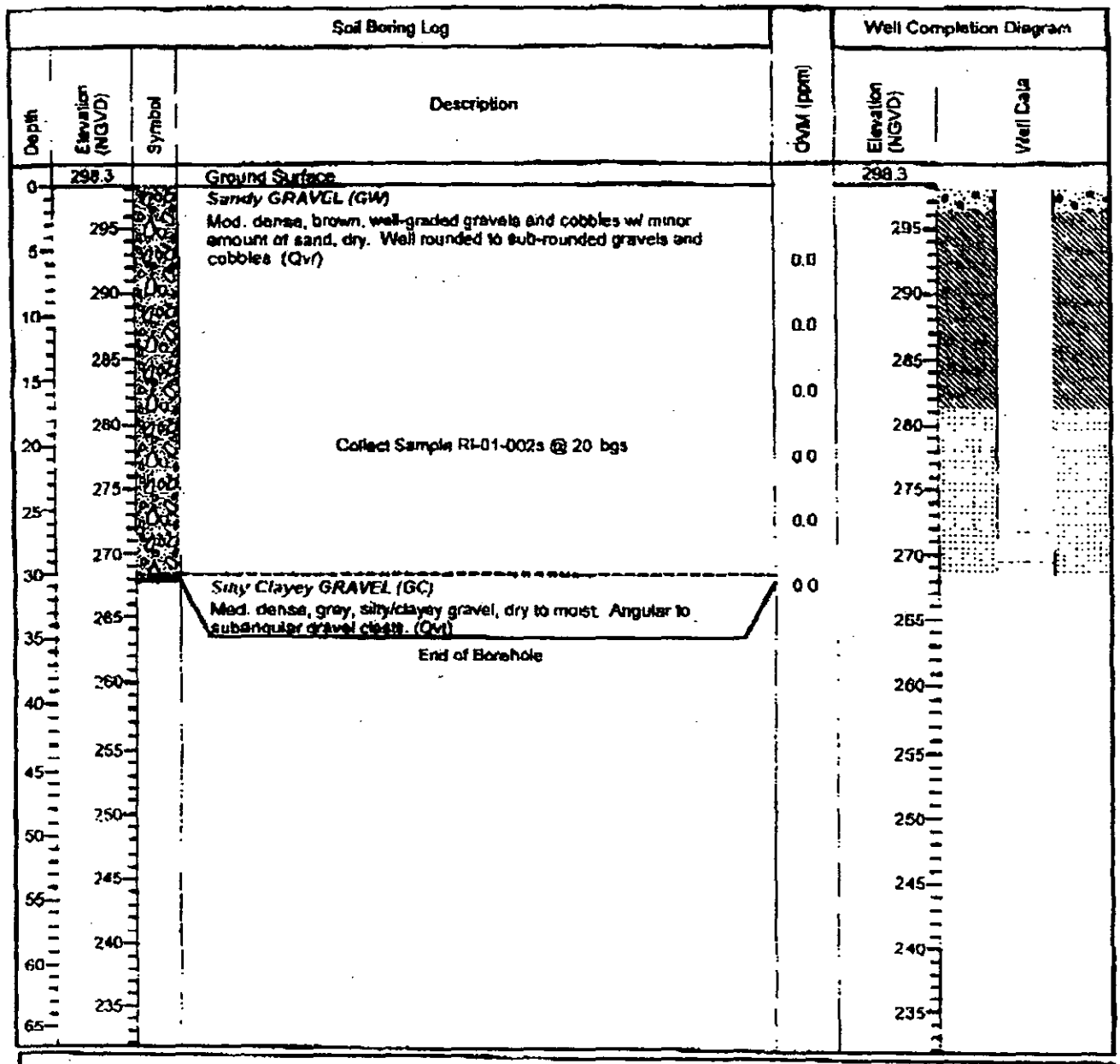
Location: Site SS-34N On-base

Log of Borehole: CW-52

Total Depth 30.5'

Depth-to-Water Dry

Engineer: D Seaver



Drill Method: H/S Auger

Drill Date: 6/5/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp [illegible]100
195th STE 200 Bothell WA 98011

Datum (NGVD): 297.79 (PVC)

Northing 665187

Easting 1503372

Project No: 2031.0001 3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

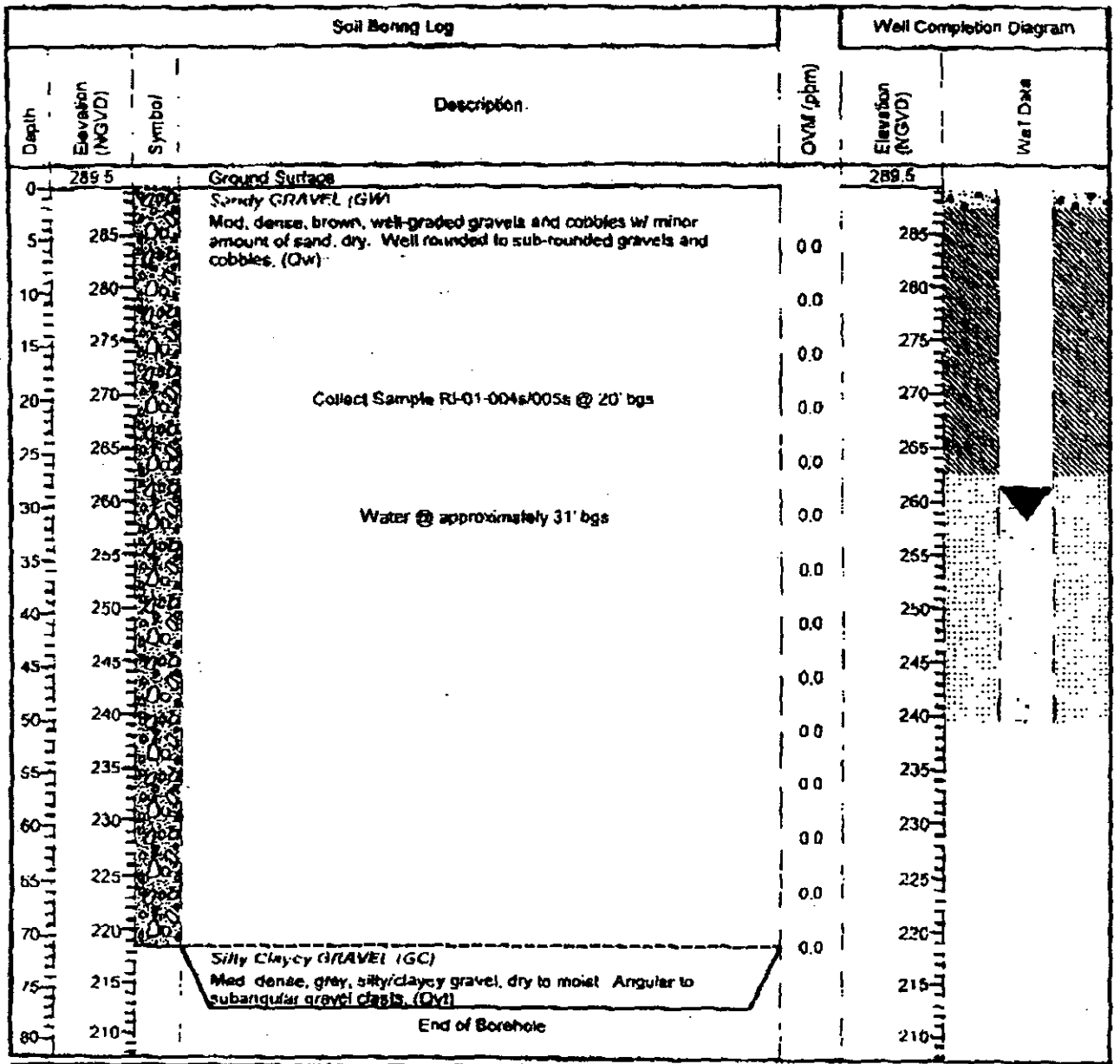
Location: Springbrook, 47th Ave.

Log of Borehole: CW-53

Total Depth 71'

Depth-to-Water 31'

Engineer: D. Seaver



Drill Method: H/S Auger

Drill Date: 6/6/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100 195th, STE 200 Bothell WA 98011

Datum (NGVD): 289.01 (PVC)

Northing 666225

Easting 1502805

Project No: 2331.0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

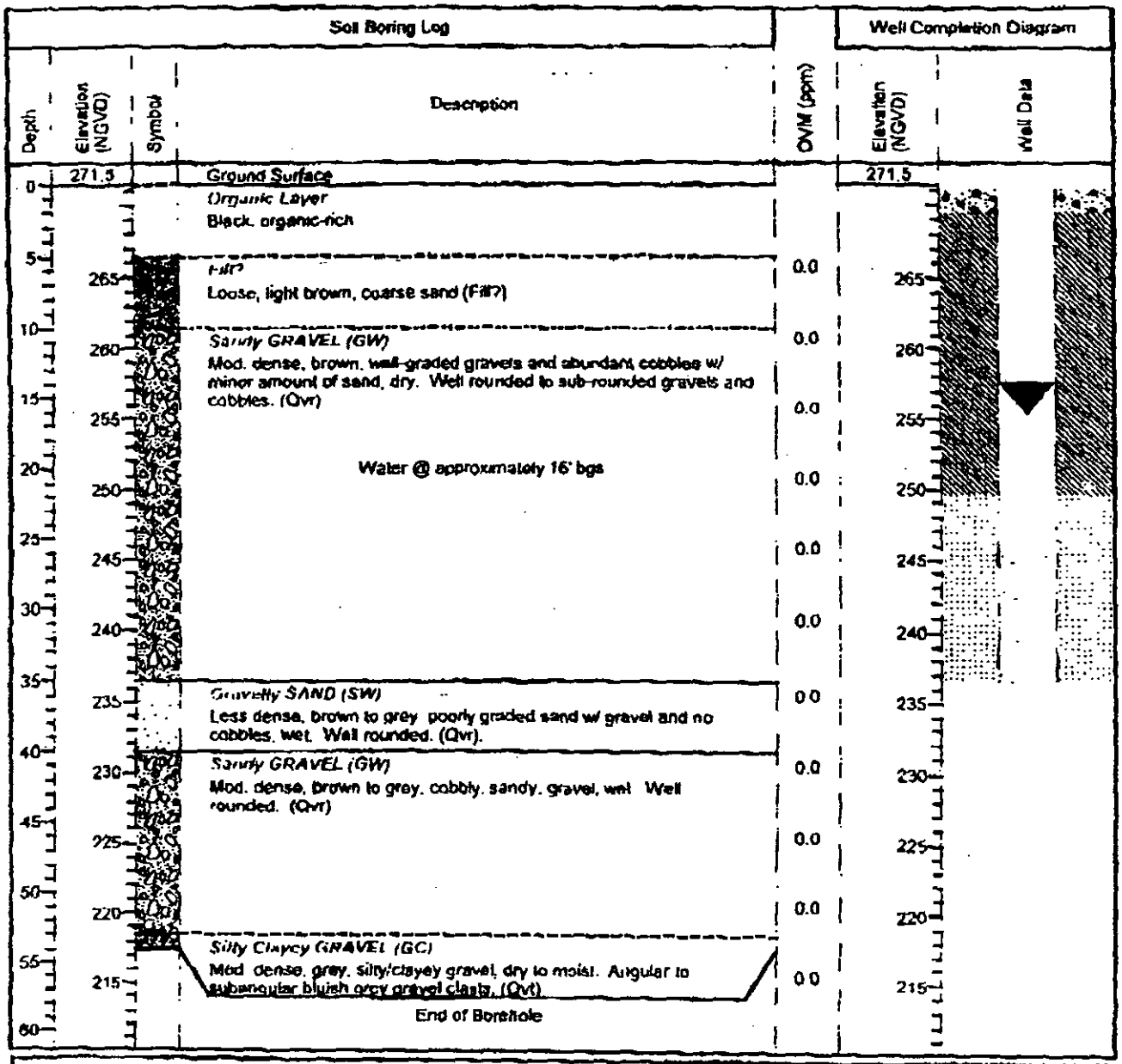
Location: Springbrook, 47th Ave.

Log of Borehole: CW-54

Total Depth 54'

Depth-to-Water 16'

Engineer: M. Ingersoll



Drill Method: H/S Auger

Drill Date: 6/12/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. . . 12100 196th, STE 200 . Bothell WA 98011

Datum (NGVD): 270.98 (PVC)

Northing 86652ft

Easting 1502836

Project No: 2331.0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

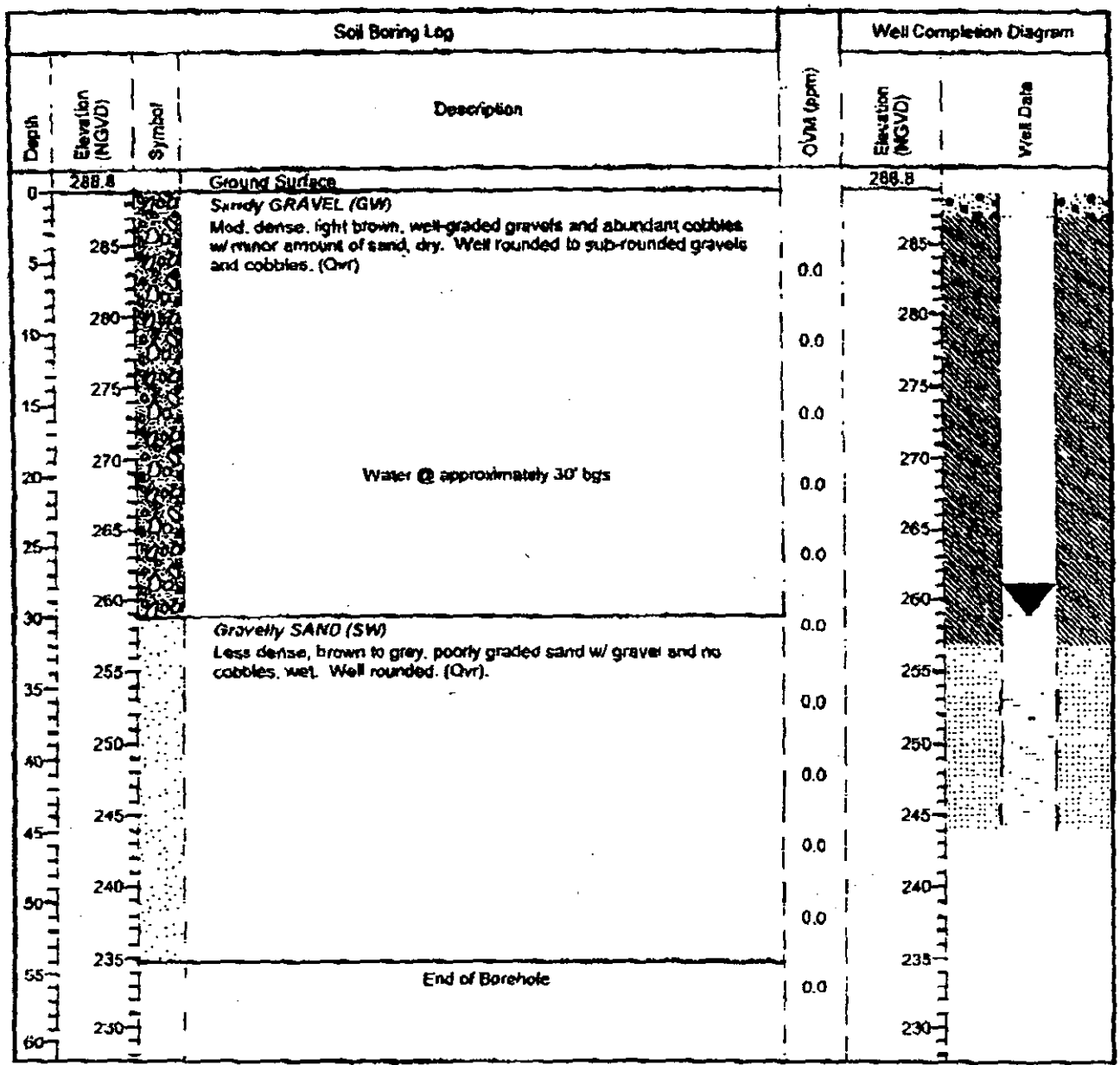
Location: Springbrook, 127th St.

Log of Borehole: CW-55a

Total Depth 45'

Depth-to-Water 30'

Engineer: D. Soaves



Drill Method: H/S Auger

Drill Date: 6/8/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100
195th. STE 200 Bothell WA 98011

Datum (NGVD): 288.38 (PVC)

Northing 668048

Easting 1502616

Project No: 2331 0001 3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

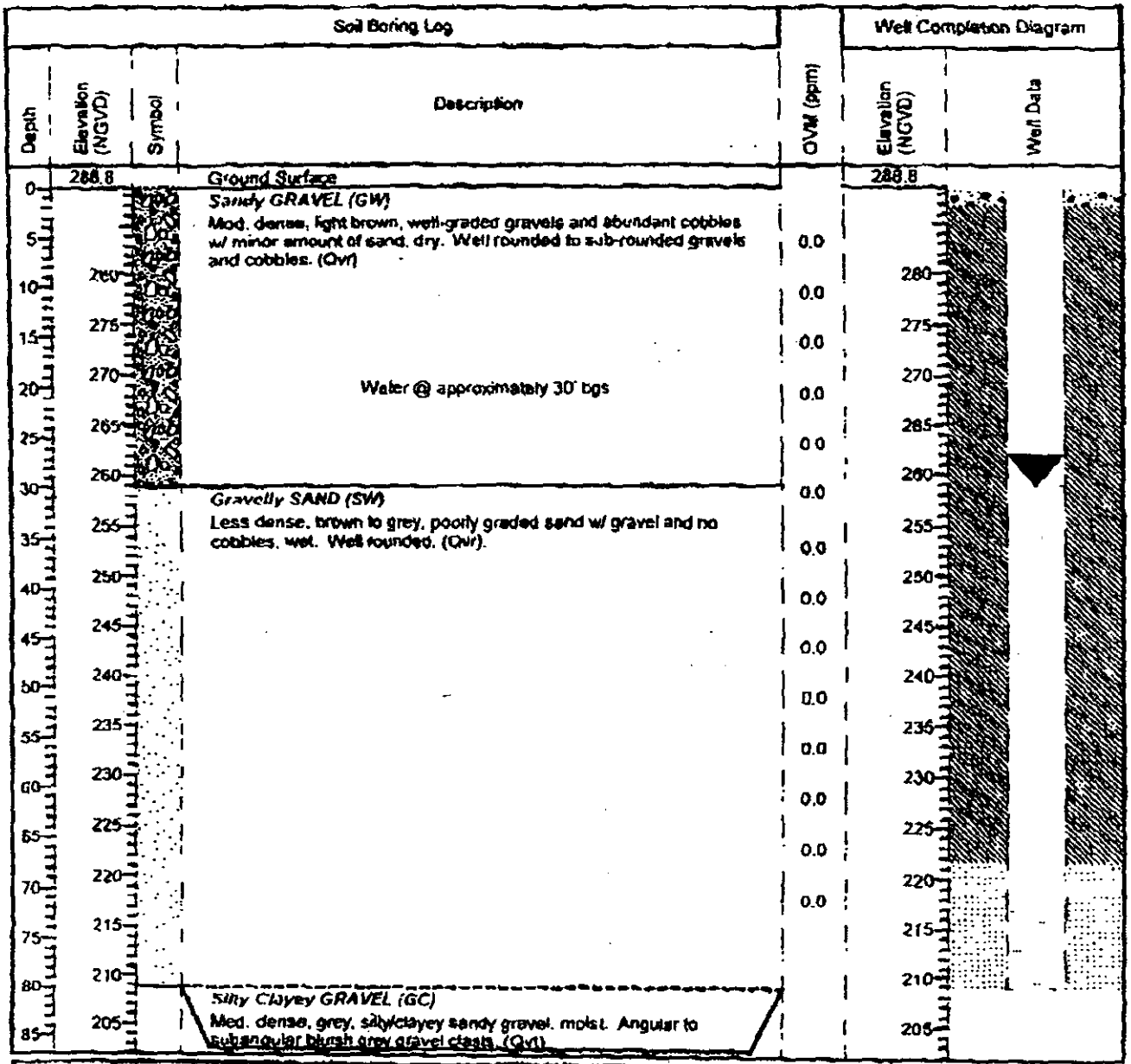
Location: Springbrook, 127th St.

Log of Borehole: CW-55b

Total Depth 80'

Depth-to-Water 30'

Engineer: D Seaver



Drill Method: H/S Auger

Drill Date: 6/6/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100
195th, STE 200 Bothell WA 98011

Datum (NGVD): 288.26 (PVC)

Northing 666048

Easting 1502622

Project No: 2331.0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

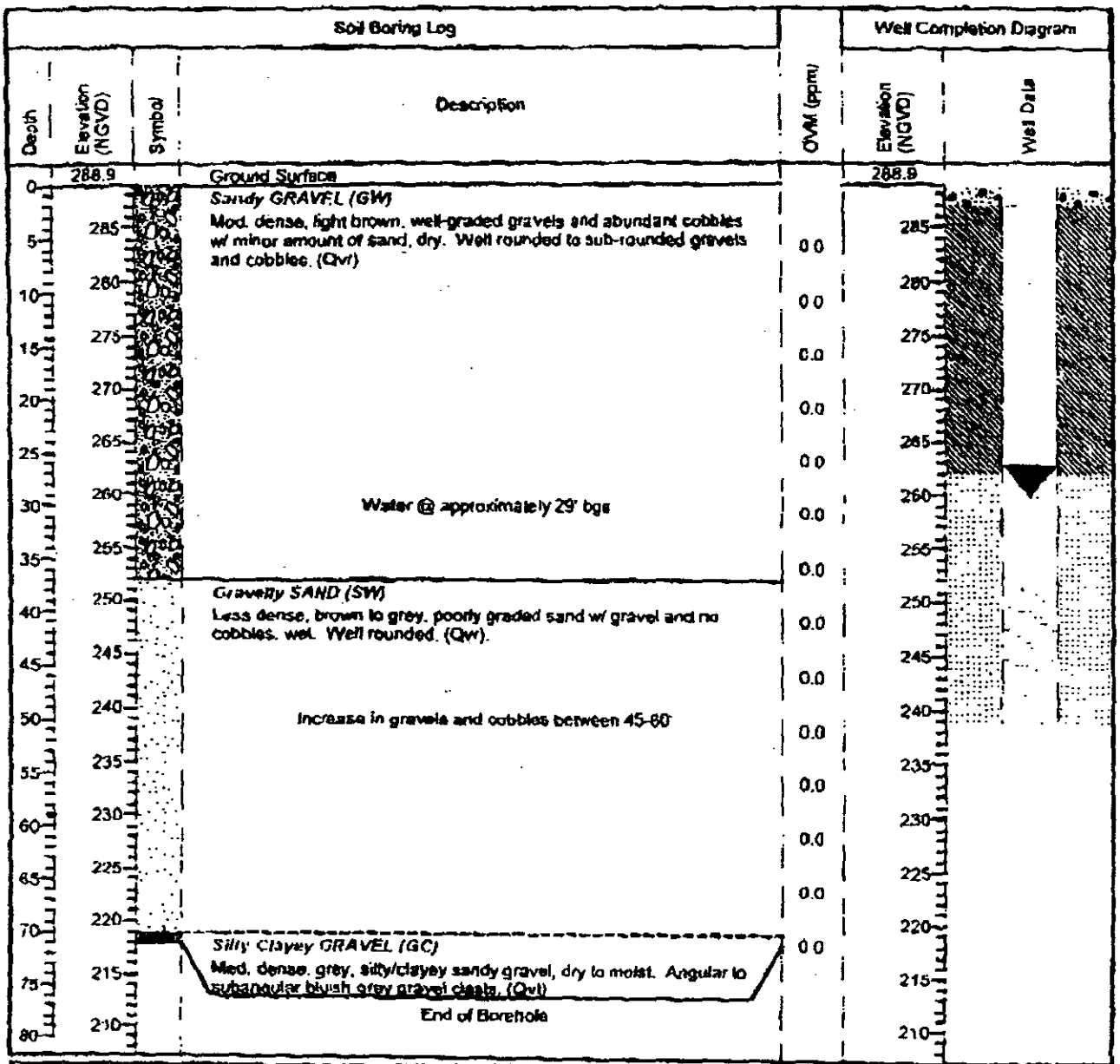
Location: Springbrook, 127th St.

Log of Borehole: CW-56

Total Depth 71'

Depth-to-Water 29'

Engineer: D. Seaver



Drill Method: H/S Auger

Drill Date: 6/7/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100 195th, STE 200. Bothell WA 98011

Datum (NGVD): 288.48 (PVC)

Northing 666058

Easting 1502494

Project No: 2331.0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

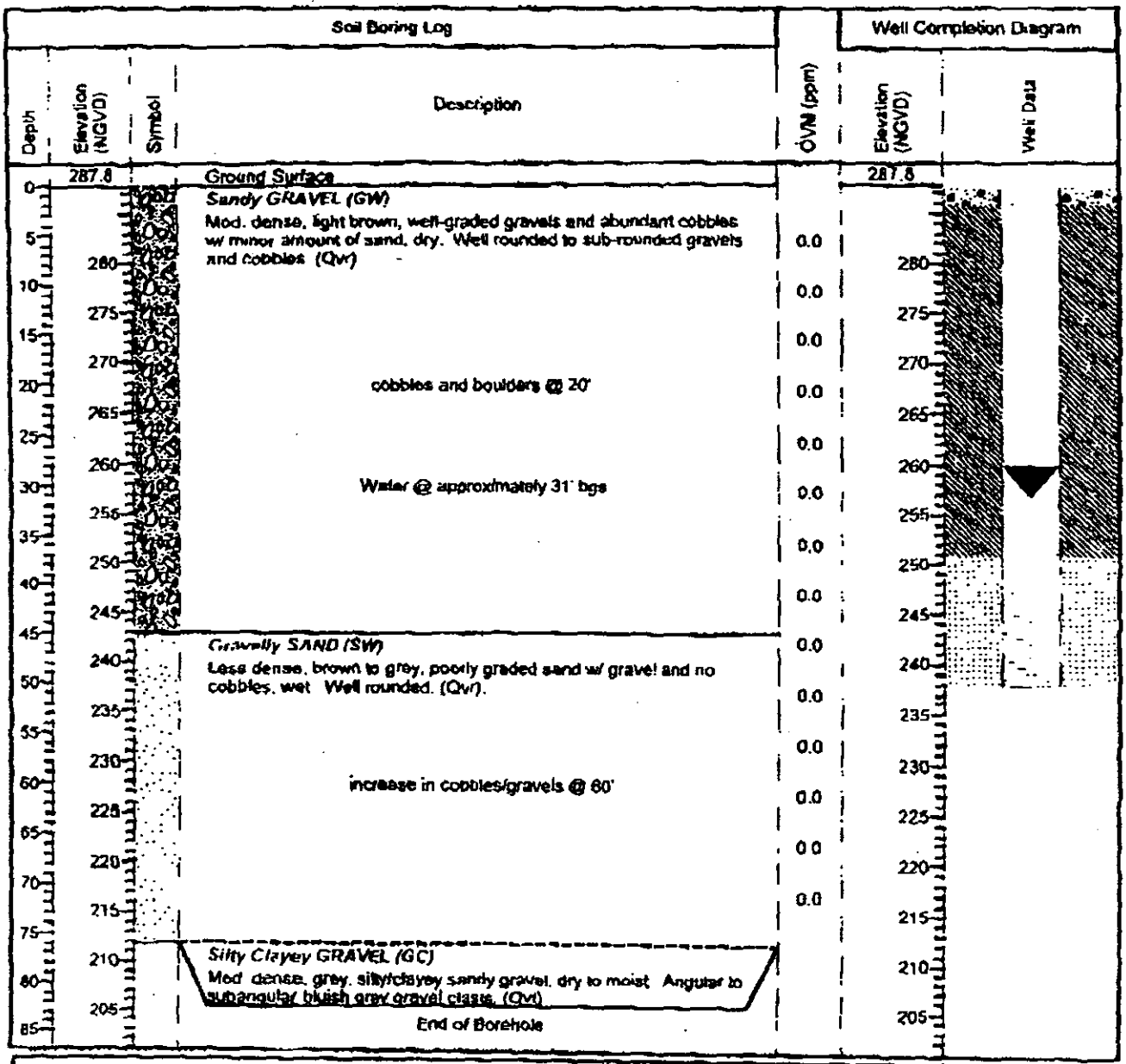
Location: Springbrook, 127th St

Log of Borehole: CW-57

Total Depth 76'

Depth-to-Water 31'

Engineer: D Seaver



Drill Method: H/S Auger

Drill Date: 6/7/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp.: 12100 195th, STE 200: Bothell WA 98011

Datum (NGVD): 287.27 (PVC)

Northing 666064

Easting 1502332

Project No: 2331 0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

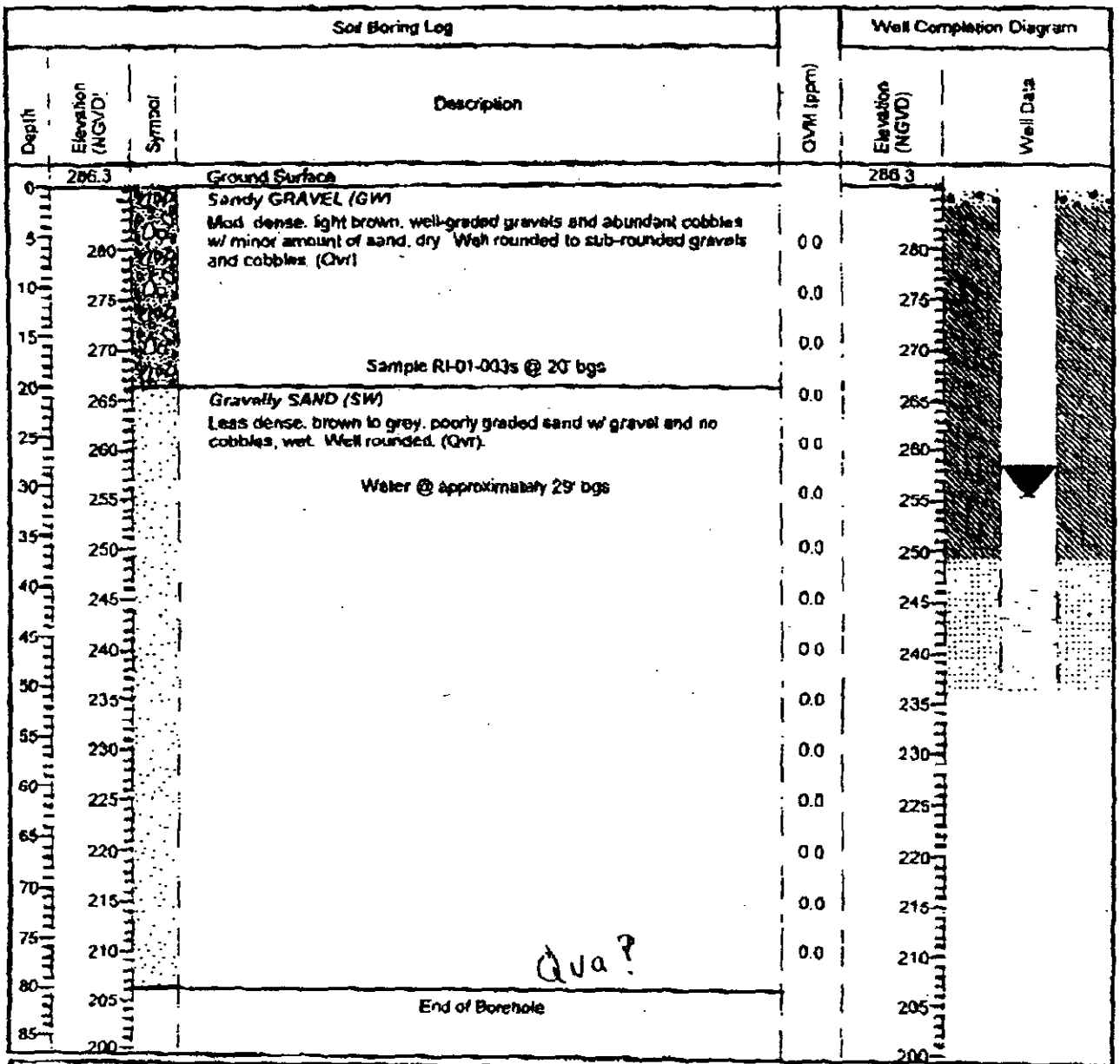
Location: Springbrook, 127th St. and Addison St.

Log of Borehole: CW-58

Total Depth 80'

Depth-to-Water 29'

Engineer: D. Seaver



Drill Method: H/S Auger

Drill Date: 6/6/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp 12100
195th, STE 200, Bothell WA 98011

Datum (NGVD): 286.67 (PVC)

Northing 668076

Easting 1502169

Project No: 2131.0001.3202.08050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

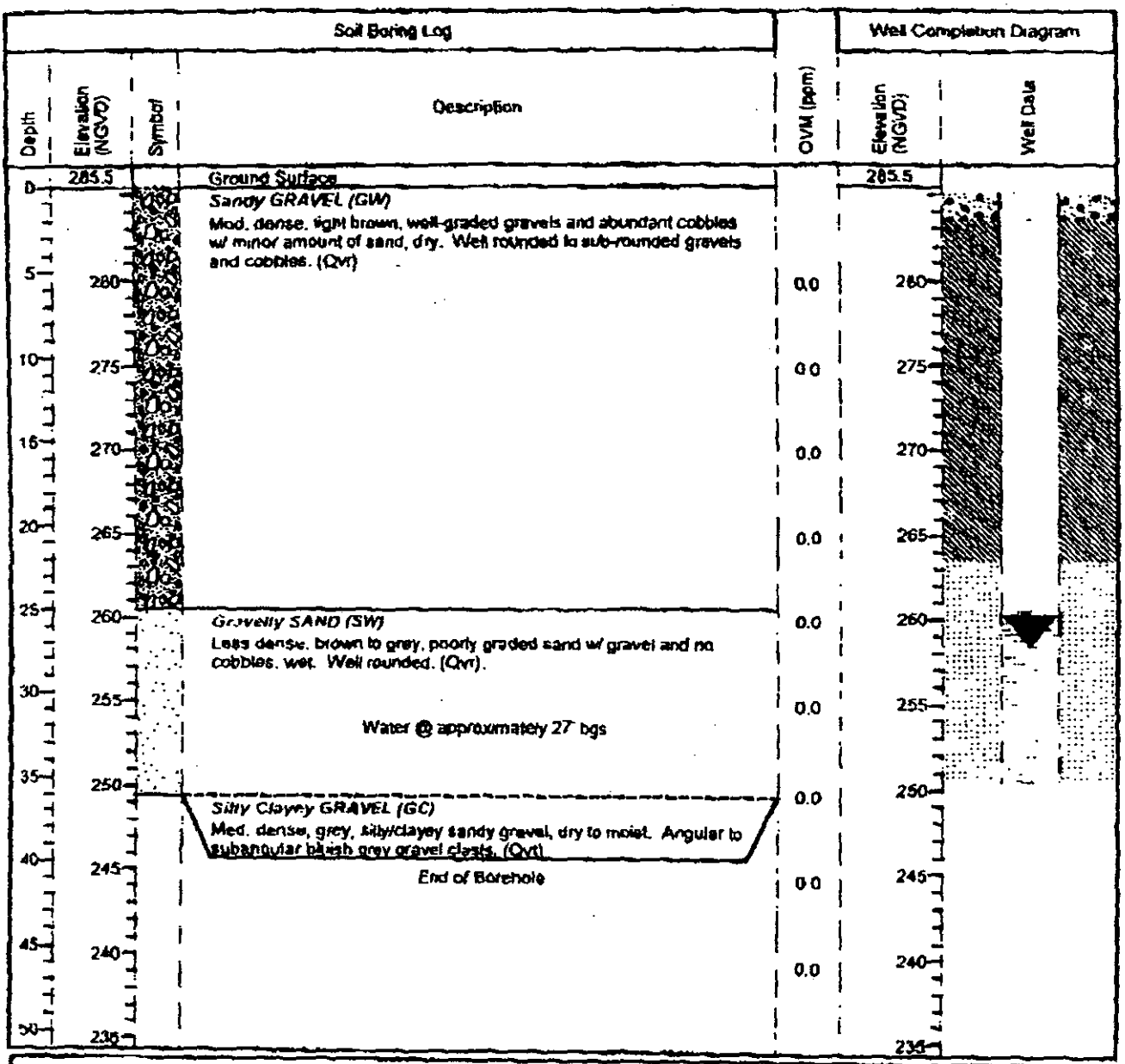
Location: Springbrook, Addison St.

Log of Borehole: CW-59

Total Depth 36'

Depth-to-Water 27'

Engineer: D Seaver



Drill Method: H/S Auger

Drill Date: 6/6/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp 12100 195th, STE 200 Bothell WA 98011

Datum (NGVD): 285.01 (PVC)

Northing 665852

Easting 1502179

Project No: 2331 0001.3202 06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

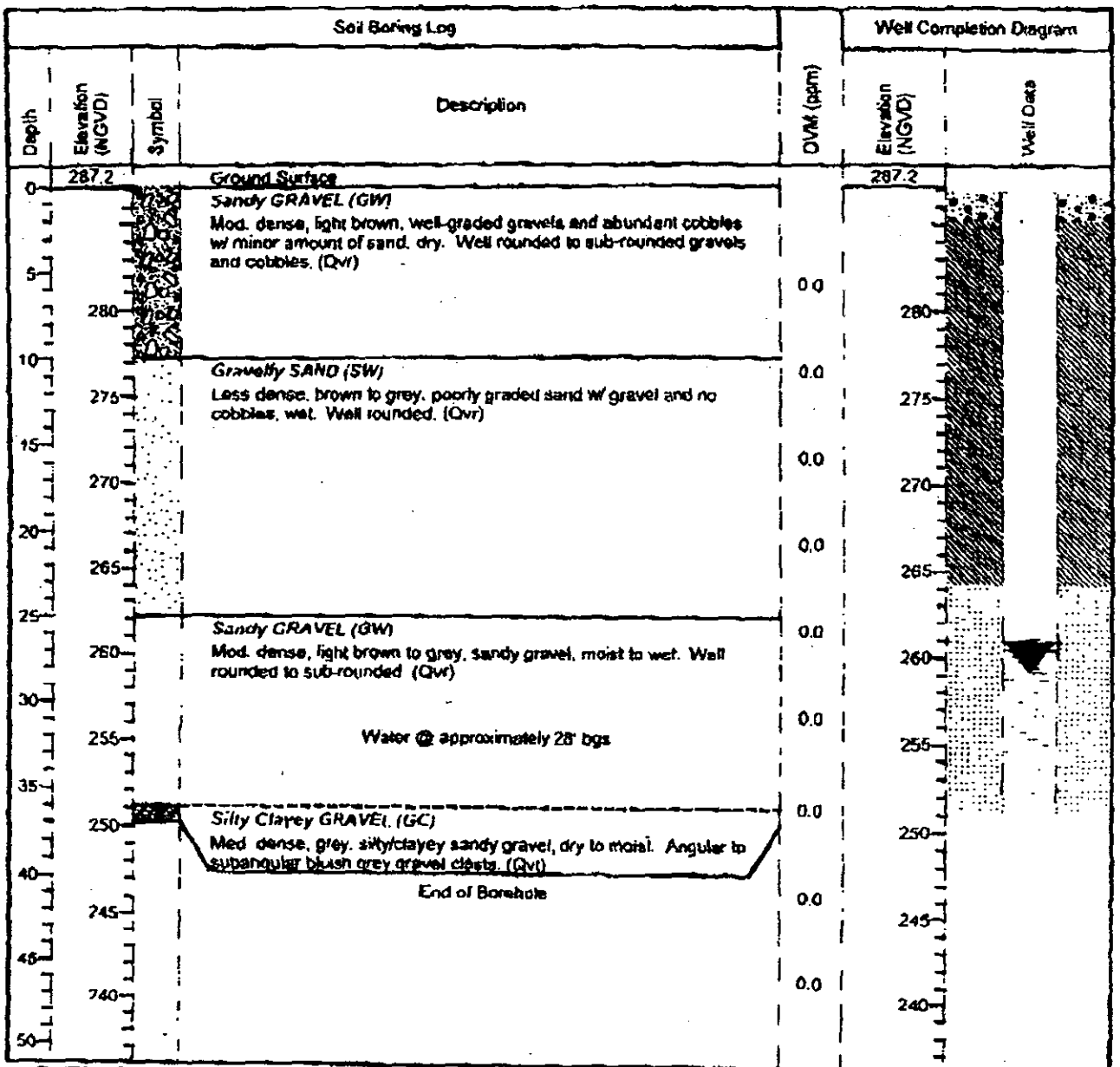
Location: Springbrook, Addison St.

Log of Borehole: CW-60

Total Depth 37'

Depth-to-Water 28'

Engineer: D. Seaver



Drill Method: HAS Auger

Drill Date: 6/5/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp · 12100 195th, STE 200i · Bothell WA 98011

Datum (NGVD): 286.68 (PVC)

Northing 665646

Easting 1502164

Project No: 2331 0001.3202 06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

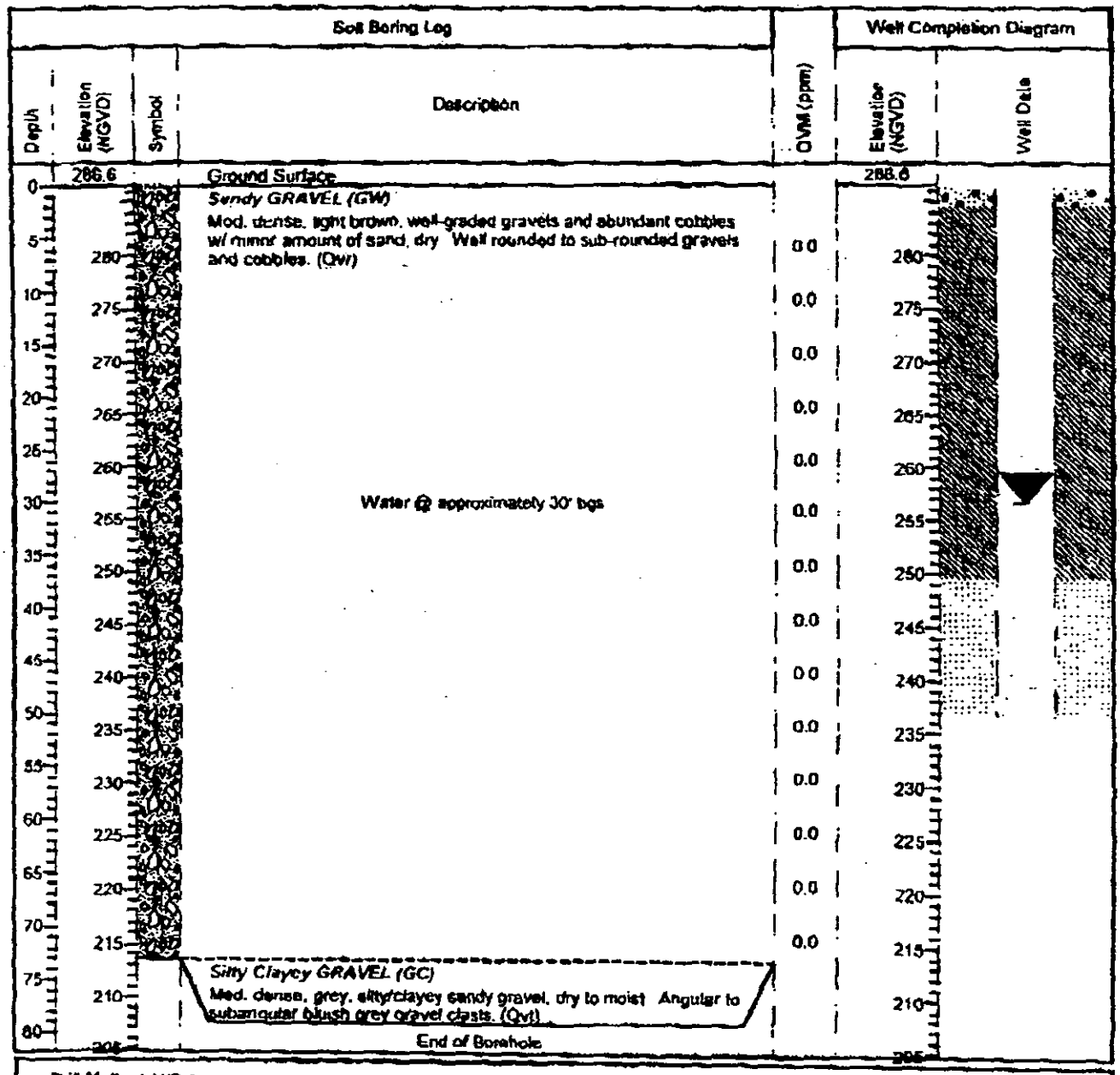
Location: Springbrook, Addison St.

Log of Borehole: CW-61

Total Depth 73'

Depth-to-Water 30'

Engineer: M. Ingersoll



Drill Method: HSA Auger

Drill Date: 6/11/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100 195th STF 200. Bothell WA 98011

Datum (NGVD): 286.24 (PVC)

Northing 666415

Easting 1502150

Project No: 2331.0001.3202.06050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

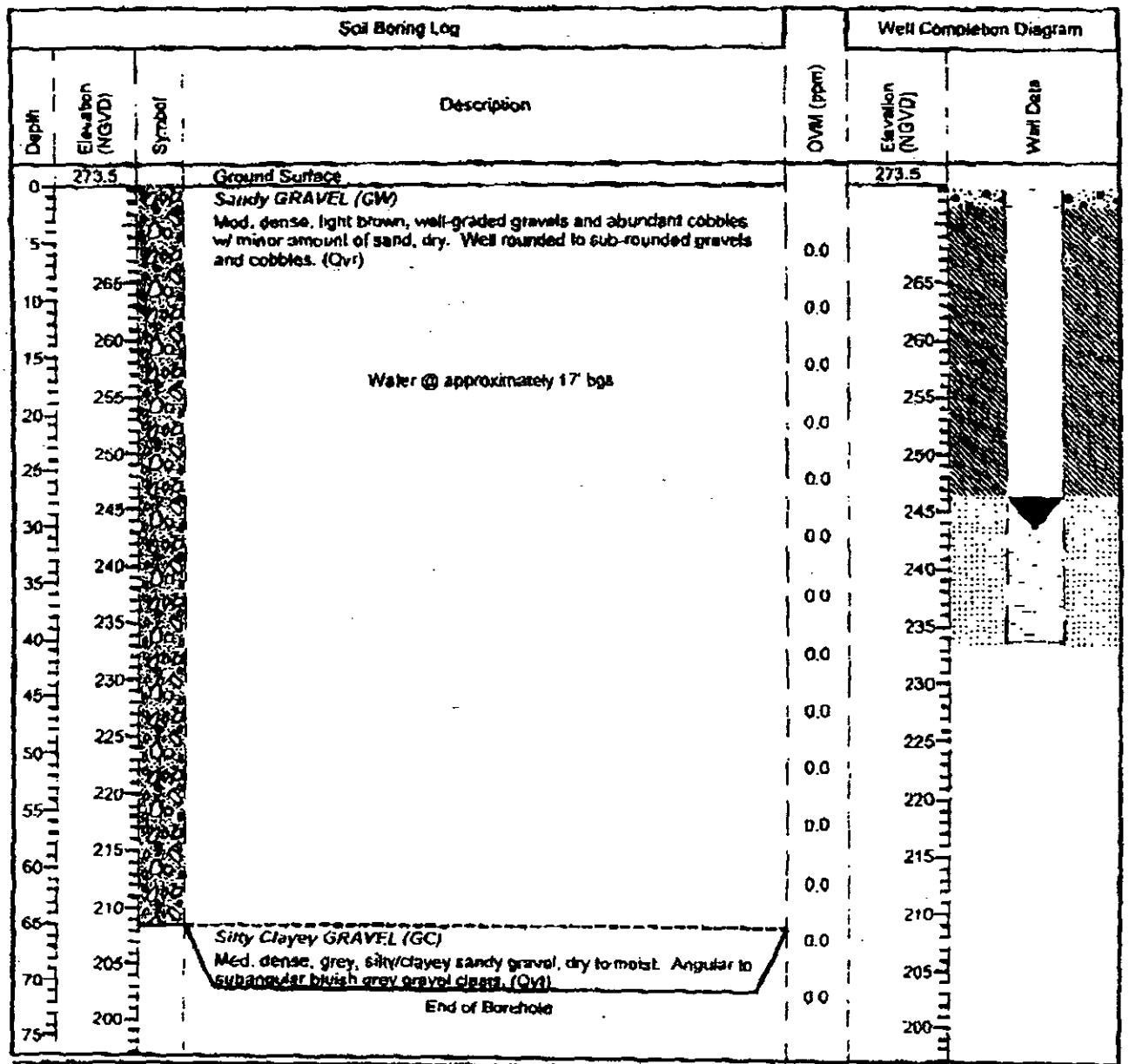
Location: Springbrook Addison St.

Log of Borehole: CW-62

Total Depth 65'

Depth-to-Water 17'

Engineer: M. Ingersoll



Drill Method: H/S Auger

Drill Date: 6/11/01

Hole Size: 6.5"

Foster Wheeler Environmental Corp. 12100 195th, STE 200 Bothell WA 98011

Datum (NGVD): 273.06 (PVC)

Northing 666729

Easting 1502207

Project No: 2331.0001 3202.08050

Project: McChord AFB Site SS-34N RI/FS

Client: AFCEE

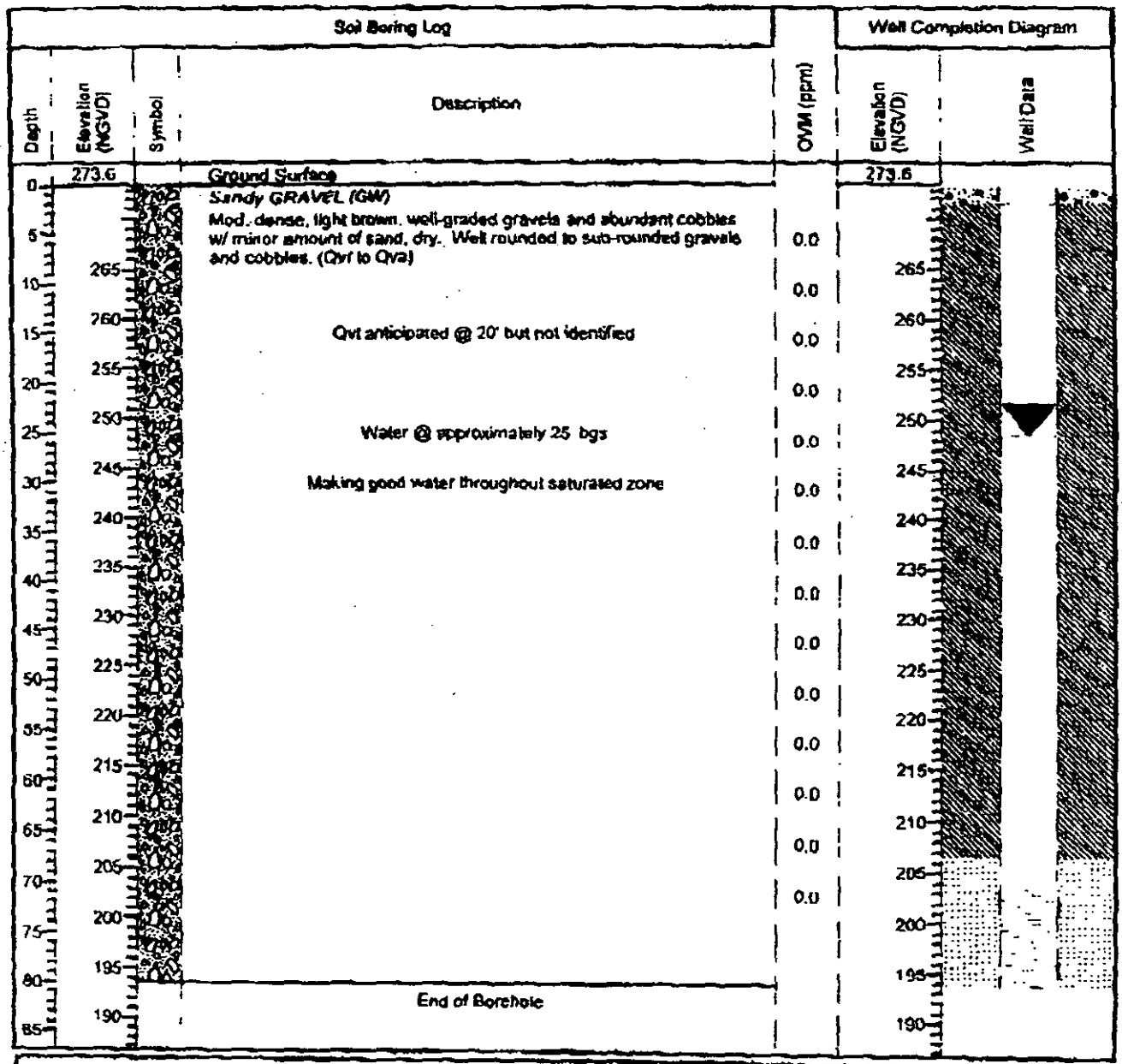
Location: Site SS-34N, On-base

Log of Borehole: CW-65a

Total Depth 80'

Depth-to-Water 25'

Engineer: M Ingersoll/D Seaver



Drill Method: Air Rotary

Drill Date: 6/8/01

Hole Size: 10"

Foster Wheeler Environmental Corp. 12100 195th, STE 200 Bothell WA 98011

Datum (NGVD): 273.29 (PVC)

Northing 866133

Easting 1503481

Sweet, Edwards & Associates, Inc.

AEF-222

BORING LOG

PROJECT CLOVER/CHAMBERS CREEK

Location SE¼ NE¼ NE¼, Sec 1 T19NR2E

Boring No. BC-2

Surface Elevation Approx. 295 Ft MSL

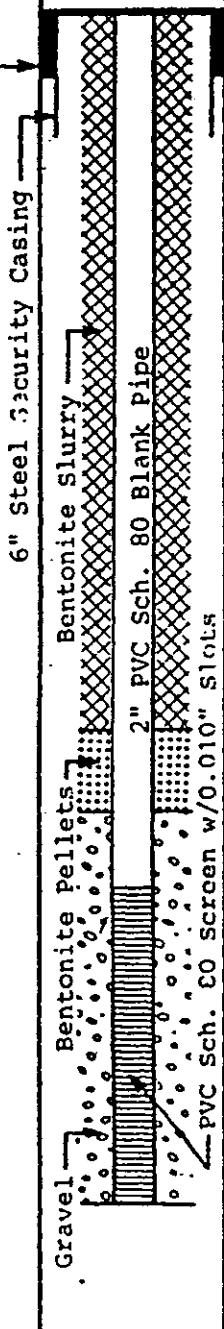
Drilling Method Air Rotary

Total Depth 38 ft

Drilled By Johnson Drilling

Date Completed 1/29/85

Logged By D.R. Dykes



WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		5	5	Cuttings		GW	0-24.0' Sandy Gravel, gray brown, sand is coarse, pebbles, cobbles, damp below 15 feet, some fine sand and silt.	
		10	10	"				
		15	15	"				
		20	20	"	▽ 19.5'			
		25	25	"		GW to GM	24.0-32.0' Sandy Silty Gravel, gray, sand is fine to coarse, silt tan colored water strike at 28.0 feet.	
		30	30	"				
		35	35	"		GW	32.0-38.0' Sandy Gravel, gray, sand is fine to coarse, some silt, saturated.	
		40	38	"			Botton of hole at 38 feet.	

Figure VII-2-13. Boring Log, BC-2

Sweet, Edwards & Associates, Inc.

BORING LOG

AEF-250

PROJECT CLOVER/CHAMBERS CREEK

Location SW¼ SW¼ SE¼, Sec 36, T20NR2E

Boring No. BC-1

Surface Elevation Approx. 273 Ft MSL

Drilling Method Air Rotary

Total Depth 40 ft

Drilled By Johnson Drilling

Date Completed 1/30/85

Logged By D.R. Dykes

WELL DETAILS	PENE-TRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERME-ABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		5	5	Cuttings		SW	0.0-7.0' Sand, dark brown, medium pebbles and cobbles in upper part, organic rich, damp. (7-6' brown silt).	
		10	10	"		GP	7.0-16.0' Gravel, gray brown, very coarse, pebbles, some sand and silt, damp.	
		15	15	"				
		20	20	"	▽ 22.95'	GW to GM	16.0-38.0' Silty Gravel, gray brown, variable proportions of sand and pebbles, cobbles, damp. Moist below 24.0'. Saturated below 32.0'.	
		25	25	"				
		30	30	"				
		35	35	"				
		40	40	"		GW	38.0-40.0' Sandy Gravel, brown, some silt, saturated	
							Bottom of hole at 40 feet.	

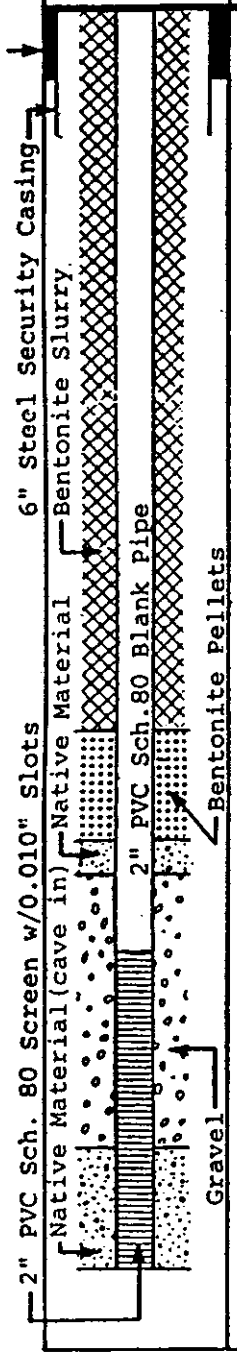


Figure VII-2-12. Boring Log, BC-1

APPENDIX E

Surface Water and Groundwater Sampling Data Sheets

Round 1

URS

~~GROUNDWATER~~ Surface Water SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny ~75°F
Date:	8/29/02	Samplers:	Dalen Davis

Gauging and Purging Data

Station Number:	SW-1	Screen Interval:	NA
Station Type:	PDL Creek Outfall 48-in culvert	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	culvert bottom Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-filtered	
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity: Calib. check on 8/29

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW1-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	middle of pipe just below lip
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

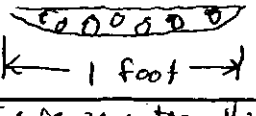
Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	14.97	7.23	125	217.1	10.45	0-5	1605		
2,000	14.94	7.22	120	198.4	10.42	0-5	1610		~200 ml
3,000	14.96	7.18	122	210.2	10.16	0-5	1615		
4,000	14.92	7.20	125	206.6	10.38	0-5	1620		

Comments Sample location at Pipe lip just below Gravelly Lake Drive

Water is standing in pipe ~5" Deep with no apparent movement. Flow apparent less than 1 foot downstream of culvert lip. Based on small channel below pipe:

Flow meter in stream ≈ 1 ft/sec.

Ave flow ~~~0.2 cfs to 0.3 cfs~~~ See Graph Paper

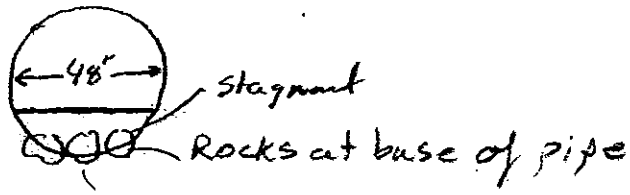


Field-filtered TDP/SRP through 0.45 micron nitrocellulose filter

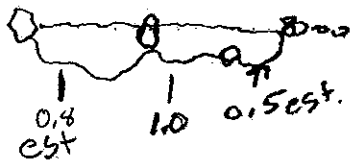
Stream Flow Msmt. 8/29/02

PDL CREEK

SW-1



Approx 2' downstream of culvert
visible flow. 1 square = 1 inch



~ 20 $in.^2$ = 0.14 ft^2
V = 4/c = 0.76
Width = 1 ft

URS

~~GROUNDWATER~~ SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny ~ 75°F
Date:	8/29/02	Samplers:	Julia C. Davis

Gauging and Purging Data

Station Number:	SW-2	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA	Annulus Diameter: NA notes
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	field-filtered	
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	~~SW2-G1~~ SW2-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

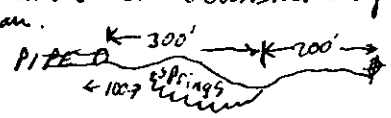
Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

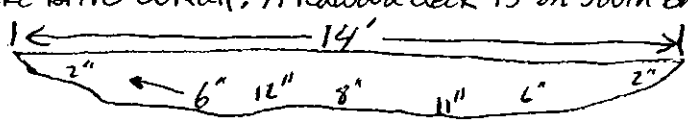
Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~500	12.71	6.68	120	173.1	10.81	0	1524		
1,500	12.67	6.63	120	166.2	10.76	0	1529		
2,500	12.69	6.68	118	156.4	10.66	0-5	1534		
3,500	12.72	6.71	120	160.2	10.48	5	1539		
4,500	12.69	6.71	120	164.4	10.66	0	1544		
5,500	12.68	6.73	119	170.2	10.64	0	1549		
							1549	Sample Time	

Comments

Sample location ~500' downstream of Gravelly Lake Drive outfall. A redwood deck is on South Bank of Stream.





Average V = 1.15 ft/second

See Graph Paper

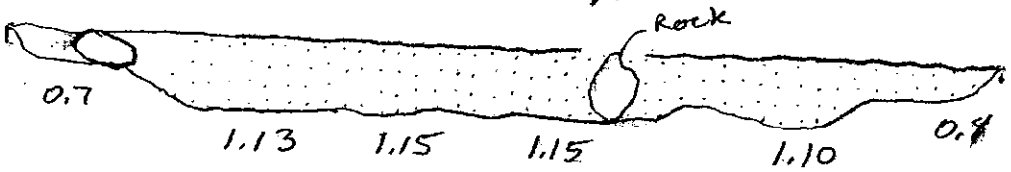
SW-2 1 Sq = 3 in = 9 in^2

130 squares = 1170 in^2 = 8.1 ft^2

V = 1.0 Av. by spot readings

1.15 by meter averaging

flow = 8.1 ft^3/sec to 9.3 ft^3/sec



Note: other small trickles on north side under blackberries (no more the 0.5 ft^3/sec)

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny ~75°F
Date:	8/29/02	Samplers:	Helen C. Orris

Gauging and Purging Data

Station Number:	SW-3			Screen Interval:	NA
Station Type:	PDL Creek Sample			Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	Bridge deck stream chann	Elevation		Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA	Elevation		One Purge Volume:	
Depth to Bottom:	NA	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-Filtered	
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity: Field checked calib. at ~7:00am

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW3-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	SW13-G1 1600 false time
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	14.53	6.91	121	152.5	11.71	0	1440		
2,000	14.48	6.89	120	160.4	11.70		1445		
3,000	14.50	6.88	119	164.2	11.69		1450		
4,000	14.49	6.88	119	154.4	11.69		1455		
							Sample	@ 1500	

Comments

Sample collected from center of bridge deck approximately 100 feet upstream of PDL stream mouth on lake.
Pump intake hung into stream thalweg at depth of approximately 4 inches.

See Graph Paper for Msmt.

SW-3 Bridge supports
1 square = 3" = 9 in²

Bridge support	Depth 1' w/ little variance					Bridge support
			fine to coarse gravel			
V=	0.9	0.8	1.0	1.0	0.7	} Avg = 0.76
	0.6	0.8	1.14	1.0	0.7	
	0.6	0.4	1.0	0.3	0.7	

V by meter average = .80

flow = 8 ft³/sec

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast 60-66°F
Date:	9/3/02	Samplers:	Galen C. Dorvee

Gauging and Purging Data

Station Number:	SW-4	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	Bridge Deck Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-filtered	
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on _____)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW4-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	[redacted]
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

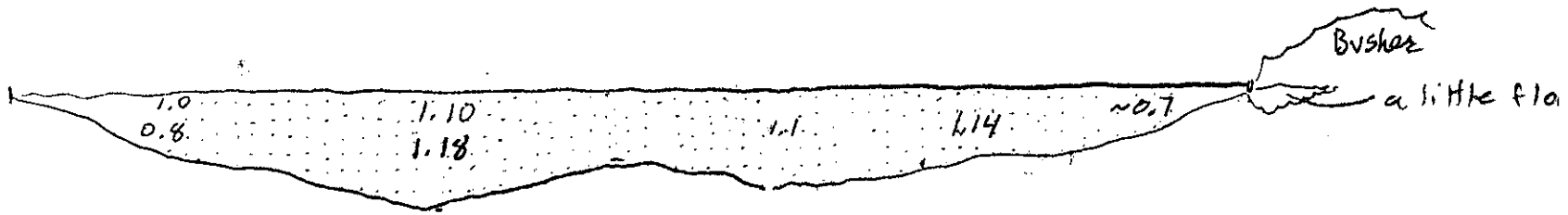
Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	15.28	7.85	135	82.7	11.06	0	1105		
2,000	15.12	7.70	133	113.1	10.74	0	1110		
3,000	15.14	7.69	130	98.6	10.72	0	1115		
4,000	15.12	7.69	130	104.2	10.72	0	1120		
5,000	15.12	7.68	132	112.0	10.74	0	1125		
								Sample @ 1130	

Comments

Sample collected from Bridge deck over Clover Creek on Gravelly Lake Drive, approximately 1,000 feet upstream of stream mouth.

See back sides for flow detail
See Graph Paper

SW-4 Clover CK at Gravelly Lake Drive



V = Ave by meter = 1.14 ft/sec

Area = 17.4 ft^2

flow = 198 ft^3/sec

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~55°F
Date:	8/29/02	Samplers:	Galen C. Doriz

Gauging and Purging Data

Station Number:	MW-2			Screen Interval:	22.91 to 27.41 btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	New			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	263.22	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	21.30	Elevation	241.92	One Purge Volume:	
Depth to Bottom:	27.91	Feet of Water:	6.61	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-Filtered	
Dissolv. Metals:	200ml poly		
Al, Fe, Mn, Mg, Na, Ca, K			
Nutrients:	200ml poly		
Cl, Fl, Br, N+N, SO4, Alk			
Metals & Nutrients	This Round only		

DOC & TOC: Doc field Filted

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity: Calibration check

DO: on 8/29/02 0645

pH: using Calitech Solution

Temperature: for pH, COND,

ORP: D.O. check in 100% humid atmosphere

Sampling Data

Sample Name:	MW2-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	24.5 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	12.86	6.67	136	101.4	7.89	5-10	0715		200-300
2,000	12.58	6.25	134	178.1	7.37	0	0720		
3,000	12.51	6.16	134	158.4	7.02	0	0725		
4,000	12.48	6.16	134	196.2	7.00	0	0730		
5,000	12.46	6.18	134	160.4	7.02	0	0735		

Comments

Monitoring well is located at the intersection of Rusell Rd. and 104th Street SW, next to the northeast corner of the Lakewood Active Park Fence.

DOC/TDP/SRP/Metals were field-filtered using 0.45 micron nitrocellulose high-volume flow-through, inline filter. Filter purged for 2 minutes prior to filling bottles. All reusable items decontaminated w/ distilled water rinse before and after use.

well lock keys in field box

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny 80°F Wind NW ~5 mpH
Date:	8/28/02	Samplers:	Galen C. Davis

Gauging and Purging Data

Station Number:	MW-4			Screen Interval:	7.48 to 11.98 feet btoc
Station Type:	Monitoring Well			Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	New			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	246.22	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	6.30	Elevation	239.92	One Purge Volume:	
Depth to Bottom:	12.48	Feet of Water:	6.18	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field Filtr	
Diss. Metals			
Al, Fe, Mg, Mn, Na, Ca		Round 1 only	
K,			
Nutrients:			
Cl, Fl, Br, NH, SO4			
Alk			

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity: calibration check on

DO: 8/28/02 1100 for pH, COND

pH: OK to 4.00 pH and cond

Temperature: with Calitech Soln.

ORP:

Sampling Data

Sample Name:	MW4-
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	10 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~~1,000~~	15.20	6.11	116	184.2	5.49	0	1530	Flow cell not full (?)	
1,000	14.37	5.81	117	281.5	4.76	0	1535		
2,000	14.16	5.74	117	214.9	4.60	0	1540		
3,000	14.11	5.90	117	212.5	4.89	0	1545		
4,000	14.11	5.70	116	299.4	4.55	0	1550		
5,000	14.12	5.70	117	329.8	4.55	0	1555		
6,000	14.12	5.72	118	320.6	4.62	0	1600		

Comments

Monitoring well is located approximately 150 feet south of the north end of 58th Court, southeast of Lakewood City Hall.

Dup/ TDP/SRP and Metals Field-Filtered w/ 0.45 micron Nitrocellulose inline high-vol filter. Filter purged for 2 minutes prior to filling bottles.

Decon H2O level meter, flow through cell before and after use w/ D.I. water rinse

Dedicated tubing left at well monument. Lock on well (keys in field box)

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny ≈70°F wind NE 5MPH
Date:	8/29/02	Samplers:	

Gauging and Purging Data

Station Number:	MW-5	Screen Interval:	14.84 to 19.34 feet btoc
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	New/Locked	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point: TOC	Elevation 250.62	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water: 15.42	Elevation 235.20	One Purge Volume:	
Depth to Bottom: 19.84	Feet of Water: 4.42	Final Purge Volume:	
Depth to LNAPL: NA	Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description: NA		Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field	Filtered
Dissolved Metals:			
Al, Fe, Mn, Mg, Na, Ca, K			
Nutrients:		Round 1 only	
Fl, Cl, Br, N+N, SO4, Alk			
DOC TOC	DOC Field-Filtered		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW5-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	17 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
500	14.49	6.53	131	88	9.55	0	1139		
1,000	13.55	6.12	120	149.8	9.41	0	1144		
2,000	13.37	6.09	120	170.3	9.33	0	1149		
3,000	13.29	6.09	120	173.1	9.42	0	1155		
4,000	13.37	6.07	120	173.6	9.35	0	1159		
5,000	13.30	6.06	119	184.6	9.47	0	1204		
6,000	13.31	6.06	119	180.4	9.43	0	1209		

Comments

Monitoring well is located approximately 30 feet west of the intersection of Avondale Ave. and Lexington Ave. The well is on the northwest corner.

Field filtered TDP/SRP/DOC/Metals using 0.45 micron nitrocellulose in line filter purged filt for 2 minuts befor filling bottles.

Lock keys in field box

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny 80°F wind west 5 mph
Date:	8/28/02	Samplers:	

Gauging and Purging Data

Station Number:	MW-6	Screen Interval:	23.41 to 27.91 feet btoc
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	New/locked	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 263.67	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	24.59 Elevation 239.08	One Purge Volume:	
Depth to Bottom:	28.41 Feet of Water: 3.82	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Dissolv. metals	200ml poly		
Nutrients	200ml poly		
DOC/TOC	125 amber		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW6-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	26 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	14.38	6.04	130	206.9	9.19	0	1420		200 ml
2,000	14.18	6.00	129	198.3	9.25	0	1425		
3,000	14.03	5.98	129	175.6	9.37	0	1430		
4,000	13.74	5.90	129	307.9	9.18	0	1435		
5,000	13.63	5.94	130	225.8	9.19	0	1440		
6,000	13.64	5.93	129	240.4	9.18	0	1445		
7,000	13.84	5.93	130	230.2	9.18	0	1450		

Comments

Monitoring well is located in the cul de sac of Seeley Lake Dr. (also called Crescent Circle. This location is just southwest of Seeley Lake.
DOC/TDP/SRP/Metals Field-filtered w/ 0.45 micron nitrocellulose inline filter.
Filter purged for 2 minutes prior to filling bottles.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	
Date:	8/28/02	Samplers:	

Gauging and Purging Data

Station Number:	MW-8	Screen Interval:	19.33 to 23.83 feet btoc
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	New locked	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 269.33	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	17.39 Elevation 251.94	One Purge Volume:	
Depth to Bottom:	24.33 Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Diss. Metals		Field Filtred	
DOC			
TOC		Round 1 only	
Nutrients			

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	~~MW8-G1~~ MW8-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	21 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	15.65	6.83	198	-156.9	2.52	0	1300		
2,000	15.40	6.98	201	-185.9	2.13	0	1305		
3,000	15.27	7.09	211	-211.5	1.65	0	1310		
4,000	15.22	7.16	209	-197.5	1.41	0	1315		
5,000	15.22	7.16	210	-176.6	1.34	0	1320		

Comments

Monitoring well is located approximately 20 feet north of the intersection of Irene Street and Rainier, on the east side of the street.
Access by driving north on Rainier from 108th in Lakeview.

DOC/TDP/SRP/metals field-filtred w/ 0.45 micron nitrocellulose inline filter (purged 2 minutes)

well keys in field box

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~60°F
Date:	9/3/02	Samplers:	Helen C. Bowers

Gauging and Purging Data

Station Number:	WS-1	Screen Interval:	NA
Station Type:	Faucet	Well Diameter:	NA Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	TOC Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Deep Aquifer Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-filtered	
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity: Calibration check on 9/3/02

DO: at 0800 ok.

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	WS1-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	at faucet outlet

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	21.58	7.26	153	219.3	5.29	0	0940		
2,000	21.80	6.94	147	166.8	6.18	0	0945		
3,000	21.72	6.88	146	182.4	6.10	0	0950		
4,000	21.70	6.86	147	168.4	6.12	0	0955		
5,000	21.70	6.88	147	166.6	6.12	0	1000		

Comments

Faucet in parking lot planter behind Behind Bed and Roses Florist on corner of Gravelly Lake Drive and Avondale Street.
Purge faucet as with well. Insert pump intake into faucet head as far as possible. Turn faucet on low. Pump at approx. 200 ml/min.
Field-filtered TDP/SRP as others

URS

GROUNDWATER SAMPLING DATA SHEET

Main 48" Line through Mall 200 North of Starbucks 3rd drain up from dk. outfall

Project Information

Project Name:	Lake Steilacoom P Study	Location:	Lakewood, Washington
Project/Task No.:		Weather:	
Date:	8/ /02	Samplers:	Galen Davis

Gauging and Purging Data

Station Number:	DW 3	Screen Interval:	
Station Type:	Parking lot Drain in 48" pipe	Well Diameter:	Annulus Diameter:
Well Condition:	—	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	Manhole Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	12.25 Elevation	One Purge Volume:	
Depth to Bottom:	12.30 Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	— Thickness:	Purge Method:	
LNAPL Description:	—	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty

Meter Information

Model & Calibration Date

pH:
Eh:
Conductivity:
DO Meter:
Turbidity:
Temperature:
Other:

Sampling Data

Sample Name:	DW3-G1
Sample Method:	Peristaltic Pump
Sampling Device:	≈ 200ml/min
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	
DO:	
Alkalinity:	
Ferrous Iron:	
Other:	

QA/QC Samples:

Duplicate:	
Replicate:	
MS/MSD:	
Blank:	
Other:	

Field Parameters

Volume (gallons)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)		ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (L/min)
500ml	17.50	6.15	0.112	130	141.8	6.00	<5	1300		
1,000ml	16.28	6.11	0.103		165.4	5.88		1303		
2,000ml	16.20	6.09	0.104	125	145.0	6.00		1308		

Comments

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~60°F
Date:	9/3/02	Samplers:	Helen C. Davis

Gauging and Purging Data

Station Number:	SW-5	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	USGS station Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-Filtered	
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on 8/27/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW5-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

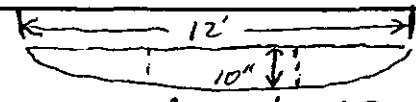
Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	15.41	7.76	135	114.0	10.70	0-5	1135		
2,000	15.15	7.61	128	138.9	10.21	0	1140		
3,000	15.06	7.54	130	141.2	10.19	0	1145		
4,000	15.00	7.54	128	143.0	10.19	0	1150		
5,000	15.02	7.56	128	146.4	10.20	0	1155		
							Sample Time =	1200	

Comments

Sample location: mid stream at USGS station below bridge on South Tacoma Way.

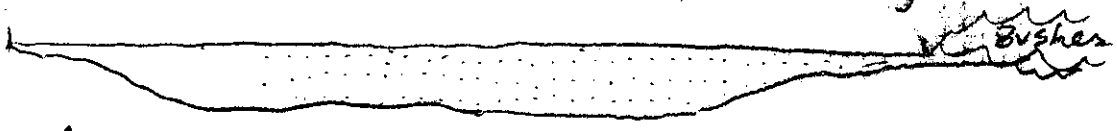
very difficult to accurately measure flow. Stream channel is complex.



Ave V = 1.3 or 1.4 ft/sec. by meter Ave

See Graph later

SW-5 at S. Tacoma Way crossing Clover Creek.



Area = 7.1 ft^2

V = 1.3 to 1.4 ft/sec by meter Averaging
No spont. points measured

flow ≈ 9 ft^3/sec

Very

GROUNDWATER SAMPLING DATA SHEET

Project Information Round 1 Springbrook

Page 1 of 1

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	65-70° F
Date:	9/23/02	Samplers:	Dalin Davis / Foster Wheeler

Gauging and Purging Data

Station Number:	CW-45			Screen Interval:	? To 50.84
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	OKay			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.99	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	30.22	Elevation	258.77	One Purge Volume:	
Depth to Bottom:	50.84	Feet of Water:	20.62	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Impeller Pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	250 ml Poly		

Meter Information

Model & Calibration Date

Hydro Lab

With flow-through cell (calibrated by Foster Wheeler on 9/23/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW-45-1
Sample Method:	Impeller Pump Low Flow
Sampling Device:	Grundfos
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
Final									
MSRMT.	13.24	7.28	212	386	2.22	ø	1000		0.2-0.3
		Final	Mstmts	only.	Purging	done	by	FW	

Comments

Monitoring well is located on 47th Street, due east of Springbrook Park
Well is 45A, the shallow well of well pair. Deep well is labeled "Hell Hole"
DTW in 45B is 33.64

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Sunny 65-70°F
Date:	9/23/02	Samplers:	Dallen Davis & Foster Wheeler

Gauging and Purging Data

Station Number:	CW-46			Screen Interval:	? To 50
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	Okay			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.44	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	30.50	Elevation	257.94	One Purge Volume:	
Depth to Bottom:	49.73	Feet of Water:	19.23	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Impeller Pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	250 ml Poly		

Meter Information

Model & Calibration Date

Hydro Lab

With flow-through cell (calibrated by Foster Wheeler on 9/23/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW-46-1
Sample Method:	Impeller Pump Low Flow
Sampling Device:	Grundfos
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
Final									
Msrmt.	13.24	7.05	178.3	387	3.33	Ø	1100		0.2-0.3

Comments

Monitoring well is located approximately 300 feet south of well 45 on 47th Street.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	~50°F
Date:	9/24/02	Samplers:	Galen Davis

Gauging and Purging Data

Station Number:	CW-59			Screen Interval:	?
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	245.01	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	27.80	Elevation	217.21	One Purge Volume:	
Depth to Bottom:	36.00	Feet of Water:	8.2	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	250 ml Poly		

Meter Information

Model & Calibration Date	
Horiba U-22	
With flow-through cell (calibrated by Hazco on _____)	
Conductivity:	
DO:	
pH:	
Temperature:	
ORP:	

Sampling Data

Sample Name:	CW-59-1
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1000	13.20	6.94	208	310	4.26	NM	Highly Turbid Too much for meter Brown		
2000	13.10	6.92	209	289	4.10	NM			
3000	12.59	7.02	204	361	3.48	NM			

Comments

Monitoring well is located on east side of Addison Street, approximately 200 feet south of Springbrook Park.
Peristaltic pump barely lifts @ this location. (very difficult)
Turbid Samples can't clean up (watch Total P results)

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	~60°F
Date:	9/24/02	Samplers:	Galen Davis

Gauging and Purging Data

Station Number:	CW-61	Screen Interval:	40 to 50
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	water in Monument (pumped at)	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 286.24	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	28.11 Elevation 258.13	One Purge Volume:	
Depth to Bottom:	~50 ?? Feet of Water: ~22	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	250 ml Poly		

Meter Information

Model & Calibration Date

Horiba U-22 _____

With flow-through cell (calibrated by Hazco on _____)

Conductivity: _____

DO: _____

pH: _____

Temperature: _____

ORP: _____

Sampling Data

Sample Name:	CW-61-1
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	13.9	6.98	196	360	3.00				0.2-0.3
2,000	14.1	7.10	196	359	2.98				
3,000	14.1	7.10	198	420	3.50				
4,000	13.18	6.92	202	374	3.13	Slightly Turbid (Visual)	Meter Can't Read		

Comments

Monitoring well is located on west side of Addison Street, due west of northwest corner of Springbrook Park.

Monument full of dirty water, must be from nearby sprinklers 'cause no rain recently, locking cap is not so tight either.

Meter seems slightly off or something is going on??

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	
Date:		Samplers:	

Gauging and Purging Data

Station Number:	CW-62			Screen Interval:	30 to 40
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	273.5	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	20.09	Elevation	253.41	One Purge Volume:	
Depth to Bottom:	?	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	250 ml Poly		

Meter Information

Model & Calibration Date

Horiba U-22 _____

With flow-through cell (calibrated by Hazco on _____)

Conductivity: _____

DO: _____

pH: _____

Temperature: _____

ORP: _____

Sampling Data

Sample Name:	CW-62-1
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	14.82	7.02	202	110	3.48	Slight			
2,000	13.56	6.94	198	158	2.10		visual		
3,000	13.46	6.84	194	210	1.84		only		
4,000	13.44	6.81	194	100	1.81	↓			

Comments

Monitoring well is in parking area at northern dead-end of Addison Street.
Turbidity higher than meter can take
Monument full of water. pumped out prior to opening
But, cap is not tight enough to prevent leakage

Round 2

URS

GROUNDWATER SAMPLING DATA SHEET

Needs well Data from Herrera

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Foggy ~40-45° F
Date:	Round Two 11/20/02	Samplers:	Gaylon Davis URS / Diana Phelan Herrera

Gauging and Purging Data

Station Number:	~~clnrs well MW-4~~ Herr MW-3	Screen Interval:	~~20 to 40~~ ?
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	Good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Get from Herrera Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	? Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA	Water Disposal/Qty:	?

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

~~Horiba U-22~~ Variable instruments by Herrera

~~With flow-through cell (calibrated by Hazco on _____)~~

Conductivity: Using Herrera data

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	~~clnrs MW-4-G2~~ Herr MW3-G2
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~3 gallons	12.9	6.15	145.7	NM	5.74	2.6			~0.2 L/min
	Purged by Herrera Diana Phelan					Final MSMTS.			

Comments

model 556 ROUND TWO

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	~45-50° overcast sprinkling
Date:	Round Two 12/4/02	Samplers:	Galen Aman

Gauging and Purging Data

Station Number:	MW-2	Screen Interval:	22.91 to 27.41 btoc
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	Good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 263.22	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	Low Flow
Depth to Water: 12/5/02 0905	21.92 Elevation 241.30	One Purge Volume:	
Depth to Bottom:	27.91 Feet of Water: 5.99	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	1	

Meter Information

	Model & Calibration Date
~~YSI 600 XLM Sonde and 610DM hand held readout~~	YSI 556
With flow-through cell (calibrated by ~~Hanco on~~ GCD)	12/4/02 0700
Conductivity:	
DO:	Using multiparam
pH:	Formazin Soln
Temperature:	
ORP:	

Sampling Data

Sample Name:	MW2-
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	24.5 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~500ml	11.58	6.99	120	212	9.25	<5	0900		~200 < 200
~1000	11.73	6.37	120	218	8.46		0910		
~1500	11.71	6.36	120	200	8.84		0920		
~2000	11.71	6.34	120	210	8.83		0930		

Comments

Monitoring well is located at the intersection of Rusell Rd. and 104th Street SW, next to the northeast corner of the Lakewood Active Park Fence.

well Drawdown is rapid Slow recharge, ~0.6 ft lower water table than in August

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny ~55°F
Date:	Round Two 12/3/02	Samplers:	Galen C. Dorn

Gauging and Purging Data

Station Number:	MW-4	Screen Interval:	7.48 to 11.98 feet btoc
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	Good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 246.22	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	Low flow
Depth to Water: 12/3/02 0755	6.42 Elevation 239.80	One Purge Volume:	
Depth to Bottom:	12.48 Feet of Water: 6.06	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at ~~200~~ 100 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	1	

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout 536

With flow-through cell (calibrated by ~~Hazco on~~ GeD) 12/3/02

Conductivity: 0800 & 1200 cal check

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW4- 02
Sample Method:	Peris. Low flow (~~200~~ 100 ml/min) GCA
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	10 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~200	12.35	6.13	123	193	9.60	Ø	1515		
~1,000	12.45	6.05	123	118	7.72	Ø	1525		
~2,000	12.39	6.04	125	90	7.83	Ø	1535		
~3,000	12.39	6.04	124	79.6	7.81	Ø	1545		

Comments

Monitoring well is located approximately 150 feet south of the north end of 58th Court, southeast of Lakewood City Hall.

Decreased flow rate possible rapid drawdown

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Overcast ~55°F
Date:	Round Two 12/3/02	Samplers:	Dalton C. Evans

Gauging and Purging Data

Station Number:	MW-5			Screen Interval:	14.84 to 19.34 feet btoc
Station Type:	Monitoring Well			Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	Good			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	250.62	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	Low Flow
Depth to Water: 12/5/02 0810	15.48	Elevation	235.14	One Purge Volume:	
Depth to Bottom:	19.84	Feet of Water:	4.36	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at ~~200~~ ml/min 100-150
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 600 ~~XLM Sonde and 610DM hand-held readout~~ 556

With flow-through cell (calibrated by ~~Hazco on~~ GCD)

Conductivity: 0800 & 1200 for check

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW5- G2
Sample Method:	Peris. Low flow (~~200~~ 100-150 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	17 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	11.85	6.20	127	169	11.65	~10	1221		~~0.4~~ 300-150
2,000	12.01	6.14	127	152	9.01	<5	1231		~~150~~ 200
3,000	12.00	6.15	127	150	9.05	<5	1241		?200
4,000	12.00	6.14	127	152	9.04	<5	1251		100
					Sample @		1255		

Comments

Monitoring well is located approximately 30 feet west of the intersection of Avondale Ave. and Lexington Ave. The well is on the northwest corner.

Flow rate ~, distracted by passerby conversation assume 100-200ml based on final MS/MSD

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Clearing Partly Cloudy ~55°F
Date:	Round Two 12/3/02	Samplers:	Galen C. Dami

Gauging and Purging Data

Station Number:	MW-6	Screen Interval:	23.41 to 27.91 feet btoc
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	Good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 263.67	Gallons per Annulus Foot: (8" manhole with 2" casing = 1.85 gal/ft; 6" manhole with 2" casing = 1.34 gal/ft)	
Depth to Water: 12/3/02 0820	25.51 Elevation 238.16	One Purge Volume:	
Depth to Bottom:	28.41 Feet of Water: 2.90	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	1	

Meter Information

Model & Calibration Date

YSI ~~600 XLM Sonde and 610DM hand held readout~~ 556

With flow-through cell (calibrated by ~~Hazco on~~ GCD 0830 12/2/02)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW6-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Lower water
Pump Intake Depth:	26 feet btoc increased to 27' w/ext.

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~~1,000~~ 200	13.01	6.11	177	65	9.76	<5	1345	25.81	<200
1,000	13.02	6.12	170	68	9.78	<5	1400		
~1500	13.01	6.10	172	67	9.78	<5	1415		

Comments

Monitoring well is located in the cul de sac of Seeley Lake Dr. (also called Crescent Circle. This location is just southwest of Seeley Lake.

Pump full bore & flowing less than 0.2 L/min. This is max for peristaltic pump depth.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~50-56°F
Date:	Round Two 12/4/02	Samplers:	John C. Ann

Gauging and Purging Data

Station Number:	MW-8			Screen Interval:	19.33 to 23.83 feet btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	269.33	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water: 12/5/02 0740	17.42	Elevation	251.91	One Purge Volume:	
Depth to Bottom:	24.33	Feet of Water:	6.91	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	1	

Meter Information

Model & Calibration Date

YSI 556 ~~600 XLM Sonde and 610DM hand-held readout~~

With flow-through cell (calibrated by ~~Hasco on~~ GCD) ~~0900~~ 0700 12/4/02

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW8-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	21 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~200	13.15	6.44	94	57.1	8.07	0	1015		~200
~1000	13.79	6.40	92	66.4	7.76	0	1020		
~2000	13.87	6.38	95	71.4	7.65	0	1025		
~3000	13.91	6.38	92	63.7	7.53	0	1030		
~4000	13.91	6.37	93	62.8	7.46	0	1035		
~5000	13.91	6.36	93	61.9	7.39	0	1040		

Comments

Monitoring well is located approximately 20 feet north of the intersection of Irene Street and Rainier, on the east side of the street.
Access by driving north on Rainier from 108th in Lakeview.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~50°F
Date:	Round Two 12/3/02	Samplers:	Dallas Acuna

Gauging and Purging Data

Station Number:	DW-1	Screen Interval:	
Station Type:	Manhole	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	Manhole top Elevation	Gallons per Annulus Foot: (8" manhole with 2" casing = 1.85 gal/ft; 6" manhole with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
		Not Sampled	

Meter Information

Model & Calibration Date

~~YSI 600 XLM Sonde and 610DM hand-held readout~~

~~With flow-through cell (calibrated by Hazco on _____)~~

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	DW1-G2
Sample Method:	~~Peris. Low flow (~200 ml/min)~~
Sampling Device:	~~Geotech Peristaltic pump~~
Tubing Depth:	Not Sampled
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
			Not	Sampled		Dry	on	12/3/02	

Comments

~~Manhole located in main 48-inch drainline under mall parking area. Third manhole up from outfall, approximately 200 feet north of Starbucks.~~

No water flowing in Pipe 12/3/02

Observed 12/5/02 – Dry

↖ Set.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast clearing partial
Date:	Round Two 12/3/02	Samplers:	Galen Davis

Gauging and Purging Data

Station Number:	DW-2	Screen Interval:	
Station Type:	Manhole	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	Manhole top Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
~~Tot dis P/SRP~~	125 ml poly		
		Not Sampled	

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on _____)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	~~DW2-C2~~
Sample Method:	~~Peris-Low flow (~200 ml/min)~~
Sampling Device:	~~Geotech Peristaltic pump~~
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
			Not	Sampled					

Comments

~~Manhole located in main 48 inch drainline under mall parking area. Third manhole up from outfall, approximately 200 feet north of Starbucks.~~

Manholes center of small area in 36" line upstream from 48" pipe DM on 12/3/02

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	
Date:	Round Two 12/3/02	Samplers:	Helen Davis

Gauging and Purging Data

Station Number:	DW-3	Screen Interval:	
Station Type:	Manhole	Well Diameter: / Annulus Diameter:	
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	Manhole top Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
~~Tot dis P/SRP~~	~~125 ml poly~~		

Meter Information

Model & Calibration Date

YSI 556

~~YSI 600 XLM Sonde and 610DM hand-held readout~~

~~With flow-through cell (calibrated by Hazco on _____)~~

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	DW3-G2
Sample Method:	~~Peris. Low-flow (~200 ml/min)~~
Sampling Device:	~~Geotech Peristaltic pump~~
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
			NO Sample						

Comments

DRY - All manholes NW corner of mall area
Not sure if still connected to main system after reconfiguration and construct

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	**Lake Steilacoom Phosphorus Study**	Location:	**Lakewood, Washington**
Project/Task No.:	**33750346.00006**	Weather:	overcast ~50°F
Date:	**Round Two** 12/3/02	Samplers:	Valeri C. Davis

Gauging and Purging Data

Station Number:	**SW-1**			Screen Interval:	**NA**
Station Type:	**PDL Creek Outfall 48-in culvert**			Well Diameter: **NA**	Annulus Diameter: **8 inches**
Well Condition:	NA			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	**culvert bottoı**	Elevation		Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA	Elevation		One Purge Volume:	
Depth to Bottom:	NA	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	**peristaltic pump at 200 ml/min**
LNAPL Description:	NA			Water Disposal/Qty:	**ground surface**

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	**125 ml poly**		
Total P	**200 ml poly**		

Meter Information

Model & Calibration Date

YSI 556
With flow-through cell
Conductivity:
DO:
pH:
Temperature:
ORP:

Sampling Data

Sample Name:	**SW1-G2**
Sample Method:	**Peris. Low flow (~200 ml/min)**
Sampling Device:	**Geotech Peristaltic pump**
Tubing Depth:	middle of pipe
Pump Intake Depth:	**~ 2 inches**

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	**None**
Replicate:	**None**
MS/MSD:	**None**
Blank:	**None**
Other:	**None**

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
12/3/02	Culvert is dry NO Sample								
12/4/02	8.81	7.55	38	58	11.10	<15	0730		
	Grab sample of road runoff Not flowing to								
	Main Stream See Photos.								

Comments

sample on 12/4/02 During short rainfall period. water appears to be draining into culvert from Gravelly Lake Drive. water is virtually stagnant

No msrbl. flow

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~50°F
Date:	Round Two 12/3/02	Samplers:	Dalan C. Dennis

Gauging and Purging Data

Station Number:	SW-2	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	1	
Total P	200 ml poly	1	

Meter Information

Model & Calibration Date

YSI ~~600 XLM Sonde and 610D/M hand-held readout~~ 556

With flow-through cell (calibrated by ~~Hance~~ Geotech on 11/29/02)

Conductivity: Calibrate 12/3/02 GCD

DO: 0800

pH: Pre-check showed good

Temperature: Cal. by Geotech

ORP:

Sampling Data

Sample Name:	SW1-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

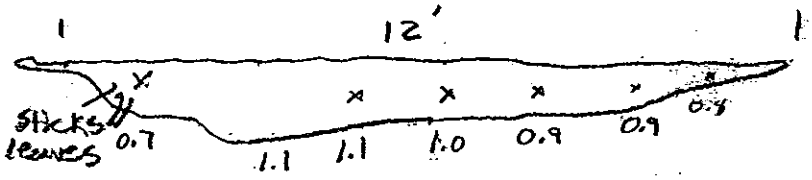
Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
NA	12.23	6.05	135	216.1	8.30	5	0920		
	Stream Grab Sample		NO PURGING						

Comments

See attached For Flow Msrmts.

SW-2 12/3/02 ~10' upst. of Round 1 mstmt. looks more uniform in channel less debris



≈95 squares (9 in² per square) = 6 ft² × 0.92 ft/sec (Active flow)

≈ 5.5 ft³/second

This seems strange because creek looks slightly larger now than in August.

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~45-50°F
Date:	Round Two 12/3/02	Samplers:	Pallen C. Lynn

Gauging and Purging Data

Station Number:	SW-3	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 556

~~YSI 600 XLM Sonde and 610DM hand-held readout~~

~~With flow-through cell (calibrated by Hasco on _____)~~

Conductivity: calib. 08:00 4 pt soln.

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW3-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	SW13-G1
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
NA	11.93	6.99	129	85.6	9.01	≈5	0900		
		Grab	Sample by	pump	NO purging				

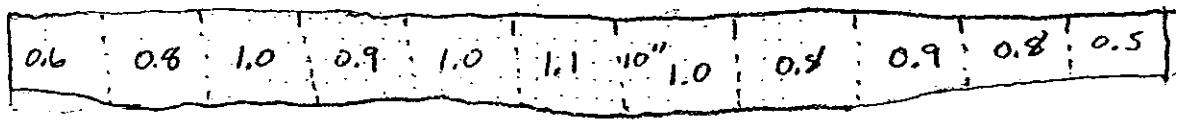
Comments

Sample collected from center of bridge deck approximately 100 feet upstream of PDL stream mouth on lake.
Pump intake hung into stream thalweg at depth of approximately 4 inches.

See attached for flow rate measurement.

SW-3 12/3/02

1 Sq = 4 in^2



Noticed high mark on bridge about ≈ 15"
water is ≈ 2 in. lower than in August

260 Sq x 4" = 1,040 in^2 = 7.22 sq. ft x 0.85 ft/sec (Ave

= 6.2 ft^3/sec.

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information Page 1 of 1

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Overcast ~50°F
Date:	Round Two 12/3/02	Samplers:	Jillian C. Dami

Gauging and Purging Data

Station Number:	SW-4	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter:	NA Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	Bridge Deck Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		
	NO Sample		

Meter Information

Model & Calibration Date

~~YSI 600 XLM Sonde and 610DM hand-held readout~~ 556

~~With flow-through cell (calibrated by Hazco on _____)~~

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW4-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	SW13-G1
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
				NO Sample					

Comments

Sample collected from Bridge deck over Clover Creek on Gravelly Lake Drive, approximately 1,000 feet upstream of stream mouth.

Creek is bone dry at this location
12/3/02 10:15 am Check on 12/4/02 also dry after rain

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~50°F
Date:	Round Two 12/3/02	Samplers:	Helen C. Brown

Gauging and Purging Data

Station Number:	SW-5	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	USGS station Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI ~~600 XLM Sonde and 610DM hand-held readout~~ 556

With flow-through cell (calibrated by Hazco on GCD 12/3/02 0800

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW5-G~~X~~2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
NA	6.29	6.49	149	59.0	7.65	<5	1056	NA	
	Grab Sample measurements just after sampling								

Comments

Sample location: mid stream at USGS station below bridge on South Tacoma Way. USGS gauge @ water is being channeled through two pieces of concrete like a weir

1.0 1.7 1.0
0.6 1.0 0.8 — 0.3

← 1.7' →

~ 1 ft/sec × 0.5 ft² ≈ 0.5 ft³/sec

URS

GROUNDWATER SAMPLING DATA SHEET

Round 2 Springbrook

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Cloudy ~ 50°F
Date:	Round Two 12/5/02	Samplers:	Dallin Dunn

Gauging and Purging Data

Station Number:	CW-45	Screen Interval:	? To 50.84
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	okay	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point: TOC	Elevation 288.99	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water: 31.00	Elevation 257.99	One Purge Volume:	3.2 gal = 12,000 ml
Depth to Bottom: 50.84	Feet of Water: 19.84	Final Purge Volume:	
Depth to LNAPL: NA	Thickness: NA	Purge Method:	Bailer
LNAPL Description: NA		Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556: cal'd. by GCD 12/5/02 0800 using 4 point cal soln

Conductivity: okay

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW45-G2
Sample Method:	
Sampling Device:	Bailer
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000 ml	10.46	6.73	904	219	3.21	0			
12,000	11.52	6.94	877	207	2.46				
15,000	11.53	6.72	871	206	2.34				
20,000	11.52	6.81	873	206	2.31				
25,000	11.49	6.87	872	205	2.29				
30,000	11.48	6.85	871	205	2.30				
35,000	11.47	6.84	880	205	2.31				
as 35,000	11.47	6.83	879	207	2.32				
~36,000	11.47	6.81	879	207	2.31		0900	Empty Time	

Comments

Monitoring well is located on 47th Street, due east of Springbrook Park
Well is 45A, the shallow well of well pair. Deep well is labeled "Hell Hole"

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Partially cloudy - 50°F
Date:	Round Two 12/5/02	Samplers:	Galen Stein

Gauging and Purging Data

Station Number:	CW-46			Screen Interval:	? To 50
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.44	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	30.25	Elevation	258.19	One Purge Volume:	3.1 gal 11,700 ml
Depth to Bottom:	49.73	Feet of Water:	19.48	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Bailer
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 Cal by GCD 12/5/02 0800 Okay

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW46-G2
Sample Method:	Bailer
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~12,000	10.51	6.71	203	191	3.55	Ø			
~24,000	11.15	6.64	203	187	3.54				
~36,000	11.15	6.64	203	195	3.57				
							1035	Sample Time	

Comments

Monitoring well is located approximately 300 feet south of well 45 on 47th Street.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Overcast
Date:	Round Two	Samplers:	[illegible]

Gauging and Purging Data

Station Number:	CW-59	Screen Interval:	?
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	fair	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point: TOC	Elevation 285.01	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water: 28.21	Elevation 256.8	One Purge Volume:	1.2 gal = 4,700 ml
Depth to Bottom: 36 X	Feet of Water: 7.79	Final Purge Volume:	
Depth to LNAPL: NA	Thickness: NA	Purge Method:	Bailer
LNAPL Description: NA		Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556: Calibr. by GCD 12/6/02 0800

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW59-G2
Sample Method:	Bailer
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1,000	13.20	7.10	215	318	5.21	>High			
3,000	12.42	6.94	212	271	4.89	High			
6,000	12.41	6.92	210	300	4.21	High			
9,000	11.94	6.93	210	310	3.89				
12,000	11.94	6.92	210	308	3.79				
15,00	11.96	6.91	208	304	3.82		1350	Sample Time	

Comments

Monitoring well is located on east side of Addison Street, approximately 200 feet south of Springbrook Park.

Turbidity very high. This is an older well that does not clean up very well.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	overcast ~45°F
Date:	Round Two 12/5/02	Samplers:	Gabe Davis

Gauging and Purging Data

Station Number:	CW-61	Screen Interval:	40 to 50
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	Okay	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point: TOC	Elevation 286.24	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	2.91 gal = 11,000 ml
Depth to Water: 50ft to bottom	31.80 Elevation 254.44	One Purge Volume:	11,000 ml
Depth to Bottom:	50 ft Feet of Water: 18.2	Total Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 cal by GCD 12/5/02 0800

~~Horiba U-22 (with flow-through cell (calibrated by Hazco on _____))~~

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW-61 GC2
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
3,000	12.41	6.99	184	372	2.78	Moderate but too high for accurate			
6,000	12.78	7.00	162	420	3.10	Meter reading			
9,000	12.76	6.89	162	368	2.89				
12,000	12.74	6.91	162	3.60	3.00				
20,000	12.77	6.94	162	394	2.89				
30,000	12.74	6.91	162	389	2.81				

Comments

Monitoring well is located on west side of Addison Street, due west of northwest corner of Springbrook Park.

Depth of well is questionable. Boring log suggest ~70' but soil bottom at about 49.5-50. Meter has a hard time stabilizing in this well water. This happened last time also. Why? Don't see any reason other than turbidity.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	
Date:	Round Two	Samplers:	

Gauging and Purging Data

Station Number:	CW-62	Screen Interval:	30 to 40
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 273.5	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	? Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

155556 Model & Calibration Date

~~Horiba U-22~~

~~With flow-through cell (calibrated by Hazco on _____)~~

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW-62~~A~~ 62
Sample Method:	~~Peristaltic Pump (low flow)~~
Sampling Device:	Not sampled
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)

NOT Sampled See Comments

Comments

Monitoring well is in parking area at northern dead-end of Addison Street.

WELL NOT SAMPLED. A BROKEN DOWN CAR ON JACKS IS SITTING ATOP THE WELL. CANNOT LOCATE OWNER.

Round 3

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~50°F
Date:	Round Three	Samplers:	GCD

Gauging and Purging Data

Station Number:	MW-8	Screen Interval:	19.33 to 23.83 feet btoc
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	GOOD	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	14.22 Elevation	One Purge Volume:	
Depth to Bottom:	24.33 Feet of Water: 10.11	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field-Filtered	
Metals	—	Field-Filtered	
Nutrients			

Meter Information

Model & Calibration Date

YSI 556 600 + 600 QM 3/4/03

With flow-through cell

Conductivity: okay see sheet

DO: AEF250

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW8-G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	21 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1L	12.04	6.85	138	215.9	3.8	0	1003		
2L	12.33	6.84	137	216.1	2.61	0	1005		
3L	12.51	6.85	138	215.9	2.31	0	1013		
4L	12.64	6.86	139	216.0	2.11	0	1018		
5L	12.62	6.85	138	215.9	2.10	0	1023		
6L	12.63	6.85	135	216.0	2.11	0	1028		

Comments

Monitoring well is located approximately 20 feet north of the intersection of Irene Street and Rainier, on the east side of the street.
Access by driving north on Rainier from 108th in Lakeview.

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	~50°F overcast
Date:	Round Three	Samplers:	GCD URS

Gauging and Purging Data

Station Number:	~~EW04~~ MW-AEF222	Screen Interval:	NA
Station Type:	Faucet	Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	TOC Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	35.46 ~~Deep Aquifer~~ Elevation	One Purge Volume:	
Depth to Bottom:	90.00 ~~NA~~ Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 600 XLM Sonde and 610DM hand-held readout

With flow-through cell (calibrated by Hazco on _____)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	~~WS1-C1~~ MW-AEF222-G3
Sample Method:	~~Peris. Low flow (~200 ml/min)~~
Sampling Device:	~~Geotech Peristaltic pump~~
Tubing Depth:	Bailer
Pump Intake Depth:	~~at faucet outlet~~

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1	12.70	6.79	0.166	215.7	10.09	∅			
5	12.64	6.51	0.177	215.7	9.87	0			
10	11.51	6.64	0.175	214.0	8.89	0			

Comments

Faucet in parking lot planter behind Behind Bed and Roses Florist on corner of Gravelly Lake Drive and Avondale Street.
Purge faucet as with well. Insert pump intake into faucet head as far as possible. Turn faucet on low. Pump at approx. 200 ml/min.

SAMPLING

WELL ~~DEVELOPMENT~~ DATA SHEET

URS

Page 1 of _____

Project Information

Project Name:	CK-Skil P Study	Location:	300' N of 100th on Lakeview
Project/Task No.:		Weather:	~50°F overcast
Date:	3/4/03	Samplers:	Adam Downes/M Blundell PC.

Gauging and Purging Data

Station Number:	MW-AEF250	Screen Interval:	
Station Type:	Mon Well	Well Diameter:	Annulus Diameter:
Well Condition:	Good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	TOC Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	23.42 Elevation	One Purge Volume:	
Depth to Bottom:	42.5 Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	Thickness:	Purge Method:	
LNAPL Description:		Water Disposal/Qty:	

Samples			
TDP			
SRP			
Cat/AN			
NO_2/NO_3			
Cl Fl Br			

Meter Information

YSI 610 DM — Model & Calibration Date

600XLM pH: 3.89 to 4.00 Soln

Eh:

Conductivity: 4.50 to 4.49 soln

DO Meter: in humid bag 9.93 on 84%

Turbidity: 0 to 0

Temperature: 7.5° C

Other: Okay

Field Parameters

Volume (gallons)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (L/min)
~1 L	10.74	5.18	0.254	232.3	7.59	0	0837		
~2 L	11.36	6.42	0.185	218.7	6.76	0	0842		
~3 L	12.26	6.73	0.176	214.6	6.39	0	0847		
~4 L	12.36	6.87	0.175	216.0	6.65	0	0852		

Comments

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	overcast ~55°F
Date:	Round Three	Samplers:	GCD

Gauging and Purging Data

Station Number:	~~DW3-G~~ WSG1	Screen Interval:	"C" Aquifer
Station Type:	~~Manhole~~ water supply well	Well Diameter:	Annulus Diameter:
Well Condition:	Good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	~~Manhole top~~	Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)
Depth to Water:		Elevation	One Purge Volume:
Depth to Bottom:		Feet of Water:	Final Purge Volume:
Depth to LNAPL:	NA	Thickness: NA	Purge Method: peristaltic pump at 200 ml/min
LNAPL Description:	NA		Water Disposal/Qty: ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	DW3-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
~1 gallon purge in system	12.37	6.89	191	382.6	9.09	0			

Comments

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	
Date:	Round Three	Samplers:	

Gauging and Purging Data

Station Number:	MW-2	Screen Interval:	22.91 to 27.41 btoc
Station Type:	Monitoring Well	Well Diameter:	2 inches — Annulus Diameter: 8 inches
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC — Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	17.16 — Elevation	One Purge Volume:	
Depth to Bottom:	27.91 — Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA — Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date
YSI 556	calibrated 11:30 3/5/03
With flow-through cell	
Conductivity:	4.45 to 4.49 soln
DO:	
pH:	3.98 & 7.00 soln
Temperature:	@ 12.00°C
ORP:	

Sampling Data

Sample Name:	MW2-G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	24.5 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1 L	10.57	6.23	122	300.3	10.69	ø	1149		
2 L	11.16	6.32	120	283	9.17	ø	1154		
3 L	11.46	6.30	120	280	8.48	ø	1159		
4 L	11.50	6.30	120	282	8.46	ø	1204		
5 L	11.50	6.30	122	283	8.46	ø	1209		

Comments

Monitoring well is located at the intersection of Rusell Rd. and 104th Street SW, next to the northeast corner of the Lakewood Active Park Fence.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Part overcast ~55°F
Date:	Round Three 3/4/03	Samplers:	Galen Gnn

Gauging and Purging Data

Station Number:	MW-4			Screen Interval:	7.48 to 11.98 feet btoc
Station Type:	Monitoring Well			Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	Good			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	~~246.22~~ ~~[illegible]~~	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	4.12	Elevation	242.10 ~~[illegible]~~	One Purge Volume:	
Depth to Bottom:	12.48	Feet of Water:	8.36	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell: See earlier sheets

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW4-G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	10 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1L	11.79	6.39	130	250	8.46	7100	1705		
2L	11.66	6.25	129	254	7.27	7100	1710		
3L	11.72	6.21	128	255	7.09	7100	1715		
4L	11.71	6.21	129	256	7.03	7100	1720		
5L									

Comments

Monitoring well is located approximately 150 feet south of the north end of 58th Court, southeast of Lakewood City Hall.

water is very turbid at first w/ yellow-brown (peat?) color

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	~60°F sunny
Date:	Round Three 3/4/03	Samplers:	Galen Dann

Gauging and Purging Data

Station Number:	MW-5	Screen Interval:	14.84 to 19.34 feet btoc
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 250.62	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	14.76 Elevation 235.86	One Purge Volume:	
Depth to Bottom:	19.84 Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 Calibrated 1540

With flow-through cell

Conductivity: 4.45 to 4.44 soln

DO: 100% in humid air

pH: 3.98 to 4.00 soln

Temperature:

ORP: ?

Sampling Data

Sample Name:	MW5- G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	17 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1L	12.00	6.42	125	239.3	8.99	10	1545		
2L	11.93	6.39	125	241.1	8.82	0-5	1550		
3L	11.87	6.30	124	242.2	9.09	0-5	1555		
4L	11.92	6.20	124	245.0	8.54	5	1600		
5L	11.90	6.29	125	244.1	8.55	0	1605		
6L	11.91	6.25	124	245	8.54	0	1610		

Comments

Monitoring well is located approximately 30 feet west of the intersection of Avondale Ave. and Lexington Ave. The well is on the northwest corner.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny ~ 60°F
Date:	Round Three 3/4/03	Samplers:	Galen Dunn

Gauging and Purging Data

Station Number:	MW-6			Screen Interval:	23.41 to 27.91 feet btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	Good			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	263.67	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	22.30	Elevation	241.37	One Purge Volume:	
Depth to Bottom:	28.41	Feet of Water:	6.11	Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	MW6-63
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	26 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1 L	13.11	6.51	140	240	8.97	0	1500		
2 L	13.01	6.32	140	244	8.64	0	1505		
3 L	13.04	6.29	140	245	8.55	0	1510		
4 L	12.99	6.29	140	246	7.92	0	1515		
5 L	13.00	6.29	140	245	8.10	0	1520		
6 L	13.01	6.30	140	245	8.12	0	1525		

Comments

Monitoring well is located in the cul de sac of Seeley Lake Dr. (also called Crescent Circle. This location is just southwest of Seeley Lake.

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Overcast ~45°F
Date:	Round Three 3/5/03	Samplers:	Galen Stein

Gauging and Purging Data

Station Number:	CW-45			Screen Interval:	? To 50.84
Station Type:	Monitoring Well			Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.99	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	27.19	Elevation		One Purge Volume:	
Depth to Bottom:	50.84	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Bailer
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 See earlier sheet

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW45-~~02~~ G3
Sample Method:	
Sampling Device:	~~Bailer~~
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1L	10.40	6.99	228	293	3.06	Ø	1620		
2L	10.58	6.99	228	293	2.86	Ø	1625		
3L	10.70	7.03	230	293	2.41	Ø	1630		
4L	10.71	7.02	228	293	2.40	Ø	1635		
5L	10.70	7.00	228	293	2.41	Ø	1640		
						Sample	1645		

Comments

Monitoring well is located on 47th Street, due east of Springbrook Park
Well is 45A, the shallow well of well pair. Deep well is labeled "Hell Hole"

CW45B = DTW = 24.10
TD = 88.1

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Overcast ~45°F windy
Date:	Round Three 3/5/03	Samplers:	GCD

Gauging and Purging Data

Station Number:	CW-46			Screen Interval:	? To 50
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.44	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	26.49	Elevation		One Purge Volume:	
Depth to Bottom:	49.73	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Bailer
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 see earlier sheet

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	CW46-~~02~~ G3
Sample Method:	Bailer
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1 L	10.63	6.48	144	289	5.37	0	1725		
2 L	10.71	6.42	188	2.89	4.41	0	1730		
3 L	10.77	6.40	186	289	4.28	0	1735		
4 L	10.78	6.40	188	289	4.26	0	1740		
5 L	10.77	6.39	148	289	4.24		1745		

Comments

Monitoring well is located approximately 300 feet south of well 45 on 47th Street.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Overcast ~50°F
Date:	Round Three 3/5/03	Samplers:	GalenDavis Just stopped raining

Gauging and Purging Data

Station Number:	CW-59	Screen Interval:	?
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	Okay	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 285.01	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	23.38 Elevation	One Purge Volume:	
Depth to Bottom:	? Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	Bailer
LNAPL Description:	NA	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	1	
1 Field Dup called CW70-G3			

Meter Information

	Model & Calibration Date
YSI 556	
Conductivity:	
DO:	
pH:	
Temperature:	
ORP:	

Sampling Data

Sample Name:	CW59-~~01~~ G3
Sample Method:	~~Bailer~~ Peristaltic Pump
Sampling Device:	200ml/min
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1L	10.29	6.70	134	287	7.58	0	1535		
2L	10.31	6.64	134	288	6.86	0	1540		
3L	10.38	6.58	132	288	6.46	0	1545		
4L	10.36	6.59	132	288	6.44	0	1550		
5L	10.36	6.58	132	287	6.46	0	1555		

Comments

Monitoring well is located on east side of Addison Street, approximately 200 feet south of Springbrook Park.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	**Lake Steilacoom Phosphorus Study**	Location:	**Lakewood, Washington (Springbrook)**
Project/Task No.:	33750346.00006	Weather:	Raining ~50°F
Date:	**Round Three** 3/5/03	Samplers:	[illegible]

Gauging and Purging Data

Station Number:	CW-61			Screen Interval:	40 to 50
Station Type:	**Monitoring Well**			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	286.24	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	27.00	Elevation		One Purge Volume:	
Depth to Bottom:	?	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	**Peristaltic Pump**
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date
YSI 556	
Conductivity:	
DO:	
pH:	
Temperature:	
ORP:	

Sampling Data

Sample Name:	CW61-~~02~~ G3
Sample Method:	Peristaltic Pump
Sampling Device:	200 ml per 2 min
Tubing Depth:	Fastest possible
Pump Intake Depth:	at full power

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1 l	11.19	7.17	173	289	6.15	0	1455		
2 l	11.38	7.24	173	289	8.00	0	1505		
3 l	11.43	7.27	173	289	5.48	0	1515		
4 l	11.39	7.26	173	289	6.72	0	1520	sample time	
							is actually 1525		

Comments

Monitoring well is located on west side of Addison Street, due west of northwest corner of Springbrook Park.

Cannot stabili DO

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	Rain ~50°F
Date:	Round Three 3/5/03 1340	Samplers:	Gilbert Dennis

Gauging and Purging Data

Station Number:	CW-62	Screen Interval:	30 to 40
Station Type:	Monitoring Well	Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	water in monument	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 273.5	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	14.04 Elevation 159.46	One Purge Volume:	
Depth to Bottom:	40.20 Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date
YSI 556	See Cal Log Sheet
Conductivity:	
DO:	
pH:	
Temperature:	
ORP:	

Sampling Data

Sample Name:	CW62-~~04~~ G3
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	
Tubing Depth:	21'
Pump Intake Depth:	1'

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
0-1L	8.82	6.53	137	291.2	6.52	Ø	1345		
2L	8.90	6.43	137	291	5.81	Ø	1350		
3L	8.96	6.41	137	291	5.54	Ø	1355		
4L	8.97	6.40	137	291	5.56	Ø	1400		
5L	8.96	6.41	137	291	5.54	Ø	1405		
6L	8.96	6.40	137	291	5.56	Ø	1410		
							"		

Comments

Monitoring well is in parking area at northern dead-end of Addison Street.

Bottom of Clover CK is 7' below TOP of well casing
DTW = 19.04 SO GW is 7' below creek

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	
Date:	Round Three 3/5/03	Samplers:	

Gauging and Purging Data

Station Number:	~~DW2~~ Clover MW3-G3	Screen Interval:	
Station Type:	~~Monitor~~	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	~~Monument~~ Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	11.14 Elevation	One Purge Volume:	
Depth to Bottom:	20.20 Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell (calibrated by Hazco on _____)

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	DW2-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1 L	9.91	6.52	161	285	5.41	0	1815		
2 L	9.44	6.53	160	285	4.39	0	1820		
3 L	9.39	6.52	160	287	4.07	0	1825		
4 L	9.38	6.51	160	287	4.02	0	1830		
5 L	9.39	6.52	160	287	4.03	0	1835		

Comments

~~Manhole located in main 48-inch drainline under mall parking area. Third manhole up from outfall, approximately 200 feet north of Starbucks.~~

WELL ON N side of Clover Creek ~500' N of Springbrook

SURFACE WATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	
Date:	Round Three	Samplers:	

Gauging and Purging Data

Station Number:	SW-1			Screen Interval:	NA
Station Type:	PDL Creek Outfall 48-in culvert			Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	culvert bottom	Elevation		Gallons per Annulus Foot: (8" annulus with 2" casing = 3.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA	Elevation		One Purge Volume:	
Depth to Bottom:	NA	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW1-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	middle of pipe
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	11.22	6.68	129	227	9.37	0			

Comments

48" culvert

x y z

H = ~1.2'

V = x = y = z =

See Back

SURFACE WATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	~60°F Slight overcast
Date:	Round Three 3/4/03	Samplers:	Golden Davis

Gauging and Purging Data

Station Number:	SW-2	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

	Model & Calibration Date
YSI 556	See First sheet of
With flow-through cell	3/4/03
Conductivity:	
DO:	
pH:	
Temperature:	
ORP:	

Sampling Data

Sample Name:	~~SW2-G2~~ SW2-G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	11.51	6.7	127	244	10.54				

Comments

See back for flow

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Part overcast
Date:	Round Three 3/4/03	Samplers:	~55° 60°F

Gauging and Purging Data

Station Number:	SW-3	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell SEE First Sheet

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW3-G1
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	SW13-G1
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	11.36	6.81	130	239	9.96	0			

Comments

Sample collected from center of bridge deck approximately 100 feet upstream of PDL stream mouth on lake.
Pump intake hung into stream thalweg at depth of approximately 4 inches.

D=0.1		D=0.9	D=0.9	D=1.0
1.3	1.8	2.4	3.0	2.4
1.2	1.7	2.3	2.4	2.3
1.1	1.4	1.5	1.6	1.6
2'	2'	2'	2'	2'

Ave = 1.87

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Rainy windy ~55°F
Date:	Round Three 3/5/03	Samplers:	Galen Dorie

Gauging and Purging Data

Station Number:	SW-4	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	Bridge Deck Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW4-~~01~~ G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	SW13-G1
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	9.55	6.77	139	293	11.10	0-5			

Comments

Sample collected from Bridge deck over Clover Creek on Gravelly Lake Drive, approximately 1,000 feet upstream of stream mouth.

SURFACE WATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	
Date:	Round Three 3/5/03	Samplers:	

Gauging and Purging Data

Station Number:	SW-5	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	USGS station Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	SW5-[illegible]G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	8.54	6.79	140	298	11.56	~5	1238		

Comments

Sample location: mid stream at USGS station below bridge on South Tacoma Way. High Flow

Staff Gauge = 15.00

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	~55°F overcast
Date:	Round Three	Samplers:	GCD

Gauging and Purging Data

Station Number:	DW-1	Screen Interval:	
Station Type:	Manhole	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	Manhole top Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly	Field Filtered	
~~Anions~~ Cations		Field-Filtered	

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell

Conductivity: SEE First sheet of the day

DO:

pH: MW AEF 250

Temperature:

ORP:

Sampling Data

Sample Name:	DW1~~-02~~ G3
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	12.10	6.61	137	264.6	8.87	0	1155		

Comments

~~Manhole located in main 48-inch drainline under mall parking area. Third manhole up from outfall, approximately 200 feet north of Starbucks.~~

Manhole located NE of Target Line along street JUST Downstream of NE Perforated Systeme JUST a trickle running through basin

DW-3 on Back

Round 4

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny, 65F
Date:	Round Four 6/23/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	SW-1	Screen Interval:	NA
Station Type:	PDL Creek Outfall 48-in culvert	Well Diameter:	NA Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	culvert botto Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	poly		

Meter Information

Model & Calibration Date: 6/23/2003

With flow-through cell

Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	SW1-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	middle of pipe
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	12.15	6.96	0.114	106.8	9.64	clear	1100	NA	200

Comments

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SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny, 65F
Date:	Round Four 6/23/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	SW-2	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA	Annulus Diameter: 8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	Poly		

Meter Information

Model & Calibration Date

YSI 556 6/23/2003

With flow-through cell

Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	SW2-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	12.84	6.58	0.108	142.6	9.42	clear	1130	NA	200

Comments

SURFACE WATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny, 65F
Date:	Round Four 6/23/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	SW-3	Screen Interval:	NA
Station Type:	PDL Creek Sample	Well Diameter: NA / Annulus Diameter:	8 inches
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	stream chann Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

Model & Calibration Date

YSI 556 6/23/2003

With flow-through cell

Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	SW3-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	SW13-G4
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	12.45	8.37	0.114	66.1	10.86	clear	1015	NA	200

Comments

Sample collected from center of bridge deck approximately 100 feet upstream of PDL stream mouth on lake.
Pump intake hung into stream thalweg at depth of approximately 4 inches.

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny, 65F
Date:	Round Four 6/18/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	SW-4	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter:	NA Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	Bridge Deck Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/23/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	SW4-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	14.25	7.07	0.122	131.2	10.69	clear	1200		200

Comments

Sample collected from Bridge deck over Clover Creek on Gravelly Lake Drive, approximately 1,000 feet upstream of stream mouth.

URS

SURFACE WATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	Sunny, 65F
Date:	Round Four 6/23/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	SW-5	Screen Interval:	NA
Station Type:	Clover Creek Sample	Well Diameter: NA	Annulus Diameter: NA
Well Condition:	NA	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	NA
Reference Point:	USGS station Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		
Total P	200 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/23/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	SW5-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	Thalweg
Pump Intake Depth:	~ 2 inches

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	14.22	7.33	0.124	115.1	10.19	clear	1300		200

Comments

Sample location: mid stream at USGS station below bridge on South Tacoma Way.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	cloudy, calm, 50F
Date:	Round Four 5/21/03	Samplers:	J. Rapp w/ Diana Phelan (Herrera)

Gauging and Purging Data

Station Number:	Herr-MW3-G2	Screen Interval:	25.5-28'
Station Type:	Monitoring Well	Well Diameter:	2 inches
Well Condition:		Annulus Diameter:	8 inches
		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	
		Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	16'	Elevation	
		One Purge Volume:	
Depth to Bottom:	28'	Feet of Water:	
		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness: NA	
		Purge Method:	Peristaltic Pump
LNAPL Description:	NA	Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

Multiple meters operated by Herrera

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	Herr- MW-3-G4
Sample Method:	Peristaltic Pump (low flow)
Sampling Device:	Geotech peristaltic pump
Tubing Depth:	20'
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (gal)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
1.7	12.3	6.38	134.2	NR	7.5	0.45	935	16.7	0.22

Comments

Monitoring well sampled by Herrera Consultants. URS collected a sample and recorded final Herrera measured parameters.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 70 F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	MW-2			Screen Interval:	22.91 to 27.41 btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	good			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	263.22	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	19.91'	Elevation	243.31	One Purge Volume:	
Depth to Bottom:	27.91	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 6/19/2003

With flow-through cell

Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	MW2-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	24.5 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	13.47	6.67	0.119	154.5	8.71	clear	1300		200
400	12.51	6.24	0.113	158.2	7.76	clear	1305		200
600	12.47	6.18	0.112	165.3	7.69	clear	1310		200
800	12.48	6.18	0.112	168.9	7.64	clear	1315		200
1000	12.52	6.18	0.112	172.7	7.6	clear	1320		200
1200	12.5	6.18	0.112	177.2	7.66	clear	1325		200

Comments

Monitoring well is located at the intersection of Rusell Rd. and 104th Street SW, next to the northeast corner of the Lakewood Active Park Fence.

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 70 F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	MW-4			Screen Interval:	7.48 to 11.98 feet btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	good			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	246.22	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	5.48'	Elevation	240.74	One Purge Volume:	
Depth to Bottom:	12.48'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 6/19/2003

With flow-through cell

Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	MW4-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	10 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	13.91	6.44	0.113	150.9	9.35	clear	1404		200
400	12.5	6.09	0.106	165.2	6.61	clear	1409		200
600	12.4	6.07	0.105	171.2	6.46	clear	1414		200
800	12.4	6.07	0.105	173.2	6.42	clear	1419		200

Comments

Monitoring well is located approximately 150 feet south of the north end of 58th Court, southeast of Lakewood City Hall.

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 70 F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	MW-5			Screen Interval:	14.84 to 19.34 feet btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:	good			Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	250.62	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	14.76'	Elevation	235.86	One Purge Volume:	
Depth to Bottom:	19.84'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/19/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	MW5-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	17 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	MW15-G4
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	12.79	6.32	0.112	150	8.35	clear	1502		200
400	12.47	6.17	0.11	161.1	8.15	clear	1507		200
600	12.44	6.17	0.11	167.8	8.11	clear	1511		200
800	12.43	6.17	0.109	169.6	8.11	clear	1515		200

Comments

Monitoring well is located approximately 30 feet west of the intersection of Avondale Ave. and Lexington Ave. The well is on the northwest corner.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	parlty cloudy, 65 F
Date:	Round Four 6/20/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	MW-6			Screen Interval:	23.41 to 27.91 feet btoc
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	263.67	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	23.86'	Elevation	239.81	One Purge Volume:	
Depth to Bottom:	28.41	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556 6/20/2003

With flow-through cell

Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	MW6-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	26 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	13.62	6.96	0.12	95.2	8.49	clear	919		200
400	12.72	6.25	0.119	100.1	8.06	clear	924		200
600	12.8	6.17	0.12	112.6	8.04	clear	929		200
800	12.54	6.15	0.12	124.4	8.08	clear	934		200
1000	12.42	6.29	0.12	131.1	9.07	clear	939		200
1200	12.4	6.2	0.12	132.6	9.11	clear	944		200

Comments

Monitoring well is located in the cul de sac of Seeley Lake Dr. (also called Crescent Circle. This location is just southwest of Seeley Lake.

GROUNDWATER SAMPLING DATA SHEET

URS

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 65F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	MW-8			Screen Interval:	19.33 to 23.83 feet btoc
Station Type:	Monitoring Well			Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	269.33	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	15.70'	Elevation	253.63	One Purge Volume:	
Depth to Bottom:	24.33'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA			Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/19/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	MW8-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	21 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	13.83	6.87	0.143	114	8.23	clear	1005		200
400	13.14	6.43	0.138	129.1	6.1	clear	1010		200
600	13.12	6.4	0.139	132.7	6.07	clear	1015		200
800	13.18	6.41	0.139	135.2	6.05	clear	1020		200
1000	13.15	6.41	0.138	137.7	6.04	clear	1025		200

Comments

Monitoring well is located approximately 20 feet north of the intersection of Irene Street and Rainier, on the east side of the street.
Access by driving north on Rainier from 108th in Lakeview.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 65F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	DW-3	Screen Interval:	NA
Station Type:	Manhole	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	Manhole top Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	Elevation	One Purge Volume:	
Depth to Bottom:	Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

Model & Calibration Date

YSI 556

With flow-through cell

Conductivity:

DO:

pH:

Temperature:

ORP:

Sampling Data

Sample Name:	DW3-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	NR	NR	NR	NR	NR	NR			

Comments

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 65F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	G-1	Screen Interval:	NA
Station Type:	Water Supply Well	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	NA Elevation	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	NA Elevation	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/19/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	G1-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	11.8	6.8	159	81	2.12		925		200

Comments

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 65F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	AEF222	Screen Interval:	NA
Station Type:	Monitoring Well	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	NA Elevation 219.5	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulu	
Depth to Water:	39.48 Elevation 180.0	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/19/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	AEF222-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	12.63	6.58	127	156.9	9.56		1207		200

Comments

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GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 65F
Date:	Round Four 6/19/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	AEF250	Screen Interval:	
Station Type:	Monitoring Well	Well Diameter:	Annulus Diameter:
Well Condition:		Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	NA Elevation 213.1	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annul	
Depth to Water:	26.50 Elevation 186.6	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/19/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	AEF250-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
	13.18	7.38	142	131.6	6.91		1132		200

Comments

GROUNDWATER SAMPLING DATA SHEET

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Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	partly cloudy 65F
Date:	Round Four 6/18/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	CW-45			Screen Interval:	? To 50.84
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.99	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	29.92'	Elevation	259.07	One Purge Volume:	
Depth to Bottom:	50.84'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/18/2003	
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	CW45-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	45 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	15.22	6.52	0.205	87.7	4.48	clear	1220		200
1200	14.13	6.6	0.193	97.5	2.26	clear	1225		200
2200	13.95	6.64	0.192	103.3	1.99	clear	1230		200
3200	13.74	6.68	0.192	110.2	1.87	clear	1235		200
4200	13.61	6.71	0.192	112.1	1.84	clear	1240		200
5200	13.61	6.74	0.192	115.9	1.79	clear	1245		200

Comments

Monitoring well is located on 47th Street, due east of Springbrook Park
Well is 45A, the shallow well of well pair. Deep well is labeled "Hell Hole"

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GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	parlty cloudy 65F
Date:	Round Four 6/18/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	CW-46			Screen Interval:	? To 50
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	288.44	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	28.90'	Elevation	259.54	One Purge Volume:	
Depth to Bottom:	49.73'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	peristaltic pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/18/2003	
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	CW46-G2
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	45 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	14.97	7.17	0.205	108.8	5.55	clear	1310		200
1200	13.7	6.96	0.193	177.5	3.34	clear	1315		200
2200	13.54	6.96	0.192	118.5	3.15	clear	1320		200
3200	13.57	6.96	0.192	119.7	3.04	clear	1325		200
4200	13.46	6.96	0.192	119.7	3	clear	1330		200

Comments

Monitoring well is located approximately 300 feet south of well 45 on 47th Street.

GROUNDWATER SAMPLING DATA SHEET

This well was not located during 4th Round

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 70F
Date:	Round Four	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	CW-59			Screen Interval:	27-37 feet bgs
Station Type:	Monitoring Well			Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot:	0.16
				(2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	
Reference Point:	TOC	Elevation	285.01	Gallons per Annulus Foot:	
				(8" annulus with 2" casing = 1.85 gal/ft; 6" annulu	
Depth to Water:		Elevation		One Purge Volume:	
Depth to Bottom:	?	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Bailer
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/18/2003	
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	CW59-G2
Sample Method:	Bailer
Sampling Device:	
Tubing Depth:	
Pump Intake Depth:	

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)

Comments

Monitoring well is located on east side of Addison Street, approximately 200 feet south of Springbrook Park.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	parlty cloudy, 70F
Date:	Round Four 6/18/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	CW-61			Screen Interval:	40 to 50
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	286.24	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	29.50'	Elevation	256.74	One Purge Volume:	
Depth to Bottom:	50'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/18/2003	
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	CW61-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	45 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	13.51	7.46	0.157	109.1	6.54	clear	1423		200
1200	12.68	7.37	0.148	114.3	3.55	clear	1428		200
2200	12.5	7.35	0.146	117.2	3.28	clear	1433		200
3200	12.5	7.36	0.146	119.5	3.18	clear	1438		200

Comments

Monitoring well is located on west side of Addison Street, due west of northwest corner of Springbrook Park.

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington (Springbrook)
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 70F
Date:	Round Four 6/18/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	CW-62			Screen Interval:	30 to 40
Station Type:	Monitoring Well			Well Diameter: 2 inches	Annulus Diameter: 8 inches
Well Condition:				Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC	Elevation	273.50	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annulus with 2" casing = 1.34 gal/ft)	
Depth to Water:	17.41'	Elevation	256.09	One Purge Volume:	
Depth to Bottom:	40'	Feet of Water:		Final Purge Volume:	
Depth to LNAPL:	NA	Thickness:	NA	Purge Method:	Peristaltic Pump
LNAPL Description:	NA			Water Disposal/Qty:	

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/18/2003	
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	CW62-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	45 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	11.81	6.78	0.11	135.2	8.7	clear	1510		200
1200	11.44	6.26	0.11	149.2	5.76	clear	1515		200
2200	11.24	6.17	0.113	152.4	5.71	clear	1520		200
3200	11.19	6.13	0.116	157.5	6.26	clear	1525		200
4200	11.14	6.14	0.118	160.8	6.48	clear	1530		200

Comments

Monitoring well is in parking area at northern dead-end of Addison Street.

URS

GROUNDWATER SAMPLING DATA SHEET

Project Information

Project Name:	Lake Steilacoom Phosphorus Study	Location:	Lakewood, Washington
Project/Task No.:	33750346.00006	Weather:	partly cloudy, 70 F
Date:	Round Four 6/20/03	Samplers:	J. Rapp

Gauging and Purging Data

Station Number:	Clover MW-3	Screen Interval:	unknown
Station Type:	Monitoring Well	Well Diameter:	2 inches Annulus Diameter: 8 inches
Well Condition:	good	Gallons per Casing Foot: (2" well: 0.16 gal/ft; 4" well: 0.65 gal/ft)	0.16
Reference Point:	TOC Elevation 271.83	Gallons per Annulus Foot: (8" annulus with 2" casing = 1.85 gal/ft; 6" annul	
Depth to Water:	14.78 Elevation 257.05	One Purge Volume:	
Depth to Bottom:	NA Feet of Water:	Final Purge Volume:	
Depth to LNAPL:	NA Thickness: NA	Purge Method:	peristaltic pump at 200 ml/min
LNAPL Description:	NA	Water Disposal/Qty:	ground surface

Containers

Analysis	Type	Primary Qty	MS/MSD Qty
Tot dis P/SRP	125 ml poly		

Meter Information

	Model & Calibration Date	
YSI 556	6/19/2003	
With flow-through cell		
Conductivity:	4.48 uS/cm	4.49
DO:	mg/L	NA
pH:	3.98 SU	4.00
Temperature:	Celsius	NA
ORP:	mV	

Sampling Data

Sample Name:	Clover MW3-G4
Sample Method:	Peris. Low flow (~200 ml/min)
Sampling Device:	Geotech Peristaltic pump
Tubing Depth:	
Pump Intake Depth:	24.5 feet btoc

Field Test Kit Results:

PID:	NA
DO:	NA
Alkalinity:	NA
Ferrous Iron:	NA
Other:	NA

QA/QC Samples:

Duplicate:	None
Replicate:	None
MS/MSD:	None
Blank:	None
Other:	None

Field Parameters

Volume (ml)	Temperature (°C)	pH (SU)	Conductivity (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Time (24 hr)	Water Level (Ft below TOC)	Flow Rate (ml/min)
200	13.01	6.58	0.128	147.4	6.09	clear	1025		200
400	12.37	6.37	0.123	152.8	5.19	clear	1030		200

Comments

Monitoring well is located between Interstate 5 and Clover Creek on the south side of 47th Street.