4.0 SITE GEOLOGY, HYDROGEOLOGY, AND GEOCHEMISTRY

An understanding of Site geology, hydrogeology, and geochemistry are important in understanding the Site conceptual model and contaminant fate and transport process; this section provides information about our current understanding of these elements. Geology and hydrogeology information was interpreted from RI soil and groundwater data and compiled from previous reports prepared for the Site and for other investigations in the Auburn valley (Dragovich et al. 1994, PGG 1996, 1998).

4.1 Geology

The Facility is located within the Auburn valley near the area where the Green and White Rivers enter the valley from the east. The Green River flows northward and the White River flows southward from this area. The current Auburn valley is a relic of the former Duwamish marine embayment of Puget Sound. This embayment was cut by subglacial meltwater into Vashon and pre-Vashon age deposits during the retreat of the Puget Lobe of the Cordilleran Ice Sheet at the end of the Vashon glaciation approximately 14,000 years ago (Dragovich et al. 1994). Following the Vashon glaciation, Puget Sound marine water extended to near the location of present-day Sumner via both the Duwamish and Puyallup marine embayments. At this time, a large north-sloping delta existed where the Puyallup River intermittently entered the Duwamish embayment near Sumner[9]. In the Duwamish embayment, a west-sloping delta was formed where the Green River, in the same course as it occupies today, entered the former embayment north of present-day Auburn. During this time, the ancient White River did not enter the Auburn valley[10]. The location of the Duwamish embayment, Puyallup embayment, and ancient deltas are shown on Figure 4-1.

Approximately 5,700 years ago, an eruption of Mount Rainier sent a large lahar (the Osceola Mudflow) down the ancient White River valley and into the Duwamish embayment. The mudflow cut off the ancient upland course of the White River and re-routed it northward toward present-day Auburn. Following the lahar, the White River incised and eroded large amounts of the mudflow debris and deposited this entrained material downstream in the Duwamish embayment at what became the White River fan near present-day Auburn (Figure 4-1).

Over time, the White River fan then pro-graded northward, filling the former Duwamish embayment above the Osceola Mudflow to near its current ground surface level in the Auburn valley. These upper valley fluvial deposits are generally considered part of the post-glacial modern alluvium deposited by the White River. Periodically through this progradation process, the White River flow direction would shift from north (toward Elliott Bay) to south (toward Commencement Bay) as the channel was filled

[9] The Puyallup River, at times, also flowed west at Sumner toward Commencement Bay creating a west-sloping delta in the Puyallup embayment.

[10] The ancient White River flowed into the Puyallup River via the present-day South Prairie Creek valley (near Orting).

with sediment. In 1906, following heavy flooding, the White River was permanently routed to the south by the construction of concrete levees.

During the RI, geologic units encountered below the Site consisted of alluvial deposits and Osceola Mudflow deposits. The alluvial deposits were generally overlain by 0 to 6 ft of fill. Interpretations of these deposits are discussed in more detail in the following sections. Geologic cross-sections along the axis of two groundwater plumes at the Site were prepared. The locations of the cross-sections are shown on Figure 4-2. Geologic cross-section A-A'', oriented north-south across the Site and then following along the length of the northern Area 1 plume, is presented on Figure 4-3a. Geologic cross-section B-B', oriented toward the northwest along the length of the western plume, is presented on Figure 4-3b. The legend for the cross-sections is presented on Figure 4-3c.

4.1.1 Alluvium

Alluvial deposits at the Site consist of re-worked Osceola Mudflow material overlain by more recent alluvium of the Green or White Rivers. The alluvium is the upper aquifer in the Auburn valley. Based on RI explorations completed to date, the alluvium consists of dark gray, fine to medium sand with varying amounts of silt, gravel, and cobbles and occasional interbedded layers of gravel or silt. Thin (typically less than 2 ft thick), discontinuous layers of peat and wood debris are also locally present within the recent alluvial deposits.

Physical testing[11] (grain size distribution and moisture content) of the alluvium was conducted on soil samples collected from eight wells at the Facility (AGW095 through AGW099 and AGW103 through AGW105). Soil samples were collected from the screened intervals of these wells during drilling. Grain size results indicate the alluvium at the Facility consists of gravel and sand mixtures with trace (less than 5 percent) fines (silt or clay). These grain size results are generally consistent with descriptions of alluvium throughout the Site; however, percentages of fines (silt) were occasionally higher in some locations based on visual soil classification, particularly west of the Facility. Moisture content ranged from 5 percent to 24 percent. Grain size distribution and moisture content for the alluvium at the Facility are presented on Figures 4-4a and 4-4b.

There is a high degree of variation in the alluvium soil texture. Most of the soil consists of poorly graded sand (Unified Soil Classification System [USCS] classification SP) and well to poorly graded gravel (USCS classification GW to GP). In places, the soil texture is a silty sand (USCS classification SM) and occasional silt layers (USCS classification ML) are present. Gravel tends to be more prevalent at the bottom of the aquifer. Peat layers are occasionally present near the top of the aquifer. Wood was occasionally detected throughout the alluvium. The high degree of variation and predominantly coarse soil texture is consistent with a relatively high energy, dynamic, alluvial depositional environment. Shallower, finer grained deposits and peat are indicative of a lower energy meandering stream depositional environment. Generally, coarser deposits have been identified at the Facility and

[11] Samples were analyzed for physical characteristics in general accordance with the RI Work Plan (Geomatrix 2003b).

finer deposits have been identified west of the Facility. The distribution of soil textures observed during the RI is demonstrated on geologic cross-sections A-A'', and B-B' shown on Figures 4-3a and 4-3b.

4.1.2 Osceola Mudflow

The Osceola Mudflow is an aquitard that separates the upper aquifer (alluvium) from the lower aquifer in the Auburn valley. Previous studies have described the Osceola Mudflow near the Facility as a heterogeneous deposit; typically gray and massive (homogeneous in structure); well-graded; containing gravel, sand, silt, and clay with occasional boulders; occasionally including wood and organic debris and angular volcanic clasts; and occasionally gray with mottled yellow patches and a sulfurous odor (Dragovich et al. 1994, PGG 1999). RI field observations are generally consistent with these previous studies, except that the gray and yellow mottled yellow patches and a sulfurous odor was only identified at one RI boring (AGW252).

The Osceola Mudflow observed in RI explorations completed to date consists of gray, well-graded sand with sub-angular gravel suspended in a matrix of silt and clay (i.e., diamicton). Grain size distribution of the Osceola Mudflow was completed from soil samples collected at one location at the Facility (AGW102) and one location to the northwest of the Facility (AGW276). Grain size results indicate the Osceola Mudflow consists of a well-graded sand with varying amounts of gravel and 20 percent to 30 percent silt and clay. The well-graded texture with a silt and clay matrix creates a lower porosity geologic unit. Moisture content of the AGW102 and AGW276 samples was 11 and 18 percent, respectively. Grain size distribution and moisture content for the Osceola Mudflow samples are presented on Figure 4-5.

A layer of silt (and sometimes clay) overlying the Osceola Mudflow was observed in most RI borings that reached the Osceola Mudflow. This silt layer ranges in thickness from approximately 1 to 14 ft. The silt layer was probably deposited along or distal of the modern (post Osceola Mudflow) White River delta foreslope (Dragovich et al. 1994). Based on the lack of bedding structure and presence of subangular to subrounded gravel observed in some of these silt and clay layers, they are considered part of the Osceola mudflow.

Previous studies indicate the Osceola Mudflow in the Auburn area thickens across the valley from east to west, with a thickness of approximately 10 ft near the eastern edge of the valley and over 40 ft near the west side of the valley before pinching out along the western valley wall (Dragovich et al. 1994). The geometry of the deposit reflects the topography of the Auburn valley that existed prior to the deposition of the Osceola Mudflow (i.e., the east side of the valley floor was higher in elevation and sloped gently to the west where the valley was lower in elevation and more channelized with steeper slopes). In RI borings, the top of the Osceola Mudflow has been observed between 69 and 110 ft bgs and ranged in elevation from -3 to -24 ft National Geodetic Vertical Datum of 1929. RI drilling typically only continued into the Osceola Mudflow less than 10 ft; however, at AGW034, drilling was advanced approximately 55 ft into but not through the mudflow. Consequently, it appears that the Osceola Mudflow is relatively thick beneath the Facility.

4.2 Hydrogeology

The uppermost aquifer in the Auburn valley consists of saturated portions of the alluvium and deposited by the Green or White Rivers. The Osceola Mudflow serves as a regional aquitard between the uppermost aquifer and deeper aquifers. Locally, beneath the Boeing property and off Boeing property to the north, the uppermost aquifer is up to 100 ft thick. For the purpose of the RI, the uppermost aquifer has been subdivided into three groundwater zones based on depth beneath ground surface (bgs)[12]:

- A shallow zone, from the water table (5 ft)[13] to 35 ft bgs
  - The shallowest wells within this zone are screened at or near the water table; water table data is considered a subset of the shallow zone data
- An intermediate zone, from 35 ft to 75 ft bgs
- A deep zone, from 75 ft to the contact with the Osceola Mudflow (typically between 80 and 100 ft bgs)
  - The depth of the Osceola Mudflow varies based on location.

4.2.1 Hydrogeology Conceptual Model

The hydrogeologic conceptual model identifies groundwater recharge and discharge throughout the Site. Groundwater recharge to the upper aquifer comes predominantly from infiltration from the White River, underflow from the White River valley, and infiltrating precipitation. Additional recharge enters the upper aquifer from the uplands along the valley sidewalls. Groundwater flows from the vicinity of the White River valley toward the north and the south creating a groundwater divide that is probably located just south of the Boeing property. Groundwater discharge occurs to the Green River and its tributaries (namely Mill Creek) to the north and downstream reaches of the White River to the south. An estimate of the direction of the regional groundwater flow based on results of the regional numerical groundwater flow model prepared for the RI (LAI 2016h) is presented on Figure 4-6. The approximate location of the groundwater divide and corresponding groundwater flow contours is consistent with previous regional hydrogeologic assessments (PGG 1996, 1998).

4.2.2 Groundwater Recharge

Groundwater recharge is primarily from infiltration from the White River with a smaller contribution from precipitation. These two sources were evaluated based on a comparative analysis of major ion

[12] The RI work plan (Geomatrix 2003b) defined these zones as follows: Shallow zone (10 ft to 30 ft), intermediate zone (40 ft to 60 ft), and deep zone (80 ft to 100 ft). The definitions were subsequently revised to incorporate additional depth intervals (e.g., 30 ft to 40 ft) that were missing from the Geomatrix definition.

[13] The depth to the water table is variable across the Site from less than 5 ft to more than 20 ft, but for the purposes of the RI, 5-ft depth is being used for the top of the shallow zone.

and bulk water isotope signature of groundwater, the White River, and precipitation. The groundwater sampling locations where the major ion and bulk water isotope samples were collected are presented on Figure 4-7. The summary of this comparative analysis is provided in Sections 4.2.2.1 and 4.2.2.2; a detailed analysis was provided in the Spring 2011 RI Data Summary Report (LAI 2012c).

4.2.2.1 Major Ion Analysis

Major ion analysis was completed to compare groundwater samples to samples collected from the White River and literature studies of precipitation. More detail about the major ion analysis is presented in the Spring 2011 RI Data Summary Report (LAI 2012c). Samples were analyzed for total dissolved solids (TDS) and the major constituents of TDS in groundwater including the cations: calcium, sodium, potassium, and magnesium; and the anions: sulfate, bicarbonate, carbonate, nitrate, and chloride and plotted on piper diagrams. A piper diagram is a graphical representation of the chemistry of water samples[14]. Samples were also analyzed for dissolved silicon compounds. Major ion, TDS, and silicon results are presented in Table 4-1. Major ion results are presented on piper diagrams for each groundwater zone on Figures 4-8 through 4-10.

The primary recharge sources to groundwater are precipitation and the White River. Depending on the relative influence of these two recharge sources, major ion results should plot between these two end-members on a piper diagram. Precipitation, although not shown on the piper diagrams, typically plots in the corner of the bicarbonate (HCO_3) field on a piper diagram (i.e., lower left corner of the anion triangle) (Freeze and Cherry 1979). The White River sample plots closer to the sulfate (SO_4) corner on the piper diagram (Figures 4-8 through 4-10). All groundwater samples were classified as calcium, bicarbonate-type water based on the Piper diagram evaluation[15] (Figures 4-8 through 4-10)[16]. In the anion portion of the Piper diagrams, groundwater data generally follow a linear trend from the White River sample (one recharge end-member) to the bicarbonate corner (lower left), where precipitation (another recharge end-member) would plot. The linear relationship between two end-members is consistent with the site hydrogeologic conceptual model of two major sources of groundwater recharge (White River and precipitation). Groundwater samples from each zone are discussed below.

Shallow zone samples do not have an obvious spatial relationship in major ion signatures (Figure 4-7). This may reflect variable recharge influence from infiltrating precipitation (depleted in sulfate) and the White River (enriched in sulfate). Intermediate zone wells have a somewhat clearer spatial relationship in major ion signatures. Intermediate zone wells AGW101 and AGW119 located closest to

[14] Piper diagrams are a standard approach for displaying major ion data to interpret geochemical facies or major ion signature. The cations and anions, expressed as milliequivalents, are plotted separately on trilinear plots and then projected onto a separate quadrilateral plot. The diagrams show the relative proportions of the major ions, not their concentrations.

[15] A calcium, bicarbonate water type means that the water results plot near the calcium apex of the cation plot and near the bicarbonate apex of the anion plot.

[16] A systematic spatial pattern was not evident in the cation distribution for the groundwater samples. Variations in the major cations commonly occur in groundwater flow systems due to chemical cation exchange reactions with the aquifer matrix (Freeze and Cherry 1979).

the White River have a similar water type to the river. Further downgradient wells AGW137, AGW168, and AGW181 show evidence of mixing between local precipitation and the White River. Downgradient intermediate well, AGW174, plots near the White River water type, which may reflect upward flow from the deep zone. The deep zone major ion data are more closely clustered together around the White River sample compared to the shallow and intermediate zone major ion data. This pattern suggests that the deep zone is more influenced by White River recharge (river infiltration to groundwater) and underflow and less influenced by infiltrating precipitation.

4.2.2.2 Bulk Water Isotope Analysis

Bulk water isotope analysis was used to further investigate and clarify groundwater recharge sources. Bulk water isotope analysis defines groundwater oxygen and hydrogen isotopic signatures. By convention, the relative enrichment or depletion in a stable isotope is expressed as the difference (δ, in parts per thousand, ‰) from an agreed-upon standard[17]. In this manner, groundwater recharge from rainwater from higher elevations (lighter, more depleted in ^{18}O, with a more negative δ ‰) such as the White River, can be distinguished from recharge resulting from lowland valley precipitation (heavier, enriched in ^{18}O, with a less negative δ ‰). The change (also known as fractionation) of light and heavy isotopes of water occurs in a predictable way defined by the Global Meteoric Water Line (GMWL). A plot of $\delta^{18}O$ versus $\delta^{2}H$ isotope data is presented on Figure 4-11 along with the GMWL for comparison. These data are also presented in Table 4-2. More detail about the bulk water isotope analysis is presented in the Spring 2011 RI Data Summary Report (LAI 2012c).

Analyses indicate that water from the White River is isotopically light ($\delta^{18}O$ -14.12 ‰, and $\delta^{2}H$ -103.0 ‰) relative to lowland precipitation ($\delta^{18}O$ -7.41 ‰, and $\delta^{2}H$ -60.6 ‰). Stable isotopes for shallow, intermediate, and deep wells fall on a mixing line between these two end-member compositions. The linear trend of the isotopic signatures between the two end-members is consistent with the Site hydrogeologic conceptual model of the two major recharge sources. A more depleted (lighter) isotopic signature is evident in upgradient wells nearest to the glacially fed White River and a more enriched (heavier) isotopic signature is evident in downgradient wells further from the White River where more opportunity for mixing has resulted in more influence from infiltrating precipitation. Isotopic signatures in the deep zone are less variable than signatures in the shallow and intermediate zones. This supports the premise that the deep zone is more influenced by White River recharge and less influenced by infiltrating precipitation. This conclusion is consistent with the results of the major ion analyses.

The isotopic signature of three wells (AGW068, AGW136, and AGW137), plot in a distinct cluster that is heavier (less negative) than the majority of wells (Figure 4-11). All three wells are located in the same general area on YMCA and JA properties. This area is also located near a mound in shallow zone groundwater elevation, which intermittently causes local southward hydraulic gradients suggesting a

[17] The standard for water is typically the Vienna Standard Mean Ocean Water.

local source of recharge. The source of recharge is unknown but could be from a leaky water, stormwater, or sewer line.

4.2.3 Site Groundwater Levels

Depth to groundwater varies spatially across the Site depending on ground surface elevation and geologic conditions. Groundwater elevations also fluctuate at a given monitoring location temporally and seasonally.

Depth to groundwater is important for assessing how groundwater interacts with surface water and for assessing vapor intrusion risk. Depth to groundwater at the Facility is generally in the range of 8 to 22 ft bgs. To the west, in northern residential Algona, groundwater is near the ground surface. To the northwest, depth to groundwater is around 5 ft bgs in shallow zone wells. The depth to groundwater is primarily a function of the ground surface elevation in relationship to the potentiometric surface of the groundwater. In addition, the northern portion of the Site has a number of intermediate zone wells that are artesian, indicating upward vertical gradients.

Maximum and minimum groundwater elevations appears to vary temporally as much as 10 to 15 ft in some locations but average variability across the Site is approximately 5 ft. The largest groundwater elevation variability generally occurs at the Facility and the lowest fluctuations occur northwest of the Facility. Minimum and maximum water level elevations for each well at the Site are presented in Table 4-3.

Groundwater elevations fluctuate seasonally in response to seasonal changes in recharge. Continuous water levels were monitored over an almost 18-month period between June 2011 and December 2012 in three intermediate zone wells located from south to north across the Site[18]. These hydrographs are presented on Figure 4-12. Water levels were at a minimum at the end of summer/early fall and at a maximum in the spring. Approximate average conditions occur in November and December on the rising limb of the hydrograph and in June and July on the falling limb of the hydrograph. Groundwater elevations during the continuous monitoring period fluctuated 3 to 5 ft seasonally.

4.2.4 Groundwater Flow

Groundwater flow in the Auburn valley is generally northward, parallel to the valley walls (PGG 1999). However, at the Site, there is a northwestern component to groundwater flow. The northwest component of flow becomes more pronounced in the area west of the Facility due to groundwater discharging to surface water features (such as the Chicago Avenue ditch, the Auburn 400 ponds, Mill Creek, and adjacent wetland areas).

[18] AGW119 is located at the southeast corner of the Safeway property; AGW137 is located north of the Prologis warehouse; AGW181 is located north of The Outlet Collection.

Synoptic water level measurements were completed approximately twice a year as part of the RI from July 2008 through December 2015. The most recent synoptic water level measurements occurred in June 2015 and December 2015. Synoptic water level measurement events were used to create groundwater elevation contours for the Site. Based on the data collected, groundwater flow only has minor seasonal variation. Groundwater elevation contours are presented for the two most recent sampling events (June and December 2015) for the shallow, intermediate, and deep groundwater zones in Figures 4-13 through 4-18.

Synoptic water level measurement events have consistently shown a generally north to northwest groundwater flow direction. Occasionally, a few anomalies to the groundwater flow patterns were identified in the shallow zone near particular well clusters where there is a high density of wells (i.e., between Buildings 17-06 and 17-07 on Boeing property). These localized anomalies were interpreted to be associated with intermittent mounding due to local preferential recharge (typically associated with precipitation events) and mounding appears to dissipate in a short time period. These anomalous water levels are localized and do not affect the general pattern of Site-wide groundwater elevation contours presented on Figures 4-13 and 4-14.

A shallow zone water level anomaly at well AGW068 at the north end of the JA property is persistent over time. Water levels collected at this location identified a persistent shallow zone groundwater mound. Locally persistent mounding would be caused by a local source of recharge. A nearby leaking water line or storm sewer are potential sources of recharge in this area. The extent of this shallow zone mound is shown on the groundwater level contour plot on Figures 4-13 and 4-14. The mound is not reflected in intermediate or deep zone groundwater levels.

4.2.5 Groundwater Discharge

Surface water features northwest of the Facility are areas of groundwater discharge. The primary surface water discharge features include the Chicago Avenue ditch, the Auburn 400 north and south flood storage ponds, and Mill Creek. Groundwater appears to discharge to these surface water features year-round. There are also a number of wetland areas on the west side of the Auburn valley that capture groundwater seasonally. Capture zones and groundwater to surface water interactions of these surface water features were discussed in the 2014 Surface Water Report (LAI 2015b). The location of major surface water discharge features are shown on groundwater level contour figures (Figures 4-13 to 4-18).

Groundwater discharge to the Chicago Avenue ditch comes from shallow zone groundwater flow upgradient of the ditch. A relatively small portion of the shallow zone downgradient of the ditch would also be expected to contribute to groundwater flow to the ditch. The portion of the aquifer that contributes water to the ditch is known as the ditch capture zone or contribution zone. The depth and downgradient extent of groundwater that is captured by the ditch can be estimated based on measured water levels in the ditch and aquifer, the width of the ditch[19] and aquifer groundwater flow parameters[20] (Chambers and Bahr 1992, Zheng et al. 1988). Based on these parameters, the estimated depth of groundwater beneath the top of the surface water captured by the Chicago Avenue ditch ranges from approximately 14 ft in September 2014 to approximately 31 ft in April 2014. The estimated downgradient extent of groundwater captured by the ditch ranged from approximately 16 ft in September to 34 ft in April. Capture zone calculations are presented in Appendix H and should be considered rough approximations for the Chicago Avenue ditch. The purpose of the capture zone calculations is to provide a working conceptual understanding of how the ditch interacts with groundwater.

Water elevation data also indicate there is an upward hydraulic gradient from groundwater to major surface water features (e.g., Mill Creek) and stormwater features (e.g., Auburn 400 north pond) throughout the year (LAI 2015b). The capture zone of these features was not estimated since the analytical equation for a simple geometry like a ditch does not directly apply to a pond geometry or the more complex geometry of Mill Creek and associated wetlands.

4.2.6 Hydraulic Parameters and Groundwater Velocity

Hydraulic parameters of interest include porosity and hydraulic conductivity. Average groundwater seepage velocity can be estimated using Darcy's Law (Freeze and Cherry 1979) based on estimates of the horizontal hydraulic gradient, hydraulic conductivity, and effective porosity. The spatial distribution of hydraulic parameters and estimated groundwater velocity was determined for the RI in a numerical groundwater flow model (groundwater model), summarized below and discussed in detail in the Groundwater Modeling Report (LAI 2016h).

4.2.6.1 Numerical Groundwater Flow Model Development

The groundwater model was constructed with the objective of verifying and refining the conceptual model of hydrogeologic conditions and groundwater flow at the Site as well as to provide a framework for evaluating treatment options during the FS. The groundwater model was developed using Aquaveo's Groundwater Modeling System (GMS) graphical user interface and solved with the U.S. Geological Survey (USGS)-developed MODFLOW-NWT code (Niswonger et al. 2011). GMS allows for the graphical creation of the conceptual model of a hydrogeologic system and direct importation of that conceptual model to a three-dimensional MODFLOW grid.

The groundwater model domain covers approximately 20.1 square miles in the Auburn Valley. The groundwater model grid includes five vertical layers to represent the shallow, intermediate, and deep

[19] The width of the ditch was measured at the staff gauge SWSG-2. The water-filled width of the ditch is assumed to be approximately 6 ft for the purpose of these calculations; however, the width varies throughout the year.

[20] The regional gradient was calculated from shallow zone groundwater elevations collected in July 2014 from AGW083 to AGW243-3. The regional gradient was 0.0019. The anisotropy ratio (horizontal divided by vertical hydraulic conductivity) was assigned a value of 5 based on the numerical groundwater model.

zones of the upper aquifer (Layers 1, 2, and 3, respectively), the Osceola Mudflow (a low permeability layer, Layer 4), and the underlying lower aquifer (Layer 5). Boundary conditions used in the groundwater model consist of rivers (White River and Green River), drains (Mill Creek, ditches, wetlands, and ponds), precipitation recharge, supply wells [21], and specified head and general head boundaries. Hydraulic conductivity was applied to the model grid with a combination of the zonal approach and highly parameterized inversion techniques (i.e., pilot points with PEST calibration). The groundwater model was set up in steady state mode to simulate relative average conditions of the hydrogeologic system of the Auburn Valley. Precipitation recharge and river stage heights were applied to the model based on estimated or observed average conditions.

The groundwater model was calibrated with a combination of manual and PEST calibration techniques. The calibration dataset included:

- 290 groundwater observation points (282 of which were within the Boeing Auburn monitoring well network);
- Estimates of losses/gains from/to the White River, Green River, and Mill Creek;
- Estimates of groundwater underflow from the White River Valley; and
- Results of two groundwater pumping activities (for which the groundwater model was temporarily converted to transient mode).

The calibrated steady-state groundwater model results consist of a head solution throughout the model domain that qualitatively corresponds well with the conceptual understanding of groundwater flow through the Auburn Valley and at the Site.

4.2.6.2 Horizontal Groundwater Gradients

Horizontal groundwater hydraulic gradients at the Facility were calculated in 2009 using groundwater level data from 2004 and 2008. Based on August 2004 measurements, the shallow zone horizontal groundwater gradient was calculated to be approximately 0.00075 feet per foot (ft/ft). Similar horizontal hydraulic gradients were calculated for the shallow zone using water level measurements from July 2008 and October 2008. Hydraulic gradients in the intermediate and deep zones in 2008 were similar to the hydraulic gradient in the shallow zone (LAI 2009d).

A quantitative analysis of horizontal hydraulic gradients (magnitude and direction) at the Site was performed for the 2016 groundwater modeling report (LAI 2016h). Hydraulic gradient calculations were performed using a best-fit piezometric surface calculation spreadsheet (Devlin 2003). Hydraulic gradients were calculated separately for the shallow, intermediate, and deep zones of the upper

[21] Supply wells simulated in the model include six City of Auburn wells (Wells 2, 3A, 3B, 4, 6, and 7), three City of Pacific wells (simulated as a single well in the model due to their proximities to each other), and a number of smaller water system or private individual wells that are outside of the Boeing Auburn Site, but within the Auburn Valley. Depths of well screens were based on well log information. Withdrawal rates were based on average recorded withdrawals (City of Pacific wells) or stated well capacities (City of Auburn and other wells). The previous City of Algona well is not pumping in the current model simulations as this well was decommissioned.

aquifer. All water levels used for the assessment were from clustered wells (i.e., wells that were screened in the shallow, intermediate, and deep zones of the upper aquifer at approximately the same location); therefore, hydraulic gradients were calculated from water levels from each zone of the upper aquifer at the same coordinate locations. The seasonal hydraulic gradient calculations are presented in Appendix H.

Using the results of this gradient analysis, average gradients were calculated for each groundwater zone in June and December 2015. For June 2015, an average gradient of 0.0016 ft/ft was calculated for all zones. For December 2015, average gradients of 0.0021 ft/ft, 0.0020 ft/ft, and 0.0023 ft/ft were calculated for the shallow, intermediate, and deep zones, respectively. The results of the 2015 hydraulic gradient analysis suggest some seasonal variation in the magnitude of the horizontal hydraulic gradient due to higher rates of recharge in the winter (December) than in the summer (June). However, there appears to be minimal variation in the horizontal hydraulic gradient direction. The current analysis of horizontal hydraulic gradients produced larger gradients than previously reported (i.e., 0.0021 ft/ft versus 0.00075 ft/ft). This difference is most likely due to the scale of analysis; the 2009 analysis was based only groundwater levels over the southern portion of the Facility; gradients over the southern portion of the Facility are significantly flatter than in downgradient areas of the Site. The current analysis presented in Appendix H focuses only on the northern portion of the property and areas north and west of the property where gradients are steeper. Steeper gradients toward the north and west are attributed primarily to decreasing aquifer hydraulic conductivity with distance from the where the Green and White Rivers enter the Auburn valley.

4.2.6.3 Hydraulic Conductivity

The hydraulic conductivity of the upper aquifer was evaluated as part of a hydrogeologic investigation near Building 17-05 (Kennedy/Jenks 1997d). Slug tests conducted at monitoring wells screened in the shallow aquifer indicated hydraulic conductivity values between 85 feet per day (ft/day; 0.30 centimeters per second [cm/sec]) and 0.1 ft/day (5×10^{-5} cm/sec). These hydraulic conductivity values likely reflect the variable hydraulic properties of the alluvium. A pumping test conducted at the north end of the Facility resulted in an estimate of the average hydraulic conductivity of 10,800 ft/day. The value of hydraulic conductivity from the Facility pumping test is higher than typical values expected for sand and gravel deposits (Freeze and Cherry 1979); the atypical value is attributed to potentially high well losses[22] (i.e., inefficient well) (Williams 1981). During the pumping test, the well was pumped at 400 gallons per minute (gpm) and produced 6.5 ft of drawdown in the pumping well. The resulting well specific capacity is 62 gallons per minute per foot. This value can be converted to an estimate of transmissivity of 12,300 square feet per day using the modified Jacob equation[23] (Driscoll

[22] The pumping well was designed with a nominal 8-inch diameter 0.020 slot PVC screen and a 10/20 size sand pack. The small slot size and fine-grained filter pack could potentially result in high screen entrance velocities and well approach velocities causing greater drawdown (more head loss) near the well (Williams 1981) relative to a properly designed well.

[23] Modified Jacob Equation for unconfined aquifer: $Q/s = T/1500$. T (transmissivity) in gallons per day per foot; Q (pumping rate) in gpm; s (drawdown in pumping well) in ft.

1986) and a rough estimate of hydraulic conductivity of 120 ft/day assuming a 100 ft thick aquifer. The actual bulk hydraulic conductivity of the alluvium at the pumping well location is likely closer to 120 ft/day than the reported pumping test value of 10,800 ft/day. For comparison, hydraulic conductivity values for the north end of the Facility (near former Building 17-05) in the numerical groundwater flow model varied from about 100 ft/day to 400 ft/day. There is an observed tendency for soil to become slightly coarser with depth in the upper aquifer, indicating slightly higher hydraulic conductivity in deep soil than in shallow soil.

The range of reported horizontal hydraulic conductivity values for the aquitard, Osceola Mudflow, is from 6 x 10^{-5} to 60 ft/day (PGG 2000). In the numerical groundwater model, vertical hydraulic conductivity was assigned a value of 0.001 ft/day[24] with a vertical anisotropy value of 100. This results in a horizontal hydraulic conductivity of 0.1 ft/day (LAI 2016h). One sample was collected of the Osceola Mudflow at well AGW102 for analysis of vertical hydraulic conductivity. The Osceola Mudflow sample had a measured vertical hydraulic conductivity of 0.0007 ft/day (2.5 x 10^{-7} cm/sec). This measured value is similar to the vertical hydraulic conductivity value of 0.003 ft/day (1 x 10^{-6} cm/sec) reported by Kennedy/Jenks as part of a hydrogeologic evaluation of Building 17-05 and the vertical hydraulic conductivity selected for use in the numerical groundwater model (LAI 2016h).

4.2.6.4 Porosity

Porosity and dry bulk density were analyzed for the upper aquifer alluvium at six monitoring well locations. Porosity values ranged from 0.31 to 0.54. Dry bulk densities ranged from 95 to 111 pounds per cubic foot. Porosity and dry bulk density results are presented in Table 4-4.

These measured porosity values are generally consistent with the literature values for porosity of a heterogeneous sand and gravel aquifer (Fetter 2001). For the purposes of modeling and calculations, total porosity is assumed to be 0.35. Effective porosity used to determine seepage velocity is assumed to be 0.30.

4.2.6.5 Seepage Velocity

A rough estimate of average groundwater seepage velocity in the area of the contaminant plumes can be estimated using Darcy's Law (Freeze and Cherry 1979) based on estimates of the hydraulic gradient, hydraulic conductivity, and effective porosity:

$Q = K*i/n$

Where:

K = hydraulic conductivity; 300 ft/day (Numerical Groundwater Flow Model)

i = hydraulic gradient; 0.0021 (Appendix H)

n = effective porosity; 0.30 (from literature values).

[24] The assigned model value was based on Fetter's range for silty sand (Fetter 2001) and was verified to be an appropriate estimate based on model calibration.

Based on the above equation, a groundwater velocity estimate for the alluvium is 2.1 ft/day or 766 feet per year (ft/year). Seepage velocity estimates from the numerical groundwater flow model ranged from approximately 150 to 400 ft/year with an average seepage velocity near the footprint of the plume of approximately 300 ft/year.

Groundwater seepage velocity within the shallow zone was estimated to range from 1.9 ft/day (690 ft/year) to 13.7 ft/day (5,000 ft/year), based on tracer testing performed as part of the Area 1 IRA (LAI 2004c). These estimates are likely affected by localized mounding during injection and higher permeability layers allowing for faster breakthrough of tracers than average groundwater velocities. Average groundwater velocities are likely near the low end of this range.

In summary, groundwater velocities in the upper aquifer alluvium are likely to be in the range of 150 ft/year to 700 ft/year. Based on particle tracking from the groundwater model, seepage velocities average approximately 300 ft/year from the Facility to Mill Creek. These relatively high seepage velocities reflect the relatively high hydraulic conductivity of the alluvium and the high rates of recharge to the aquifer system due to infiltration from the White River and underflow.

4.2.7 Vertical Hydraulic Gradients

Vertical hydraulic gradients were calculated at select well pairs within the project area. Gradients were calculated between shallow and intermediate; intermediate and deep; and shallow and deep wells clustered at the same location (typically within 20 ft). Vertical gradients were also calculated at multi-level wells. The gradient calculation represents the difference in water level divided by the difference in elevation between the midpoints of the corresponding screens. Vertical gradients were calculated at 27 well clusters in June 2015 and at 28 well clusters in December 2015[25]. Vertical gradients for June 2015 and December 2015 are presented in Tables 4-5a and 4-5b, respectively.

Vertical gradients are generally downward near the Facility and upward in the northwest portion of the Site where groundwater discharge occurs to Mill Creek and stormwater features. Observed variability in this trend is likely a reflection of the relatively complex hydrologic and geologic setting. The strongest downward vertical gradients between the shallow and deep zones occur on the Facility at AGW200 (0.0054) and just north of the Facility at AGW212 (0.0076). The strongest upward vertical gradients between the shallow and deep zones occur north and west of The Outlet Collection at AGW231 and AGW197 (-0.0239), AGW235 (-0.0119), and west of the Facility at AGW251 (-0.0135). Vertical gradients calculated from the shallow zone to the deep zone at the 27 well clusters are shown spatially on Figure 4-19 for data collected in June 2015.

Vertical gradients were further evaluated using the semi-continuous groundwater level data collected at clustered wells AGW125 (shallow zone) and AGW126 (intermediate zone) located at the north

[25] Although vertical gradients may vary somewhat across years depending on recharge sources, evaluation of vertical gradients in December and June is appropriately representative because these two time frames represent approximately average water levels during the rising and falling portions of the water year.

portion of the Facility in Area 1. Vertical gradients were calculated at this well cluster by subtracting groundwater level measurements and dividing by the distance between the screen midpoints (15 ft). This calculation gave a continuous characterization of vertical gradients between the shallow and intermediate zones from October 2008 through February 2009. During this time, vertical gradients were just slightly above zero (downward) except during heavy rainfall periods that occurred in early November 2008 and early January 2009. During these periods, the vertical gradient temporarily reversed and became upward. The cause of this relationship is discussed further in the paragraph below. A semi-continuous plot of precipitation and AGW125/AGW126 vertical gradients is presented on Figure 4-20. A semi-continuous plot of AGW125/AGW126 vertical gradients and White River stage is presented on Figure 4-21.

Heavy rainfall events cause water levels to rise in both the intermediate and shallow zones in a similar pattern. However, at the AGW125/AGW126 well cluster, the shallow zone well (AGW125) responds more slowly than the intermediate well, which causes a temporary upward positive vertical hydraulic gradient. This effect supports the conclusion that the White River is the major recharge source for groundwater at the Facility. The well responses may be due to the relative difference in hydraulic conductivity and storage coefficient between the shallow and intermediate zones at this location. The intermediate zone likely has a higher hydraulic conductivity and lower storage coefficient than the shallow zone and therefore, would tend to respond more quickly to a sudden recharge event particularly if the recharge source is some distance upgradient (e.g., heavy precipitation resulting in significant increases in river stage and discharge). Typically, a sudden recharge event would be expected to cause a downward gradient due to infiltrating precipitation, but impervious surfaces and stormwater collection and conveyance at the Facility limit recharge from precipitation. The more rapid response in intermediate zone water levels support infiltration from the White River as the predominant groundwater recharge source at the Facility.

4.3 Groundwater Use near the Boeing Auburn Site

Boeing reviewed groundwater use near the Site to evaluate the potential for exposure to contaminated groundwater and to evaluate potential influences of groundwater pumping on hydraulic flow within the aquifer. Groundwater systems that were reviewed consist of Group A, Group B, and individual private wells in the vicinity of the Site. Group A public water systems are defined by WDOH as serving more than 15 connections and more than 25 people per day; large municipal purveyors fall in this category. Group B public water systems are defined by WDOH as serving fewer than 15 connections and less than 25 people per day (WDOH 2014a). Boeing completed a review of municipal well use and associated critical area and wellhead protection ordinances (LAI 2010c) and a review of individual private wells (LAI 2014i) near the Site. In addition, WDOH completed an evaluation of the potential human health hazard posed by known contaminants in groundwater (WDOH 2012). At the time of the WDOH review in 2012, the known extent of the trichloroethene (TCE) plume was as far north as West Main Street in Auburn. Since that time, additional wells have determined the plume extends over a slightly larger area than the 2012 characterization. However, this did not change the conclusions of the WDOH review and the assessment by WDOH in 2012 concerning drinking water impacts still applies to the current understanding of the plume. Both reviews completed by WDOH and Boeing concluded that groundwater contamination does not pose a significant risk to human health because people are not drinking contaminated water. No private individual drinking water wells have been identified in the areas with groundwater contamination (LAI 2014i). However, private individual wells are not tracked or regulated in the same manner as public Group A and Group B supply wells and may not be listed in publicly available information sources; Ecology continues to request that owners of individual private wells near the Site notify their City's public utility for testing and notify Ecology about well locations.

4.3.1 Group A Wells

The Cities of Auburn and Pacific operate the two large municipal Group A water supply systems within 1 mile of the Facility. Algona is currently served by the City of Auburn Municipal Water System. There are also a few small private Group A water systems within 1 mile of the Facility. A description of Group A wells within 1 mile of the Facility is presented in the Critical Area/Wellhead Protection Ordinance Review memorandum (LAI 2010c).

4.3.1.1 City of Algona

The City of Algona previously operated a municipal water supply well west of the Facility. In 1996, the City of Auburn took over responsibility for providing water to Algona through an intertie system (i.e., a pipe connecting the two cities water distribution systems). Pumping of the Algona well was discontinued and the well was decommissioned. The well appears to have been active between 1970 and 1996 (WDOH 2012). The 10-inch well was 65 ft deep (Carollo Engineers 2015) and screened in the upper aquifer. The water right allowed for pumping of 175 acre-ft/year on an annual basis (i.e., 108 gpm). Pumping of this well was simulated using the numerical groundwater model. Modeling results indicate that pumping from the well had only a localized effect on groundwater gradients and likely had a *de minimis* effect on groundwater flow direction or gradients at the Facility. The location of this well was outside of the extent of the groundwater plumes and it is unlikely that it was impacted by releases from the Facility. Effects of pumping from this well on the extent of the groundwater plumes are discussed further in Section 8.1.4 and presented on Figure 8-6. The former location of this well is shown on Figure 4-22.

4.3.1.2 City of Auburn

The City of Auburn has eight production wells located within the Auburn valley. However, only three of these wells are within a mile of the Facility. These wells are identified as City of Auburn wells 3A, 3B, and 4. In addition, the City of Auburn well 1 is slightly more than 1 mile from the Facility. All four of these wells are located east, crossgradient, of the Facility and are shown on Figure 4-22.

Wells 3A, 3B, and 4 are constructed such that well screens draw groundwater from the lower aquifer, beneath the Osceola Mudflow aquitard. The depth and location of these wells, crossgradient of the

Facility, makes it unlikely that they will be impacted by releases from the Facility. Well 1 is possibly screened in the uppermost aquifer (screened between 103 and 134 ft); however, pumping from this well was discontinued in 1998. No City of Auburn production wells are currently operating in the uppermost aquifer. Additionally, the location of the wells is crossgradient to the direction of groundwater flow.

The City of Auburn recently updated their wellhead protection assessment for their groundwater supply system (Carollo Engineers 2015). Evaluation of the updated wellhead protection zones for the water supply wells, confirmed that the groundwater contaminant plume is not within the footprint of the City of Auburn's groundwater supply well capture zones. The wellhead protection zones for City of Auburn's groundwater supply wells are presented on Figure 4-22.

4.3.1.3 City of Pacific

The City of Pacific has three wells clustered at their wellfield south of the Facility. These wells are identified as East Well, West Well, and South Well and the depths of these wells range from 47 to 56 ft. All three wells are screened in the uppermost aquifer. Wellhead protection zones for 6-month, 1-year, and 10-year time-of-travel zones were estimated by the City of Pacific for each well using the fixed radius method (City of Pacific 2008). Using the fixed radius approach, the City of Pacific wells have a potential capture zone radius of approximately 2,730 ft over a 10-year period using a pumping rate of 1000 gpm. The fixed radius calculated wellhead protection zones for the City of Pacific wells are presented on Figure 4-22.

The fixed radius method does not take into account groundwater flow direction. The actual capture zones are more likely elongated in the upgradient direction of groundwater flow and are likely appreciably narrower than the capture zone calculated using the fixed radius method. The actual capture zones most likely extend for a long distance upgradient, but only a short distance downgradient. Since the water supply wells are upgradient of the Facility, the capture zone is not expected to appreciably intersect portions of the groundwater plumes originating at the Facility. This assessment is consistent with the results of groundwater level measurements indicating that the capture zone of the City of Pacific wells is limited to the very southern portion of the Facility and groundwater data from the Sentry wells discussed below.

Boeing has installed nine Sentry wells[26] to evaluate the potential impact of groundwater contamination on the City of Pacific's wells. These wells are sampled semi-annually for VOCs by Boeing. With Ecology approval, sampling at one of these wells (AGW121) was discontinued after June 2009. Sentry well data are tabulated and sent to the City of Pacific on a semi-annual basis. In 2001 through 2004, concentrations of tetrachloroethene (PCE) and TCE were occasionally detected at the Sentry wells at concentrations below the Site screening levels and below the maximum contaminant level (MCL) drinking water criteria. PCE was detected in November 2001 at a maximum concentration

[26] The nine Sentry wells include AGW074, AGW087 through AGW091, and AGW119 through AGW121.

of 0.4 micrograms per liter (µg/L) at AGW087, AGW088, and AGW089; 0.3 µg/L at AGW090; and 0.2 µg/L at AGW091. In June 2004, TCE was detected at a maximum concentration of 0.2 µg/L at AGW089. However, there has never been a significant concern that the City of Pacific drinking water quality would be affected. No VOCs of concern have been detected at any of the Sentry wells since 2004. City of Pacific samples their groundwater wells for VOCs every 3 years (City of Pacific 2008); the most recent event was May 2015 and VOCs were not detected (WDOH 2016). City of Pacific supply well locations are shown on Figure 4-22.

4.3.1.4 Other Water Systems

There are three additional Group A water systems located within 1 mile of the Facility. These include Danner Corporation, South Auburn Water Association (SAWA), and Auburn Mobile Park (Figure 4-22). The Danner Corporation well is located south of the White River and on the south side of the groundwater flow divide shown on Figure 4-6. In addition, this well is 260 ft deep and is located in the lower aquifer (below the Osceola Mudflow). The depth and location of this well means that it will not be impacted by releases from the Facility.

The SAWA and Auburn Mobile Park wells are located directly east of the Facility. These wells are screened in the uppermost aquifer at 92 and 58 ft deep, respectively. The average annual pumping rates for these systems were estimated at 8 gpm and 16 gpm (LAI 2010c). Due to their locations east of the Facility (i.e., crossgradient) and their relatively low pumping rates, both of these water systems are unlikely to be impacted by releases from the Facility. The Auburn Mobile Park well is monitored for VOCs every year; the most recent sampling event was in September 2015 and VOCs were not detected (WDOH 2016). The SAWA well is monitored for VOCs every 3 years for VOCs; the most recent sampling event that could be found was in September 2011 and VOCs were not detected (WDOH 2016).

4.3.2 Group B Wells and Private Domestic Wells

The location and use of Group B wells and private domestic wells was evaluated and described in the area of the groundwater plumes that extend from the Facility to the north and northwest in the private well survey memorandum (LAI 2014i). This study area was defined conservatively to include areas beyond the known area of the plumes. For example, the northern study area boundary is about 1,000 ft north of the northern extent of the intermediate zone plume. The key results from the private well survey are summarized below. Group B wells near the Site and possible individual private wells located within the study area are shown on Figure 4-23[27].

All Group B wells are east of the Facility and outside of the study area. Potential private individual well users included properties identified by the Cities of Auburn and Algona that are within city boundaries, but not being served by the City of Auburn Municipal Water System. All potential

[27] Well locations are typically recorded by Section, Township, and Range, meaning the locations are not precise. Locations designated on the map should be considered approximate.

properties with private individual wells that were identified by the City of Auburn and Algona are outside of the study area. These wells are not shown on Figure 4-23, as they are not located in the study area. WDOH sampled one well in Algona that is reportedly still in use[28] and did not detect any VOCs of concern (LAI 2014i).

Other possible private individual wells located within the study area were identified by LAI through review of online databases and historical reports and information (LAI 2014i). Eight of the wells were identified as potential water supply wells screened in the upper aquifer[29]. Two of these wells are located in Algona and six of these wells are located in Auburn (Figure 4-23). None of the eight wells were the private individual wells previously identified by the City of Algona or the City of Auburn. Additionally, none of the wells could be confirmed to be still in existence. Information about these eight wells is provided in Table 4-6. If any of the wells do still exist, they are unlikely to be currently used for drinking water due to their age and proximity to municipal water supplies. Most of the purported wells were installed before 1961 with the most recent installed in 1975.

4.3.3 Summary

The water supply for the portion of the Auburn valley that includes the Facility is almost entirely supplied by either the City of Auburn or the City of Pacific. Both of these municipal purveyors get their entire water supply from groundwater. Three other Group A well systems (Danner Corporation, SAWA, and Auburn Mobile Park) supply water from wells located within 1 mile of the Facility. None of these Group A wells are threatened by groundwater contamination associated with the Boeing Auburn property because the wells are located upgradient, crossgradient, or in a deeper aquifer. None of the Group B groundwater supply systems near the Facility are threatened by groundwater contamination associated with the Facility because they are located crossgradient of the Boeing Auburn property. Private individual wells do not appear to be threatened by groundwater contamination because they are either outside of the area of groundwater contamination or are likely no longer used for drinking water. There are no other known private wells used for drinking water at the Site or groundwater supply wells near the Facility.

4.4 Geochemistry

Numerous soil and groundwater samples were analyzed for geochemical parameters during the RI. Geochemical parameters were collected to facilitate evaluation of contaminant fate and transport, including retardation and biodegradation. Major ion analyses and bulk water isotope analyses are discussed in Sections 4.2.2.1 and 4.2.2.2, respectively as part of the groundwater recharge discussion.

Evaluation of total organic carbon [TOC] in soil can be used to determine a solute retardation factor for TCE and breakdown products in groundwater. Solute retardation is an important process affecting

[28] Only use is for filling a small Koi pond and occasional watering.
[29] Water supply wells are wells that are not resource protection wells, dewatering wells, decommissioned wells, or irrigation wells.

transport of TCE and breakdown products in the aquifer and primarily affects how quickly a compound is transported in comparison to groundwater seepage velocities. The solute retardation factor evaluation based on TOC analysis in soil samples is presented in Section 4.4.1.

Groundwater geochemistry is important in understanding both source contributions and contaminant fate and transport processes. To understand source areas and geochemistry that may be associated with releases, an evaluation of conductivity at and near the Facility was conducted in 2011; a discussion of the findings from the conductivity evaluation is presented in Section 4.4.2.1. Additionally, a number of groundwater parameters were measured to evaluate the natural attenuation process for chlorinated volatile organic compounds (CVOC; e.g., TCE). The purpose of the natural attenuation measurements was to evaluate whether these processes are occurring at the Site and where they may be affecting CVOC concentrations in the aquifer. Natural attenuation parameters measured in groundwater included alkalinity, chloride, iron (II), nitrate, DO, ORP, sulfate, sulfide, and methane[30]. A discussion of natural attenuation results is provided in Section 4.4.3. Additionally, Boeing conducted isotopic fingerprinting through compound specific isotope analysis (CSIA) at select locations in June 2011 (LAI 2012c) and additional locations in June 2012 (LAI 2012d). CSIA provides information both about potential contaminant sources and about reductive degradation of CVOCs. A discussion of CSIA is provided in Section 4.4.4; additional detail about the CSIA analysis was presented in the spring 2011 RI Data Summary Report (LAI 2012c). Analytical results for conventional and natural attenuation parameter data collected during the RI are presented in Appendix I.

4.4.1 Solute Retardation Factor

Soil samples collected from above and below the water table at the Facility were analyzed for TOC as part of RI activities described in the RI work plan (Geomatrix 2003b). TOC analysis was performed on 48 soil samples across the Facility. Results ranged from 0.043 percent (ASB0150) to 4.88 percent (ASB0170). Of these 48 samples, 10 samples had detectable levels of petroleum hydrocarbons, which likely contributed to the elevated TOC concentrations. These 10 samples were collected from locations associated with SWMUs with petroleum hydrocarbon releases (See Section 6). In addition, the boring log for one other sample indicates the presence of natural organic material. These 11 samples had elevated TOC concentrations and were considered biased high relative to typical aquifer conditions. Excluding these 11 samples, TOC ranged from 0.043 to 0.614 percent; the average TOC value was 0.15 percent. TOC soil results are presented in Table 4-7.

A retardation factor (R) for VOCs of concern, such as TCE, can be calculated from TOC data and an estimate of the solute distribution coefficient (K_d):

$$R = 1 + (p_B /n) * K_d$$

[30] In addition to NA parameters discussed in this section, the RI work plan (Geomatrix 2003) also included measurement of conventional parameters ammonia, sulfite, total suspended solids and total dissolved solids at select wells. This data is presented in Appendix I along with the results for NA parameters.

p_B = Bulk dry density (grams per cubic centimeter [g/cm^3]) for uniform dense sand = 1.75 (Peck et al. 1974)

n = Porosity (unitless); 0.35 (total porosity)

K_d = Distribution Coefficient (milliliters per gram [mL/g]); K_{oc}* f_{oc} (Fetter 1993)

K_{oc} = Organic Carbon Distribution Coefficient (mL/g); 94 mL/g (Ecology 2015)

f_{oc} = Organic Carbon Fraction (unitless); 0.00043 to 0.00614 (range of TOC values), 0.0015 (average TOC value).

Based on the equation above, the calculated retardation factor for TCE ranges from 1.20 to 3.89. The average TCE retardation factor is calculated as 1.70. A retardation factor of 1.70 means that TCE would be expected to travel at 0.59 (1 divided by 1.70) times as fast as the average horizontal groundwater seepage velocity (about half as fast). Calculated TCE retardation factors at each well based on TOC soil results are presented in Table 4-7. Figure 4-24 presents TCE retardation factors at each location where soil TOC samples were collected.

Given the variability in TOC values observed at the Facility, and the range of literature values for other inputs to the calculated retardation factor (i.e., K_{oc} estimates in the literature vary for TCE between about 25 and 316), actual TCE retardation would be expected to vary spatially from the calculated average. Other VOCs such as cis-1,2-dichloroethene (cDCE) and vinyl chloride (VC) have K_{oc} values that are lower than TCE (35.5 mL/g and 18.6 mL/g, respectively). Consequently, these TCE breakdown products would be expected to migrate at a faster rate.

4.4.2 Conductivity

Conductivity is measured at each well during sampling events; however, in June 2011, conductivity was plotted and evaluated for spatial trends to better understand source areas and evaluate geochemistry that may be associated with releases. Conductivity is a measure of how readily water will conduct an electrical current; it reflects the amount of ions (similar to TDS) present in solution. Anthropogenic impacts (e.g., contaminant releases, leaking sewer lines, road runoff) can increase conductivity. Conductivity measurements were evaluated at all 129 wells[31] sampled in June 2011 (LAI 2012c). Conductivity data are presented in each groundwater zone on Figures 4-25 through 4-27[32]. Conductivity data is presented in Table 4-8.

Conductivity varied most widely in the shallow zone, with both the minimum (37 µS/cm) and maximum (1,047 µS/cm) observed conductivity values occurring in the shallow groundwater zone. This substantial variation is consistent with expected anthropogenic effects to the shallow zone. Shallow zone conductivity is generally low (less than 200 µS/cm) on the east side of the access road between Building 17-07 and Building 17-06 (West Road) and moderate (200 to 600 µS/cm) west of

[31] There were are 61 shallow zone wells, 51 intermediate zone wells, and 17 deep zone wells sampled in June 2011.

[32] For ease of interpretation, conductivity results were divided into three categories: Low: 0 to 200 microSiemens per centimeter (µS/cm), moderate: 200 to 600 µS/cm, and high: >600 µS/cm.

West Road. The noticeably higher shallow zone conductivity in the northwestern portion of the Boeing property may be due to historical releases that had the effect of increasing dissolved solids in groundwater. Known historical releases in the northwestern portion of the Boeing property that may affect conductivity include the acid scrubber drain line (AOC A-09), the north lagoon (SWMU S-26), and the wastewater pre-treatment plant (WWPTP; SWMU S-06). These are further discussed in Section 6.0.

Relatively high levels of conductivity were noted at shallow zone wells AGW068 (844 µS/cm), AGW050 (1,047 µS/cm) and AGW027 (696 µS/cm). The cause of the high conductivity value at AGW027, north of Building 17-07, is unknown, but may be related to upgradient releases in Building 17-07. The high conductivity at AGW050 is probably related to a nearby acid scrubber drain line leak (AOC A-09; see Section 6.0). The cause of high conductivity at AGW068 is unknown, but the well is associated with other anomalous data including a shallow zone groundwater mound, which suggests that the high conductivity may be related to a leaking underground utility. In the intermediate zone, conductivity was generally low to moderate, ranging from 98 µS/cm to 449 µS/cm. Conductivity values south of Building 17-07 are consistently low (less than 200 µS/cm). Across the remainder of the Site, no discernible patterns in the intermediate zone conductivity distribution were noted. In the deep zone, conductivity was generally low and exhibited limited spatial variability, generally ranging from 144 µS/cm to 260 µS/cm The highest conductivity observed in the deep zone occurred at the two wells located farthest northwest, AGW178 and AGW183 (207 µS/cm and 220 µS/cm, respectively) and well AGW034 (260 µS/cm) west of Building 17-07.

4.4.3 Natural Attenuation Indicators

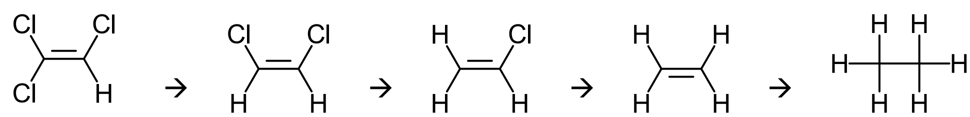
The purpose of the natural attenuation measurements was to evaluate whether these processes are occurring at the Site and where they may be affecting CVOC concentrations in the aquifer. Natural attenuation indicators evaluated as part of this study include aquifer oxidation-reduction (redox) parameters: nitrate, ferrous iron (iron (II)), sulfate, and methane[33]; and other natural attenuation indicators: TOC, alkalinity, and chloride. The information provided by each natural attenuation indicator discussed in this section is summarized in Table 4-9. Data related to natural attenuation indicators is presented in Appendix I.

Natural attenuation of Site chlorinated compounds (TCE, cDCE, and VC) through biotic (i.e., biological) and abiotic processes typically requires anaerobic aquifer conditions. When oxygen is depleted in an aquifer, anaerobic bacteria use the less oxidized natural electron acceptors in sequential order: nitrate, manganese (IV), iron (III), sulfate, and carbon dioxide. Resulting low nitrate and sulfate, and

[33] Other indicators of aquifer redox conditions include DO and ORP; however, DO and ORP are less reliable due to difficulty in measuring these parameters consistently and accurately. DO and ORP values are presented in Appendix I, but are not discussed in this section due to their variability.

elevated iron (II) and methane (from carbon dioxide reduction) are generally considered the most reliable indicators of aquifer reduced redox conditions[34].

TCE and breakdown products present in the aquifer are also electron acceptors and can be reductively dechlorinated under increasingly reduced redox conditions at each sequential step. At each step of reductive dechlorination, a chlorine ion present on the chlorinated hydrocarbon molecule (e.g., TCE) is replaced with hydrogen resulting in the formation of successively less chlorinated (less oxidized) molecules, as follows:



Because TCE is relatively oxidized, TCE is reduced to cDCE under mildly reducing (iron-reducing) conditions (Chapelle 1996). Less oxidized cDCE and VC require successively more reduced aquifer conditions for anaerobic degradation. CDCE is reduced under sulfate-reducing to methanogenic conditions (Chapelle 1996, Vogel et al. 1987) and VC is reduced to ethene/ethane under methanogenic conditions (Ballapragada et al. 1997, Vogel and McCarty 1985). Biotic degradation of TCE to VC also requires presence of Dehalococcoides bacteria (AFCEE 2004, Major et al. 2003). Various strains of Dehalococcoides are the only bacteria that have been identified as responsible for dechlorination of cDCE to VC, while the remaining dechlorination steps to non-toxic end products (i.e., ethene and ethane) occur via a wider range of chemical and biological processes.

4.4.3.1 Site Aquifer Oxidation Reduction Conditions

A number of studies have been completed during the RI that have looked at partial indicators of aquifer redox conditions (i.e., nitrate and sulfate in June 2011 (LAI 2012c), iron in June 2012 (LAI 2012e) and western plume natural attenuation assessment (LAI 2015c). These studies have assisted in the understanding of Site aquifer redox conditions; however, areas near the Area 1 IRA (see Section 7.0) and the Algona pilot test (LAI 2015c) have been evaluated more thoroughly. General Site aquifer redox conditions are discussed below. Appendix I presents all natural attenuation data collected. Site aquifer redox evaluation will be further evaluated during the FS phase of the project.

Aerobic aquifer conditions generally appear to occur at the Safeway Property and on the east side of the Boeing property. In these areas, concentrations of nitrate are generally above 1.0 milligrams per liter (mg/L), iron (II) is not detected, and sulfate concentrations are above 1.0 mg/L.

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[34] Sulfide is the short-lived intermediary of sulfate reduction but is commonly not detected because it complexes with iron (II) to precipitate on the aquifer matrix as iron sulfide (Wiedemeier 2004). Sulfide data is presented in Appendix I.

Anaerobic aquifer conditions generally appear to occur at the western edge of the Boeing property (vicinity of Building 17-07) extending to the northwest. In these areas, nitrate and sulfate are generally not detected and iron (II) is detected. An extensive evaluation of natural attenuation and aquifer redox conditions was performed in December 2014 for the western plume area extending west from the Facility to the Algona neighborhood (LAI 2015c). Data in this area were generally indicative of a Type 2 aquifer environment, defined as an aquifer that is anaerobic due to naturally occurring organic carbon (Wiedemeier 2004). This is consistent with the observed organic soils and peaty deposits associated with a low energy depositional environment in this area. The natural occurrence of organic carbon and reduced aquifer conditions in the Algona area are conducive to biotic and abiotic degradation of TCE and breakdown products. Further natural attenuation evaluation is planned Site-wide to determine other areas that have aerobic aquifer conditions conducive to degradation of TCE and breakdown products. Anaerobic conditions also persist in Area 1 following the IRA (Section 7.0).

4.4.3.2 Other Parameters

Other useful parameters for evaluation of natural attenuation through biotic and abiotic processes include TOC, alkalinity, and chloride. These parameters were monitored at a limited number of wells in the beginning of the RI in accordance with the RI work plan (Geomatrix 2003b). TOC is an indicator of available electron donor. Alkalinity indicates an aquifer's ability to buffer low pH conditions caused by fermentation of natural organic carbon and added electron donor substrates. Chloride is released through reductive dechlorination of TCE and breakdown products and may become elevated where starting concentrations of these chlorinated compounds are high.

Total Organic Carbon

Background TOC concentrations in groundwater at the Site generally range from 1.5 mg/L to around 50 mg/L. In general, TOC concentrations are less than 10 mg/L except at wells where elevated TOC is likely due to natural organic content in the aquifer. TOC concentrations are higher than this range at wells near the enhanced natural attenuation pilot test in Algona where elevated TOC is related to substrate injections. Historically, TOC concentrations in Area 1 were also elevated because of substrate injections associated with the IRA (see Section 7.0); however, current concentrations have dropped within the background range. Maximum TOC concentrations at wells sampled for this constituent at the Site are shown in Figure 4-28.

TOC greater than 10 mg/L is considered adequate for substantial reductive dechlorination (Major et al. 2003) at sites where reductive dechlorination is stimulated through injection of electron donor. Lower concentrations, less than 5 mg/L, may be adequate for somewhat slower natural attenuation sustained over a longer period.

Alkalinity

Measured alkalinity at the Facility ranges from 17 mg/L to 342 mg/L, and averages about 100 mg/L. In addition to background alkalinity values, alkalinity was measured at select wells in Area 1 following electron donor injection for bioremediation. Aquifers with alkalinity greater than 300 mg/L have substantial buffering capacity, while alkalinity less than 100 mg/L indicates limited buffering capacity (AFCEE 2004).

The highest alkalinity values occurred in Area 1 following electron donor injection for bioremediation. Elevated alkalinity at these wells may be the result of increased microbial activity in this area. Microbial activity releases carbon dioxide, which reacts with water to form carbonic acid. The carbonic acid can dissolve carbonate minerals present in the aquifer soil, increasing alkalinity (see Section 7.0).

Chloride

Chloride concentrations at the Facility generally range from approximately 2 to 5 mg/L. Notable exceptions are maximum concentrations detected at wells AGW002 (12.4 mg/L) and AGW064 (7.8 mg/L) in Area 1. Elevated chloride at these wells may be the result of reductive dechlorination over time near the IRA in Area 1.

4.4.4 Compound Specific Isotope Analysis

CSIA measures isotope ratios in a single compound dissolved in a sample. TCE is the compound of interest and carbon-13 (^{13}C) and chlorine-37 (^{37}Cl) are the isotopes of interest. The CSIA analysis was completed as part of the RI to provide information both about potential contaminant sources and about reductive dechlorination of TCE.

Carbon and chlorine atoms that comprise TCE can have unique stable isotopic signatures depending on the stock materials used to manufacture the TCE. Therefore, TCE from different manufacturers typically has different isotopic signatures (Beneteau et al. 1999). In some circumstances, the difference in isotopic signature can be used to identify different sources of dissolved TCE in groundwater.

The isotopic ratios in a compound such as TCE will change as a result of reductive dechlorination because the isotopically lighter molecules are more easily degraded. As a result, the remaining undegraded TCE molecules are enriched in heavier isotopes compared to the source material; for TCE this results in a heavier [more positive] $\delta^{13}C$ and $\delta^{37}Cl$ isotopic signature[35]. TCE in groundwater that has undergone degradation will exhibit a heavier isotopic signature than the source material.

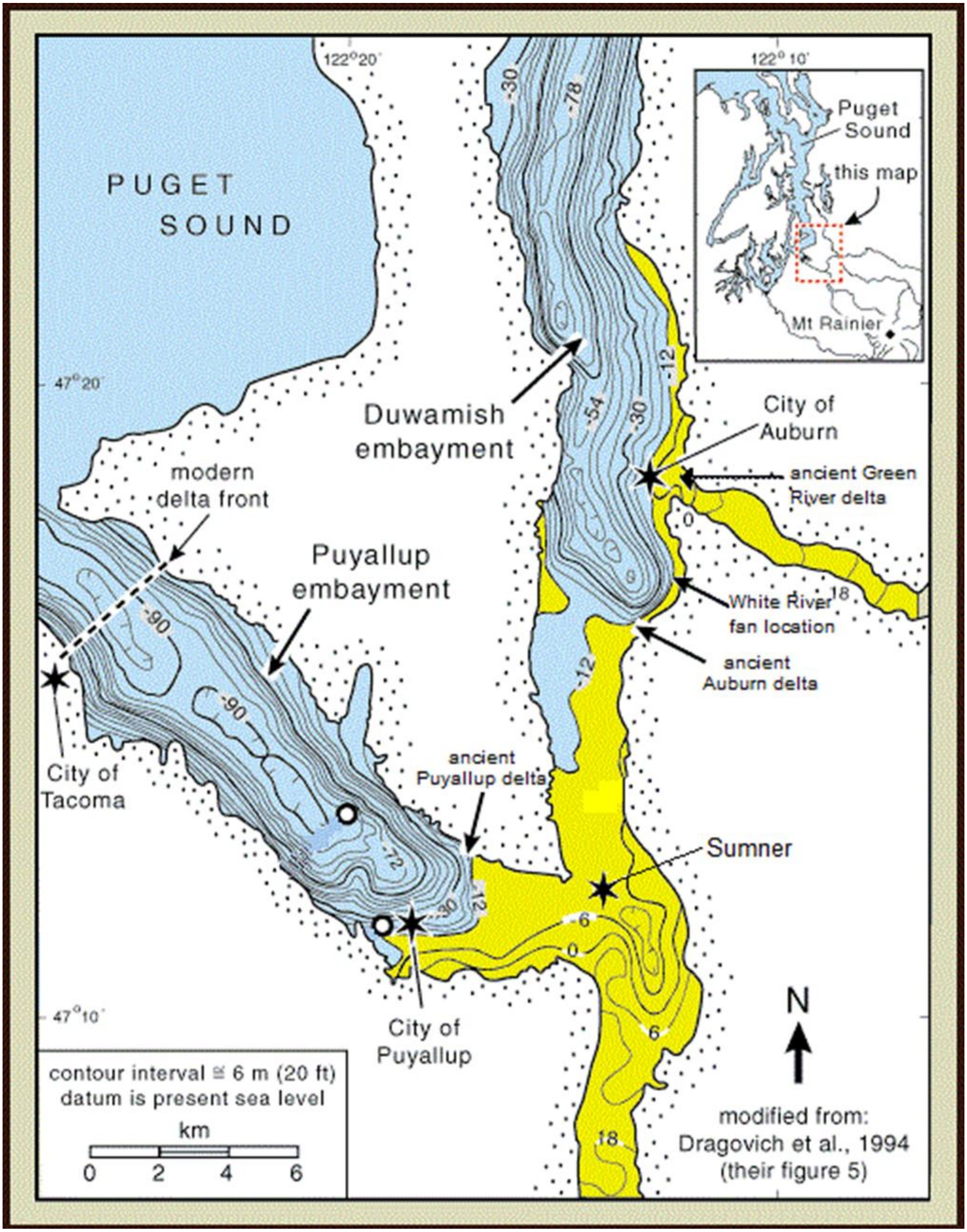
[35] By convention, the relative enrichment or depletion in a stable isotope is expressed as the difference or delta (δ) in parts per thousand (‰) from an agreed-upon standard. For carbon and chloride isotopes, the standards are the Vienna Pee Dee Belemnite and the Standard Mean Ocean Chloride, respectively.

CSIA was completed for samples collected from thirteen monitoring wells. Carbon isotope analysis was completed for all thirteen locations, while the chlorine isotope analysis was completed for six of the thirteen locations. The $\delta^{13}C$ results range from -27.3‰ (AGW165) to -11.7‰ (AGW201-2), while $\delta^{37}Cl$ results range from 3.3‰ (AGW137) to 5.4‰ (AGW156). The CSIA results are presented in Table 4-10. Figure 4-29 presents the measured delta values for carbon and chlorine isotopes in TCE. Data from the six locations where both carbon and chlorine isotope analyses were completed were plotted on a scatter diagram shown on Figure 4-30.

To evaluate the whether the isotope ratios could give clues about possible sources of TCE, the carbon and chlorine isotope ratios from various manufacturers were examined. Published values for TCE isotope ratios range from approximately -34‰ to -23‰ for $\delta^{13}C$ and -3‰ to 4‰ for $\delta^{37}Cl$ (EPA 2008). Of the wells measured, AGW165 ($\delta^{13}C$ -27.3‰ and $\delta^{37}Cl$ 3.5‰), which is relatively near the 17-07 source area[36], has the lightest isotope ratio and appears to be isotopically closest to undegraded TCE. As the TCE degrades, the isotopic ratios of the carbon and chlorine tend to remain relatively consistent and results from downgradient areas with progressive degradation should plot relatively close to a straight line (see figure 4-30). One sample from AGW137 stands out as having a slightly different carbon to chlorine ratio than the other samples, suggesting there may be influence from a secondary source at this well. However, the data set is too small to draw definitive conclusions about a secondary source. In a larger data set, differences in isotopic ratios could potentially indicate different contaminant sources.

As previously discussed, reductive dechlorination preferentially targets molecules with the lighter isotopes (e.g., ^{12}C) and causes the compound to become enriched with the heavier isotope resulting in a delta value that is less negative. Consequently, as reductive dechlorination progresses, the isotopic ratio of both chlorine and carbon in the degraded TCE should plot farther from the original undegraded TCE but the ratio of the chlorine to carbon delta values should remain relatively consistent (see Figure 4-30). A change in $\delta^{13}C$ values greater than 2‰ indicates reductive dechlorination is a significant process (EPA 2008). Of the wells analyzed, all but two (AGW201-5 and AGW201-6) showed greater than 2‰ difference compared to the $\delta^{13}C$ at AGW165 near the 17-07 source area. AGW201-5 and AGW201-6 are screened in the intermediate and deep zones directly downgradient of AGW165; the smaller change in the $\delta^{13}C$ values at these wells suggests that degradation in the intermediate and deep zone near the source may be limited. Conversely, the shallow zone screened at this location, AGW201-2, shows a significant change in the $\delta^{13}C$ compared to AGW165 indicating that significant degradation is taking place in the shallow zone. Additional evaluation of CSIA data and additional CSIA sampling may be completed as part of the FS for evaluation of different sources and additional lines of evidence for assessing biodegradation.

[36] See Section 8 for further discussion on source areas



Notes: 1. Modified from USGS (2000), modified from Dragovich et al. 1994.
2. Yellow areas represent land within the valleys not submerged beneath the ancient marine embayments prior to the Osceola Mudflow.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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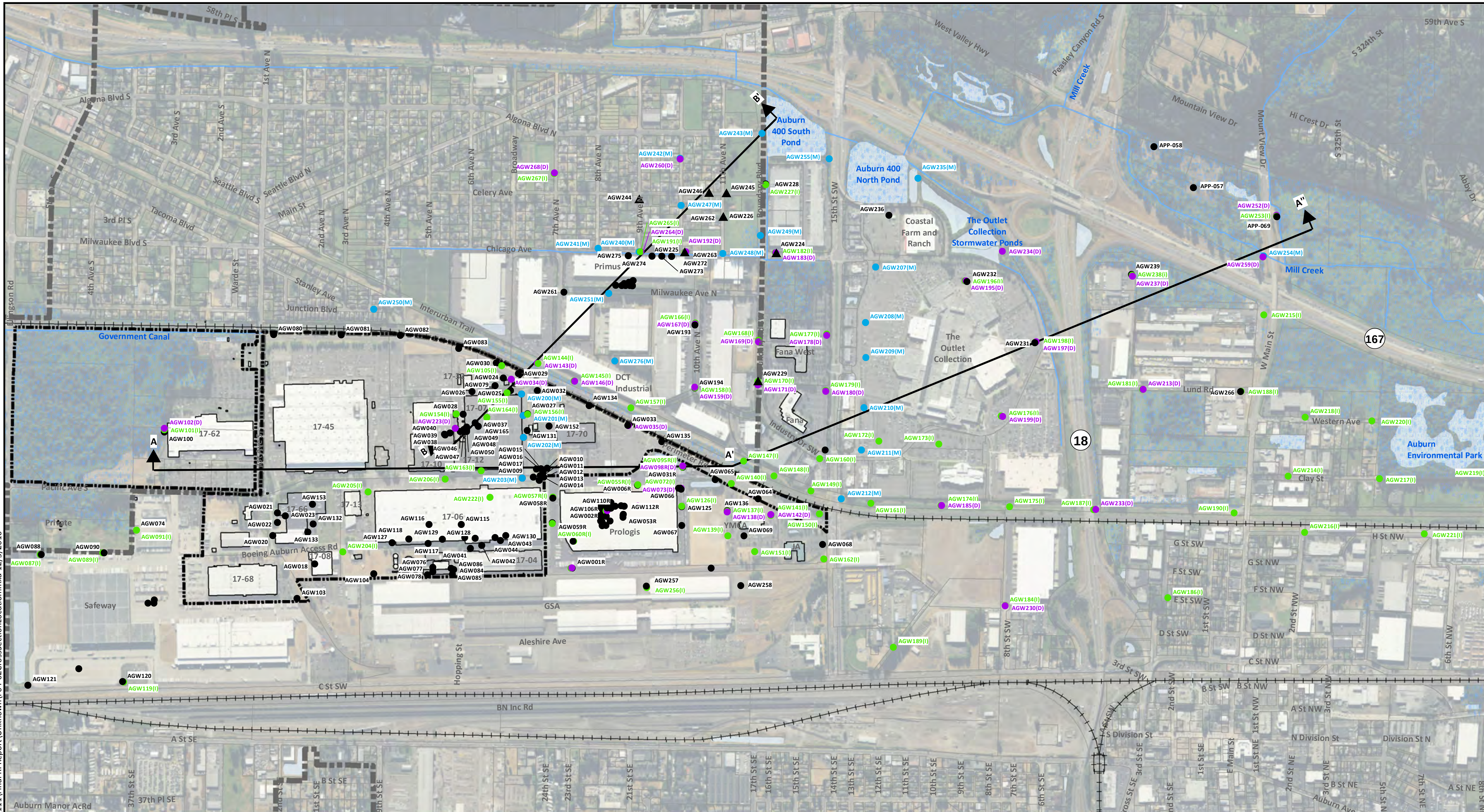
Boeing Auburn Remedial Investigation Auburn, Washington	**Former Duwamish Embayment**	Figure 4-1



Notes

1. Well designations beginning with APP are installed and owned by WSDOT.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- ▲ Offsite Water Table Well
- ● Shallow Monitoring Well (2 to 30 ft BGS)
- (I) ● Intermediate Monitoring Well (40 to 60 ft BGS)
- (D) ● Deep Monitoring Well (80 to 100 ft BGS)
- (M) ● Multi-Level Well
- Wetland Areas
- Water Bodies
- Waterways
- Cross-Section Location

N

0 1,000 2,000

Scale in Feet

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

Boeing Auburn Remedial Investigation Auburn, Washington	**Cross-Section Location**	Figure 4-2

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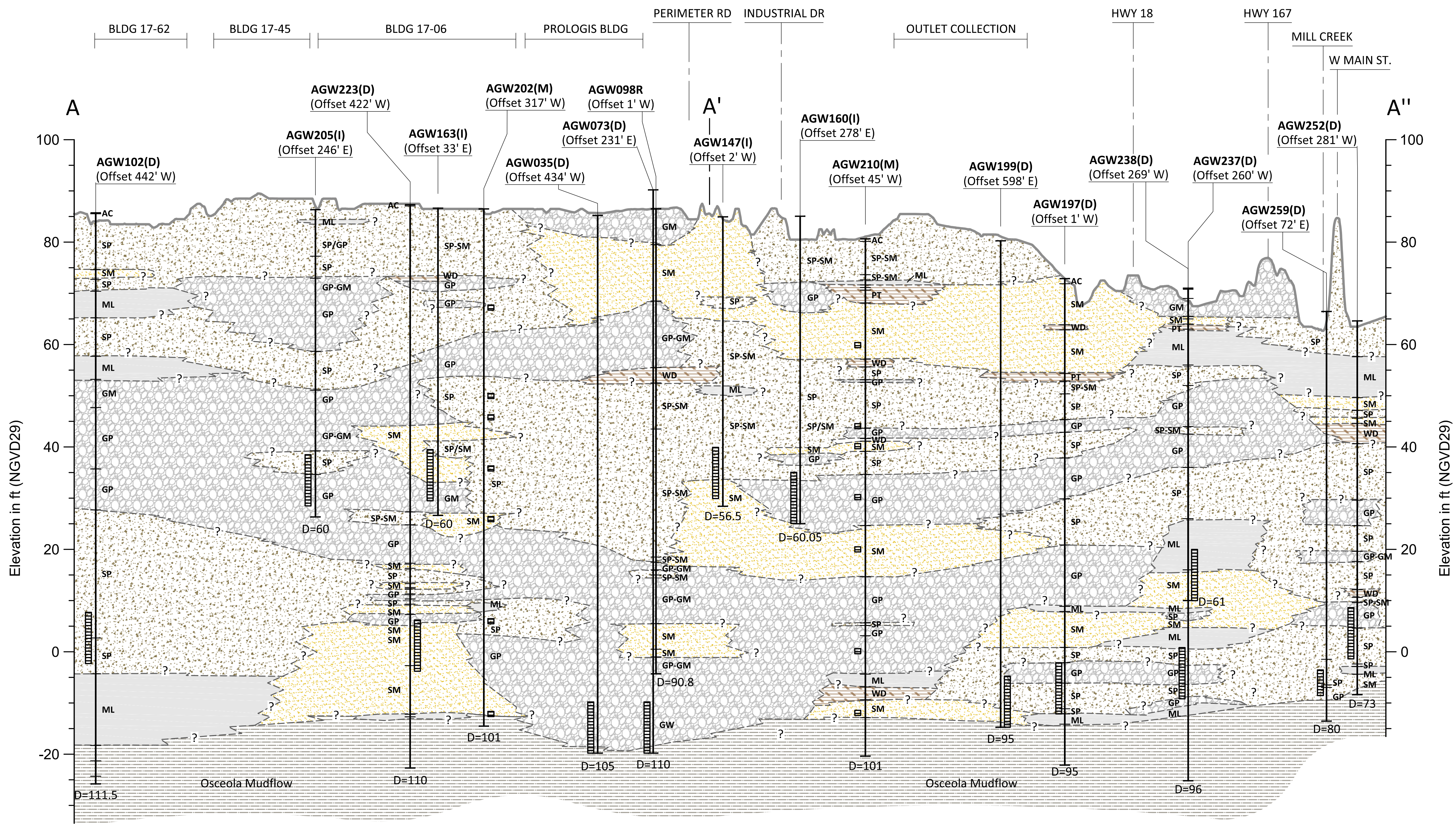

Notes

1. This cross section approximates conditions between data collections points.
2. See Geologic Cross Section A-A'' legend on Figure 4-3c.

0 1000 2000
Scale in Feet
50x Vertical Exaggeration

Ground surface elevation source: King County Lidar

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Geologic Cross-Section A-A''

Figure
4-3a

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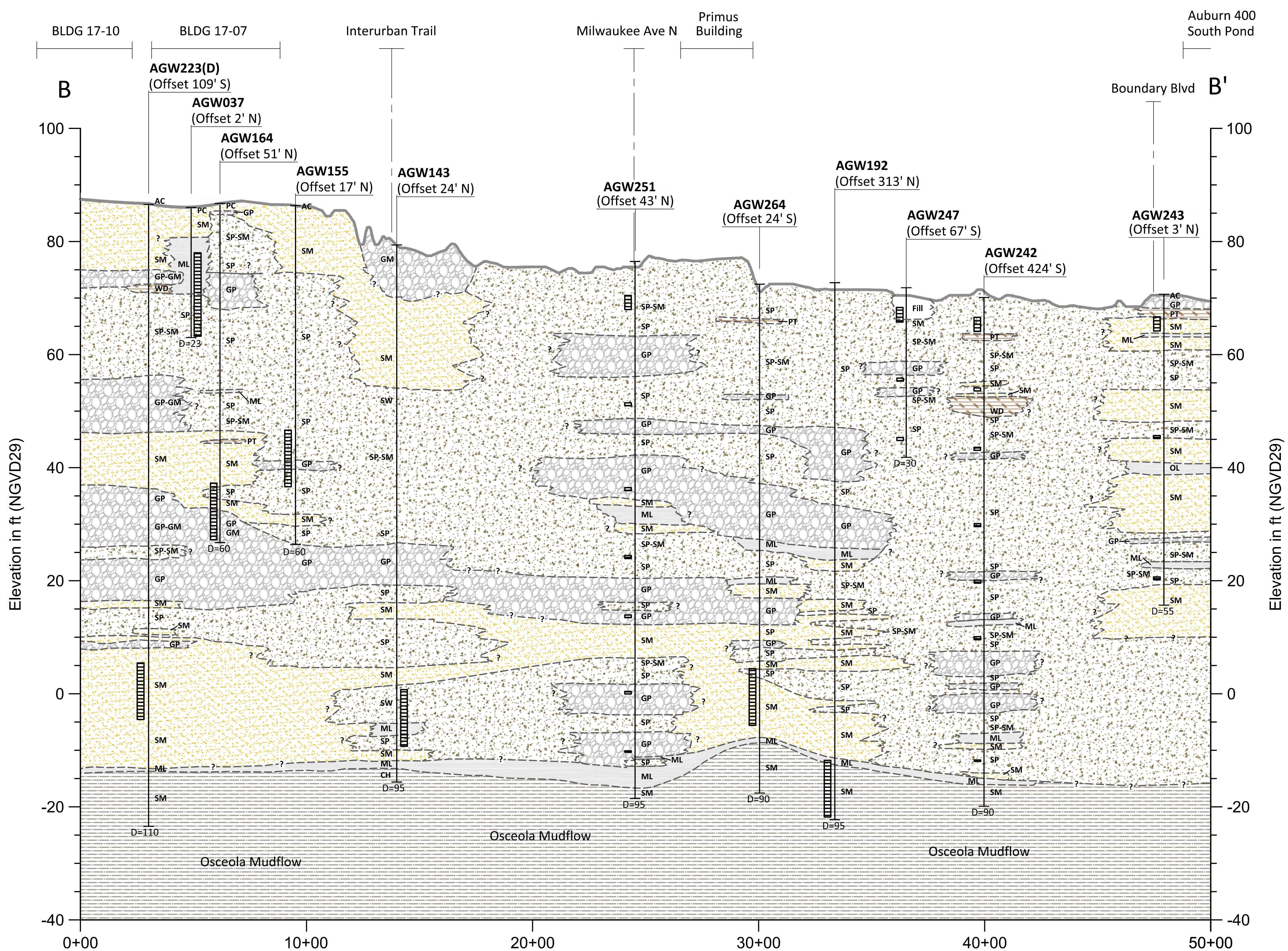
LANDAU ASSOCIATES, INC. | G:\Projects\025\164\130\111\Final RI Report\Section 4.0\F04-3a CrossSectionA.dwg (A) "Figure 4-3a" 1/24/2017



Notes

1. This cross section approximates conditions between data collections points.
2. See Geologic Cross Section B-B' legend on Figure 4-3c.

0 500 1000

Scale in Feet
25x Vertical Exaggeration

Ground surface elevation source: King County Lidar

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Geologic Cross-Section B-B'

Figure
4-3b

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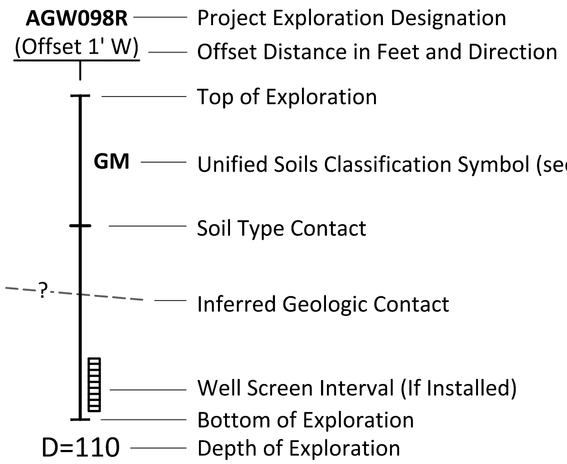

USCS Symbol Legend

AC	asphalt concrete
GM	silty gravel
GP	poorly-graded gravel
GW	well-graded gravel
ML	inorganic silt with slight plasticity
OL	organic silt
PT	peat
SM	silty sand
SP	poorly-graded sand
SW	well-graded sand
WD	wood

Hatch Legend

- Peat or Wood Debris
- Silt or Organic Silt
- Silty sand
- Poorly graded sand with little to no fines
- Gravel
- Osceola mudflow

Notes

1. Soil descriptions are generalized based on interpretation of field and laboratory data. Contacts shown are based on interpretation between exploration locations. Actual contacts may be gradational and differ from those shown.
2. See report text for descriptions of geologic units.
3. For Cross Section location, see Cross Section Location Figure 4-2.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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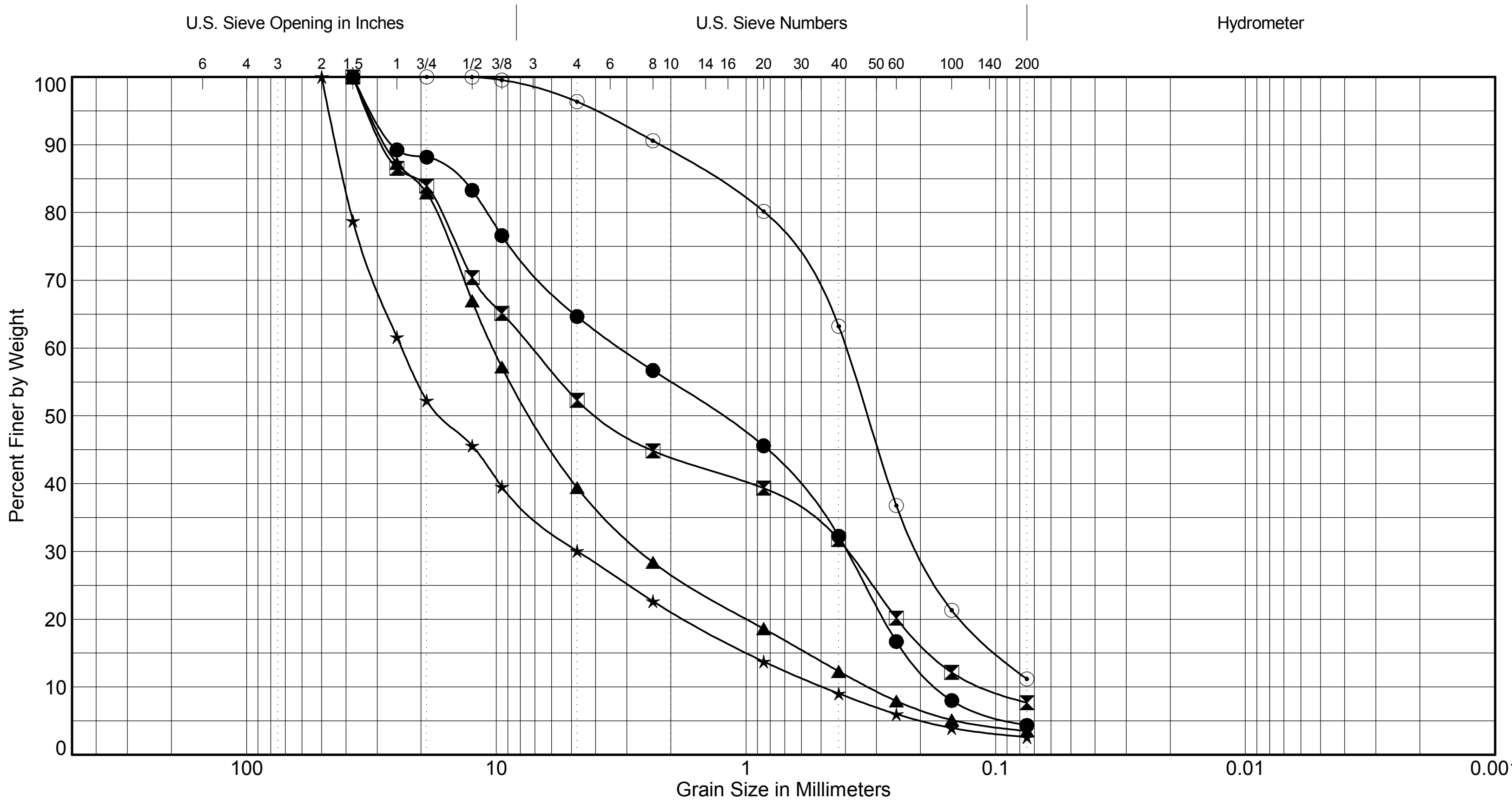
Auburn, Washington

Geologic Cross-Sections A-A" and B-B' Legend

Figure 4-3c



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	AGW095	10	50.0	15	Very gravelly, fine to coarse SAND with trace silt (35.3% Gravel, 60.3% Sand, 4.3% Fines)	SP
⧗	AGW096	5	25.0	11	Very sandy GRAVEL with silt (47.7% Gravel, 44.6% Sand, 7.7% Fines)	GP-GM
▲	AGW097	11	50.0	--	Very sandy GRAVEL with trace silt (60.6% Gravel, 35.9% Sand, 3.5% Fines)	GP
★	AGW098	5	80.0	5	Sandy GRAVEL with trace silt (69.9% Gravel, 27.5% Sand, 2.6% Fines)	GP
⊙	AGW099	11	86.0	24	Fine to coarse SAND with silt and trace gravel (3.6% Gravel, 85.2% Sand, 11.2% Fines)	SP-SM

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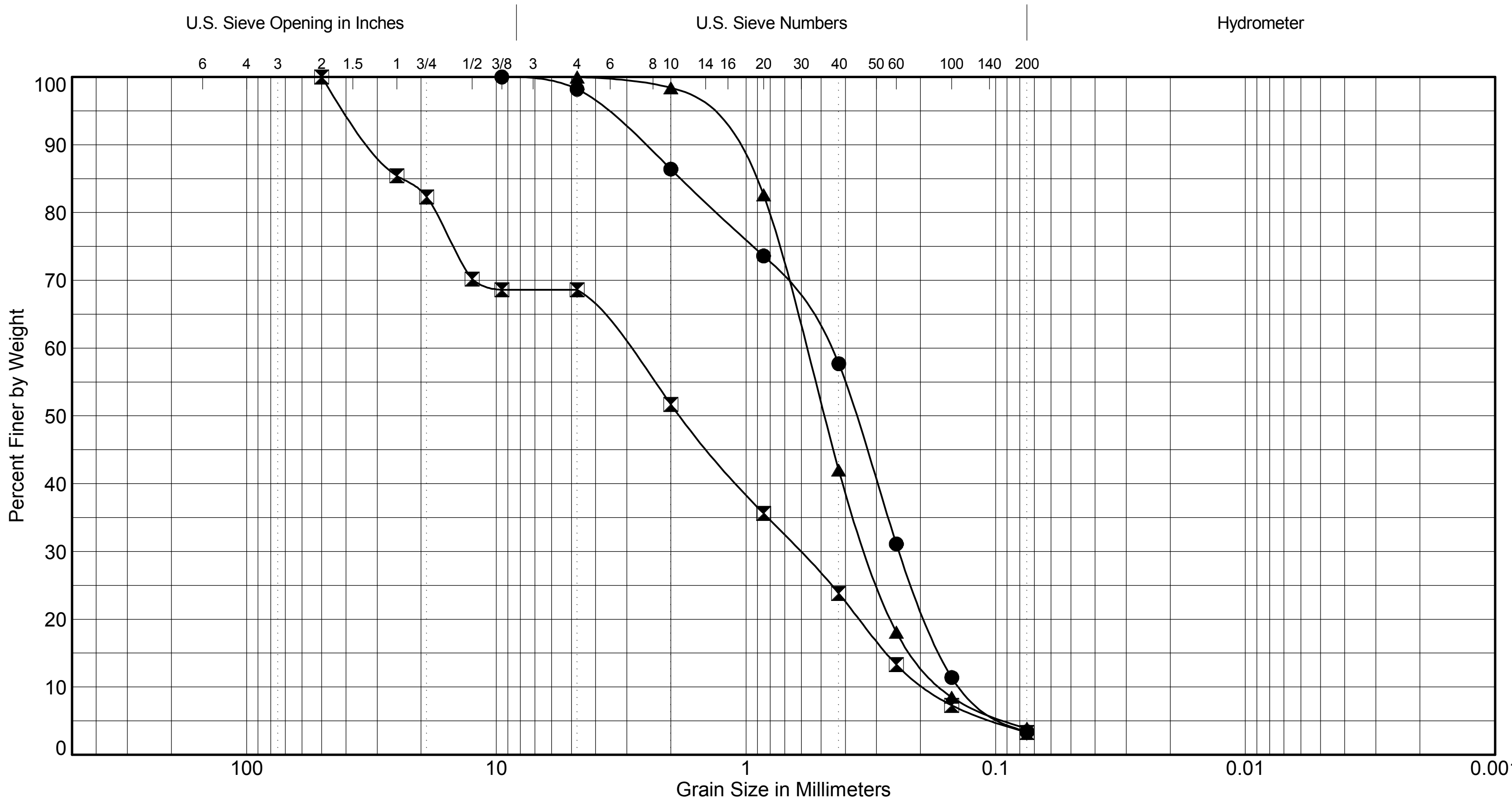
Boeing Auburn Remedial Investigation Auburn, Washington	Grain Size Distribution Alluvium (AGW095 - AGW099)	Figure 4-4a



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	AGW103	4	20.0	21	Fine to coarse SAND, trace silt and gravel (1.8% Gravel, 94.8% Sand, 3.4% Fines)	SP
⧗	AGW104	4	20.0	9	Very gravelly, fine to coarse SAND with trace silt (31.4% Gravel, 65.3% Sand, 3.3% Fines)	SP
▲	AGW105	10	50.0	23	Fine to medium SAND with trace silt (96.1% Sand, 3.9% Fines)	SP

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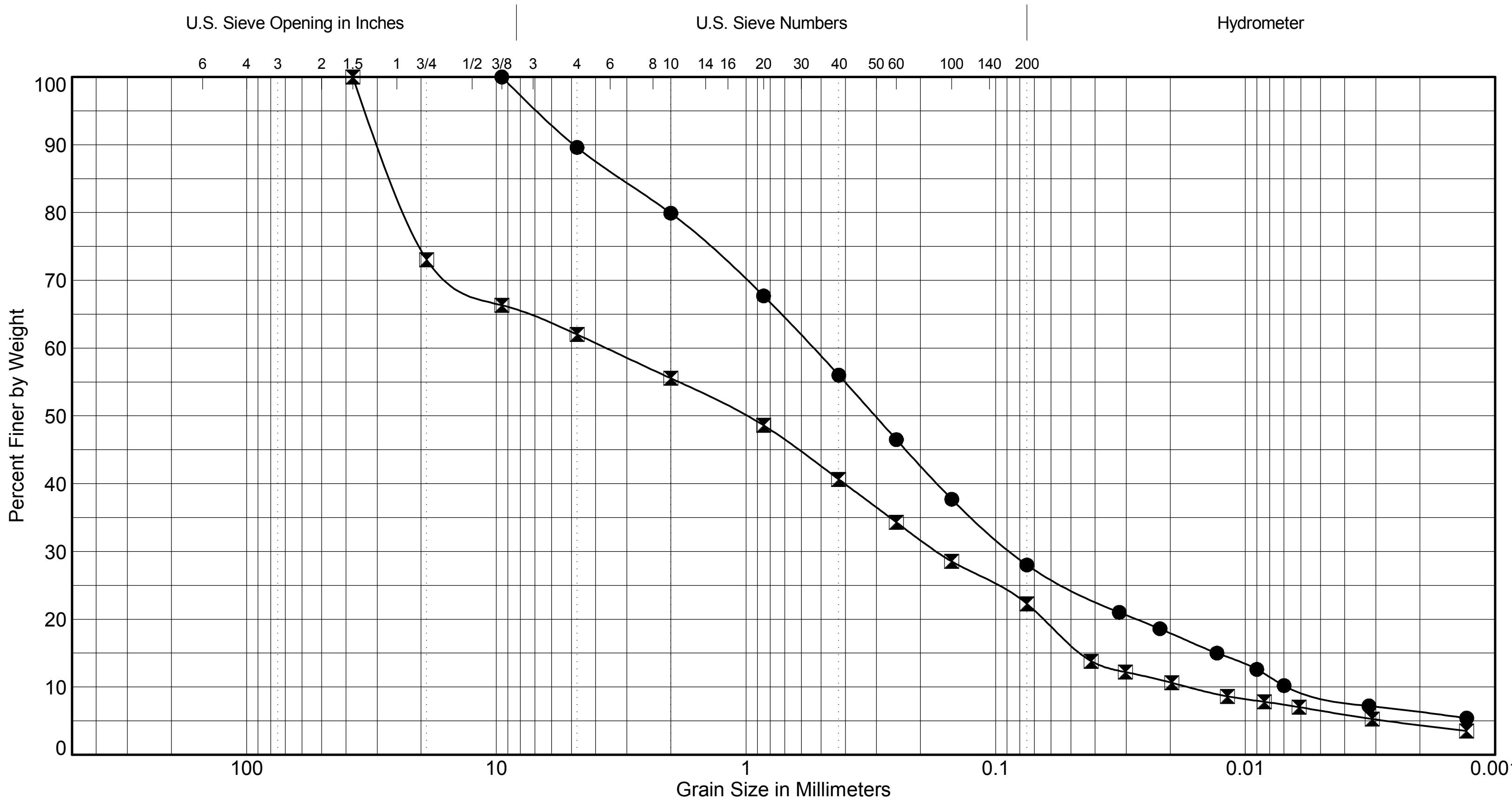
Auburn, Washington

Grain Size Distribution
Alluvium
(AGW103 - AGW105)

Figure
4-4b



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	AGW102	14	110.0	18	Silty, fine to coarse SAND with gravel and clay (10.4% Gravel, 61.6% Sand, 28.0% Fines)	SM
⧗	AGW276	40	103.0	11	Silty, very gravelly SAND with trace clay (38.0% Gravel, 39.7% Sand, 22.3% Fines)	SM

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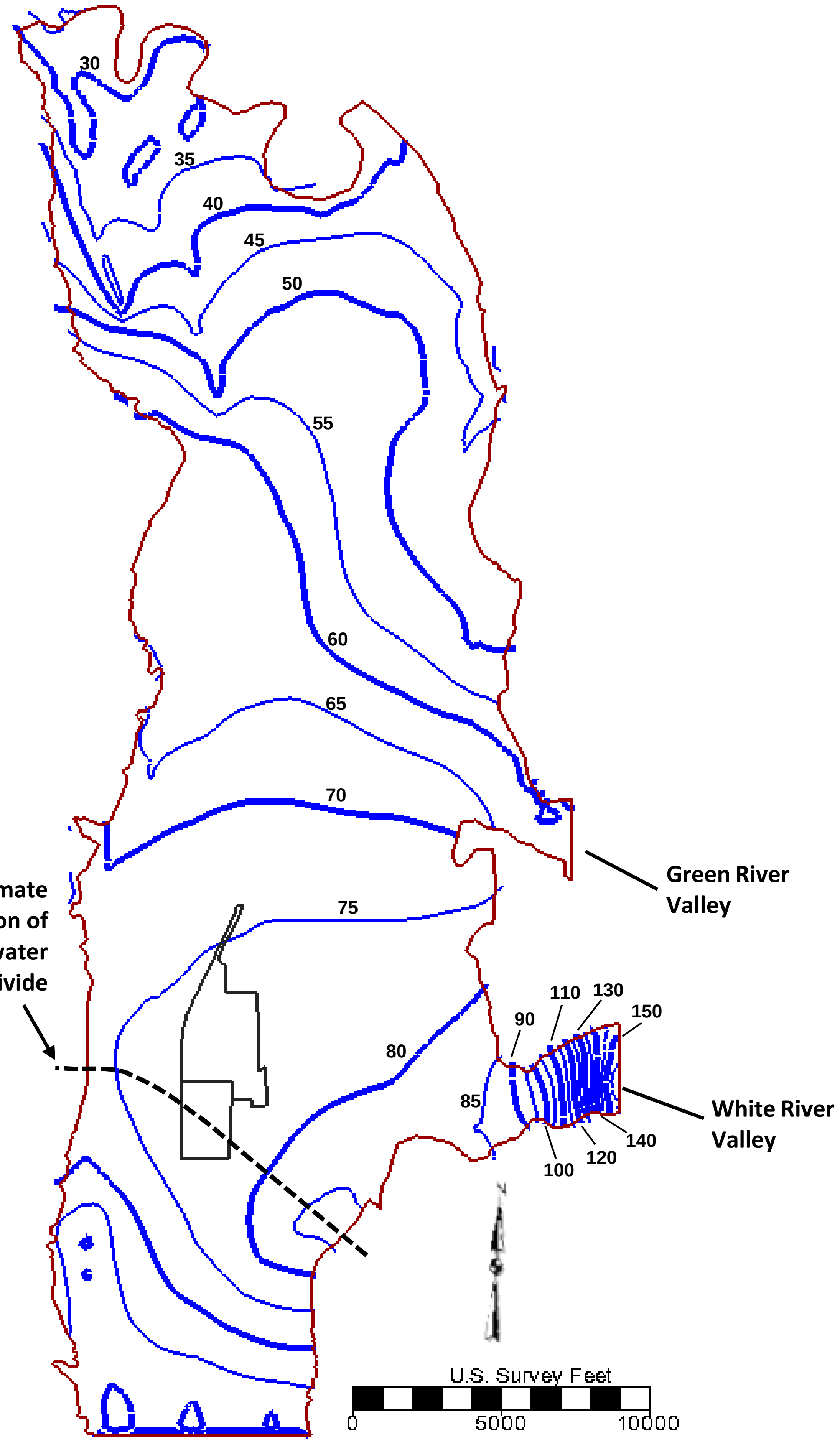
Grain Size Distribution
Osceola Mudflow
(AGW102 and AGW276)

Figure
4-5



Notes

1. Simulated Groundwater Level Contours are from the Numerical Groundwater Model. Groundwater flow divide is interpolated from contours and understanding of hydrogeologic conceptual model.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

Model Area
Boeing Property
65
Simulated Groundwater Level Contours and Levels (ft NAVD88).

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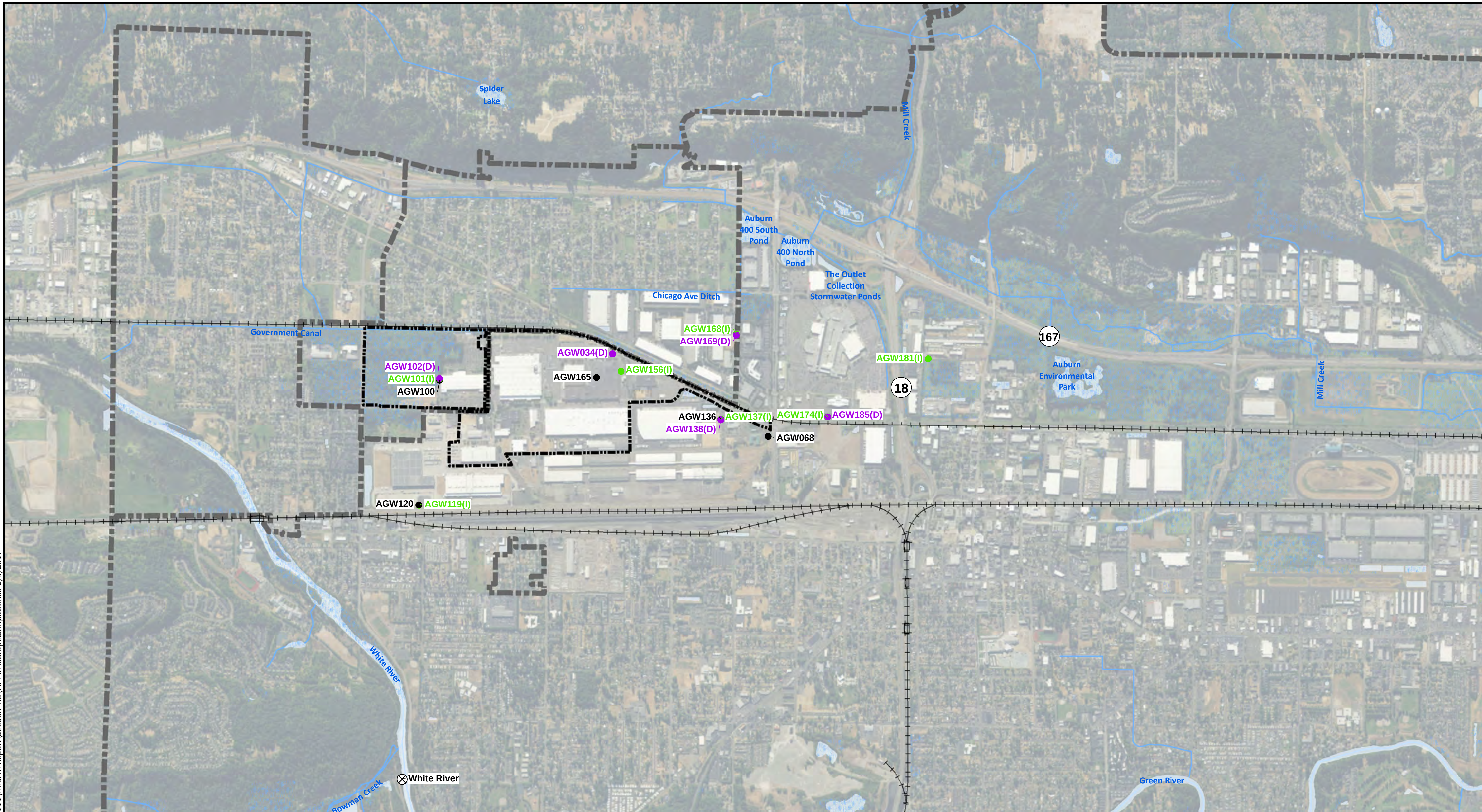
Regional Groundwater Flow
Upper Aquifer

Figure
4-6



Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend
- Surface Water Sample
- Monitoring Wells Sampled
- Shallow Zone
- Intermediate Zone
- Deep Zone
- Wetland Areas
- Water Bodies
- Waterways

N

0 2,000 4,000
Scale in Feet

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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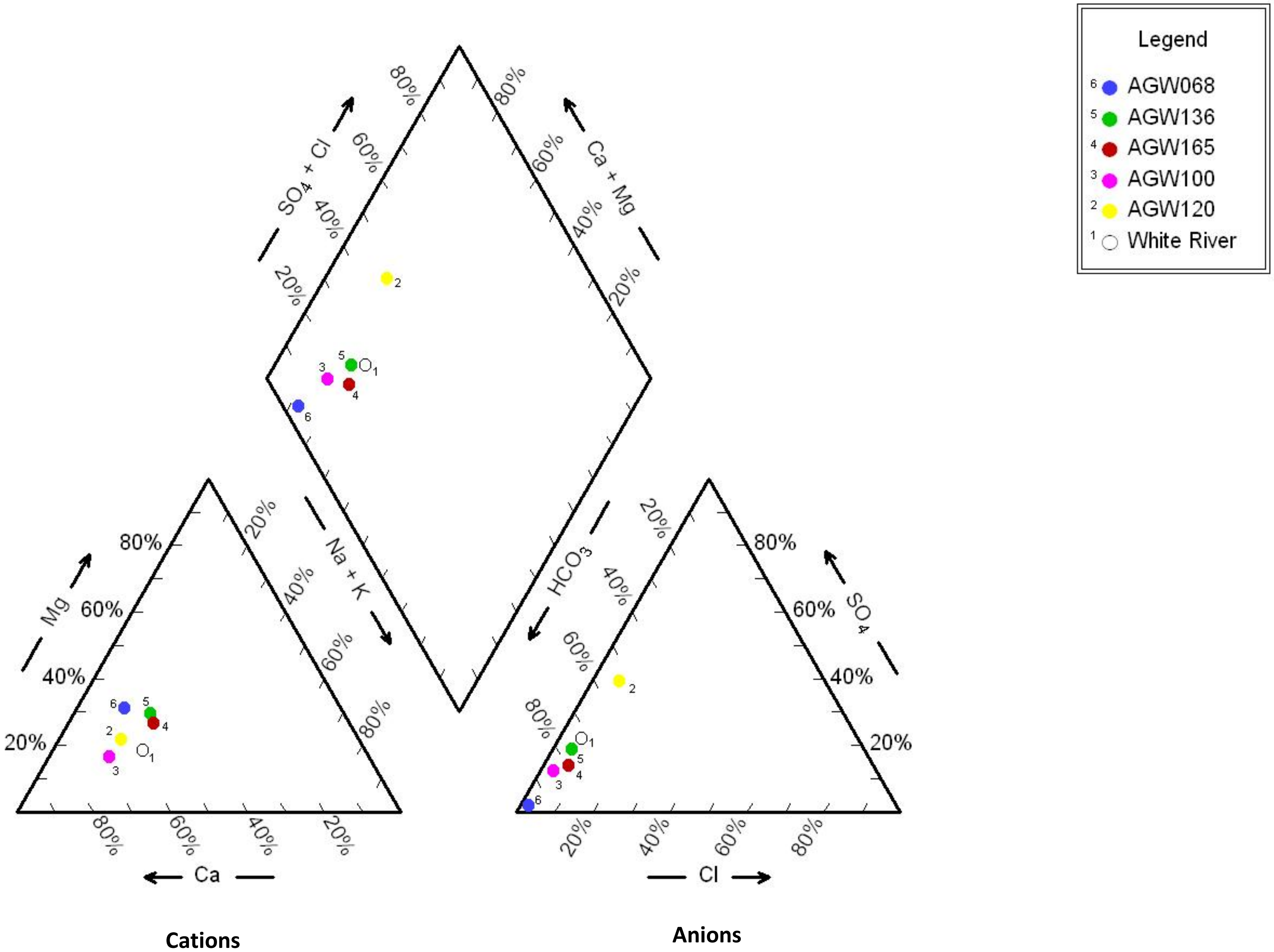
Major Ion and Bulk Water Isotope Groundwater Sampling Locations

Figure 4-7



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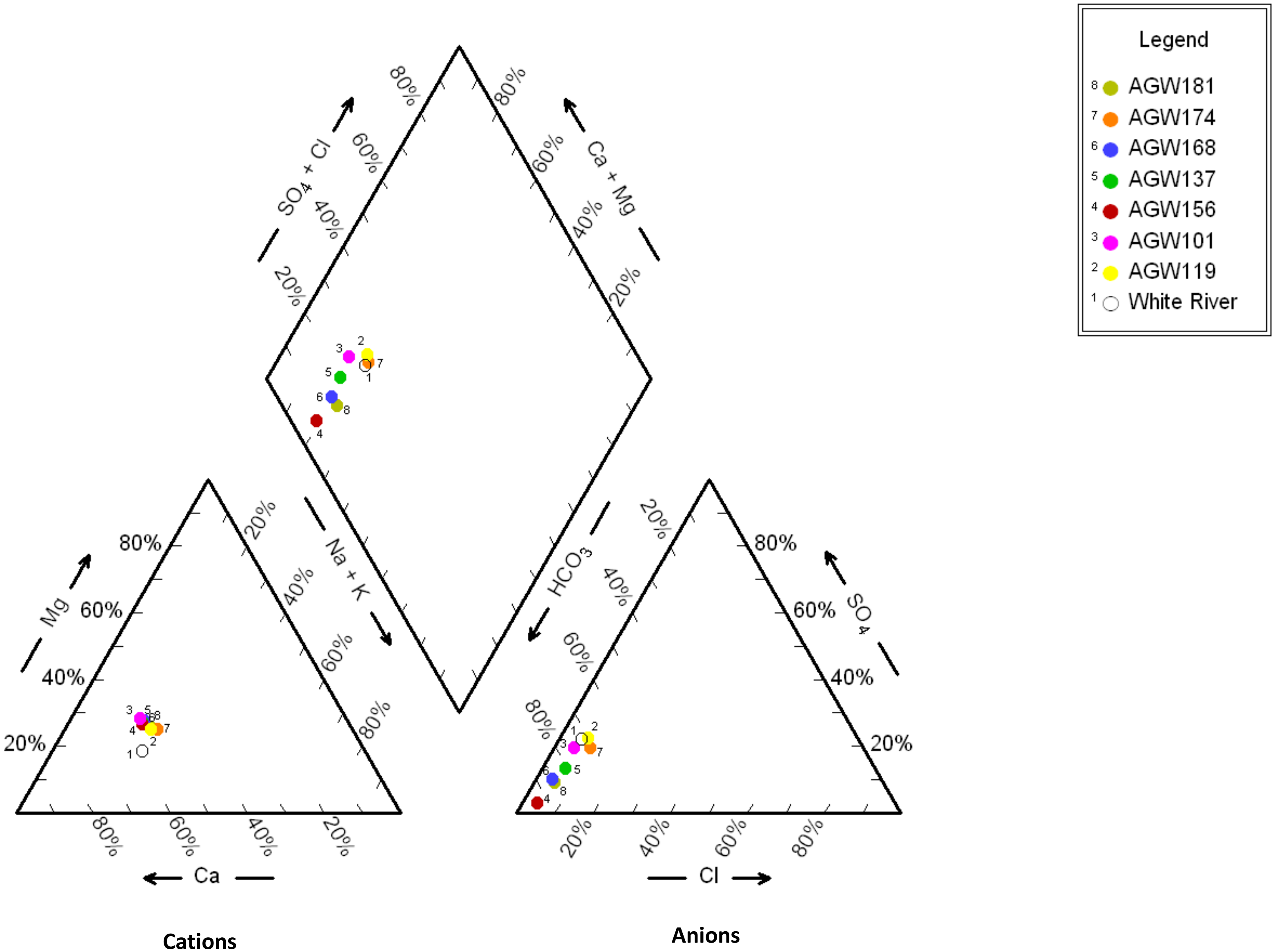
Boeing Auburn Remedial Investigation Auburn, Washington	**Shallow Zone Major Ions** **June 2011**	Figure 4-8



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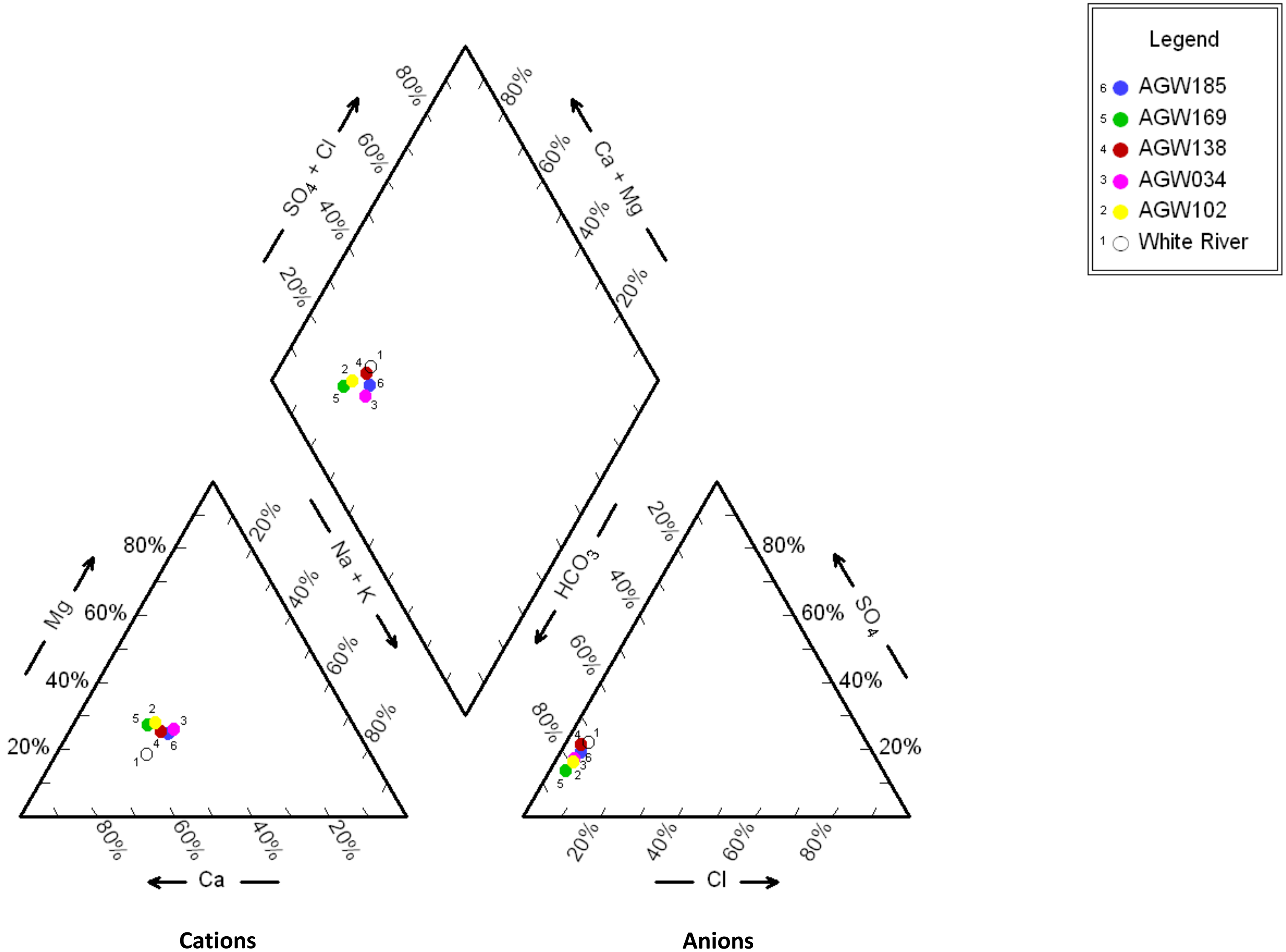
Boeing Auburn
Remedial Investigation
Auburn, Washington

Intermediate Zone Major Ions
June 2011

Figure
4-9



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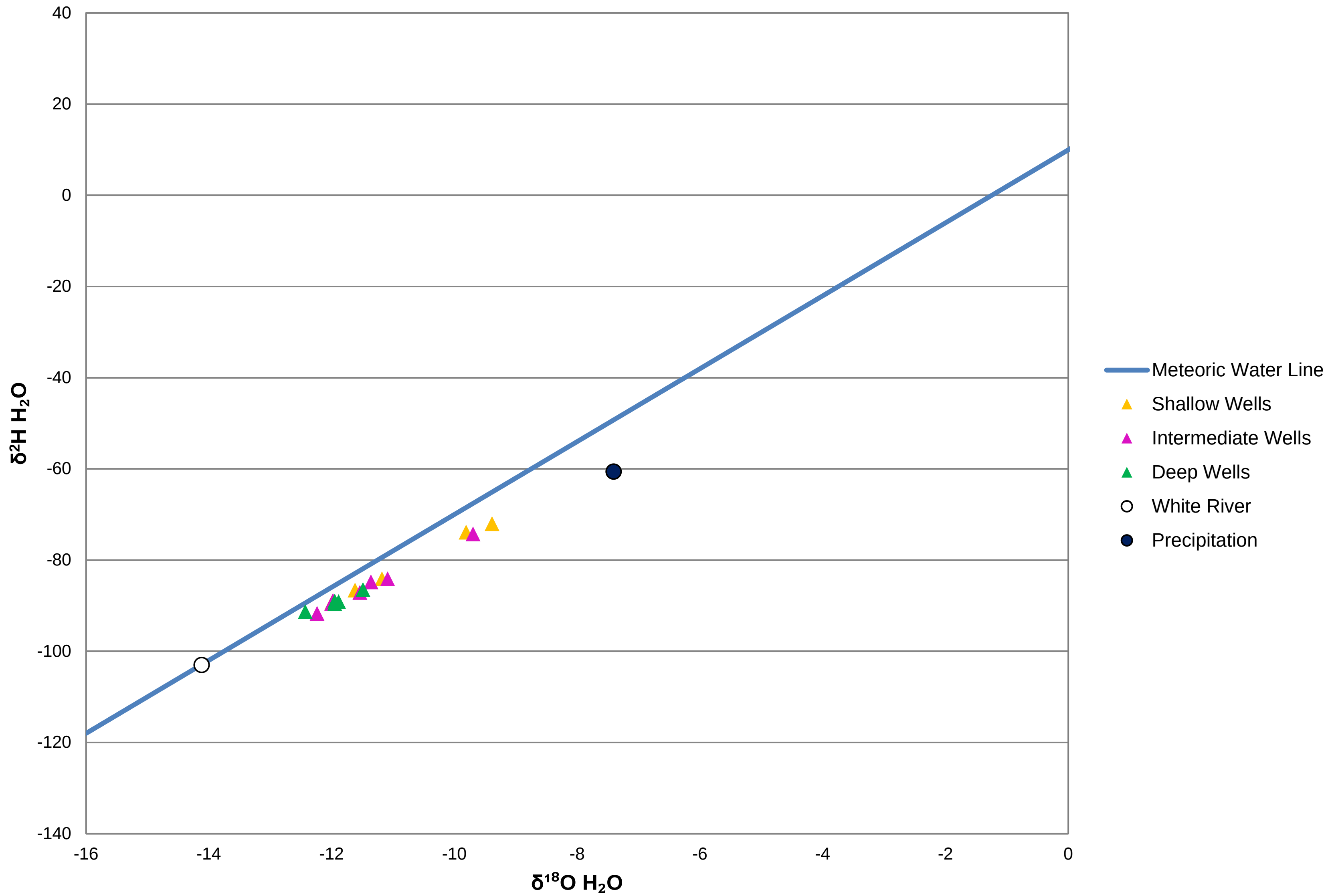
Boeing Auburn Remedial Investigation Auburn, Washington	**Deep Zone Major Ions** **June 2011**	Figure 4-10



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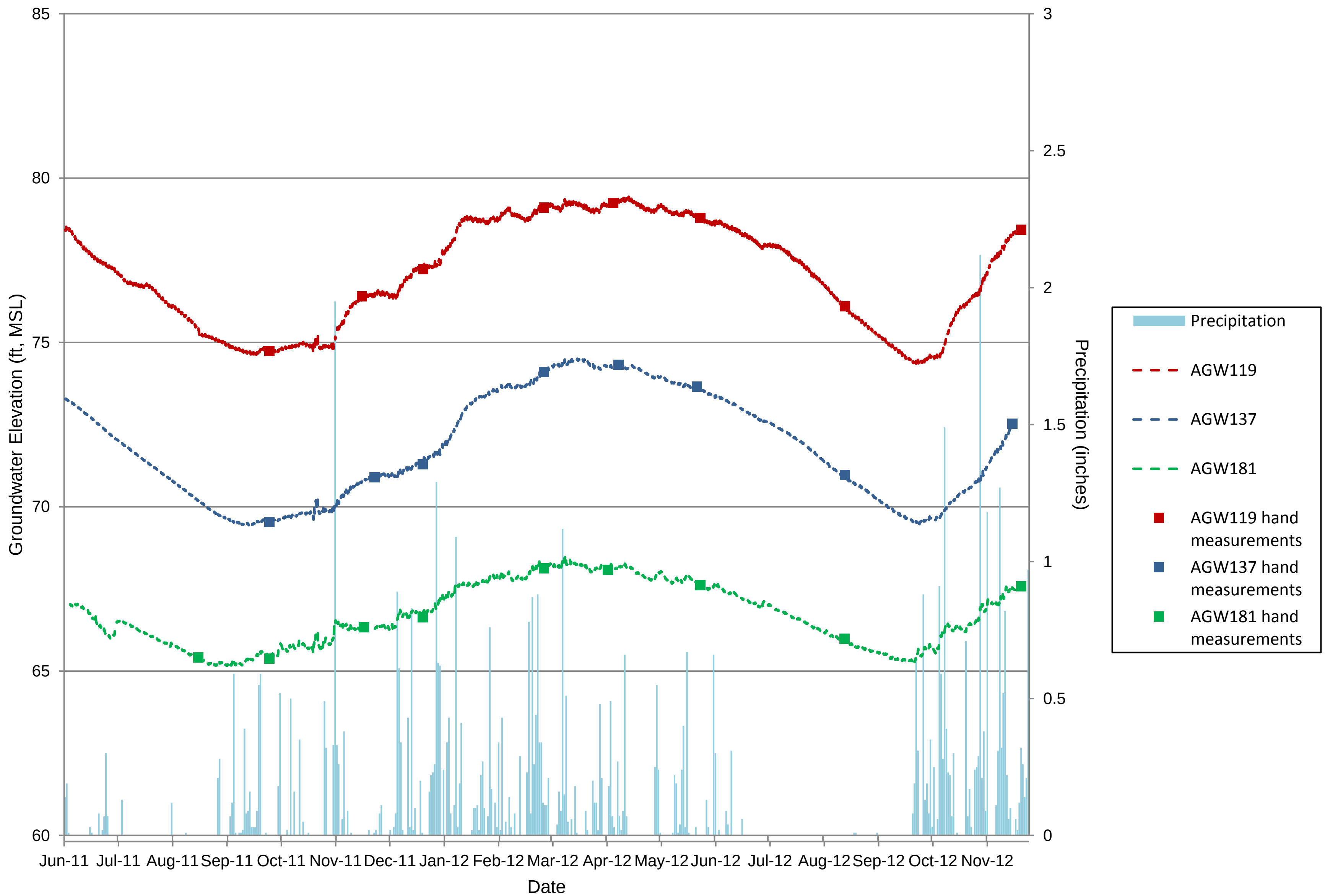
Boeing Auburn Remedial Investigation Auburn, Washington	**Bulk Water Isotope Results** **June 2011**	Figure 4-11



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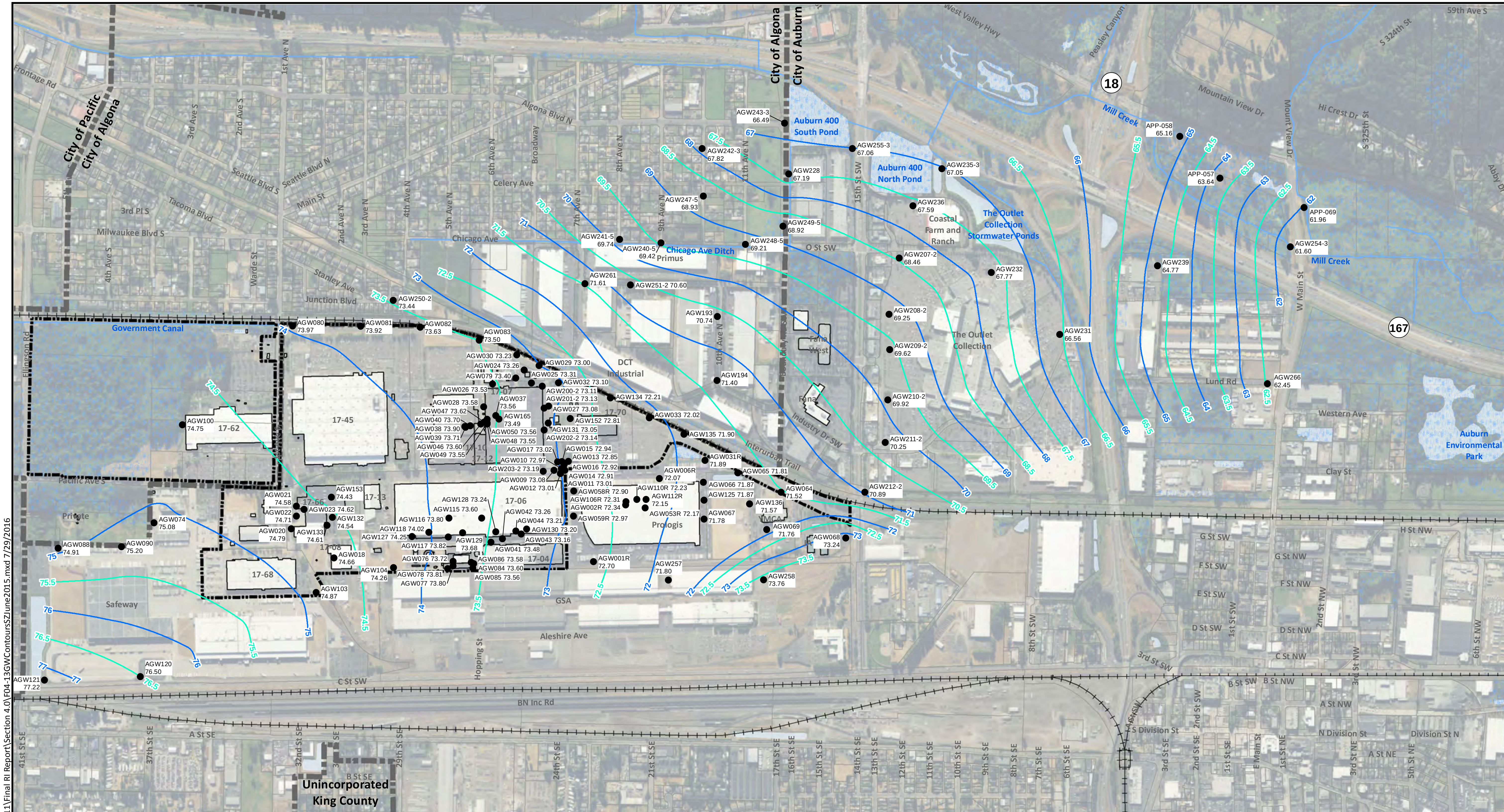
Boeing Auburn Remedial Investigation Auburn, Washington	**AGW119, AGW137, and AGW181 Hydrographs**	Figure 4-12



Legend

- AGW121 79.13 — Monitoring Well Designation, Groundwater Elevation (ft, MSL)
- 72 / 72.5 — Groundwater Elevation Contours
- Boeing Property
- Waterway
- Wetland Area
- City Limits

Notes

1. All water level data in ft, MSL. Vertical datum is NGVD29. Data collected in June 2015.
2. Multilevel wells have multiple channels. Channel designations are included in the well ID (ex: AGW208-2). Groundwater elevations listed are for the channel closest to 30 ft below ground surface.
3. Wells with APP designation are owned by WSDOT.
4. Wells installed specifically as water table wells are not included.
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 1,000 2,000

Scale in Feet

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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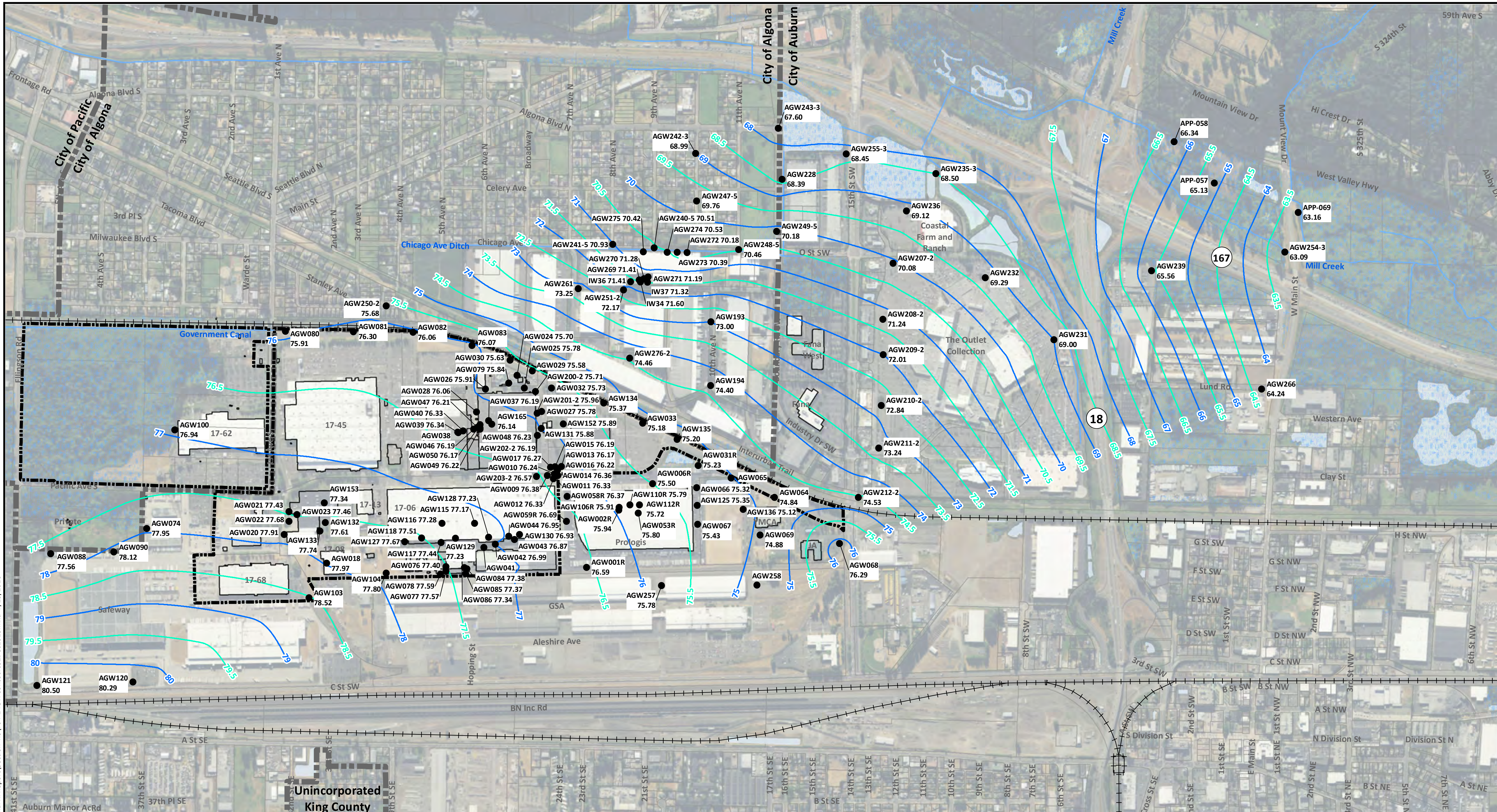
Boeing Auburn Remedial Investigation Auburn, Washington	**Shallow Zone Groundwater Elevation Contours June 2015**	Figure 4-13



Legend

- AGW121 80.50 ● Monitoring Well Designation / Groundwater Elevation (ft, MSL)
- 72 / 72.5 Groundwater Elevation Contours
- Boeing Property
- City Limits
- Wetland Areas
- Water Bodies
- Waterways

Note

1. All water level data in ft, MSL. Vertical datum is NGVD29. Data collected in December 2015.
2. Multilevel wells have multiple channels. Channel designations are included in the well ID (ex: AGW208-2). Groundwater elevations listed are for the channel closest to 30 ft below ground surface.
3. Wells without a posted water level were inaccessible or had anomalous data.
4. Wells with APP designation are owned by WSDOT.
5. Wells installed specifically as water table wells are not included.
6. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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Shallow Zone Groundwater Elevation Contours December 2015

Figure 4-14

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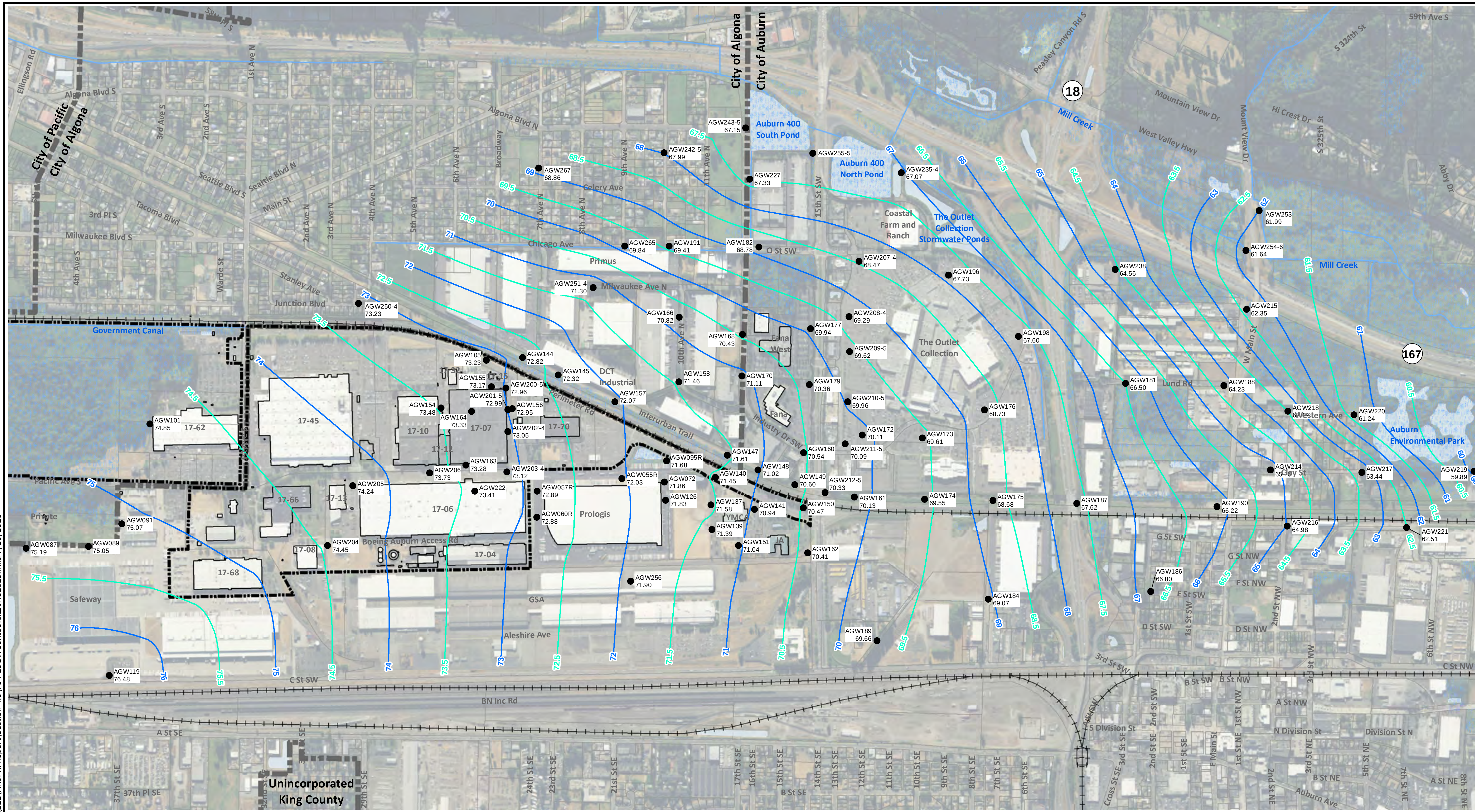

Legend

- ● AGW119 78.48 — Monitoring Well Designation, Groundwater Elevation (ft, MSL)
- 72 / 72.5 — Groundwater Elevation Contours
- Boeing Property
- Waterway
- Wetland Area
- City Limits

Notes

1. All water level data in ft, MSL. Vertical datum is NGVD29. Data collected in June 2015.
2. Multilevel wells have multiple channels. Channel designations are included in the well ID (ex: AGW208-2).
3. Wells without a posted water level had anomalous data.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

N

0 1,000 2,000

Scale in Feet

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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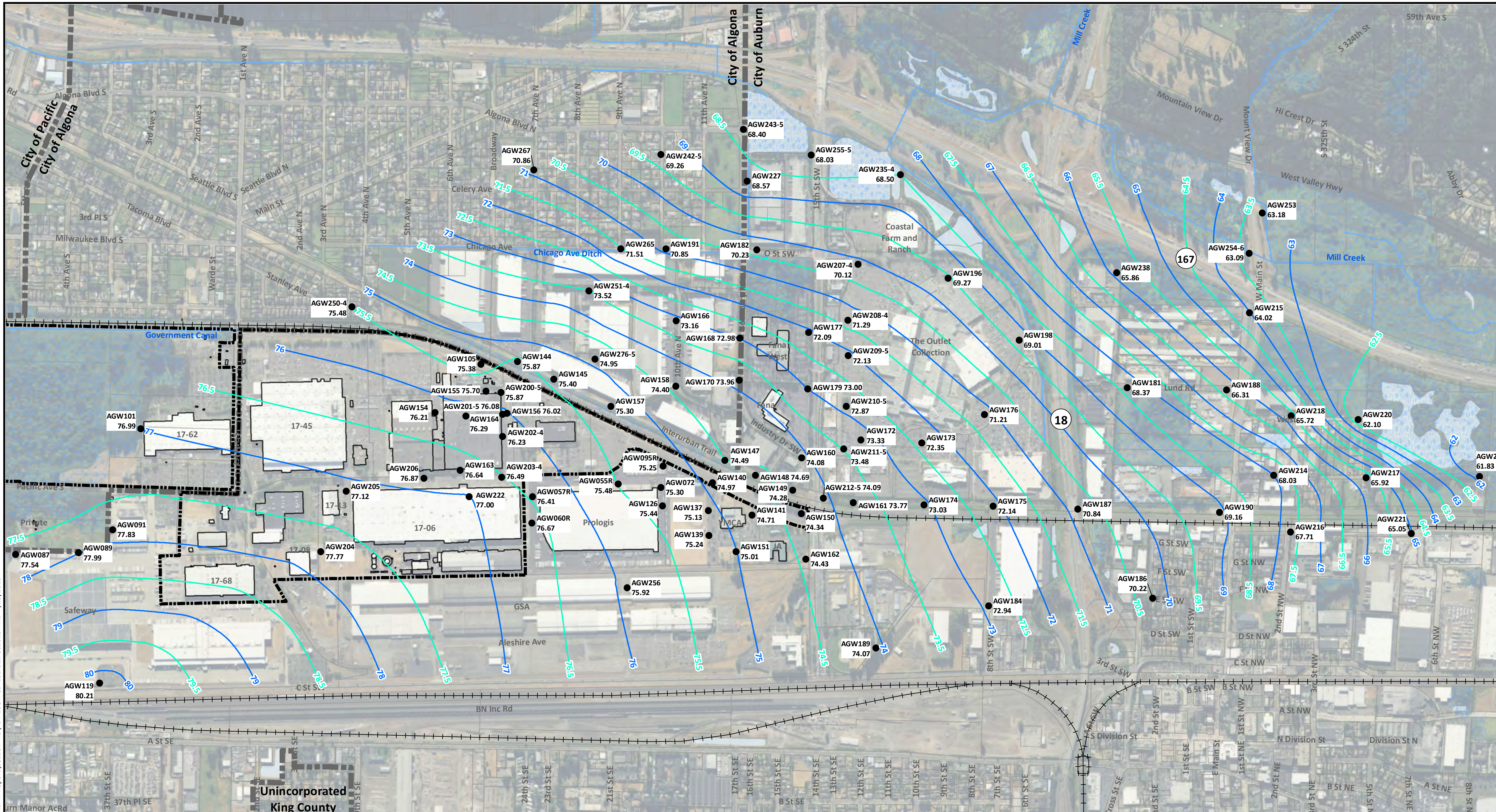
Boeing Auburn Remedial Investigation Auburn, Washington	**Intermediate Zone Groundwater Elevation Contours June 2015**	Figure 4-15



Legend

AGW121 ● Monitoring Well Designation
80.50 Groundwater Elevation (ft, MSL)

72 / 72.5 Groundwater Elevation Contours

Boeing Property

City Limits

Wetland Areas

Water Bodies

Waterways

Note

1. All water level data in ft, MSL. Vertical datum is NGVD29. Data collected in December 2015.
2. Multilevel wells have multiple channels. Channel designations are included in the well ID (ex: AGW208-2).
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 1,000 2,000

Scale in Feet

N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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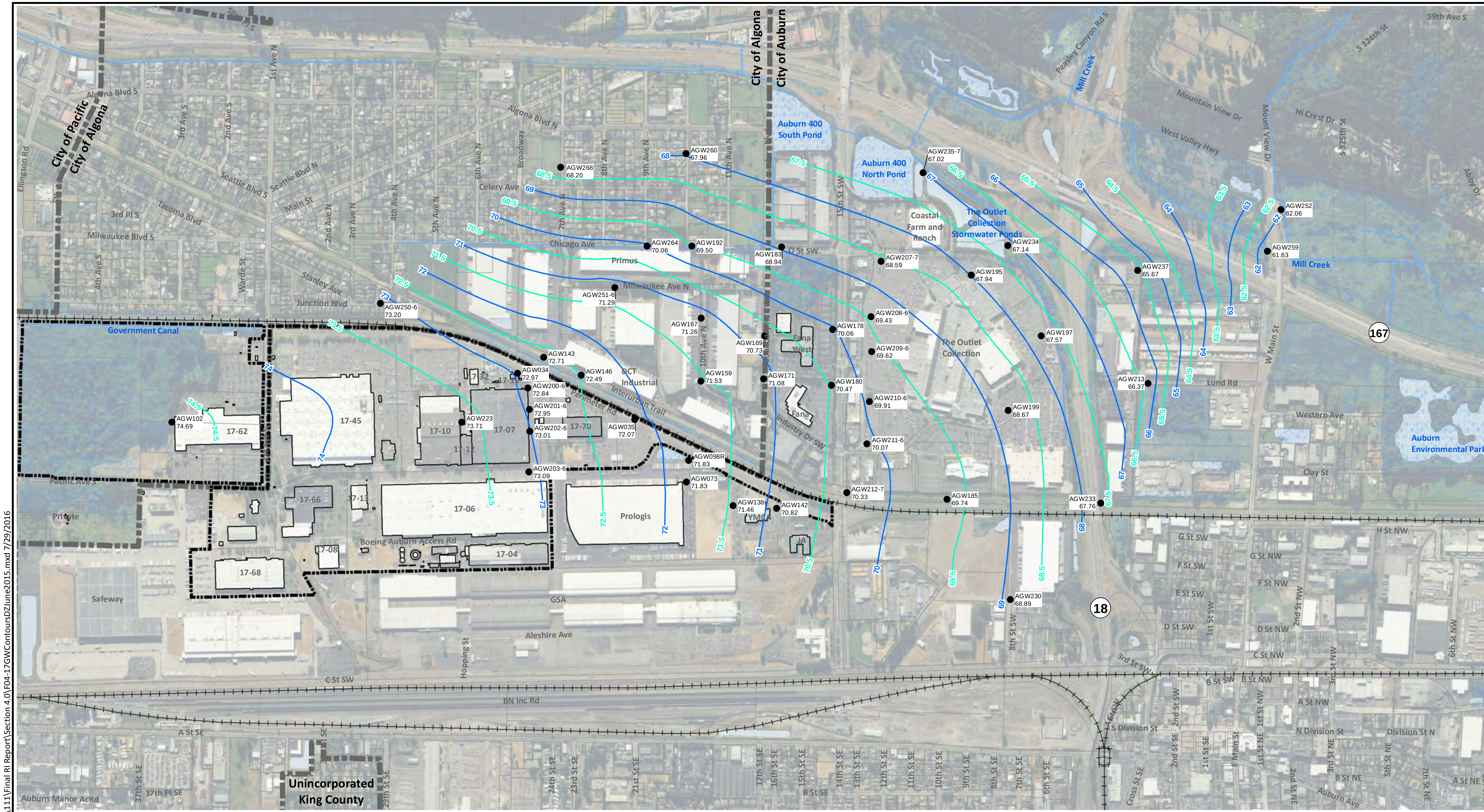
Boeing Auburn Remedial Investigation Auburn, Washington	**Intermediate Zone Groundwater Elevation Contours December 2015**	Figure 4-16



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Legend

- ● AGW102 76.06 — Monitoring Well Designation, Groundwater Elevation (ft, MSL)
- 72 / 72.5 — Groundwater Elevation Contours
- Boeing Property
- Waterway
- Wetland Area
- City Limits

Notes

1. All water level data in ft, MSL. Vertical datum is NGVD29. Data collected in June 2015.
2. Multilevel wells have multiple channels. Channel designations are included in the well ID (ex: AGW208-2).
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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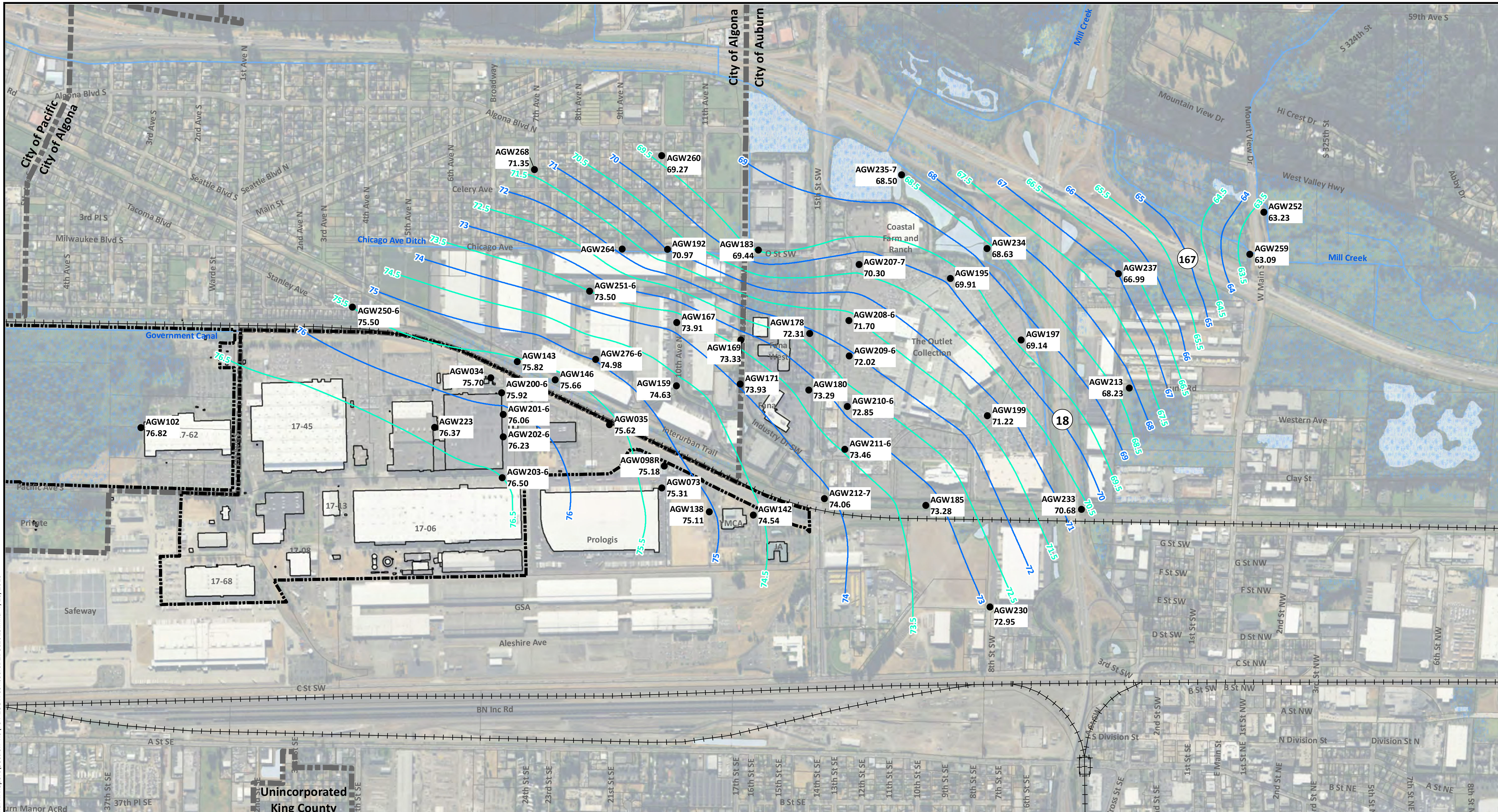
Boeing Auburn Remedial Investigation Auburn, Washington	**Deep Zone Groundwater Elevation Contours June 2015**	Figure 4-17



Legend

- AGW121 80.50 ● Monitoring Well Designation Groundwater Elevation (ft, MSL)
- 72 / 72.5 Groundwater Elevation Contours
- Boeing Property
- City Limits
- Wetland Areas
- Water Bodies
- Waterways

Note

1. All water level data in ft, MSL. Vertical datum is NGVD29. Data collected in December 2015.
2. Multilevel wells have multiple channels. Channel designations are included in the well ID (ex: AGW208-2).
3. Wells without a posted water level had anomalous data.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Scale in Feet: 0 — 1,000 — 2,000

N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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Remedial Investigation
Auburn, Washington

Deep Zone Groundwater Elevation Contours December 2015

Figure 4-18

Notes
1. Water levels collected on June 15-16, 2015.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend
- Neutral Hydraulic Gradient
- Upward Hydraulic Gradient
- Downward Hydraulic Gradient
- Wetland Areas
- Water Bodies
- Waterways

0 1,000 2,000
Scale in Feet

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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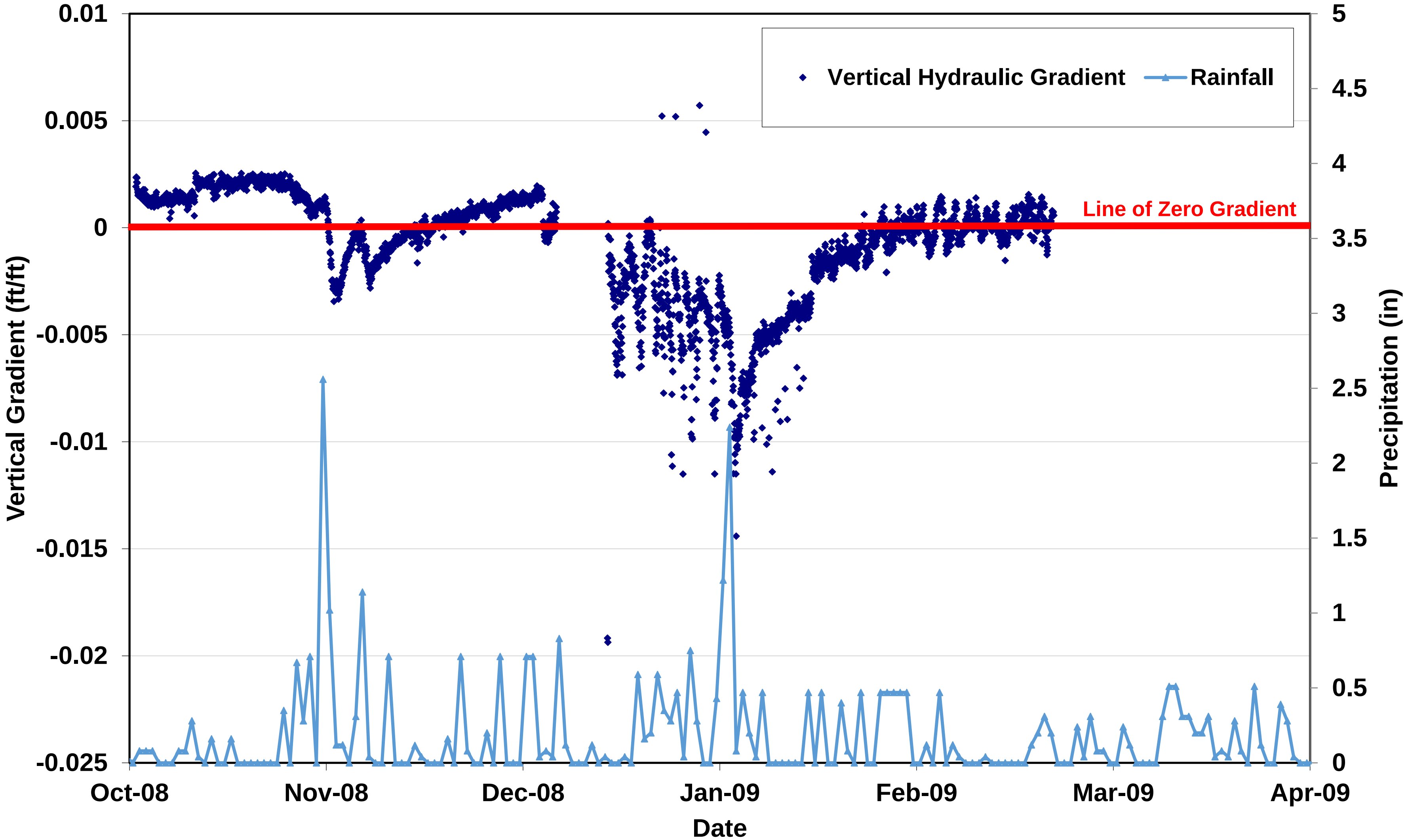
Boeing Auburn Remedial Investigation Auburn, Washington	**Vertical Hydraulic Gradient Shallow to Deep Zone June 2015**	Figure 4-19

Source: \\edmdata\projects\025\164\WIP\T\GW_Data Continuous WL Elevations\Chart WL & Vertical Gradient.xls



Note

1. Positive value indicates downward gradient, negative value indicates upward gradient.
2. Vertical Gradients were calculated for continuous water levels collected from AGW125 (shallow zone) and AGW126 (intermediate zone).

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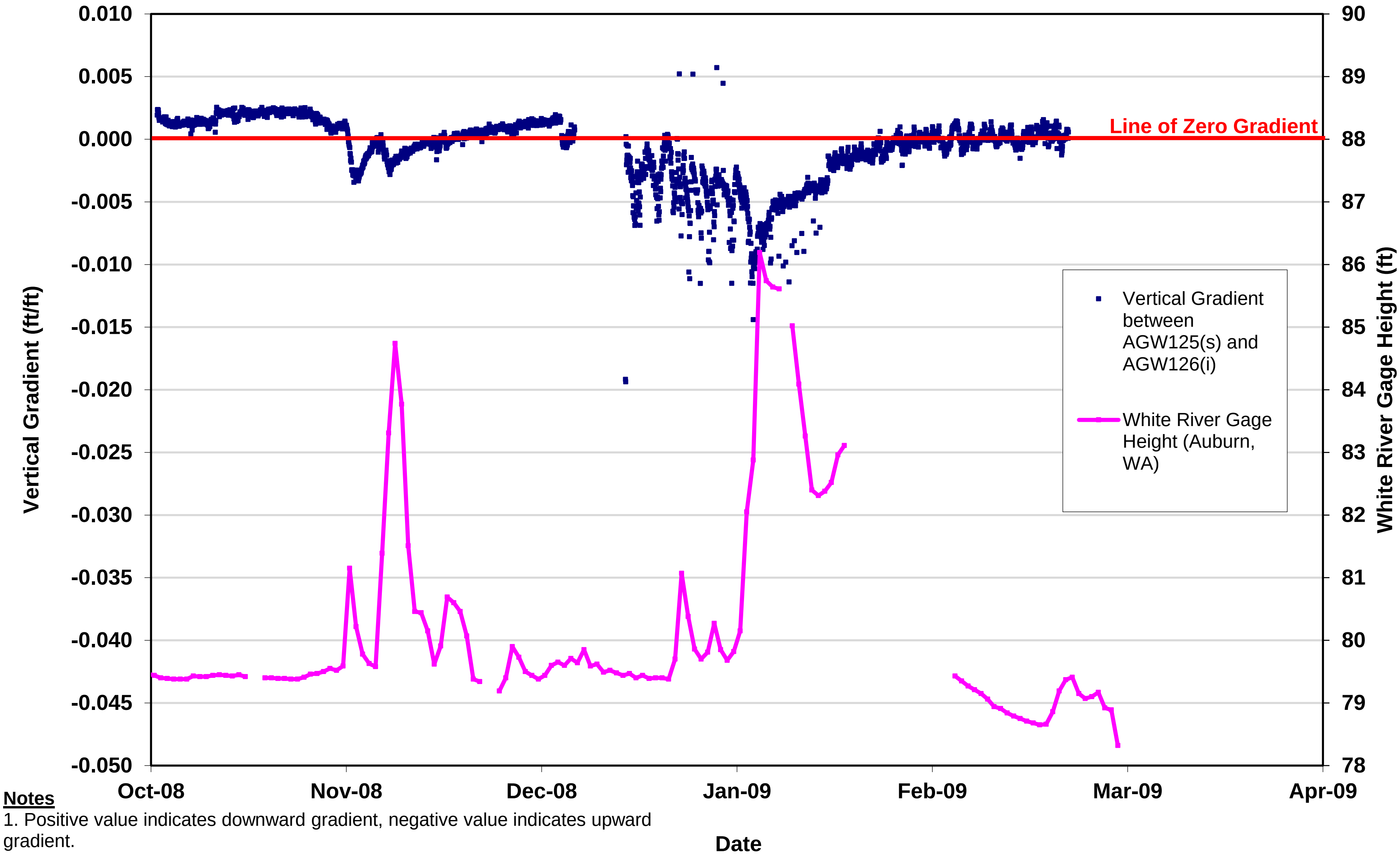
Boeing Auburn Remedial Investigation Auburn, Washington	**Precipitation and Vertical Groundwater Gradients**	Figure 4-20



Notes

1. Positive value indicates downward gradient, negative value indicates upward gradient.
2. Vertical Gradients were calculated for continuous water levels collected from AGW125 (shallow zone) and AGW126 (intermediate zone).
3. White River gage height data is taken from USGS 12100496 White River near Auburn, Washington.

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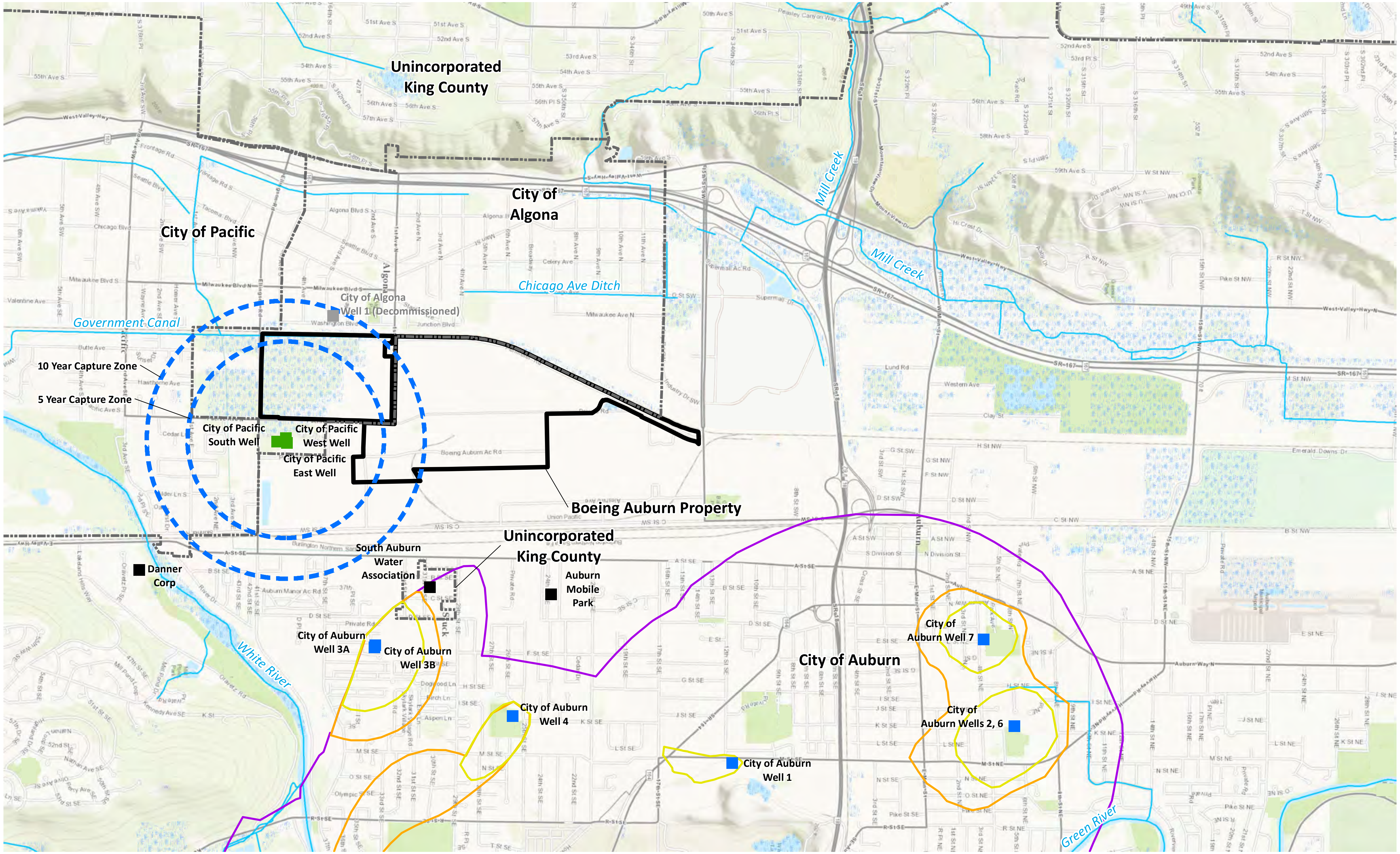
Boeing Auburn Remedial Investigation Auburn, Washington	**White River Gage Height and Vertical Groundwater Gradients**	Figure 4-21



Legend

- City of Algona Decommissioned Well
- City of Pacific Well
- City of Auburn Well
- Other Group A Wells
- 6 Month Wellhead Protection Area
- 1 Year Wellhead Protection Area
- 5 Year Wellhead Protection Area
- 10 Year Wellhead Protection Area
- Capture Zone
- Boeing Property
- City Limits
- Waterways
- Water Bodies
- Wetland Areas

Notes

1. TCE contours represent concentrations in the deep zone of the shallow aquifer 80 to 100 ft below ground surface.
2. Information about wellhead protection areas could only be found for the City of Auburn and City of Pacific wells.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 2,000 4,000

Scale in Feet

N

Data Sources: King County 2015; Esri World Imagery.

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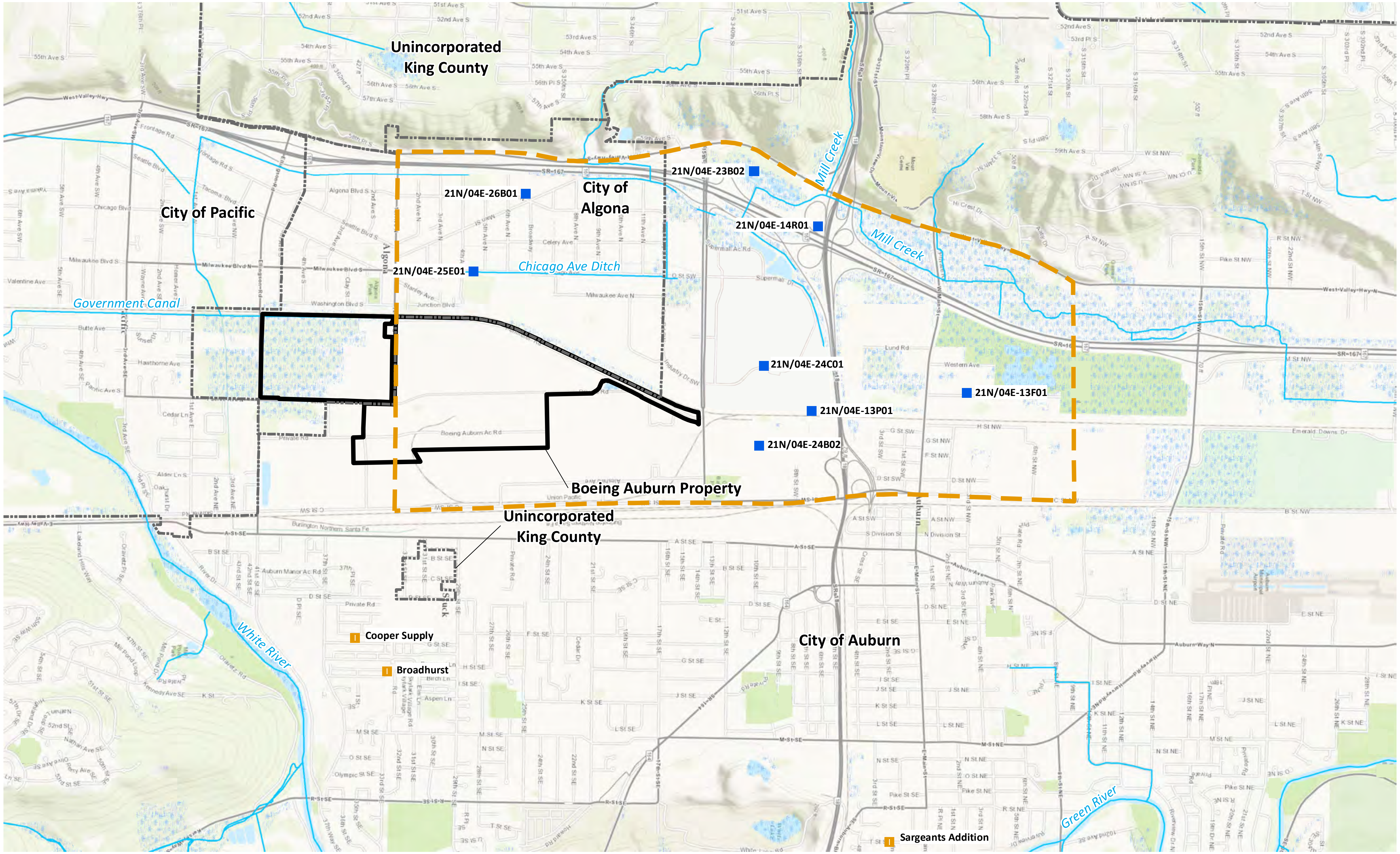
Remedial Investigation
Auburn, Washington

Group A Wells and Wellhead Protection Areas

Figure 4-22



Legend

- Possible Private Individual Well
- Active Group B Well
- Inactive Group B Well
- Private Well Study Area
- Boeing Property
- City Limits
- Waterways
- Water Bodies
- Wetland Areas

Notes

1. Locations of wells are based on TSR data and should be considered approximate.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 2,000 4,000

Scale in Feet

N

Data Sources: WSDH, Division of Enviromental Health, Office of Drinking Water; King County GIS; Esri World Imagery.

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Remedial Investigation
Auburn, Washington

Group B and Private Individual Well Locations

Figure 4-23

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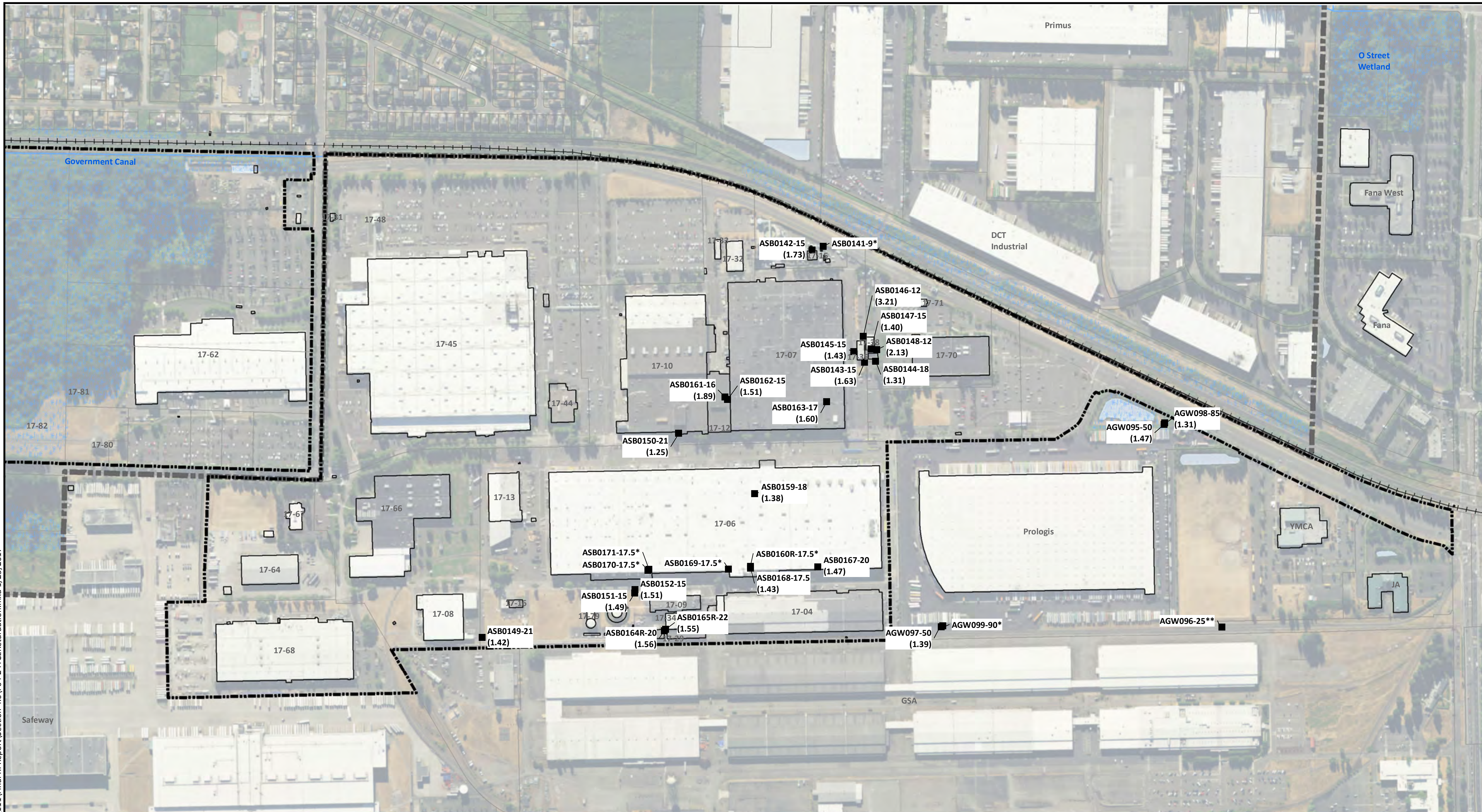

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Notes

1. ASB designations are for borings. AGW designations are for wells.
2. The TCE retardation factor is calculated using a bulk dry density of 1.75 g/cm3 and an organic carbon distribution coefficient of 94 mL/g.
3. * Indicates evidence of petroleum hydrocarbons present.
   ** Indicates evidence of natural organics present.
4. A TCE retardation factor was not calculated at locations where evidence of petroleum hydrocarbon or visual evidence of natural organics were present.
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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Legend

- Soil Borings
- Wetland Areas
- Water Bodies
- Waterways

0 500 1,000

Scale in Feet

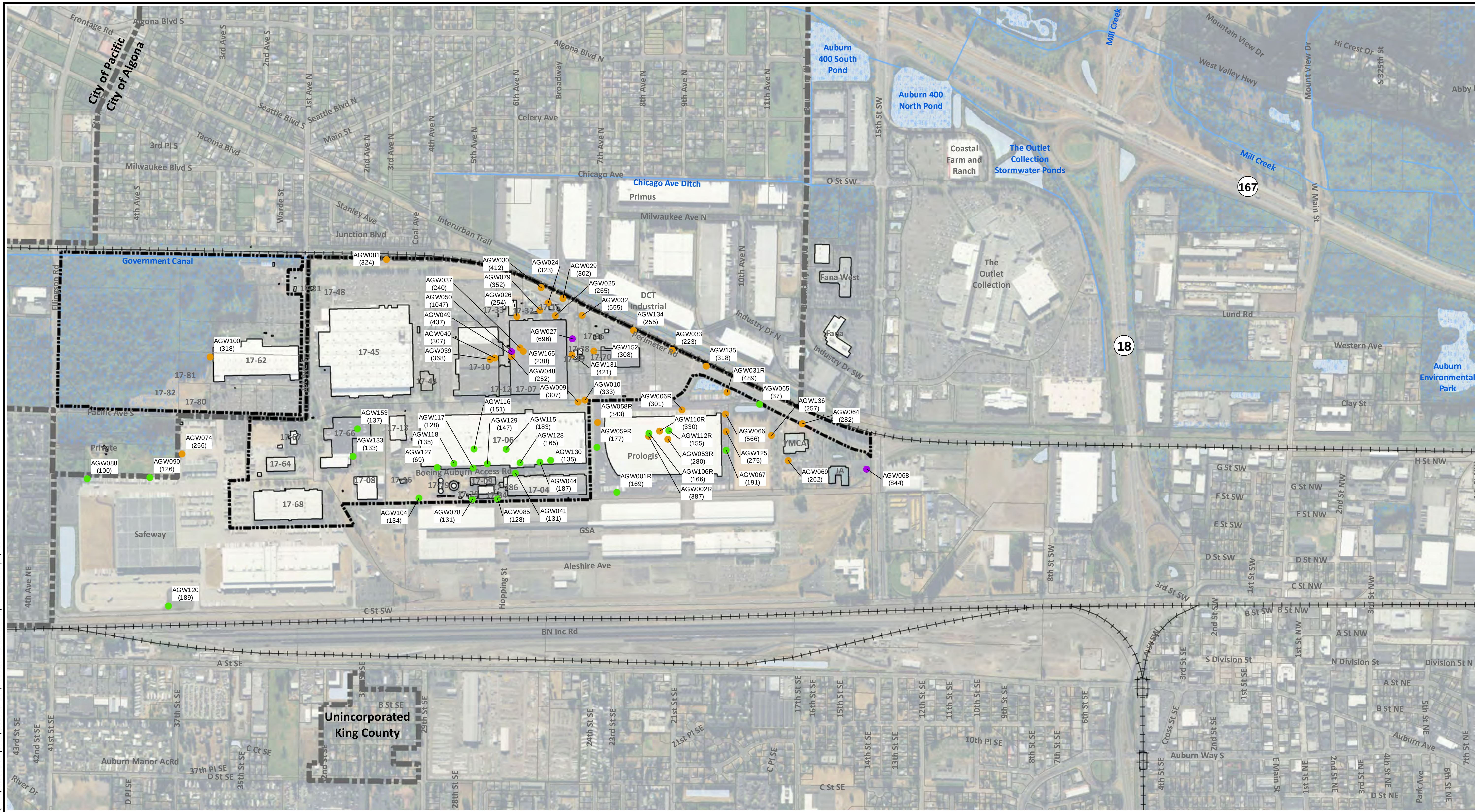
N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

Boeing Auburn
Auburn, Washington

TCE Retardation Factors for Locations where Soil TOC Samples Collected

Figure 4-24



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Notes

1. Conductivity results are shown in micro Siemens per centimeter (µS/cm).
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Conductivity Result >600 µS/cm
- Conductivity Result 200-600 µS/cm
- Conductivity Result 0-200 µS/cm
- Boeing Property
- City Limits

0 1,000 2,000

Scale in Feet

N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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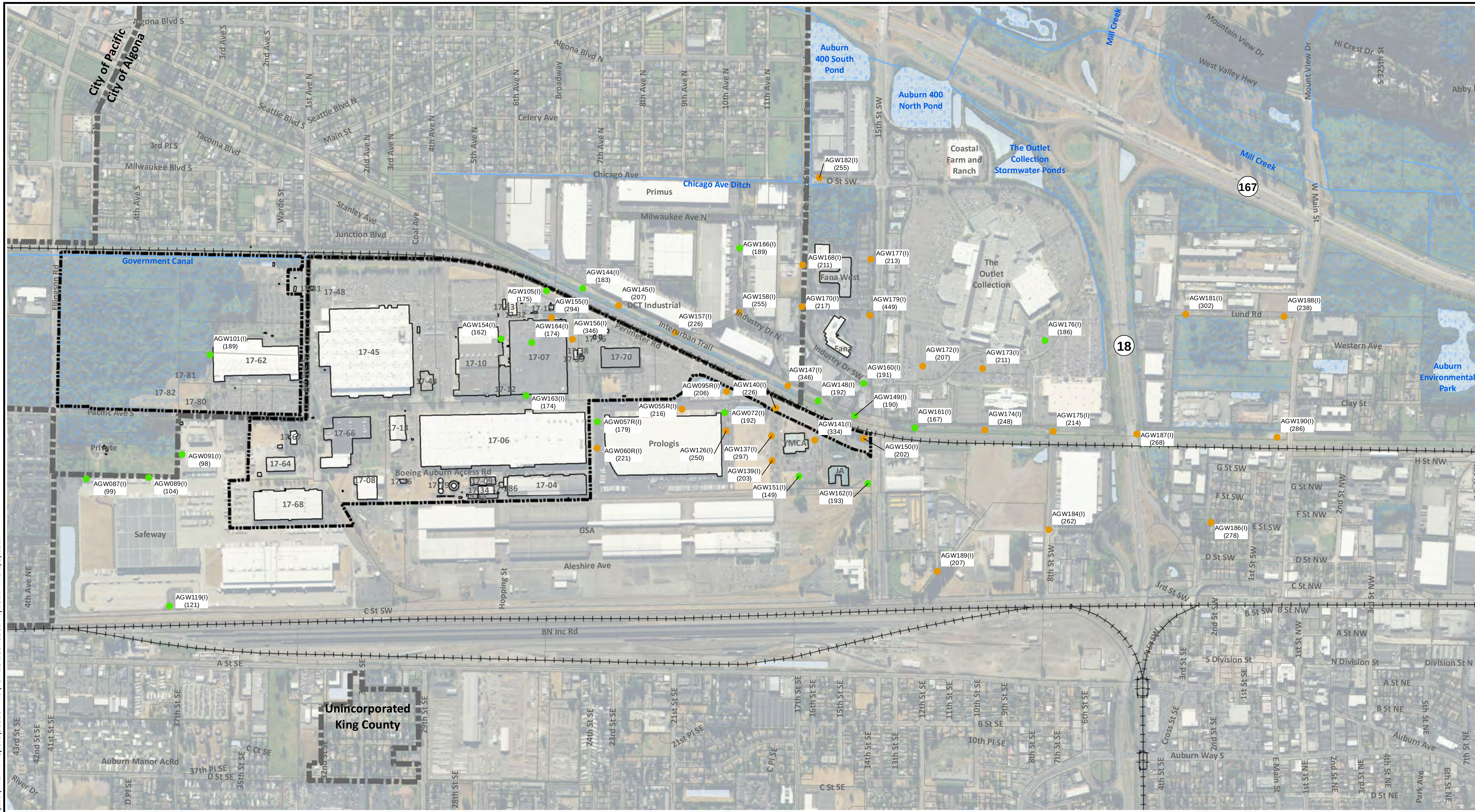
Boeing Auburn
Remedial Investigation
Auburn, Washington

Shallow Zone Conductivity June 2011

Figure 4-25



Notes

1. Conductivity results are shown in micro Siemens per centimeter (µS/cm).
2. Well designations ending in (I) indicate intermediate zone wells.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Conductivity Result > 600 µS/cm
- Conductivity Result 200-600 µS/cm
- Conductivity Result 0-200 µS/cm
- Boeing Property
- City Limits

0 1,000 2,000

Scale in Feet

N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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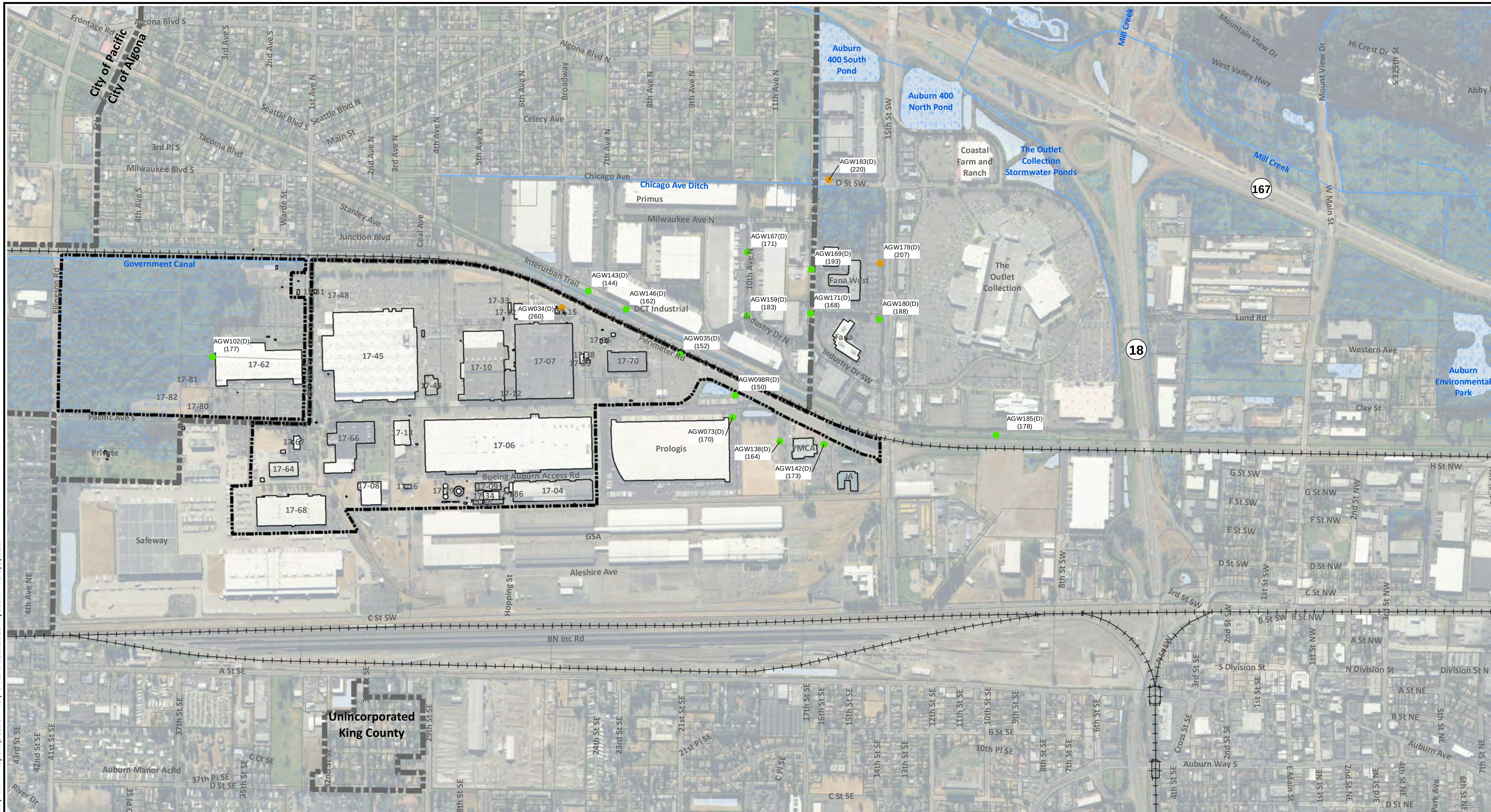
Boeing Auburn Remedial Investigation Auburn, Washington	**Intermediate Zone Conductivity June 2011**	Figure 4-26



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Notes

1. Conductivity results are shown in micro Siemens per centimeter (µS/cm).
2. Well designations ending in (D) indicate deep zone wells.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Conductivity Result > 600 µS/cm
- Conductivity Result 200-600 µS/cm
- Conductivity Result 0-200 µS/cm
- Boeing Property
- City Limits

0 1,000 2,000

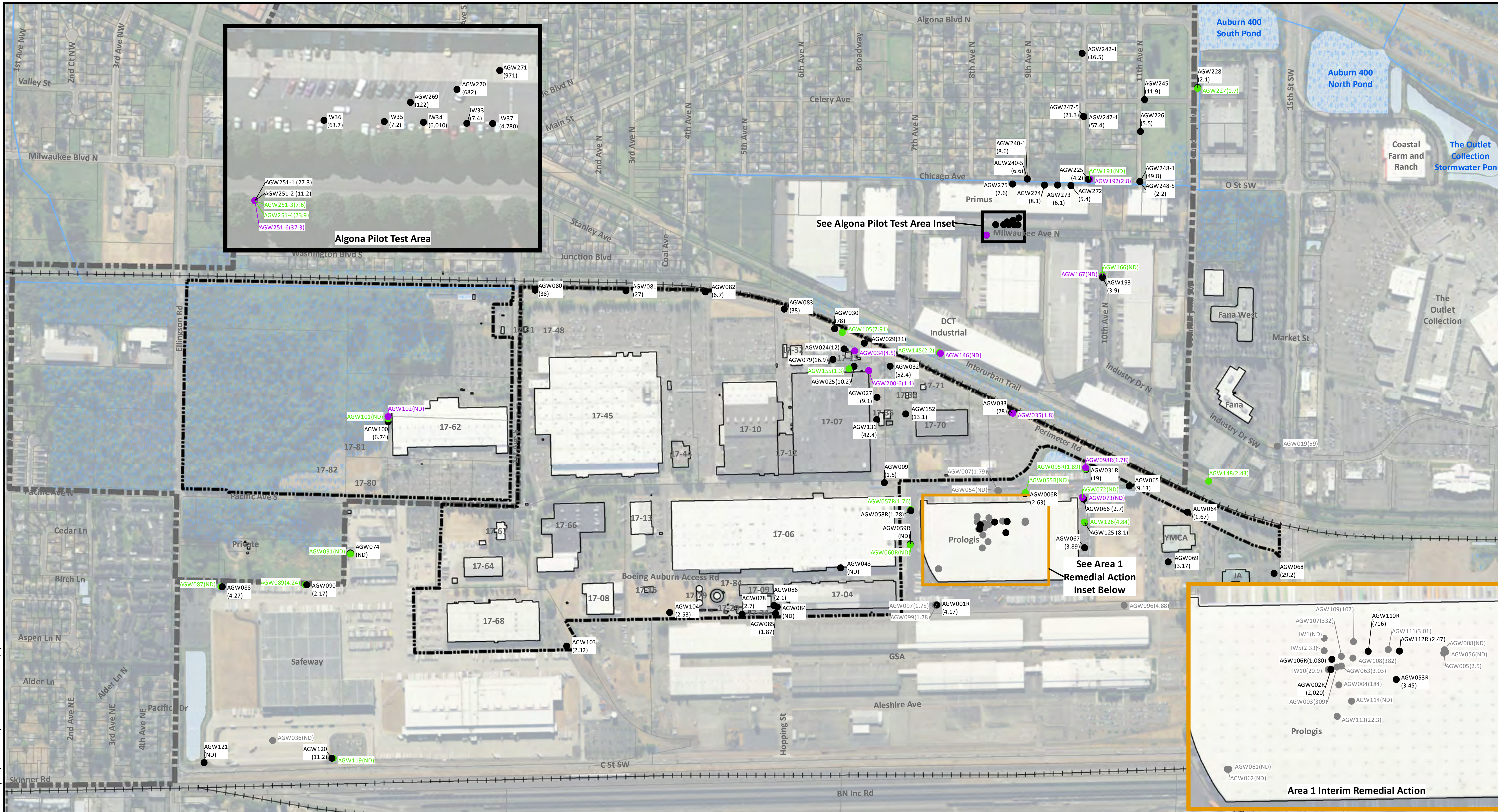
Scale in Feet

N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

Landau Associates

Boeing Auburn Remedial Investigation Auburn, Washington	**Deep Zone** **Conductivity June 2011**	Figure 4-27



Notes

1. High TOC values in the Algona Pilot Test area and Area 1 Interim Remedial Action area are the result of bioremediation electron donor amendments.
2. Maximum total organic carbon (TOC) concentrations for all wells sampled for this constituent.
3. All concentrations shown in mg/L.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Shallow Zone Well - Active
- Intermediate Zone Well - Active
- Deep Zone Well - Active
- Decommissioned Well
- Wetland Areas
- Water Bodies
- Waterways

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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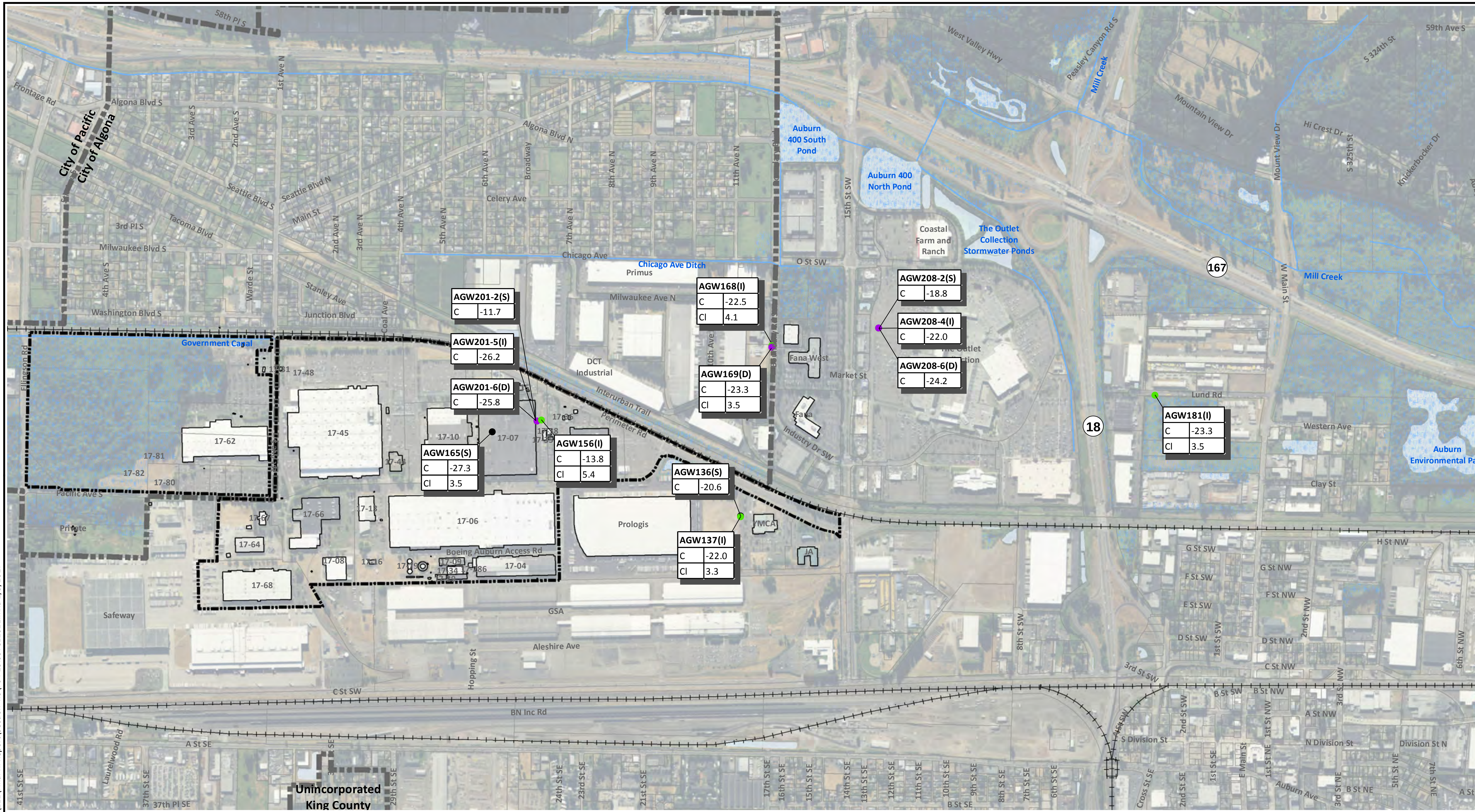
Boeing Auburn Remedial Investigation Auburn, Washington	**Groundwater Maximum Total Organic Carbon Concentrations**	Figure 4-28



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Notes

1. All chlorine data references SMOC (Standard Mean Ocean Chloride). All carbon data references VPDB (Vienna Pee Dee Belemnite.)
2. Chlorine units: δ37Cl ‰ = delta (δ) of 37Cl in parts per thousand (‰) from the standard. Carbon units: δ13C ‰ = delta (δ) of 13C in parts per thousand (‰) from the standard.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

Compound Specific Carbon and Chlorine Isotopes for TCE

- Shallow Zone
- Intermediate Zone
- Deep Zone
- Boeing Property
- City Limits

0 1,000 2,000

Scale in Feet

N

Base Map Source: Geometrix 2003; Parcel Data Source: King County 2015; Aerial Photo Source: Esri World Imagery.

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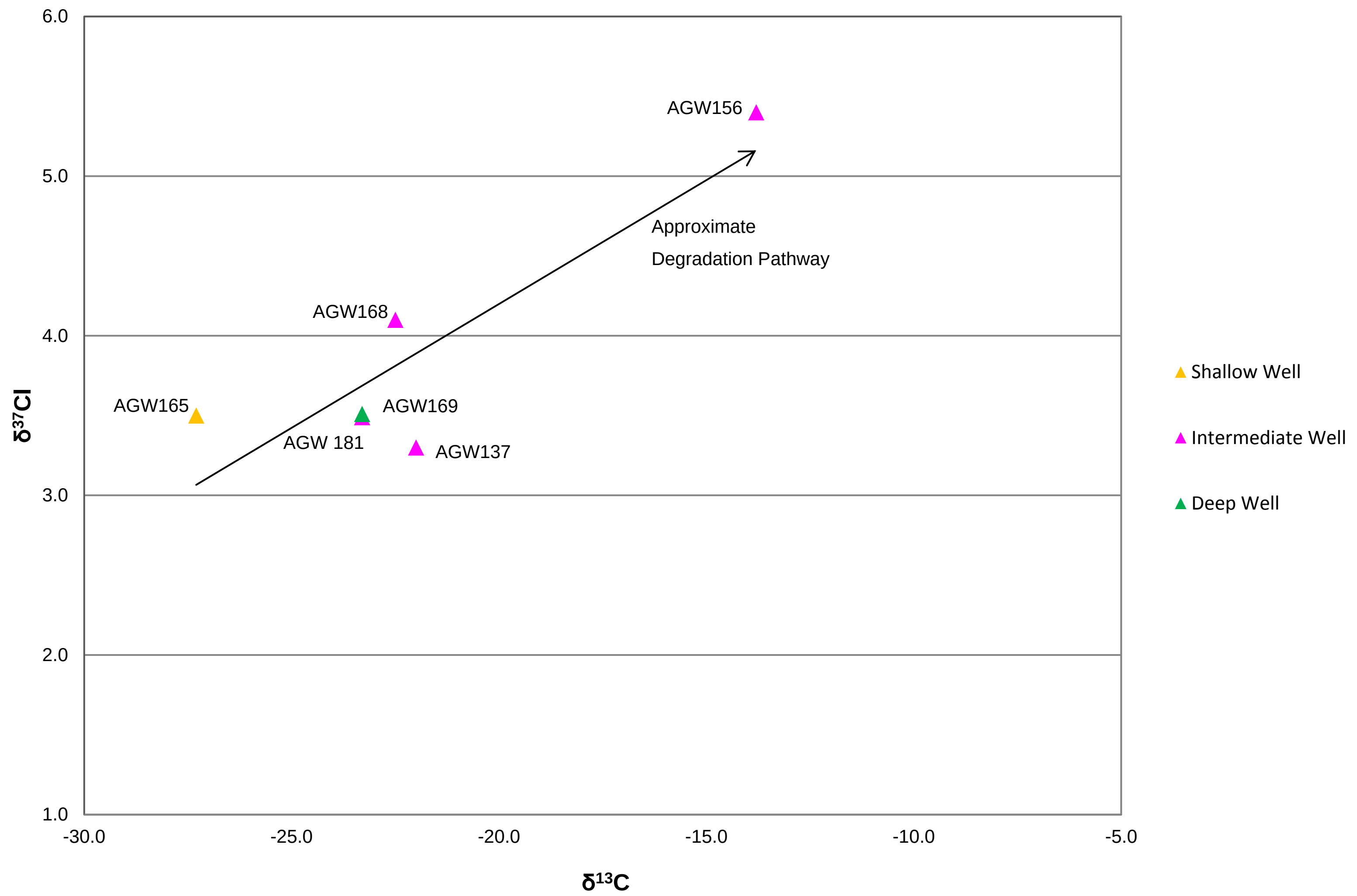
Boeing Auburn Remedial Investigation Auburn, Washington	**Compound Specific Carbon and Chlorine Isotopes for TCE** **June 2011 and 2012**	Figure 4-29



Landau Associates

Boeing Auburn
Remedial Investigation
Auburn, Washington

Compound Specific Isotope Analysis
Carbon versus Chlorine in TCE
June 2011

Figure
4-30

Table 4-1
Major Ion Data Results
Boeing Auburn Remedial Investigation
Auburn, Washington

Location: Aquifer Depth: Sample Date:	AGW034 Deep 06/23/2011	AGW068 Shallow 06/23/2011	AGW100 Shallow 06/24/2011	AGW101 Intermediate 06/24/2011	AGW102 Deep 06/24/2011	AGW119 Intermediate 06/23/2011	AGW120 Shallow 06/23/2011	AGW136 Shallow 06/21/2011
DISSOLVED METALS (mg/L); Method EPA200.8/SW6010B								
Silicon	**22.6**	**28.9**	**20.2**	**18.2**	**19.4**	**12.9**	**13.3**	**24.6**
TOTAL METALS (mg/L); Method SW6010B								
Calcium	**20.4**	**52.5**	**31.7**	**19.9**	**16.7**	**10.4**	**21.0**	**24.4**
Magnesium	**6.83**	**17.7**	**4.66**	**6.36**	**5.53**	**3.0**	**4.49**	**8.72**
Potassium	**4.7**	**4.1**	**2.8**	**2.5**	**2.6**	**1.5**	**3.0**	**3.4**
Sodium	**10.7**	**11.0**	**7.0**	**6.4**	**6.5**	**4.3**	**4.7**	**9.3**
CONVENTIONALS (mg/L)								
Sulfate (EPA 300.0)	**16.2**	**5.1**	**13.6**	**13.8**	**11.1**	**9.2**	**24.2**	**21.4**
Total Dissolved Solids (EPA 160.1)		**152**	**165**	**129**	**126**	**99.0**	**118**	**206**
Chloride (EPA 300.0)	**3.4**	**5.2**	**3.0**	**2.9**	**2.6**	**2.4**	**3.4**	**4.4**
Nitrate (EPA 300.0)	**0.1**	0.1 U	**0.1**	**0.5**	**0.4**	**0.5**	**1.1**	0.1 U
Alkalinity, Total (SM2320)	**92.8**	**342**	**118**	**67.4**	**69.2**	**36.7**	**41.7**	**109**
Alkalinity as Bicarbonate (SM2320)	**92.8**	**342**	**118**	**67.4**	**69.2**	**36.7**	**41.7**	**109**

Notes:
Bold = detected compound
U = Indicates the compound was not detected at the reported concentration.

Abbreviations/Acronyms:
EPA = US Environmental Protection Agency
mg/L = milligrams per liter

Table 4-1
Major Ion Data Results
Boeing Auburn Remedial Investigation
Auburn, Washington

Location: Aquifer Depth: Sample Date:	AGW137 Intermediate 06/21/2011	AGW138 Deep 06/21/2011	AGW156 Intermediate 06/22/2011	AGW165 Shallow 06/20-22/2011	AGW168 Intermediate 06/22/2011	AGW169 Deep 06/22/2011	AGW174 Intermediate 06/23/2011	AGW181 Intermediate 06/21/2011
DISSOLVED METALS (mg/L); Method EPA200.8/SW6010B								
Silicon	**27.1**	**17.4**	**26.1**	**25.2**	**20.6**	**19.5**	**19.3**	**19.8**
TOTAL METALS (mg/L); Method SW6010B								
Calcium	**29.2**	**16.4**	**42.3**	**22.7**	**23.8**	**22.3**	**21.7**	**34.6**
Magnesium	**9.11**	**4.98**	**12.7**	**7.14**	**7.52**	**6.94**	**6.48**	**10.4**
Potassium	**3.8**	**2.6**	**5.8**	**3.4**	**3.3**	**3.0**	**2.8**	**4.1**
Sodium	**10.0**	**7.3**	**14.4**	**9.6**	**8.3**	**7.8**	**10.3**	**14.8**
CONVENTIONALS (mg/L)								
Sulfate (EPA 300.0)	**17.9**	**15.2**	**4.4**	**14.0**	**8.8**	**11.7**	**17.3**	**12.4**
Total Dissolved Solids (EPA 160.1)	**234**	**138**	**246**	**182**	**158**	**152**	**163**	**201**
Chloride (EPA 300.0)	**6.4**	**2.4**	**4.8**	**5.2**	**3.0**	**2.9**	**6.4**	**5.9**
Nitrate (EPA 300.0)	0.1 U	**0.4**	0.1 U	0.1 U	0.1 U	0.1 U	**0.8**	0.1 U
Alkalinity, Total (SM2320)	**137**	**66.7**	**182**	**102**	**96.6**	**90.4**	**79.4**	**151**
Alkalinity as Bicarbonate (SM2320)	**137**	**66.7**	**182**	**102**	**96.6**	**90.4**	**79.4**	**151**

Notes:

Bold = detected compound

U = Indicates the compound was not detected at the reported concentration.

Abbreviations/Acronyms:

EPA = US Environmental Protection Agency

mg/L = milligrams per liter

Table 4-1
Major Ion Data Results
Boeing Auburn Remedial Investigation
Auburn, Washington

Location: Aquifer Depth: Sample Date:	AGW185 Deep 06/23/2011	White River 06/23/2011
DISSOLVED METALS (mg/L); Method EPA200.8/SW6010B		
Silicon	**18.9**	**5.54**
TOTAL METALS (mg/L); Method SW6010B		
Calcium	**20.2**	**5.25**
Magnesium	**6.09**	**1.01**
Potassium	**2.7**	**0.5**
Sodium	**10.8**	**2.2**
CONVENTIONALS (mg/L)		
Sulfate (EPA 300.0)	**16.9**	**4.0**
Total Dissolved Solids (EPA 160.1)	**156**	**38.0**
Chloride (EPA 300.0)	**3.6**	**0.8**
Nitrate (EPA 300.0)	**0.1**	**0.1**
Alkalinity, Total (SM2320)	**84.0**	**16.5**
Alkalinity as Bicarbonate (SM2320)	**84.0**	**16.5**

Notes:

Bold = detected compound

U = Indicates the compound was not detected at the reported concentration.

Abbreviations/Acronyms:

EPA = US Environmental Protection Agency

mg/L = milligrams per liter

Table 4-2
Bulk Water Isotope Data Results June 2011
Boeing Auburn Remedial Investigation
Auburn, Washington

Sample Name	Sample Date	Bulk Water Isotopes	
		δ^2H ‰ (VSMOW)	δ^{18}O ‰ (VSMOW)
AGW034	6/23/2011	-89.6	-11.95
AGW068	6/23/2011	-72.0	-9.39
AGW100	6/24/2011	-84.1	-11.18
AGW101	6/24/2011	-89.5	-12.00
AGW102	6/24/2011	-91.3	-12.43
AGW119	6/23/2011	-91.7	-12.24
AGW120	6/23/2011	-89.4	-12.00
AGW136	6/21/2011	-73.9	-9.81
AGW137	6/21/2011	-74.3	-9.70
AGW138	6/21/2011	-89.1	-11.89
AGW156	6/22/2011	-87.1	-11.54
AGW165	6/22/2011	-86.6	-11.62
AGW168	6/22/2011	-88.9	-11.98
AGW169	6/22/2011	-89.0	-11.95
AGW174	6/23/2011	-84.8	-11.36
AGW181	6/21/2011	-84.1	-11.09
AGW185	6/23/2011	-86.5	-11.49
Precipitation	6/23/2011	-60.6	-7.41
White River	6/23/2011	-103.0	-14.12

Note:
1. Bulk water isotopes analyzed by Isotech Laboratories, Inc.

Abbreviation/Acronym:
VSMOW = Vienna Standard Mean Ocean Water

Units:

δ^2H ‰ $= \{[(^2H/^1H)_{sample} - (^2H/^1H)_{VSMOW}]/(^2H/^1H)_{VSMOW}\}*1000$

$\delta^{18}O$ ‰ $= \{[(^{18}O/^{16}O)_{sample} - (^{18}O/^{16}O)_{VSMOW}]/(^{18}O/^{16}O)_{VSMOW}\}*1000$

Table 4-3
Minumim and Maximum Groundwater Elevations
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW001R (a)	S	12/16/03	68.48	12/29/15	76.59	8.11
AGW002R (a)	S	10/02/06	68.55	12/29/15	75.94	7.39
AGW006R (a)	S	10/26/09	68.73	12/29/15	75.50	6.77
AGW009	S(WT)	10/26/09	69.61	12/29/15	76.38	6.77
AGW010	S(WT)	10/26/09	69.54	12/29/15	76.24	6.70
AGW011	S	10/26/09	69.55	12/29/15	76.33	6.78
AGW012	S	10/26/09	69.57	12/29/15	76.33	6.76
AGW013	S	10/26/09	69.43	12/29/15	76.17	6.74
AGW014	S	10/26/09	69.45	12/29/15	76.36	6.91
AGW015	S	10/26/09	69.48	12/29/15	76.19	6.71
AGW016	S	10/23/08	69.54	12/29/15	76.22	6.68
AGW017	S	10/26/09	69.57	12/29/15	76.27	6.70
AGW018	S	10/23/08	71.42	12/29/15	77.97	6.55
AGW020	S	10/26/09	71.72	12/29/15	77.91	6.19
AGW021	S	10/23/08	71.60	12/29/15	77.43	5.83
AGW022	S	10/23/08	71.65	12/29/15	77.68	6.03
AGW023	S	10/23/08	71.59	12/29/15	77.46	5.87
AGW024	S	08/16/04	68.98	12/30/15	75.70	6.72
AGW025	S	10/26/09	70.36	12/30/15	75.78	5.42
AGW026	S	10/26/09	70.61	12/30/15	75.91	5.30
AGW027	S	10/26/09	69.78	12/30/15	75.78	6.00
AGW028	S	10/27/09	70.57	12/30/15	76.06	5.49
AGW029	S	10/23/08	70.23	12/30/15	75.58	5.35
AGW030	S	10/23/08	70.72	12/30/15	75.63	4.91
AGW031R (a)	S	10/26/09	68.60	12/30/15	75.23	6.63
AGW032	S(WT)	10/26/09	70.12	12/30/15	75.73	5.61
AGW033	S(WT)	10/22/08	68.68	12/30/15	75.18	6.50
AGW034	D	10/27/09	70.17	12/30/15	75.70	5.53
AGW035	D	10/26/09	68.96	12/30/15	75.62	6.66
AGW037	S(WT)	10/26/09	70.44	12/30/15	76.19	5.75
AGW038	S	10/22/08	69.89	12/30/15	75.53	5.64
AGW039	S(WT)	10/27/09	70.65	12/30/15	76.34	5.69
AGW040	S(WT)	10/27/09	70.65	12/30/15	76.33	5.68
AGW042	S	10/26/09	69.68	12/29/15	76.99	7.31
AGW043	S	10/26/09	69.57	12/29/15	76.87	7.30
AGW044	S(WT)	09/28/15	69.53	12/29/15	76.95	7.42
AGW046	S	10/27/09	70.45	12/30/15	76.19	5.74
AGW047	S	10/27/09	70.47	12/30/15	76.21	5.74
AGW048	S	10/27/09	70.43	12/30/15	76.23	5.80
AGW049	S	10/27/09	70.41	12/30/15	76.22	5.81
AGW050	S	10/27/09	70.46	12/30/15	76.17	5.71
AGW053R (a)	S(WT)	10/02/06	68.40	02/06/06	75.94	7.54
AGW055R (a)	I	10/26/09	68.62	12/29/15	75.48	6.86

Table 4-3
Minumim and Maximum Groundwater Elevations
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW057R (a)	S	10/26/09	69.41	12/29/15	76.41	7.00
AGW058R (a)	S(WT)	10/26/09	69.40	12/29/15	76.37	6.97
AGW059R (a)	S	10/26/09	69.38	12/31/15	76.69	7.31
AGW060R (a)	I	10/26/09	69.29	12/31/15	76.67	7.38
AGW064	S(WT)	10/26/09	68.08	12/30/15	74.84	6.76
AGW065	S(WT)	10/26/09	68.45	12/30/15	76.16	7.71
AGW066	S(WT)	10/26/09	68.44	02/03/06	75.41	6.97
AGW067	S(WT)	10/26/09	68.33	02/03/06	75.51	7.18
AGW068	S(WT)	05/26/05	69.35	05/30/14	76.59	7.24
AGW069	S(WT)	10/26/09	68.16	05/30/14	75.08	6.92
AGW072	I	10/22/08	67.93	12/29/15	75.30	7.37
AGW073	D	10/26/09	68.41	06/02/14	84.87	16.46
AGW074	S(WT)	08/17/04	72.23	12/15/03	78.61	6.38
AGW076	S	10/26/09	69.91	12/29/15	77.40	7.49
AGW077	S	10/26/09	70.30	12/29/15	77.57	7.27
AGW078	S	10/26/09	70.30	12/29/15	77.59	7.29
AGW079	S	08/16/04	69.16	06/02/09	80.34	11.18
AGW080	S	10/23/08	71.64	12/31/15	75.91	4.27
AGW081	S(WT)	10/23/08	71.37	06/06/06	78.60	7.23
AGW082	S	10/26/09	71.05	12/30/15	76.06	5.01
AGW083	S	10/26/09	71.33	12/30/15	76.07	4.74
AGW084	S	10/26/09	70.02	12/29/15	77.38	7.36
AGW085	S(WT)	10/26/09	70.00	12/29/15	77.37	7.37
AGW086	S	10/23/08	70.04	12/29/15	77.34	7.30
AGW087	I	12/14/09	67.94	12/29/15	77.54	9.60
AGW088	S(WT)	12/14/09	71.30	12/29/15	77.56	6.26
AGW089	I	08/17/04	72.20	12/29/15	77.99	5.79
AGW090	S	08/17/04	72.26	12/29/15	78.12	5.86
AGW091	I	08/17/04	71.66	12/15/03	78.26	6.60
AGW095R (a)	I	10/26/09	68.62	12/30/15	75.25	6.63
AGW098R (a)	D	10/26/09	68.56	12/30/15	75.18	6.62
AGW100	S	08/16/04	72.12	12/29/15	76.94	4.82
AGW101	I	08/16/04	72.21	12/29/15	76.99	4.78
AGW102	D	08/16/04	72.09	12/29/15	76.82	4.73
AGW103	S	10/23/08	71.51	12/29/15	78.52	7.01
AGW104	S	10/26/09	70.82	12/29/15	77.80	6.98
AGW105	I	10/23/08	70.46	12/30/15	75.38	4.92
AGW106R (a)	S	10/02/06	68.49	12/29/15	75.91	7.42
AGW110R (a)	S	10/02/06	68.44	02/03/06	75.87	7.43
AGW112R (a)	S	10/02/06	68.38	06/03/13	77.47	9.09
AGW115	S(WT)	10/27/09	70.16	12/29/15	77.17	7.01
AGW116	S(WT)	10/27/09	70.44	12/29/15	77.28	6.84
AGW117	S(WT)	10/26/09	70.32	12/29/15	77.44	7.12

Table 4-3
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Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW118	S(WT)	10/27/09	70.69	12/29/15	77.51	6.82
AGW119	I	10/23/08	73.02	12/29/15	80.21	7.19
AGW120	S	10/23/08	73.03	12/29/15	80.29	7.26
AGW121	S	10/23/08	73.66	12/29/15	80.50	6.84
AGW125	S	10/26/09	68.38	12/29/15	75.35	6.97
AGW126	I	10/26/09	68.40	12/29/15	75.44	7.04
AGW127	S(WT)	10/22/08	70.89	12/29/15	77.67	6.78
AGW128	S(WT)	09/28/15	69.02	12/31/15	77.23	8.21
AGW129	S(WT)	10/23/08	70.33	12/29/15	77.23	6.90
AGW130	S(WT)	10/27/09	69.73	12/29/15	76.93	7.20
AGW131	S	10/26/09	69.69	12/30/15	75.88	6.19
AGW132	S	10/23/08	71.42	12/29/15	77.61	6.19
AGW133	S	09/09/08	70.91	12/29/15	77.74	6.83
AGW134	S	10/26/09	69.16	12/30/15	75.37	6.21
AGW135	S	10/26/09	68.72	12/30/15	75.20	6.48
AGW136	S	10/26/09	68.16	12/30/15	75.12	6.96
AGW137	I	10/30/08	67.88	12/30/15	75.13	7.25
AGW138	D	10/26/09	68.14	12/30/15	75.11	6.97
AGW139	I	10/26/09	67.93	12/30/15	75.24	7.31
AGW140	I	10/27/09	68.24	12/30/15	74.97	6.73
AGW141	I	09/23/09	67.72	12/30/15	74.71	6.99
AGW142	D	10/26/09	67.50	12/05/13	78.07	10.57
AGW143	D	10/26/09	69.47	12/31/15	75.82	6.35
AGW144	I	10/28/09	69.75	12/31/15	75.87	6.12
AGW145	I	10/26/09	69.47	12/31/15	75.40	5.93
AGW146	D	10/26/09	69.26	12/31/15	75.66	6.40
AGW147	I	10/26/09	67.88	12/31/15	74.49	6.61
AGW148	I	10/26/09	67.84	12/31/15	74.69	6.85
AGW149	I	10/26/09	67.45	12/31/15	74.28	6.83
AGW150	I	10/26/09	67.35	12/30/15	74.34	6.99
AGW151	I	10/26/09	67.63	12/30/15	75.01	7.38
AGW152	S	10/26/09	69.48	12/30/15	75.89	6.41
AGW153	S	10/26/09	71.43	12/31/15	77.34	5.91
AGW154	I	10/17/11	71.85	12/30/15	76.21	4.36
AGW155	I	10/17/11	71.49	12/30/15	75.70	4.21
AGW156	I	10/17/11	71.08	12/30/15	76.02	4.94
AGW157	I	10/18/11	70.17	03/29/10	75.90	5.73
AGW158	I	12/10/12	65.53	12/31/15	74.40	8.87
AGW159	D	10/18/11	69.79	12/31/15	74.63	4.84
AGW160	I	10/18/11	68.85	12/31/15	74.08	5.23
AGW161	I	10/18/11	68.33	12/29/15	73.77	5.44
AGW162	I	10/17/11	68.59	12/30/15	74.43	5.84
AGW163	I	10/17/11	71.35	12/30/15	76.64	5.29

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Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW164	I	10/17/11	71.60	12/30/15	76.29	4.69
AGW165	S	08/25/10	70.90	12/30/15	76.14	5.24
AGW166	I	10/18/11	69.46	12/31/15	73.16	3.70
AGW167	D	10/18/11	69.73	12/31/15	73.91	4.18
AGW168	I	10/18/11	69.17	12/31/15	72.98	3.81
AGW169	D	10/18/11	69.31	12/31/15	73.33	4.02
AGW170	I	10/18/11	69.49	12/31/15	73.96	4.47
AGW171	D	10/18/11	69.43	12/31/15	73.93	4.50
AGW172	I	10/18/11	68.42	12/30/15	73.33	4.91
AGW173	I	09/01/10	67.57	12/30/15	72.35	4.78
AGW174	I	10/18/11	67.85	12/29/15	73.03	5.18
AGW175	I	10/18/11	67.01	12/29/15	72.14	5.13
AGW176	I	09/14/10	67.32	12/30/15	71.21	3.89
AGW177	I	09/21/10	68.06	12/31/15	72.09	4.03
AGW178	D	10/18/11	68.76	12/31/15	72.31	3.55
AGW179	I	09/22/10	68.22	12/31/15	73.00	4.78
AGW180	D	10/18/11	68.96	12/31/15	73.29	4.33
AGW181	I	10/17/11	65.38	12/29/15	68.37	2.99
AGW182	I	10/18/11	68.12	12/31/15	70.23	2.11
AGW183	D	08/27/15	67.81	05/30/14	70.16	2.35
AGW184	I	12/12/12	60.44	12/30/15	72.94	12.50
AGW185	D	10/18/11	67.96	12/02/15	74.89	6.93
AGW186	I	09/06/11	65.30	12/29/15	70.22	4.92
AGW187	I	10/18/11	66.07	12/29/15	70.84	4.77
AGW188	I	09/08/11	63.24	12/04/12	66.41	3.17
AGW189	I	09/05/13	67.67	12/30/15	74.07	6.40
AGW190	I	10/18/11	64.90	12/29/15	69.16	4.26
AGW191	I	08/26/15	67.96	05/29/14	70.87	2.91
AGW192	D	09/08/11	63.51	12/31/15	70.97	7.46
AGW193	S	10/18/11	69.41	09/10/14	74.50	5.09
AGW194	S	10/18/11	69.74	12/31/15	74.40	4.66
AGW195	D	10/18/11	66.88	12/30/15	69.61	2.73
AGW196	I	10/18/11	66.77	12/30/15	69.27	2.50
AGW197	D	10/18/11	66.45	12/30/15	69.14	2.69
AGW198	I	10/18/11	66.48	12/30/15	69.01	2.53
AGW199	D	10/18/11	67.27	12/30/15	71.22	3.95
AGW200-1	S	11/18/11	71.65	12/30/15	75.74	4.09
AGW200-2	S	09/05/13	71.57	12/30/15	75.71	4.14
AGW200-3	I	11/18/11	71.62	12/30/15	75.71	4.09
AGW200-6	D	09/05/13	71.15	12/30/15	75.92	4.77
AGW201-1	S	11/21/11	71.52	12/30/15	75.94	4.42
AGW201-2	S	09/05/13	71.42	12/30/15	75.96	4.54
AGW201-5	I	09/05/13	71.26	12/30/15	76.08	4.82

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Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW201-6	D	09/05/13	71.22	12/30/15	76.06	4.84
AGW202-1	S	11/22/11	71.46	12/30/15	76.20	4.74
AGW202-2	S	09/05/13	71.38	12/30/15	76.19	4.81
AGW202-4	I	09/05/13	71.28	12/30/15	76.23	4.95
AGW202-6	D	09/05/13	71.24	12/30/15	76.23	4.99
AGW203-1	S	11/23/11	71.63	12/30/15	77.45	5.82
AGW203-2	S	09/05/13	71.32	12/30/15	76.57	5.25
AGW203-4	I	09/05/13	71.27	12/30/15	76.49	5.22
AGW203-6	D	09/05/13	71.24	12/30/15	76.50	5.26
AGW204	I	09/03/13	72.74	12/29/15	77.77	5.03
AGW205	I	09/03/13	72.68	12/29/15	77.12	4.44
AGW206	I	09/03/13	72.02	12/30/15	76.87	4.85
AGW207-1	S	12/08/11	68.29	12/30/15	70.10	1.81
AGW207-2	S	09/03/13	67.77	12/30/15	70.08	2.31
AGW207-3	I	12/08/11	68.32	12/30/15	70.09	1.77
AGW207-4	I	09/03/13	67.80	12/30/15	70.12	2.32
AGW207-5	I	12/08/11	68.32	12/30/15	70.12	1.80
AGW207-7	D	09/03/13	67.89	12/30/15	70.30	2.41
AGW208-1	S	12/08/11	68.97	12/30/15	71.25	2.28
AGW208-2	S	09/03/13	68.35	12/30/15	71.24	2.89
AGW208-3	I	12/08/11	68.96	12/30/15	71.28	2.32
AGW208-4	I	09/03/13	68.35	12/30/15	71.29	2.94
AGW208-5	I	12/09/11	69.11	12/30/15	71.71	2.60
AGW208-6	D	09/03/13	68.42	12/30/15	71.70	3.28
AGW208-7	D	12/09/11	69.11	12/30/15	71.78	2.67
AGW209-1	S	12/12/11	69.29	12/30/15	72.01	2.72
AGW209-2	S	09/03/13	68.56	12/30/15	72.01	3.45
AGW209-5	I	09/03/13	68.52	12/30/15	72.13	3.61
AGW209-6	D	09/03/13	68.50	12/30/15	72.02	3.52
AGW210-1	S	12/12/11	69.53	12/30/15	72.89	3.36
AGW210-2	S	09/03/13	68.65	12/30/15	72.84	4.19
AGW210-5	I	09/03/13	68.64	12/30/15	72.87	4.23
AGW210-6	D	09/03/13	68.59	12/30/15	72.85	4.26
AGW211-1	S	12/13/11	69.60	12/30/15	73.23	3.63
AGW211-2	S	09/03/13	68.83	12/30/15	73.24	4.41
AGW211-5	I	09/03/13	68.61	12/30/15	73.48	4.87
AGW211-6	D	09/03/13	68.59	12/30/15	73.46	4.87
AGW212-1	S	06/15/15	70.14	12/29/15	74.33	4.19
AGW212-2	S	09/04/13	68.48	12/29/15	74.53	6.05
AGW212-5	I	09/04/13	68.70	12/29/15	74.09	5.39
AGW212-7	D	09/04/13	68.66	06/18/12	75.95	7.29
AGW213	D	09/04/13	65.43	12/29/15	68.23	2.80
AGW214	I	09/03/13	64.23	12/29/15	68.03	3.80

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Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW215	I	08/27/15	61.32	12/6/12	64.47	3.15
AGW216	I	09/04/13	63.90	12/30/15	67.71	3.81
AGW217	I	09/03/13	62.62	12/29/15	65.92	3.30
AGW218	I	09/03/13	62.72	12/29/15	65.72	3.00
AGW219	I	12/31/15	56.83	04/26/12	61.55	4.72
AGW220	I	09/04/13	60.72	04/26/12	62.72	2.00
AGW221	I	09/03/13	61.58	05/27/14	65.05	3.47
AGW222	I	09/03/13	71.65	12/29/15	77.00	5.35
AGW223	D	09/03/13	72.12	12/30/15	76.37	4.25
AGW224	S(WT)	09/05/13	68.69	03/07/13	70.85	2.16
AGW225	S	08/14/15	67.93	12/08/15	70.66	2.73
AGW226	S	08/14/15	67.38	04/01/14	69.80	2.42
AGW227	I	08/27/15	66.45	12/06/15	69.36	2.91
AGW228	S	08/27/15	66.39	12/09/15	69.34	2.95
AGW229	S(WT)	09/04/13	69.74	12/31/15	73.86	4.12
AGW230	D	09/05/13	67.22	12/30/15	72.95	5.73
AGW231	S	06/15/15	66.56	12/30/15	69.00	2.44
AGW232	S	09/05/13	66.90	12/30/15	69.29	2.39
AGW233	D	09/06/13	66.41	12/29/15	70.68	4.27
AGW234	D	06/12/13	66.21	12/30/15	68.63	2.42
AGW235-1	S	08/19/13	66.58	03/11/14	67.61	1.03
AGW235-2	S	08/28/15	65.86	12/11/14	68.61	2.75
AGW235-3	S	06/16/15	67.05	12/30/15	68.50	1.45
AGW235-4	I	08/28/15	66.17	03/11/14	68.68	2.51
AGW235-5	I	06/16/15	67.07	12/30/15	68.50	1.43
AGW235-6	I	06/16/15	67.05	12/30/15	68.48	1.43
AGW235-7	D	06/16/15	67.02	12/30/15	68.50	1.48
AGW236	S	08/19/13	67.29	03/13/14	69.25	1.96
AGW237	D	08/28/15	64.35	12/29/15	66.99	2.64
AGW238	I	08/28/15	64.00	12/29/15	65.86	1.86
AGW239	S	08/28/15	63.85	12/29/15	65.56	1.71
AGW240-1	S(WT)	08/14/15	68.21	12/07/15	69.64	1.43
AGW240-3	S	09/03/14	69.13	12/31/15	70.48	1.35
AGW240-5	S	08/14/15	68.34	12/07/15	70.63	2.29
AGW241-1	S(WT)	08/26/15	68.31	12/31/15	70.24	1.93
AGW241-3	S	09/04/14	69.40	12/31/15	70.90	1.50
AGW241-5	S	08/26/15	68.41	12/31/15	70.93	2.52
AGW242-1	S(WT)	08/25/15	66.91	12/31/15	68.81	1.90
AGW242-2	S	08/25/15	66.92	12/31/15	69.01	2.09
AGW242-3	S	06/16/15	67.82	12/31/15	68.99	1.17
AGW242-4	I	09/03/14	67.94	12/31/15	69.24	1.30
AGW242-5	I	08/25/15	66.92	12/31/15	69.26	2.34
AGW242-6	I	09/03/14	67.96	12/31/15	69.27	1.31

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Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW243-1	S(WT)	08/26/15	65.79	12/31/15	67.25	1.46
AGW243-3	S	08/26/15	65.98	03/02/15	68.44	2.46
AGW243-5	I	08/26/15	66.45	12/31/15	68.40	1.95
AGW244	S(WT)	08/25/15	67.40	12/03/15	70.03	2.63
AGW245	S(WT)	08/26/15	66.45	12/03/15	68.70	2.25
AGW246	S(WT)	08/26/15	67.01	12/03/15	69.77	2.76
AGW247-1	S(WT)	08/14/15	67.59	12/31/15	69.75	2.16
AGW247-3	S	09/04/14	68.44	12/31/15	69.77	1.33
AGW247-5	S	08/14/15	67.58	12/31/15	69.76	2.18
AGW248-1	S(WT)	08/26/15	67.75	12/08/15	69.87	2.12
AGW248-3	S	09/04/14	68.69	12/31/15	70.45	1.76
AGW248-5	S	08/26/15	67.84	12/08/15	70.54	2.70
AGW249-1	S(WT)	08/26/15	66.90	12/09/15	69.46	2.56
AGW249-3	S	09/05/14	68.41	12/31/15	70.17	1.76
AGW249-5	S	08/26/15	67.55	12/09/15	70.36	2.81
AGW250-1	S(WT)	08/25/15	71.04	12/30/15	75.70	4.66
AGW250-2	S	08/25/15	71.01	12/30/15	75.68	4.67
AGW250-3	I	08/25/15	71.00	12/30/15	75.68	4.68
AGW250-4	I	09/04/14	71.57	12/30/15	75.48	3.91
AGW250-5	I	09/04/14	71.46	12/30/15	75.43	3.97
AGW250-6	D	08/25/15	70.81	12/30/15	75.50	4.69
AGW250-7	D	09/04/14	71.45	12/30/15	75.47	4.02
AGW251-1	S(WT)	08/14/15	69.09	12/31/15	72.14	3.05
AGW251-2	S	08/14/15	69.08	12/31/15	72.17	3.09
AGW251-3	I	08/14/15	69.11	12/31/15	72.28	3.17
AGW251-4	I	09/03/14	70.14	12/31/15	73.52	3.38
AGW251-5	I	09/03/14	70.14	12/31/15	73.51	3.37
AGW251-6	D	08/27/15	68.98	12/31/15	73.50	4.52
AGW251-7	D	09/03/14	70.10	12/31/15	73.49	3.39
AGW252	D	08/27/15	61.73	12/29/15	63.23	1.50
AGW253	I	08/27/15	61.68	12/29/15	63.18	1.50
AGW254-1	S(WT)	08/27/15	61.33	12/10/14	63.26	1.93
AGW254-2	S	08/27/15	61.41	12/29/15	63.07	1.66
AGW254-3	S	06/16/15	61.60	12/29/15	63.09	1.49
AGW254-4	I	06/16/15	61.62	12/29/15	63.08	1.46
AGW254-5	I	08/27/15	61.43	12/29/15	63.09	1.66
AGW254-6	I	06/16/15	61.64	12/29/15	63.09	1.45
AGW255-1	S(WT)	08/28/15	65.59	12/10/14	67.38	1.79
AGW255-3	S	08/28/15	65.82	12/30/15	68.45	2.63
AGW255-5	I	06/09/15	67.20	12/10/14	68.27	1.07
AGW256	I	08/26/15	68.66	12/30/15	75.92	7.26
AGW257	S	08/26/15	68.55	12/30/15	75.78	7.23
AGW258	S	08/26/15	71.29	03/02/15	74.59	3.30

Table 4-3
Minumim and Maximum Groundwater Elevations
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Minimum Groundwater Elevation Date	Minimum Groundwater Elevations (ft, msl)	Maximum Groundwater Elevation Date	Maximum Groundwater Elevations (ft, msl)	Fluctuation (ft)
AGW259	D	08/27/15	61.49	12/29/15	63.09	1.60
AGW260	D	08/25/15	66.90	12/31/15	69.27	2.37
AGW261	S	08/27/15	69.63	12/31/15	73.25	3.62
AGW262	S(WT)	08/27/15	67.21	12/31/15	69.30	2.09
AGW263	S(WT)	08/25/15	67.54	12/22/15	69.27	1.73
AGW264	D	06/08/15	63.43	04/09/15	70.78	7.35
AGW265	I	08/25/15	68.24	12/31/15	71.51	3.27
AGW266	S	08/28/15	61.07	12/29/15	64.24	3.17
AGW267	I	08/25/15	68.48	12/31/15	70.86	2.38
AGW268	D	06/16/15	68.20	12/31/15	71.35	3.15
AGW269	S	08/27/15	68.50	12/30/15	71.41	2.91
AGW270	S	08/13/15	68.72	12/30/15	71.28	2.56
AGW271	S	08/13/15	68.66	12/30/15	71.19	2.53
AGW272	S	08/13/15	67.98	12/30/15	70.18	2.20
AGW273	S	08/13/15	68.15	12/07/15	70.46	2.31
AGW274	S	08/13/15	68.26	12/30/15	70.53	2.27
AGW275	S	08/13/15	68.35	12/30/15	70.42	2.07
AGW276-1	S(WT)	12/08/15	72.49	12/30/15	74.48	1.99
AGW276-2	S	12/08/15	72.49	12/30/15	74.46	1.97
AGW276-3	S	12/08/15	72.51	12/30/15	74.47	1.96
AGW276-4	I	12/09/15	72.35	12/30/15	75.00	2.65
AGW276-5	I	12/30/15	74.95	12/08/15	75.13	0.18
AGW276-6	D	12/08/15	72.39	12/30/15	74.98	2.59
AGW276-7	D	12/08/15	72.33	12/30/15	74.92	2.59
APP-057	S	08/27/15	63.43	12/09/15	65.59	2.16
APP-058	S	06/15/15	63.64	12/29/15	66.34	2.70
APP-069	S	08/27/15	61.67	12/29/15	63.16	1.49

Notes:

1. Water table is a subset of the shallow zone.
2. Vertical Datum: National Geodetic Vertical Datum of 1929, US ft (+/-0.01 ft), msl.
3. Water level data presented is for the current monitoring well network.

(a) Replacement wells (signified by R) minimum and maximum groundwater elevation includes comparison with original well groundwater elevation.

Abbreviations/Acronyms:

D = deep zone
ft = feet
I = intermediate zone
msl = mean sea level
S = shallow zone
S(WT) = shallow zone (water table)

Table 4-4
Porosity and Bulk Density
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Depth (ft bgs)	Dry Density (pcf)	Porosity (unitless)
AGW100	20	84	0.53
AGW101	50	100	0.42
AGW102	110	117	0.31
AGW103	20	79	0.54
AGW104	20	90	0.47
AGW105	50	88	0.52

Abbreviations/Acronyms:
bgs = below ground surface
ft = feet
pcf = pounds per cubic foot

Table 4-5a
Vertical Hydraulic Gradient June 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW100	Shallow	74.75	85.72	20.00	65.72	-0.10	29.92	-0.0033	Upward
AGW101(I)	Intermediate	74.85	85.80	50.00	35.80				
AGW250-2	Shallow	73.44	78.79	26.25	52.54	0.21	25.00	0.0084	Downward
AGW250-4	Intermediate	73.23	78.79	51.25	27.54				
AGW200-2	Shallow	73.11	86.72	29.50	57.22	0.15	30.00	0.0050	Downward
AGW200-5	Intermediate	72.96	86.72	59.50	27.22				
AGW201-2	Shallow	73.13	86.65	29.50	57.15	0.14	30.00	0.0047	Downward
AGW201-5	Intermediate	72.99	86.65	59.50	27.15				
AGW202-2	Shallow	73.14	86.72	30.50	56.22	0.09	20.00	0.0045	Downward
AGW202-4	Intermediate	73.05	86.72	50.50	36.22				
AGW203-2	Shallow	73.19	86.85	29.50	57.35	0.07	19.00	0.0037	Downward
AGW203-4	Intermediate	73.12	86.85	48.50	38.35				
AGW031R	Shallow	71.89	86.22	23.00	63.22	0.21	27.28	0.0077	Downward
AGW095R	Intermediate	71.68	85.94	50.00	35.94				
AGW136	Shallow	71.57	86.89	23.00	63.89	-0.01	15.44	-0.0006	Upward
AGW137	Intermediate	71.58	86.95	38.50	48.45				
AGW193	Shallow	70.74	78.58	24.75	53.83	-0.08	30.28	-0.0026	Upward
AGW166	Intermediate	70.82	78.00	54.45	23.55				
AGW194	Shallow	71.40	82.52	24.50	58.02	-0.06	19.97	-0.0030	Upward
AGW158(I)	Intermediate	71.46	82.55	44.50	38.05				
AGW251-2	Shallow	70.60	76.46	25.25	51.21	-0.70	27.00	-0.0259	Upward
AGW251-4	Intermediate	71.30	76.46	52.25	24.21				
AGW224	Shallow	68.98	73.25	9.45	63.80	0.12	42.90	0.0028	Downward
AGW182	Intermediate	68.86	73.40	52.50	20.90				
AGW225	Shallow	69.00	72.71	9.00	63.71	-0.41	45.99	-0.0089	Upward
AGW191	Intermediate	69.41	72.72	55.00	17.72				
AGW229	Shallow	71.08	80.45	9.90	70.55	-0.03	45.02	-0.0007	Upward
AGW170	Intermediate	71.11	80.53	55.00	25.53				
AGW242-3	Shallow	67.82	70.09	26.75	43.34	-0.17	23.50	-0.0072	Upward
AGW242-5	Intermediate	67.99	70.09	50.25	19.84				
AGW212-2	Shallow	70.89	83.32	29.75	53.57	0.56	30.00	0.0187	Downward
AGW212-5	Intermediate	70.33	83.32	59.75	23.57				
AGW211-2	Shallow	70.25	83.32	29.75	53.57	0.16	30.00	0.0053	Downward
AGW211-5	Intermediate	70.09	83.32	59.75	23.57				
AGW210-2	Shallow	69.92	80.63	30.00	50.63	-0.04	30.00	-0.0013	Upward
AGW210-5	Intermediate	69.96	80.63	60.00	20.63				
AGW209-2	Shallow	69.62	78.73	29.50	49.23	0.00	30.00	0.0000	Neutral
AGW209-5	Intermediate	69.62	78.73	59.50	19.23				
AGW208-2	Shallow	69.25	75.80	29.30	46.50	-0.04	20.00	-0.0020	Upward
AGW208-4	Intermediate	69.29	75.80	49.30	26.50				
AGW207-2	Shallow	68.46	76.87	29.75	47.12	0.00	20.00	0.0000	Neutral
AGW207-4	Intermediate	68.46	76.87	49.75	27.12				
AGW235-2	Shallow	66.40	70.23	18.75	51.48	-0.67	20.00	-0.0335	Upward
AGW235-4	Intermediate	67.07	70.23	38.75	31.48				

Table 4-5a
Vertical Hydraulic Gradient June 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW232	Shallow	67.77	78.26	25.50	52.76	-0.26	24.67	-0.0105	Upward
AGW196	Intermediate	68.03	78.09	50.00	28.09				
AGW231	Shallow	66.56	73.50	25.00	48.50	-1.33	28.11	-0.0473	Upward
AGW198	Intermediate	67.89	73.39	53.00	20.39				
AGW239	Shallow	64.77	71.16	25.50	45.66	0.21	30.66	0.0068	Downward
AGW238	Intermediate	64.56	71.00	56.00	15.00				
AGW254-3	Shallow	61.6	66.46	31.25	35.21	-0.04	30	-0.0013	Upward
AGW254-6	Intermediate	61.64	66.46	61.25	5.21				
APP-069	Shallow	61.96	65.88	15	50.88	-0.03	27.98	-0.0011	Upward
AGW253	Intermediate	61.99	65.9	43	22.9				
AGW101(I)	Intermediate	74.85	85.80	50.00	35.80	0.16	32.91	0.0049	Downward
AGW102(D)	Deep	74.69	85.89	83.00	2.89				
AGW250-4	Intermediate	73.23	78.79	51.25	27.54	0.03	30.00	0.0010	Downward
AGW250-6	Deep	73.20	78.79	81.25	-2.46				
AGW200-5	Intermediate	72.96	86.72	59.50	27.22	0.12	20.00	0.0060	Downward
AGW200-6	Deep	72.84	86.72	79.50	7.22				
AGW201-5	Intermediate	72.99	86.65	59.50	27.15	0.04	20.00	0.0020	Downward
AGW201-6	Deep	72.95	86.65	79.50	7.15				
AGW202-4	Intermediate	73.05	86.72	50.50	36.22	0.04	30.00	0.0013	Downward
AGW202-6	Deep	73.01	86.72	80.50	6.22				
AGW203-4	Intermediate	73.12	86.85	48.50	38.35	0.03	31.00	0.0010	Downward
AGW203-6	Deep	73.09	86.85	79.50	7.35				
AGW095R	Intermediate	71.68	85.58	50.00	35.58	-0.32	35.02	-0.0091	Upward
AGW098R	Deep	72.00	86.06	85.50	0.56				
AGW137	Intermediate	71.58	86.89	38.50	48.39	0.12	45.19	0.0027	Downward
AGW138	Deep	71.46	86.95	83.75	3.20				
AGW166	Intermediate	70.82	78.00	54.45	23.55	-0.44	34.96	-0.0126	Upward
AGW167	Deep	71.26	78.34	89.75	-11.41				
AGW158(I)	Intermediate	71.46	82.55	44.50	38.05	-0.07	40.41	-0.0017	Upward
AGW159(D)	Deep	71.53	82.64	85.00	-2.36				
AGW251-4	Intermediate	71.30	76.46	52.25	24.21	0.01	24.00	0.0004	Downward
AGW251-6	Deep	71.29	76.46	76.25	0.21				
AGW182	Intermediate	68.86	73.40	52.50	20.90	-0.08	36.81	-0.0022	Upward
AGW183	Deep	68.94	73.34	89.25	-15.91				
AGW191	Intermediate	69.41	72.72	55.00	17.72	-0.09	34.51	-0.0026	Upward
AGW192	Deep	69.50	72.71	89.50	-16.79				
AGW170	Intermediate	71.11	80.53	55.00	25.53	-0.2	22.31	-0.0090	Upward
AGW171	Deep	71.31	80.72	77.50	3.22				
AGW242-5	Intermediate	67.99	69.84	50.25	19.59	0.03	30.62	0.0010	Downward
AGW260	Deep	67.96	69.47	80.50	-11.03				
AGW212-5	Intermediate	70.33	83.32	59.75	23.57	-0.03	39.90	-0.0008	Upward
AGW212-7	Deep	70.36	83.32	99.65	-16.33				
AGW211-5	Intermediate	70.09	82.58	60.00	22.58	0.02	20.00	0.0010	Downward
AGW211-6	Deep	70.07	82.58	80.00	2.58				

Table 4-5a
Vertical Hydraulic Gradient June 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW210-5	Intermediate	69.96	80.63	60.00	20.63	0.05	20.00	0.0025	Downward
AGW210-6	Deep	69.91	80.63	80.00	0.63				
AGW209-5	Intermediate	69.62	78.73	59.50	19.23	0	20.00	0.0000	Neutral
AGW209-6	Deep	69.62	78.73	79.50	-0.77				
AGW208-4	Intermediate	69.29	75.80	49.30	26.50	-0.14	30.00	-0.0047	Upward
AGW208-6	Deep	69.43	75.80	79.30	-3.50				
AGW207-4	Intermediate	68.46	76.87	49.75	27.12	-0.12	30.25	-0.0040	Upward
AGW207-7	Deep	68.58	76.87	80.00	-3.13				
AGW235-4	Intermediate	67.07	70.23	38.75	31.48	0.05	32.25	0.0016	Downward
AGW235-7	Deep	67.02	70.23	71.00	-0.77				
AGW196	Intermediate	68.03	78.09	50.00	28.09	-0.21	34.91	-0.0060	Upward
AGW195	Deep	68.24	78.18	85.00	-6.82				
AGW198	Intermediate	67.89	73.39	53.00	20.39	0.01	27.14	0.0004	Downward
AGW197	Deep	67.88	73.25	80.00	-6.75				
AGW238	Intermediate	64.56	71.00	56.00	15.00	-1.11	19.18	-0.0579	Upward
AGW237	Deep	65.67	70.82	75.00	-4.18				
AGW254-6	Intermediate	61.64	66.46	61.25	5.21	0.01	10.26	0.0010	Downward
AGW259	Deep	61.63	66.45	71.5	-5.05				
AGW253	Intermediate	61.99	65.9	43	22.90	-0.07	18.99	-0.0037	Upward
AGW252	Deep	62.06	65.91	62	3.91				
AGW100	Shallow	74.75	85.72	20.00	65.72	0.06	62.83	0.0010	Downward
AGW102(D)	Deep	74.69	85.89	83.00	2.89				
AGW250-2	Shallow	73.44	78.79	26.25	52.54	0.24	55.00	0.0044	Downward
AGW250-6	Deep	73.20	78.79	81.25	-2.46				
AGW200-2	Shallow	73.11	86.72	29.50	57.22	0.27	50.00	0.0054	Downward
AGW200-6	Deep	72.84	86.72	79.50	7.22				
AGW201-2	Shallow	73.13	86.65	29.50	57.15	0.18	50.00	0.0036	Downward
AGW201-6	Deep	72.95	86.65	79.50	7.15				
AGW202-2	Shallow	73.14	86.72	30.50	56.22	0.13	50.00	0.0026	Downward
AGW202-6	Deep	73.01	86.72	80.50	6.22				
AGW203-2	Shallow	73.19	86.85	29.50	57.35	0.10	50.00	0.0020	Downward
AGW203-6	Deep	73.09	86.85	79.50	7.35				
AGW031R	Shallow	71.89	86.22	23.00	63.22	-0.11	62.66	-0.0018	Upward
AGW098R	Deep	72.00	86.06	85.50	0.56				
AGW136	Shallow	71.57	86.89	23.00	63.89	0.11	60.69	0.0018	Downward
AGW138	Deep	71.46	86.95	83.75	3.20				
AGW193	Shallow	70.74	78.58	24.75	53.83	-0.52	65.24	-0.0080	Upward
AGW167	Deep	71.26	78.34	89.75	-11.41				
AGW194	Shallow	71.40	82.52	24.50	58.02	-0.13	60.38	-0.0022	Upward
AGW159(D)	Deep	71.53	82.64	85.00	-2.36				
AGW251-2	Shallow	70.60	76.46	25.25	51.21	-0.69	51.00	-0.0135	Upward
AGW251-6	Deep	71.29	76.46	76.25	0.21				
AGW224	Shallow	68.98	73.25	9.45	63.80	0.04	79.71	0.0005	Downward
AGW183	Deep	68.94	73.34	89.25	-15.91				

Table 4-5a
Vertical Hydraulic Gradient June 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW225	Shallow	69.00	72.71	9.00	63.71	-0.50	80.50	-0.0062	Upward
AGW192	Deep	69.50	72.71	89.50	-16.79				
AGW229	Shallow	71.08	80.45	9.90	70.55	-0.23	67.33	-0.0034	Upward
AGW171	Deep	71.31	80.72	77.50	3.22				
AGW242-3	Shallow	67.82	70.09	26.75	43.34	-0.14	54.37	-0.0026	Upward
AGW260	Deep	67.96	69.47	80.50	-11.03				
AGW212-2	Shallow	70.89	83.32	29.75	53.57	0.53	69.90	0.0076	Downward
AGW212-7	Deep	70.36	83.32	99.65	-16.33				
AGW211-2	Shallow	70.25	83.32	29.75	53.57	0.18	50.99	0.0035	Downward
AGW211-6	Deep	70.07	82.58	80.00	2.58				
AGW210-2	Shallow	69.92	80.63	30.00	50.63	0.01	50.00	0.0002	Downward
AGW210-6	Deep	69.91	80.63	80.00	0.63				
AGW209-2	Shallow	69.62	78.73	29.50	49.23	0.00	50.00	0.0000	Neutral
AGW209-6	Deep	69.62	78.73	79.50	-0.77				
AGW208-2	Shallow	69.25	75.80	29.30	46.50	-0.18	50.00	-0.0036	Upward
AGW208-6	Deep	69.43	75.80	79.30	-3.50				
AGW207-2	Shallow	68.46	76.87	29.75	47.12	-0.12	50.25	-0.0024	Upward
AGW207-7	Deep	68.58	76.87	80.00	-3.13				
AGW235-2	Shallow	66.40	70.23	18.75	51.48	-0.62	52.25	-0.0119	Upward
AGW235-7	Deep	67.02	70.23	71.00	-0.77				
AGW232	Shallow	67.77	78.26	25.50	52.76	-0.47	59.58	-0.0079	Upward
AGW195	Deep	68.24	78.18	85.00	-6.82				
AGW231	Shallow	66.56	73.50	25.00	48.50	-1.32	55.25	-0.0239	Upward
AGW197	Deep	67.88	73.25	80.00	-6.75				
AGW239	Shallow	64.77	71.16	25.50	45.66	-0.90	49.84	-0.0181	Upward
AGW237	Deep	65.67	70.82	75.00	-4.18				
AGW254-3	Shallow	61.60	66.46	31.25	35.21	-0.03	40.26	-0.0007	Upward
AGW259	Deep	61.63	66.45	71.50	-5.05				
APP-069	Shallow	61.96	65.88	15.00	50.88	-0.10	46.97	-0.0021	Upward
AGW252	Deep	62.06	65.91	62.00	3.91				

Note:
1. Vertical Datum: National Geodetic Vertical Datum of 1929, US ft (+/-0.01 ft), msl.

Abbreviations/Acronyms:
bgs = below ground surface
ft = foot/feet
msl = mean sea level

Table 4-5b
Vertical Hydraulic Gradient December 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW100	Shallow	76.94	85.72	20.00	65.72	-0.05	29.92	-0.0017	Upward
AGW101(I)	Intermediate	76.99	85.80	50.00	35.80				
AGW250-2	Shallow	75.68	78.79	26.25	52.54	0.20	25.00	0.0080	Downward
AGW250-4	Intermediate	75.48	78.79	51.25	27.54				
AGW200-2	Shallow	75.71	86.72	29.50	57.22	-0.16	30.00	-0.0053	Upward
AGW200-5	Intermediate	75.87	86.72	59.50	27.22				
AGW201-2	Shallow	75.96	86.65	29.50	57.15	-0.12	30.00	-0.0040	Upward
AGW201-5	Intermediate	76.08	86.65	59.50	27.15				
AGW202-2	Shallow	76.19	86.72	30.50	56.22	-0.04	20.00	-0.0020	Upward
AGW202-4	Intermediate	76.23	86.72	50.50	36.22				
AGW203-2	Shallow	76.57	86.85	29.50	57.35	0.08	19.00	0.0042	Downward
AGW203-4	Intermediate	76.49	86.85	48.50	38.35				
AGW031R	Shallow	75.23	86.22	23.00	63.22	-0.02	27.28	-0.0007	Upward
AGW095R	Intermediate	75.25	85.94	50.00	35.94				
AGW136	Shallow	75.12	86.89	23.00	63.89	-0.01	15.44	-0.0006	Upward
AGW137	Intermediate	75.13	86.95	38.50	48.45				
AGW193	Shallow	73.00	78.58	24.75	53.83	-0.16	30.28	-0.0053	Upward
AGW166	Intermediate	73.16	78.00	54.45	23.55				
AGW194	Shallow	74.40	82.52	24.50	58.02	0.00	19.97	0.0000	Neutral
AGW158(I)	Intermediate	74.40	82.55	44.50	38.05				
AGW251-2	Shallow	72.17	76.46	25.25	51.21	-1.35	27.00	-0.0500	Upward
AGW251-4	Intermediate	73.52	76.46	52.25	24.21				
AGW276-2	Shallow	74.46	79.11	25.25	53.86	-0.49	35.00	-0.0140	Upward
AGW276-5	Intermediate	74.95	79.11	60.25	18.86				
AGW224	Shallow	70.50	73.25	9.45	63.80	0.19	42.90	0.0044	Downward
AGW182	Intermediate	70.31	73.40	52.50	20.90				
AGW225	Shallow	70.15	72.71	9.00	63.71	-0.70	45.99	-0.0152	Upward
AGW191	Intermediate	70.85	72.72	55.00	17.72				
AGW229	Shallow	73.86	80.45	9.90	70.55	-0.10	45.02	-0.0022	Upward
AGW170	Intermediate	73.96	80.53	55.00	25.53				
AGW242-3	Shallow	68.99	70.09	26.75	43.34	-0.27	23.50	-0.0115	Upward
AGW242-5	Intermediate	69.26	70.09	50.25	19.84				
AGW212-2	Shallow	74.53	83.32	29.75	53.57	0.44	30.00	0.0147	Downward
AGW212-5	Intermediate	74.09	83.32	59.75	23.57				
AGW211-2	Shallow	73.24	83.32	29.75	53.57	-0.24	30.00	-0.0080	Upward
AGW211-5	Intermediate	73.48	83.32	59.75	23.57				
AGW210-2	Shallow	72.84	80.63	30.00	50.63	-0.03	30.00	-0.0010	Upward
AGW210-5	Intermediate	72.87	80.63	60.00	20.63				
AGW209-2	Shallow	72.01	78.73	29.50	49.23	-0.12	30.00	-0.0040	Upward
AGW209-5	Intermediate	72.13	78.73	59.50	19.23				
AGW208-2	Shallow	71.24	75.80	29.30	46.50	-0.05	20.00	-0.0025	Upward
AGW208-4	Intermediate	71.29	75.80	49.30	26.50				
AGW207-2	Shallow	70.07	76.87	29.75	47.12	-0.04	20.00	-0.0020	Upward
AGW207-4	Intermediate	70.11	76.87	49.75	27.12				

Table 4-5b
Vertical Hydraulic Gradient December 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW235-2	Shallow	67.63	70.23	18.75	51.48	-0.87	20.00	-0.0435	Upward
AGW235-4	Intermediate	68.50	70.23	38.75	31.48				
AGW232	Shallow	69.29	78.26	25.50	52.76	-0.28	24.67	-0.0113	Upward
AGW196	Intermediate	69.57	78.09	50.00	28.09				
AGW231	Shallow	69.00	73.50	25.00	48.50	-0.30	28.11	-0.0107	Upward
AGW198	Intermediate	69.30	73.39	53.00	20.39				
AGW239	Shallow	65.56	71.16	25.50	45.66	-0.30	30.66	-0.0098	Upward
AGW238	Intermediate	65.86	71.00	56.00	15.00				
AGW254-3	Shallow	63.09	66.46	31.25	35.21	0	30	0.0000	Neutral
AGW254-6	Intermediate	63.09	66.46	61.25	5.21				
APP-069	Shallow	63.16	65.88	15.00	50.88	-0.02	27.98	-0.0007	Upward
AGW253	Intermediate	63.18	65.9	43.00	22.9				
AGW101(I)	Intermediate	76.99	85.80	50.00	35.80	0.17	32.91	0.0052	Downward
AGW102(D)	Deep	76.82	85.89	83.00	2.89				
AGW250-4	Intermediate	75.48	78.79	51.25	27.54	-0.02	30.00	-0.0007	Upward
AGW250-6	Deep	75.50	78.79	81.25	-2.46				
AGW200-5	Intermediate	75.87	86.72	59.50	27.22	-0.05	20.00	-0.0025	Upward
AGW200-6	Deep	75.92	86.72	79.50	7.22				
AGW201-5	Intermediate	76.08	86.65	59.50	27.15	0.02	20.00	0.0010	Downward
AGW201-6	Deep	76.06	86.65	79.50	7.15				
AGW202-4	Intermediate	76.23	86.72	50.50	36.22	0.00	30.00	0.0000	Neutral
AGW202-6	Deep	76.23	86.72	80.50	6.22				
AGW203-4	Intermediate	76.49	86.85	48.50	38.35	-0.01	31.00	-0.0003	Upward
AGW203-6	Deep	76.50	86.85	79.50	7.35				
AGW095R	Intermediate	75.25	85.58	50.00	35.58	-0.10	35.02	-0.0029	Upward
AGW098R	Deep	75.35	86.06	85.50	0.56				
AGW137	Intermediate	75.13	86.89	38.50	48.39	0.02	45.19	0.0004	Downward
AGW138	Deep	75.11	86.95	83.75	3.20				
AGW166	Intermediate	73.16	78.00	54.45	23.55	-0.75	34.96	-0.0215	Upward
AGW167	Deep	73.91	78.34	89.75	-11.41				
AGW158(I)	Intermediate	74.40	82.55	44.50	38.05	-0.23	40.41	-0.0057	Upward
AGW159(D)	Deep	74.63	82.64	85.00	-2.36				
AGW251-4	Intermediate	63.08	76.46	52.25	24.21	-0.01	24.00	-0.0004	Upward
AGW251-6	Deep	63.09	76.46	76.25	0.21				
AGW276-5	Intermediate	74.95	79.11	60.25	18.86	-0.03	20.00	-0.0015	Upward
AGW276-6	Deep	74.98	79.11	80.25	-1.14				
AGW182	Intermediate	70.31	73.40	52.50	20.90	0.87	36.81	0.0236	Downward
AGW183	Deep	69.44	73.34	89.25	-15.91				
AGW191	Intermediate	70.85	72.72	55.00	17.72	-0.12	34.51	-0.0035	Upward
AGW192	Deep	70.97	72.71	89.50	-16.79				
AGW170	Intermediate	73.96	80.53	55.00	25.53	-0.2	22.31	-0.0090	Upward
AGW171	Deep	74.16	80.72	77.50	3.22				
AGW242-5	Intermediate	69.26	69.84	50.25	19.59	-0.01	30.62	-0.0003	Upward
AGW260	Deep	69.27	69.47	80.50	-11.03				

Table 4-5b
Vertical Hydraulic Gradient December 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW212-5	Intermediate	74.09	83.32	59.75	23.57	0.00	39.90	0.0000	Neutral
AGW212-7	Deep	74.09	83.32	99.65	-16.33				
AGW211-5	Intermediate	73.48	82.58	60.00	22.58	0.02	20.00	0.0010	Downward
AGW211-6	Deep	73.46	82.58	80.00	2.58				
AGW210-5	Intermediate	72.87	80.63	60.00	20.63	0.02	20.00	0.0010	Downward
AGW210-6	Deep	72.85	80.63	80.00	0.63				
AGW209-5	Intermediate	72.13	78.73	59.50	19.23	0.11	20.00	0.0055	Downward
AGW209-6	Deep	72.02	78.73	79.50	-0.77				
AGW208-4	Intermediate	71.29	75.80	49.30	26.50	-0.41	30.00	-0.0137	Upward
AGW208-6	Deep	71.70	75.80	79.30	-3.50				
AGW207-4	Intermediate	70.11	76.87	49.75	27.12	-0.18	30.25	-0.0060	Upward
AGW207-7	Deep	70.29	76.87	80.00	-3.13				
AGW235-4	Intermediate	68.50	70.23	38.75	31.48	0.00	32.25	0.0000	Neutral
AGW235-7	Deep	68.50	70.23	71.00	-0.77				
AGW196	Intermediate	69.57	78.09	50.00	28.09	-0.34	34.91	-0.0097	Upward
AGW195	Deep	69.91	78.18	85.00	-6.82				
AGW198	Intermediate	69.30	73.39	53.00	20.39	-0.15	27.14	-0.0055	Upward
AGW197	Deep	69.45	73.25	80.00	-6.75				
AGW238	Intermediate	65.86	71.00	56.00	15.00	-1.13	19.18	-0.0589	Upward
AGW237	Deep	66.99	70.82	75.00	-4.18				
AGW254-6	Intermediate	63.09	66.46	61.25	5.21	0	10.26	0.0000	Neutral
AGW259	Deep	63.09	66.45	71.5	-5.05				
AGW253	Intermediate	63.18	65.9	43	22.90	-0.05	18.99	-0.0026	Upward
AGW252	Deep	63.23	65.91	62	3.91				
AGW100	Shallow	76.94	85.72	20.00	65.72	0.12	62.83	0.0019	Downward
AGW102(D)	Deep	76.82	85.89	83.00	2.89				
AGW250-2	Shallow	75.68	78.79	26.25	52.54	0.18	55.00	0.0033	Downward
AGW250-6	Deep	75.50	78.79	81.25	-2.46				
AGW200-2	Shallow	75.71	86.72	29.50	57.22	-0.21	50.00	-0.0042	Upward
AGW200-6	Deep	75.92	86.72	79.50	7.22				
AGW201-2	Shallow	75.96	86.65	29.50	57.15	-0.10	50.00	-0.0020	Upward
AGW201-6	Deep	76.06	86.65	79.50	7.15				
AGW202-2	Shallow	76.19	86.72	30.50	56.22	-0.04	50.00	-0.0008	Upward
AGW202-6	Deep	76.23	86.72	80.50	6.22				
AGW203-2	Shallow	76.57	86.85	29.50	57.35	0.07	50.00	0.0014	Downward
AGW203-6	Deep	76.50	86.85	79.50	7.35				
AGW031R	Shallow	75.23	86.22	23.00	63.22	-0.12	62.66	-0.0019	Upward
AGW098R	Deep	75.35	86.06	85.50	0.56				
AGW136	Shallow	75.12	86.89	23.00	63.89	0.01	60.69	0.0002	Downward
AGW138	Deep	75.11	86.95	83.75	3.20				
AGW193	Shallow	73.00	78.58	24.75	53.83	-0.91	65.24	-0.0139	Upward
AGW167	Deep	73.91	78.34	89.75	-11.41				
AGW194	Shallow	74.40	82.52	24.50	58.02	-0.23	60.38	-0.0038	Upward
AGW159(D)	Deep	74.63	82.64	85.00	-2.36				

Table 4-5b
Vertical Hydraulic Gradient December 2015
Boeing Auburn Remedial Investigation
Auburn, Washington

Well Cluster	Groundwater Zone	Groundwater Elevation (ft, msl)	Ground Surface Elevation (ft, msl)	Center of Screen (bgs)	Center of Screen Elevation (ft, msl)	Water Level Difference (ft)	Screen Elevation Difference (ft)	Vertical Hydraulic Gradient	
AGW251-2	Shallow	72.17	76.46	25.25	51.21	9.08	51.00	0.1780	Downward
AGW251-6	Deep	63.09	76.46	76.25	0.21				
AGW276-2	Shallow	74.46	79.11	25.25	53.86	-0.52	55.00	-0.0095	Upward
AGW276-6	Deep	74.98	79.11	80.25	-1.14				
AGW224	Shallow	70.50	73.25	9.45	63.80	1.06	79.71	0.0133	Downward
AGW183	Deep	69.44	73.34	89.25	-15.91				
AGW225	Shallow	70.15	72.71	9.00	63.71	-0.82	80.50	-0.0102	Upward
AGW192	Deep	70.97	72.71	89.50	-16.79				
AGW229	Shallow	73.86	80.45	9.90	70.55	-0.30	67.33	-0.0045	Upward
AGW171	Deep	74.16	80.72	77.50	3.22				
AGW242-3	Shallow	68.99	70.09	26.75	43.34	-0.28	54.37	-0.0052	Upward
AGW260	Deep	69.27	69.47	80.50	-11.03				
AGW212-2	Shallow	74.53	83.32	29.75	53.57	0.44	69.90	0.0063	Downward
AGW212-7	Deep	74.09	83.32	99.65	-16.33				
AGW211-2	Shallow	73.24	83.32	29.75	53.57	-0.22	50.99	-0.0043	Upward
AGW211-6	Deep	73.46	82.58	80.00	2.58				
AGW210-2	Shallow	72.84	80.63	30.00	50.63	-0.01	50.00	-0.0002	Upward
AGW210-6	Deep	72.85	80.63	80.00	0.63				
AGW209-2	Shallow	72.01	78.73	29.50	49.23	-0.01	50.00	-0.0002	Upward
AGW209-6	Deep	72.02	78.73	79.50	-0.77				
AGW208-2	Shallow	71.24	75.80	29.30	46.50	-0.46	50.00	-0.0092	Upward
AGW208-6	Deep	71.70	75.80	79.30	-3.50				
AGW207-2	Shallow	70.07	76.87	29.75	47.12	-0.22	50.25	-0.0044	Upward
AGW207-7	Deep	70.29	76.87	80.00	-3.13				
AGW235-2	Shallow	67.63	70.23	18.75	51.48	-0.87	52.25	-0.0167	Upward
AGW235-7	Deep	68.50	70.23	71.00	-0.77				
AGW232	Shallow	69.29	78.26	25.50	52.76	-0.62	59.58	-0.0104	Upward
AGW195	Deep	69.91	78.18	85.00	-6.82				
AGW231	Shallow	69.00	73.50	25.00	48.50	-0.45	55.25	-0.0081	Upward
AGW197	Deep	69.45	73.25	80.00	-6.75				
AGW239	Shallow	65.56	71.16	25.50	45.66	-1.43	49.84	-0.0287	Upward
AGW237	Deep	66.99	70.82	75.00	-4.18				
AGW254-3	Shallow	63.09	66.46	31.25	35.21	0.00	40.26	0.0000	Neutral
AGW259	Deep	63.09	66.45	71.50	-5.05				
APP-069	Shallow	63.16	65.88	15.00	50.88	-0.07	46.97	-0.0015	Upward
AGW252	Deep	63.23	65.91	62.00	3.91				

Note:
1. Vertical Datum: National Geodetic Vertical Datum of 1929, US ft (+/-0.01 ft), msl.

Abbreviations/Acronyms:
bgs = below ground surface
ft = foot/feet
msl = mean sea level

Table 4-6
Possible Private Wells of Concern
Boeing Auburn Remedial Investigation
Auburn, Washington

Well ID	Information Source	Owner	Year Constructed	Type of Well	Ground Surface Elevation (ft)	Depth of Well (ft)	Year Water Level Measured	Water Level (ft bgs)	Diameter of well (inches)	Use
21N/04E-13F01	1, 2, 3	J. A. Sumpter	--	Driven	70	53	2/23/1961	Flowing	1 1/2	Domestic
21N/04E-13P01	1, 2, 3, 4	P. Schoordyke	--	Driven	73	50	1961	1	2	Domestic, Stock
21N/04E-14R01	4	--	--	--	73	130.5	--	--	--	--
21N/04E-23B02	1, 2, 3, 4	A. M. Wells	--	Driven	75	30	1/26/1961	1.00	2	Domestic
21N/04E-24B02	4	--	1924	--	77	98	1925	18.00	36	--
21N/04E-24C01	3	B. Maquez	--	Drilled	76	135	5/9/1961	6.59	6	Domestic
21N/04E-25E01	1, 2, 4	--	8/19/1975	Drilled	100	65	8/15/1975	1.35	10	--
21N/04E-26B01	3	C.E. Lane	--	Driven	80	42	1961	0	1 1/2	Domestic

Abbreviations/Acronyms:
-- = unknown
bgs = below ground surface
ft = foot/feet
ID = identification

Information Sources:
1. King County Database
2. U.S. Geological Survey (USGS) Database
3. USGS Water-Supply Bulletin
4. South King County Groundwater Management Plan

Table 4-7
Total Organic Carbon Analytical Results in Soil
Boeing Auburn Remedial Investigation
Auburn, Washington

Location ID	Sample Date	Total Organic Carbon (Percent)	Total Organic Carbon Fraction	Trichloroethene Retardation Factor	Notes
AGW095-50	12/16/2003	0.099	0.00099	1.47	
AGW096-25	12/16/2003	2.4	0.024	--	Natural organics observed in boring
AGW097-50	12/16/2003	0.082	0.00082	1.39	
AGW098-85	12/16/2003	0.066	0.00066	1.31	
AGW099-90	12/16/2003	0.07	0.0007	1.33	
ASB0141-6	5/4/2004	1.1	0.011	--	Petroleum hydrocarbons detected
ASB0141-9	5/4/2004	1.99	0.0199	--	Petroleum hydrocarbons detected
ASB0142-12	5/4/2004	0.188	0.00188	1.88	
ASB0142-15	5/4/2004	0.156	0.00156	1.73	
ASB0143-12	5/4/2004	0.194	0.00194	1.91	
ASB0143-15	5/4/2004	0.134	0.00134	1.63	
ASB0144-15	5/4/2004	0.533	0.00533	3.51	
ASB0144-18	5/4/2004	0.066	0.00066	1.31	
ASB0145-12	5/4/2004	0.207	0.00207	1.97	
ASB0145-15	5/4/2004	0.092	0.00092	1.43	
ASB0146-12	5/5/2004	0.471	0.00471	3.21	
ASB0147-15	5/5/2004	0.085	0.00085	1.40	
ASB0148-12	5/5/2004	0.24	0.0024	2.13	
ASB0148-15	5/5/2004	0.614	0.00614	3.89	
ASB0149-15	5/5/2004	0.175	0.00175	1.82	
ASB0149-21	5/5/2004	0.09	0.0009	1.42	
ASB0150-18	5/6/2004	0.043	0.00043	1.20	
ASB0150-21	5/6/2004	0.054	0.00054	1.25	
ASB0151-12	5/6/2004	0.091	0.00091	1.43	
ASB0151-15	5/6/2004	0.104	0.00104	1.49	
ASB0152-12	5/6/2004	0.071	0.00071	1.33	
ASB0152-15	5/6/2004	0.109	0.00109	1.51	
ASB0159-16	8/30/2004	0.084	0.00084	1.39	
ASB0159-18	8/30/2004	0.08	0.0008	1.38	
ASB0160R-17.5	9/7/2004	0.841	0.00841	--	Petroleum hydrocarbons detected
ASB0161-14	8/31/2004	0.221	0.00221	2.04	
ASB0161-16	8/31/2004	0.19	0.0019	1.89	
ASB0162-14	8/31/2004	0.108	0.00108	1.51	
ASB0162-15	8/31/2004	0.108	0.00108	1.51	
ASB0163-14	8/31/2004	0.066	0.00066	1.31	
ASB0163-17	8/31/2004	0.127	0.00127	1.60	
ASB0164R-20	9/2/2004	0.12	0.0012	1.56	
ASB0165R-22	9/2/2004	0.116	0.00116	1.55	
ASB0167-15	9/7/2004	0.071	0.00071	1.33	
ASB0167-20	9/7/2004	0.099	0.00099	1.47	
ASB0168-15	9/8/2004	1.01	0.0101	--	Petroleum hydrocarbons detected
ASB0168-17.5	9/8/2004	0.092	0.00092	1.43	
ASB0169-15	9/8/2004	0.899	0.00899	--	Petroleum hydrocarbons detected
ASB0169-17.5	9/8/2004	0.892	0.00892	--	Petroleum hydrocarbons detected

Table 4-7
Total Organic Carbon Analytical Results in Soil
Boeing Auburn Remedial Investigation
Auburn, Washington

Location ID	Sample Date	Total Organic Carbon (Percent)	Total Organic Carbon Fraction	Trichloroethene Retardation Factor	Notes
ASB0170-15	9/9/2004	3.28	0.0328	--	Petroleum hydrocarbons detected
ASB0170-17.5	9/9/2004	4.88	0.0488	--	Petroleum hydrocarbons detected
ASB0171-15	9/9/2004	3.37	0.0337	--	Petroleum hydrocarbons detected
ASB0171-17.5	9/9/2004	2.06	0.0206	--	Petroleum hydrocarbons detected

Note
1. ASB designations are for borings. AGW designations are for wells.
2. The TCE retardation factor is calculated using a bulk dry density of 1.75 g/cm^3 and an organic carbon distribution coefficient of 94 mL/g.
3. The TCE retardation factor was not calculated for locations where there was evidence of petroleum hydrocarbons or natural organics.

Abbreviations/Acronyms:

g/cm^3 = grams per cubic centimeter
mL/g = milliliter per gram
TCE = trichloroethene
-- = Not applicable

Table 4-8
Conductivity June 2011
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Date	Conductivity (µS/cm)
AGW001R	S	6/20/2011	169
AGW002R	S	6/28/2011	387
AGW006R	S	6/24/2011	301
AGW009	S	6/13/2011	307
AGW010	S	6/13/2011	333
AGW024	S	6/13/2011	323
AGW025	S	6/13/2011	265
AGW026	S	6/13/2011	254
AGW027	S	6/13/2011	696
AGW029	S	6/14/2011	302
AGW030	S	6/14/2011	412
AGW031R	S	6/23/2011	489
AGW032	S	6/13/2011	555
AGW033	S	6/14/2011	223
AGW034	D	6/23/2011	260
AGW035	D	6/14/2011	152
AGW037	S	6/20/2011	240
AGW039	S	6/20/2011	368
AGW040	S	6/20/2011	307
AGW041	S	6/21/2011	131
AGW044	S	6/22/2011	187
AGW048	S	6/16/2011	252
AGW049	S	6/16/2011	437
AGW050	S	6/16/2011	1047
AGW053R	S	6/28/2011	280
AGW055R	I	6/24/2011	216
AGW057R	I	6/20/2011	179
AGW058R	S	6/20/2011	343
AGW059R	S	6/20/2011	177
AGW060R	I	6/20/2011	221
AGW064	S	6/24/2011	282
AGW065	S	6/23/2011	37
AGW066	S	6/24/2011	566
AGW067	S	6/20/2011	191
AGW068	S	6/23/2011	844
AGW069	S	6/23/2011	262
AGW072	I	6/24/2011	192
AGW073	D	6/24/2011	170
AGW074	S	6/21/2011	256

Table 4-8
Conductivity June 2011
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Date	Conductivity (µS/cm)
AGW078	S	6/15/2011	131
AGW079	S	6/14/2011	352
AGW081	S	6/14/2011	324
AGW085	S	6/15/2011	128
AGW087	I	6/21/2011	99
AGW088	S	6/21/2011	100
AGW089	I	6/21/2011	104
AGW090	S	6/21/2011	126
AGW091	I	6/21/2011	98
AGW095R	I	6/23/2011	206
AGW098R	D	6/23/2011	150
AGW100	S	6/24/2011	318
AGW101	I	6/24/2011	189
AGW102	D	6/24/2011	177
AGW104	S	6/15/2011	134
AGW105	I	6/14/2011	175
AGW106R	S	6/28/2011	166
AGW110R	S	6/28/2011	330
AGW112R	S	6/28/2011	155
AGW115	S	6/22/2011	183
AGW116	S	6/23/2011	151
AGW117	S	6/23/2011	128
AGW118	S	6/23/2011	135
AGW119	I	6/23/2011	121
AGW120	S	6/23/2011	189
AGW125	S	6/20/2011	275
AGW126	I	6/20/2011	250
AGW127	S	6/21/2011	69
AGW128	S	6/22/2011	165
AGW129	S	6/23/2011	147
AGW130	S	6/22/2011	135
AGW131	S	6/15/2011	421
AGW133	S	6/15/2011	133
AGW134	S	6/14/2011	255
AGW135	S	6/14/2011	318
AGW136	S	6/21/2011	257
AGW137	I	6/21/2011	297
AGW138	D	6/20/2011	164
AGW139	I	6/23/2011	203

Table 4-8
Conductivity June 2011
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Date	Conductivity (µS/cm)
AGW140	I	6/23/2011	226
AGW141	I	6/24/2011	334
AGW142	D	6/24/2011	173
AGW143	D	6/20/2011	144
AGW144	I	6/20/2011	183
AGW145	I	6/20/2011	207
AGW146	D	6/20/2011	162
AGW147	I	6/23/2011	346
AGW148	I	6/23/2011	192
AGW149	I	6/23/2011	190
AGW150	I	6/23/2011	202
AGW151	I	6/23/2011	149
AGW152	S	6/15/2011	308
AGW153	S	6/15/2011	137
AGW154	I	6/15/2011	162
AGW155	I	6/13/2011	294
AGW156	I	6/22/2011	346
AGW157	I	6/20/2011	226
AGW158	I	6/22/2011	255
AGW159	D	6/22/2011	183
AGW160	I	6/24/2011	191
AGW161	I	6/23/2011	167
AGW162	I	6/24/2011	193
AGW163	I	6/15/2011	174
AGW164	I	6/20/2011	174
AGW165	S	6/22/2011	238
AGW166	I	6/24/2011	189
AGW167	D	6/24/2011	171
AGW168	I	6/22/2011	211
AGW169	D	6/22/2011	193
AGW170	I	6/22/2011	217
AGW171	D	6/22/2011	168
AGW172	I	6/24/2011	207
AGW173	I	6/24/2011	211
AGW174	I	6/23/2011	248
AGW175	I	6/23/2011	214
AGW176	I	6/24/2011	186
AGW177	I	6/22/2011	213
AGW178	D	6/22/2011	207

Table 4-8
Conductivity June 2011
Boeing Auburn Remedial Investigation
Auburn, Washington

Well	Groundwater Zone	Date	Conductivity (µS/cm)
AGW179	I	6/22/2011	449
AGW180	D	6/22/2011	188
AGW181	I	6/21/2011	302
AGW182	I	6/24/2011	255
AGW183	D	6/24/2011	220
AGW184	I	6/24/2011	262
AGW185	D	6/23/2011	178
AGW186	I	6/24/2011	278
AGW187	I	6/23/2011	268
AGW188	I	6/23/2011	238
AGW189	I	6/24/2011	207
AGW190	I	6/21/2011	286

Abbreviations/Acronyms:
D = deep zone
I = intermediate zone
µS/cm = microSiemens per centimeter
S = shallow zone

Table 4-9
Information Provided By Natural Attenuation Parameters
Boeing Auburn Remedial Investigation
Auburn, Washington

Field Parameters	Units	Information Provided
DO	mg/L	Aquifer is considered anaerobic at DO concentrations less than 1.0 mg/L.
ORP	mV	Negative values indicate reducing conditions.
pH	unitless	Optimum condition for biological activity is within the range of 6 to 8.
Iron(II)	mg/L	Concentrations above background indicate iron-reducing conditions.

Laboratory Analyses	Units	Information Provided
TOC	mg/L	Measure of available electron donor. Concentrations less than 10 mg/L considered depleted.
Chloride	mg/L	Concentrations above background may result from reductive dechlorination of elevated concentrations of TCE and breakdown products.
Nitrate	mg/L	Concentrations below background indicate nitrate-reducing conditions.
Sulfate	mg/L	Concentrations below background indicate sulfate-reducing conditions.
Sulfide	mg/L	Sulfide concentrations above background indicate sulfate-reducing conditions.
AMEE	µg/L	Concentrations of ethene and ethane are indicative of complete reductive dechlorination to non-toxic end products. Increasing methane concentrations indicate methanogenic aquifer redox conditions. Acetylene indicates the occurrence of abiotic reductive elimination.
Alkalinity	mg/L	Indicates buffering capacity of the aquifer. Increasing alkalinity can also indicate increased microbial activity; metabolism of micro-organisms produces carbon dioxide resulting in dissolution of carbonate minerals, if present.
VOCs	µg/L	Concentrations of TCE breakdown products are indicative of reductive dechlorination.

Abbreviations/Acronyms:
AMEE = acetylene, methane, ethene, ethane
DO = dissolved oxygen
µg/L = micrograms per liter
mg/L = milligrams per liter
mV = millivolt
ORP = oxygen reduction potential
TCE = trichloroethene
TOC = total organic compound
VOC = volatile organic compound

Table 4-10
Compound Specific Isotope Data Results June 2011
Boeing Auburn Remedial Investigation
Auburn, Washington

Sample Name	Sample Date	TCE Concentration (µg/L)	Compound Specific Isotope Analysis TCE	
			$\delta^{13}C$ ‰ (VPDB)	$\delta^{37}Cl$ ‰ (SMOC)
AGW136	6/21/2011	1.0	-20.6	--
AGW137	6/21/2011	4.2	-22.0	3.3
AGW156	6/22/2011	2.5	-13.8	5.4
AGW165	6/22/2011	2.2	-27.3	3.5
AGW168	6/22/2011	5.0	-22.5	4.1
AGW169	6/22/2011	4.8	-23.3	3.5
AGW181	6/21/2011	5.8	-23.3	3.5
AGW201-2	6/21/2012	0.8	-11.7	--
AGW201-5	6/21/2012	6.9	-26.2	--
AGW201-6	6/21/2012	11.0	-25.8	--
AGW208-2	6/21/2012	5.1	-18.8	--
AGW208-4	6/21/2012	5.6	-22.0	--
AGW208-6	6/21/2012	7.5	-24.2	--

Note:

Compound specific isotope analysis analyzed by Universtiy of Oklahoma Isotope Laboratory.

Abbreviations/Acronyms:

µg/L = micrograms per liter
-- = not analyzed
SMOC = standard mean ocean chloride
TCE = trichloroethene
VPDB = Vienna Pee Dee Belemnite

Units:

$\delta^{13}C$ ‰ = delta (δ) of ^{37}Cl in parts per thousand (‰) from the standard
$\delta^{37}Cl$ ‰ = delta (δ) of ^{13}C in parts per thousand (‰) from the standard