October 1, 2007

0-61M-107030/Phase 51/T4

Mr. Matt McClincy
Oregon Department of Environmental Quality
2020 S.W. 4th Avenue
Portland, Oregon 97201

Dear Mr. McClincy:

Re: Evaluation of Groundwater Discharge to the Willamette River
RP - Portland Site
Portland, Oregon

At the request of the United States Environmental Protection Agency (EPA) and the Oregon Department of Environmental Quality (DEQ), SLLI has reviewed the relation of groundwater flow beneath the Rhône-Poulenc (RP) property (identified by a bold outline on figures presented with this document) and surrounding properties, to potential areas of discharge in the Willamette River. As discussed at the July 10, 2007 meeting between DEQ and SLLI, EPA and DEQ have questioned whether discharge areas for groundwater have been adequately defined, and whether data gaps exist related to potential deep gravel zone discharge that need to be filled to allow the Lower Willamette Group (LWG) to complete the Remedial Investigation/Feasibility Study (RI/FS) for the Portland Harbor Superfund Site (Portland Harbor). EPA also questioned whether potential areas of discharge occur within identified Areas of Potential Concern (AOPCs), where sediment capping is an anticipated remedy and whether upland source control measures are planned to address areas of discharge that occur within the Willamette River Navigation Channel.

To address these concerns, SLLI has completed a comprehensive review of the conceptual geologic and hydrogeologic models for the RP property and surrounding properties, to evaluate areas of potential groundwater discharge to the Willamette River. This review integrates available geologic, hydrogeologic, and analytical chemistry data into the conceptual hydrogeologic model to identify whether data gaps exist relative to discharge of groundwater carrying RP-like constituents to the Willamette River, and if so, to determine whether they should be addressed by the in-river RI/FS, or deferred until the remedial design (RD) is developed.

As will be demonstrated in the body of this document, SLLI has determined that:

- Discharge areas for the Deep Gravel Zone (DGZ) identified by SLLI are well understood. They are well defined downstream of the railroad bridge (adjacent to Siltronic property). They are adequately defined upstream of the railroad bridge (adjacent to Arkema property) to complete the Portland Harbor RI/FS.

- No additional data gaps related to the DGZ need to be filled in order for LWG to complete the Portland Harbor RI/FS. Application of simplifying and conservative assumptions

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addresses unknowns regarding the extent of the discharge zones and concentrations of RP-like constituents that may be present within these zones.

- The location where the maximum concentration of RP-like constituents in groundwater intersects the Willamette River is well defined. Groundwater flow toward, as well as discharge to the Willamette River, is well understood. The location of the maximum concentrations detected in LWG transition zone water (TZW) samples matches the location at which the maximum concentrations would be predicted to occur, in the absence of actual TZW results.

- An upland source control measure, the North Front Avenue Interim Source Control Measure (NFA ISCM), is currently planned for implementation by SLLI to reduce concentrations of RP-like constituents in the DGZ that may be discharging to the Willamette River.

- The NFA ISCM also will address potential discharge of RP-like constituents that may be occurring within the Willamette River Navigation Channel.

- Some data gaps may need to be filled during RD, including a more precise definition of potential discharge zones, if any, upstream of the railroad bridge and the concentrations of RP-like constituents present in these zones, if any, after implementing source control. These data gaps do not prevent completion of the Portland Harbor RI/FS.

The evaluation is based on geologic, hydrogeologic, and analytical data developed by SLLI, Siltronic Corporation (Siltronic), Northwest Natural (NWN)/Gasco, Arkema, Inc. (Arkema), the City of Portland Bureau of Environmental Services (BES), and the LWG. The evaluation also includes preliminary data from SLLI's recently completed Stage 1 Source Control Evaluation (SCE) beach area investigation. The evaluation is presented in the following sections:

- <u>Data Review and Conceptual Hydrogeologic Model</u> - Summarizes current geologic, hydrogeologic, and analytical data into a hydrogeologic conceptual site model that describes the DGZ and clarifies relationships between geology and the occurrence and movement of 1,2-dichlorobenzene (1,2-DCB) in area groundwater. 1,2-DCB is selected for the purpose of this evaluation because 1,2-DCB:
    - Is mobile in groundwater;
    - Is detected in groundwater at the RP property and in TZW samples in the Willamette River near the railroad bridge;
    - Has a method detection limit well below screening level values (SLVs) as published in Table 3-1 of the Joint Source Control Strategy (JSCS) (DEQ/EPA 2005, Table 3-1 updated July 2007), and
    - Is generally not considered a constituent of potential concern associated with surrounding properties that also have impacted groundwater resulting from either historical or present-day operations.

- <u>Evaluation</u> – Assesses presence of 1,2-DCB in the DGZ in relation to potential migration to the Willamette River.

- Conclusions – Summarizes findings regarding potential data gaps associated with the LWG in-river RI/FS, and also summarizes the planned effect of the proposed NFA ISCM on discharge of RP-like constituents to the Willamette River.

Five figures have been prepared for this evaluation, including:

- Figure 1 – Site Location Map
- Figure 2 – Mapped Discharge Zones, Deep Alluvial Gravel (DAG) Occurrence, and Basalt Surface Contour Elevations
- Figure 3 – Cross Sections (A-A', B-B', C-C', and F-F') Showing 1,2-DCB Concentrations (Most Recent Available Data, 2002-2007)
- Figure 4 – Deep Gravel Zone (DGZ) & Basalt Zone Groundwater Elevations (November 2006) and Approximate 1,2-DCB 130 µg/L Contour (Based on Most Recent Available Data, 2002-2007)
- Figure 5 – 1,2-DCB Concentrations for the RP Property and Surrounding Properties (Most Recent Available Data, 2002-2007)

DATA REVIEW AND CONCEPTUAL HYDROGEOLOGIC MODEL

This section includes a review of the regional and local geologic and hydrogeologic setting for the RP property and surrounding properties. This portion of the data review compares the relationships between regional and local models to demonstrate that site-specific information collected by SLLI is correlative with data collected by others, and that these data are consistent with the regional setting.

A discussion of the distribution of 1,2-DCB follows the geologic and hydrogeologic presentation, and presents an additional line of evidence to support the relationships described in the geologic and hydrogeologic presentation.

Finally, the geologic, hydrogeologic, and 1,2-DCB distribution information are then used to describe how the current conceptual hydrogeologic model accounts for the extent of 1,2-DCB observed in groundwater beneath the RP property and surrounding properties, as well as its potential distribution in TZW.

Regional Geology

The RP property is located within the Portland basin, which is a northwest-southwest-trending structural feature that contains a thick sequence of alluvial deposits overlying the basalt flows of the Columbia River Basalt Group (CRBG) (Beeson and others, 1991; United States Geological Survey [USGS], 1993). The basin is bounded on the northwest by the Tualatin Mountains, formed by uplift along the Portland Hills fault zone (Tolan and Reidel, 1989). From top to bottom, the alluvial deposits in the basin consist of Quaternary deposits (artificial fill, flood-plain and channel deposits of the Willamette and Columbia Rivers, and deposits from Ice-Age catastrophic floods from glacial Lake Missoula), and older alluvial deposits of Pliocene to Miocene age (Troutdale Formation and Sandy River Mudstone) (Beeson and others, 1991). The Miocene CRBG consists of a series of flood basalt flows of varying extent, thickness, structure, magnetic polarity, and geochemistry. The LWG presents a consistent interpretation of regional geology in their Programmatic Work Plan (LWG, 2004).

Local Geology

The RP property is located approximately 7 river miles south of the confluence of the Willamette and Columbia Rivers, on the left bank (looking downstream) of the Willamette River. The RP property sits on a bench lying between the Willamette River on the northeast and the Tualatin Mountains on the southwest (see Figure 1). The RP property is located approximately 2,000 feet away from the Willamette River at an elevation of approximately 35 to 45 feet above mean sea level (amsl).

The area surrounding the RP property previously was dominated by lakes, including Kittridge and Doane Lakes. The lakes were connected by sloughs developed on the former flood plain of the Willamette River. The flood plain was buried beneath fill during industrial development.

SLLI has defined three geologic zones beneath the RP property and surrounding properties (AMEC, 2007a). The zones are the Alluvium, Deep Alluvial Gravel (DAG), and Basalt Geologic Zones. Descriptions of these units are summarized as follows:

- <u>Alluvium</u> – The Alluvium consists of unconsolidated fill and naturally-deposited lake and stream sediment deposited by the Willamette River. The Alluvium is broadly characterized as silty sand and sandy silt extending to depths ranging from as shallow as approximately 40 feet below ground surface (bgs) on the RP property (see Figure 3, cross section A-A' and B-B'), to more than 200 feet bgs on Siltronic property (see Figure 3, cross section C-C'). These depths are equivalent to elevations of 10 feet below mean sea level (bmsl) on the RP property, and approximately 165 feet bmsl on Siltronic property (see Figure 3).

  The fill component of the Alluvium extends to depths of approximately 4 to 30 feet bgs, equivalent to elevations of approximately 35 to 5 feet amsl, across the RP property and surrounding properties. Materials comprising the fill include variable amounts of clay, silt, and sand from Willamette River dredge spoils, plant organic material, and miscellaneous debris such as brick, gravel, foundry sands, wire, concrete, and battery casings. These materials were placed in former Doane Lake and along the western bank of the Willamette River during industrial development throughout the first part of the 20th century. The fill materials are difficult to distinguish from alluvial materials when debris is absent because both fill and alluvial material are texturally similar to Willamette River sediments. An upper layer of clay and silty clay is distinguishable beneath former Doane Lake, extending to a depth of approximately 25 feet bgs (10 feet amsl) and having an average thickness of 15 feet. A silty layer is observed on the north side of the railroad tracks at approximately the same depth/elevation and thickness.

- <u>DAG</u> – The DAG underlies the Alluvium and consists of subrounded to rounded alluvial and colluvial gravel and cobbles in a matrix of primarily sand with some silt. These materials were most likely deposited during catastrophic Ice-Age flooding of the Columbia and Willamette Rivers, and from erosion and downhill movement of hillside materials along buried topography. The DAG ranges from approximately 2 to 40 feet thick, and has bottom depths ranging from approximately 50 feet bgs (15 feet bmsl) on the RP property, to at least

200 feet bgs (165 feet bmsl) on the Siltronic and NWN/Gasco properties. The DAG is not laterally continuous beneath the Alluvium. As shown on Figure 2, it locally mantles the surface of the underlying Basalt, particularly on the eastern wall of a buried north-trending valley. The available data indicate that the DAG occurs in three areas as described below:

- *Arkema Lot 1 Riverbank* – An isolated area of DAG is present near the Willamette River on Lot 1 and Tract A, where the DAG is 15 feet thick at monitoring well W-19 and less than 5 feet thick at boring ARK-01 and monitoring well RP-13. This DAG area is isolated because it is not encountered at monitoring well RP-08 or in borings ARK-05, ARK-12, and ARK-13 (see Figure 2). The interpretation of an isolated area of DAG is further supported by geotechnical borings advanced by URS along a proposed sewer alignment beneath the Willamette River on the upstream of side of the railroad bridge. No gravel was encountered in two borings (WGB-1 and WGB-2) advanced approximately 10 to 30 feet into the underlying basalt (URS 2001).

- *RP Property North to Siltronic Riverbank* – This area contains an extensive and relatively thick (as much 40 feet thick at RP-07) deposit of DAG (see Figure 2). In this area, the DAG generally thickens from the RP property toward the Willamette River. On the RP property, the DAG is generally less than 10 feet thick (see cross sections A-A' and B-B' in Figure 3), whereas on the ESCO Corporation (ESCO) property, the thickness of the DAG ranges from less than 5 to approximately 10 feet where it mantles the floor and eastern wall of the buried valley cut into the underlying basalt (see cross section B-B' in Figure 3). Farther east, the DAG is present beneath the western ends of Arkema Lots 1 and 2 where it mantles the eastern wall of the buried valley (see Figure 2 and cross sections A-A' and B-B' on Figure 3). Beneath the Siltronic property, the DAG is 5 to 40 feet thick. The DAG's greatest thicknesses were encountered at monitoring well MW-03 (10 feet thick), which encountered the bottom of the ancient valley (see cross section F-F' in Figure 3), and at monitoring well RP-07 (40 feet thick) located on a bench developed on the eastern wall of the ancient valley (see cross section C-C' in Figure 3).

- *Siltronic-NWN/Gasco Property* – The DAG occurs at its deepest depths beneath the riverfront edges of Siltronic-NWN/Gasco properties (see Figure 2 and cross section C-C' in Figure 3). At this location, the DAG was encountered at depths of approximately 180 to 210 feet bgs, which are equivalent to elevations between approximately 145 and 165 feet bmsl. Here the DAG appears to mantle the lower part of a southwest-facing valley wall. The thickness of the DAG here ranges from 5 to 30 feet.

- <u>Basalt</u> – The Basalt underlies the Alluvium and, where present, the DAG. The Basalt beneath the RP property and surrounding properties is part of the CRBG. In the west Portland business district, approximately 3 miles southeast of the RP property, the CRBG is at least 700 feet thick and consists of a series of lava flows separated by discontinuous layers of interflow tuff and sediment (Beeson and others, 1991). In the area of the RP property, the variable surface of the Basalt is observed to be highly fractured to massive and highly weathered to fresh.

  The surface of the Basalt represents ancient topography, which is characterized by a north-trending valley (see Figure 2), that is more than 100 feet below the bottom of the Willamette River (see cross section C-C' on Figure 3) along the Siltronic and NWN/Gasco riverfront. As shown in Figure 2, the valley may continue north (to the former location of the ancestral Willamette River), or it may swing to the northwest. The uncertainty arises because it is not known whether in-river direct-push borings north of the Siltronic property encountered refusal on Basalt (as interpreted on Figure 2) or on DAG. Understanding the ancient topography of the Basalt is important because the weathered portions of the Basalt surface play a key role in groundwater transport, as will be discussed further in the next sections regarding regional and local hydrogeology.

Regional Hydrogeology

At the regional scale, groundwater within the Portland basin is expected to flow from recharge areas on hills and ridges toward discharge areas along stream valleys. In the vicinity of the RP property, this means that groundwater is expected to flow to the northeast from the adjacent Tualatin Mountains toward the Willamette River. Similarly, groundwater on the other side of the Willamette River is expected to flow southwestward to the river, from the southwestern portion of the topographic high in the vicinity of St. John's and University Park (see Figure 1). Regional hydrogeologic units present at the RP property and vicinity include the unconsolidated sedimentary aquifer (USA) and the older rocks unit (includes the CRBG), as presented by the USGS Water-Resources Investigation Report 90-4196 (USGS, 1993).

At the sub-regional level, the LWG has defined four hydrogeologic units for the Portland Harbor that are of interest for their in-river RI/FS (LWG, 2004), three of which are pertinent for the RP property. LWG further classifies these units into three groundwater flow systems (refer to Figure 5-2a in LWG 2004 for a generalized conceptual site model of these groundwater flow systems). LWG groundwater flow systems and the hydrogeologic units that comprise them are described in detail LWG's Programmatic Work Plan (LWG, 2004), and described briefly below.

1. Shallow Flow System
   - FFA – The FFA hydrogeologic unit consists of fill materials, the fine-grained facies of flood deposits, and recent alluvial materials. The FFA is considered by LWG to be part of the regionally defined USA. The shallow flow system includes the more shallow portion of the FFA.
2. Intermediate Flow System
   - FFA – Again, the FFA is considered by LWG to be part of the regionally defined USA. The intermediate flow system includes the deeper portion of the FFA hydrogeologic unit.
3. Deep Flow System
   - CGF – The CGF hydrogeologic unit consists of coarse-grained flood deposits and the Upper Troutdale Formation. The sands and gravels of the coarse-grained flood deposits have been observed at the RP property (i.e., the DAG), while the Upper Troutdale Formation has not.
   - CRBG – The CRBG hydrogeologic unit is present at the RP property (i.e., Basalt).

In general, LWG has stated that the three groundwater flow systems will apply at the majority of sites within Portland Harbor, but recognizes that local groundwater flow systems may differ from their broadly defined systems. At the RP property and surrounding properties, four hydrogeologic zones have been established by SLLI. The relationship between RP hydrogeologic zones and the LWG flow systems is discussed in more detail in the "Local Hydrogeology" section when SLLI's interpretation of hydrogeology and discharge to the Willamette River differs from the LWG's interpretation

Groundwater modeling evidence developed by the USGS (Morgan and McFarland, 1996) for a numerical flow simulation of the Portland basin suggests that the groundwater discharge along the reach of the Willamette River near the RP property is in the range of 0.3 to 3 centimeters per day (cm/day). This is generally consistent with discharges measured by the LWG during TZW sampling activities completed in 2005 (LWG, 2006a; LWG, 2006b). Measurements were collected in focused areas associated with nine specific sites between River Miles 4 and 9. The majority of the measurements were positive, regardless of sediment type, with the average daily discharge rate calculated at 1.48 cm/day. Therefore, this stretch of the Willamette River appears to be predominantly gaining (i.e., having positive discharges), though both positive and negative discharge was measured at each of the nine sites targeted for this portion of the RI/FS, including RP. Additional discussion of discharge measurements associated with RP property is presented in the "Groundwater Discharge Zones" section below.

Local Hydrogeology

Groundwater is present within all three local geologic zones described at the RP property and surrounding properties (Alluvium, DAG, and Basalt). On the basis of groundwater elevation measurements and hydraulic conductivities, SLLI has defined four hydrogeologic zones. These four zones are the Fill Zone, the Alluvium Zone, the DGZ, and the Basalt Zone. These four zones have been established on the basis of the Stages 1 and 2 SCE investigations completed by SLLI in 2006 (AMEC, 2006a; AMEC, 2007a). This model supersedes and more clearly defines the local hydrogeology than does the previous model that included only three hydrogeologic zones (Fill/Shallow Alluvium, Alluvium, Basalt), as presented in the earlier Groundwater Characterization Report (GCR) (AMEC, 2003).

In general, groundwater flow at the RP property and surrounding properties is predominantly horizontal toward the Willamette River, based on the relatively small differences in groundwater elevations as measured at different depths within the defined hydrogeologic zones. Vertical flow is generally downward across these zones nearest the Tualatin Mountains, but can be locally upward, from the Basalt Zone to the DGZ, or from the DGZ to the Alluvium Zone, with increasing proximity to the Willamette River. The four current hydrogeologic zones and their pertinent hydrogeologic properties are summarized as follows:

- Fill Zone – The Fill Zone consists of both unsaturated and saturated fill material associated with the infilling of former Doane Lake and a low-lying marshy area north of the BNSF Railway Company (BNSF) railroad tracks. The Fill Zone is discontinuous and is distinguished from the Alluvium, DGZ, and Basalt Zones by relatively high groundwater elevations, and by horizontal groundwater flow directions that are variable and influenced by local surface water bodies. The vertical component of groundwater flow is downward, into the Alluvium Zone, based on water level measurements collected in November 2006 (AMEC, 2007a).

The upper boundary of the Fill Zone is the water table; therefore, groundwater in the Fill Zone is unconfined (Freeze and Cherry, 1979). The depth to groundwater in the Fill Zone is generally less than 15 feet bgs. Groundwater levels in wells completed in the Fill Zone near the Willamette River do not exhibit tidal fluctuation, based on water level measurements recorded by the LWG at the RP-07 well cluster in 2005. The Fill Zone does not appear to be hydraulically connected to the Willamette River at the riverbank. On the basis of ten short-term slug tests performed at wells located on RP, Metro, ESCO, Schnitzer, and Gould properties, the geometric mean hydraulic conductivity of the Fill Zone is 0.97 feet per day (ft/day), ranging from 0.08 to 13.40 ft/day (AMEC, 2001; AMEC, 2007a). This hydraulic conductivity is what would be expected for a hydrogeologic unit consisting of a mix of clay, silt, and sand (Freeze and Cherry, 1979), and will result in the relatively slow migration of solute-phase constituents.

- <u>Alluvium Zone</u> – The Alluvium Zone consists of saturated native silty sand and sandy silt. The Alluvium Zone is distinguished from the DGZ and Basalt Zone by its generally fine-grained lithology and low permeability.

  The horizontal groundwater flow direction in the Alluvium Zone is to the north and northeast, toward the Willamette River. Overall, the vertical component of groundwater flow within the Alluvium Zone is downward, based on water level measurements collected in November 2006 (AMEC, 2007a). The Alluvium Zone is considered to be semi-confined and appears to be hydraulically connected to the Willamette River, based on water level measurements recorded by the LWG at the RP-07 well cluster in 2005.

  On the basis of 39 short-term slug tests, the geometric mean hydraulic conductivity of the Alluvium Zone is 0.89 ft/day, ranging from 0.01 to 10.7 ft/day (AMEC, 2001, AMEC, 2007a). This hydraulic conductivity is typical of silt and sand (Freeze and Cherry, 1979).

- <u>DGZ</u> – The DGZ consists of alluvial gravel, colluvial gravel, and permeable weathered basalt that collectively have larger hydraulic conductivities than the overlying Alluvium Zone and the underlying Basalt Zone. As a point of clarification, the DGZ includes the coarse-grained (gravel and cobble) lower portion of the previously defined Alluvium Zone from the GCR, and the uppermost permeable, weathered portion of the previously defined Basalt Zone from the GCR. This distinction is important to note because of: 1) LWG use of the now dated hydrogeologic zones from the GCR in their *Round 2 Groundwater Pathway Assessment, Transition Zone Water Site Characterization Summary Report* (LWG, 2006c) to describe where contaminants are mostly likely to discharge to the Willamette River, and 2) LWG's application of their broad groundwater flow systems to the RP property and surrounding properties. These two points may have led LWG to incorrect conclusions regarding migration of RP-like constituents to the Willamette River, as will be discussed further in the "Conceptual Hydrogeologic Model" section below.

  Groundwater in the DGZ flows horizontally to the north and northeast, toward the Willamette River. Based on water level measurements collected in November 2006 (AMEC, 2007a), in general, a downward vertical gradient is observed between wells screened in the Alluvium and the DGZ, whereas, in general, there is an upward vertical gradient observed between two wells screened within the DGZ. Groundwater levels in wells completed in the DGZ exhibit tidal fluctuation, based on water level measurements recorded by the LWG at the RP-07 well cluster in 2005, and based on recent and currently unpublished pumping test water level data collected in the Lake Area (LA) Pilot Study area (performed in July 2007). Therefore, the DGZ is considered to be semi-confined and appears to be hydraulically connected to the Willamette River, at least along flow paths that include wells within the LA Pilot Study area and RP-07.

On the basis of 32 short-term slug tests, the geometric mean hydraulic conductivity of the DGZ is 11.96 ft/day, ranging from 0.68 to 263 ft/day (AMEC, 2001; AMEC, 2007a). This is a much greater average hydraulic conductivity than was measured for the Fill or Alluvium Zones, and is typical of coarse-grained materials (Freeze and Cherry, 1979).

The DGZ is part of the LWG's deep groundwater flow system, which is reported to discharge to the Willamette River where it intersects the river bottom. LWG indicates that this flow system is not anticipated to play a significant role in constituent transport because most groundwater plumes occur in more shallow units. However, this statement is not accurate relative to the DGZ, and will be addressed further in the "Conceptual Hydrogeologic Model" section.

- Basalt Zone – The Basalt Zone consists of weathered to competent basalt that has lower hydraulic conductivities than the overlying DGZ. Groundwater in the Basalt Zone is considered to be semi-confined, and it flows horizontally to the north and northeast, toward the Willamette River. Based on water level measurements collected in November 2006 (AMEC, 2007a), it appears there is a vertical downward gradient from the Alluvium Zone to the Basalt Zone at and near the RP property near the base of the Tualatin Mountains, whereas an upward vertical gradient is observed at wells closer to the Willamette River completed on ESCO and Siltronic properties. Groundwater levels in wells completed in the Basalt Zone exhibit tidal fluctuation based on water level measurements recorded by the LWG at the RP-07 well cluster in 2005.

  On the basis of three short-term slug tests performed at wells located on RP and ESCO properties, the geometric mean hydraulic conductivity of the Basalt Zone is 3.2 ft/day, ranging from 1.7 to 8 ft/day (AMEC, 2001; AMEC, 2007a). This conductivity is much lower than in the DGZ, but slightly greater than in the Fill or the Alluvium Zones, as would be expected for a competent to fractured rock (Freeze and Cherry, 1979).

As stated at the beginning of this section, differences in groundwater elevations at different depths are relatively small, indicating that flow is dominantly horizontal toward the Willamette River. The net vertical component of groundwater flow at and in the vicinity of the RP property is downward, from the Fill Zone to the Alluvium Zone to the Basalt Zone, especially in the most landward monitoring locations. Closer to the Willamette River, however, upward flow is locally present from the Basalt Zone to the DGZ, or from the DGZ to the Alluvium Zone.

Groundwater Discharge Zones

As part of a groundwater discharge study conducted for the Portland Harbor RI/FS, the LWG measured groundwater discharge to TZW in the Willamette River at 10 locations off-shore of the

Siltronic and Arkema properties, to evaluate the potential flux of groundwater to the Willamette River in this area (LWG, 2006c). The measurements were made in fall and early winter of 2005 under presumed maximum flux conditions at the end of the water year when river stage is usually lowest. Monitoring locations were primarily located between the riverbank and the navigation channel, but two locations downstream of the railroad bridge were within the navigation channel. The average discharges ranged from -1.6 cm/day to 14 cm/day, with maximum discharges from 0.7 cm/day to 29 cm/day. The average discharge for the two monitoring locations within the navigation channel ranged from -1.6 cm/day to 1.2 cm/day, with maximum discharge ranging from 2.8 cm/day to 3.5 cm/day).

On the basis of these results, the LWG identified two potential discharge zones (LWG, 2006c), as illustrated on Figure 3 (cross sections A-A' and F-F') and Figure 4. Discharge zone locations are based on scaled measurements from LWG Figure 9-7 of the *Round 2 Groundwater Pathway Assessment, Transition Zone Water, Site Characterization Summary Report* (LWG, 2006c).

1. One discharge zone is located off the Siltronic property, and is associated with a sand patch in the river bottom just north (downstream) of the railroad bridge at an elevation of approximately 20 to 45 feet bmsl. This discharge zone is partially located within the navigation channel (see Figure 4). Maximum discharges in the sand patch off the Siltronic property ranged from 2.2 to 29 cm/day (see Figure 4 for all data).

2. The LWG also identified an inferred groundwater discharge zone located off Arkema Lot 1 and Tract A property within a mixed silt and sand area south (upstream) of the railroad bridge at an elevation of approximately 10 to 30 feet bmsl. The inferred discharge zone offshore of Arkema Lot 1 is based on a single monitoring point having a maximum discharge of 6.7 cm/day.

The discharges measured in each of these two zones suggest there is the potential for groundwater to discharge to the Willamette River in these areas and that local discharge rates can vary from the area-wide average rates of 0.3 to 3 cm/day estimated by the USGS (1996). One possible reason for variation is that LWG collected the samples during periods of maximum flux. In addition, variations can be explained on the basis of local geology. As illustrated in cross section F-F' (see Figure 3), more permeable material of the DGZ occurs near the river bottom where the sand patch has been mapped in the bed of the Willamette River off-shore of Siltronic property and, therefore, appears to represent a preferential migration pathway from groundwater to the Willamette River. The mixed area of river bottom sand and silt offshore of Arkema Lot 1 and Tract A property appears to be connected to a more silty zone within the Alluvium (see cross section A-A' on Figure 3), though some small sand lenses have been identified.

Groundwater Chemistry

The relationships between groundwater flow and the presence of RP-like constituents is evaluated using 1,2-DCB as an indicator compound because it represents RP-like constituents in groundwater, and was detected in TZW samples obtained by LWG in 2005. The following sources of 1,2-DCB data were reviewed for this evaluation:

- Source control investigations conducted by SLLI in 2005, 2006, and 2007 on Arkema Lots 1 and 2, and Siltronic properties (AMEC, 2006a; AMEC, 2007a; AMEC, unpublished preliminary data from the July/August 2007 Stage 1 SCE beach investigation on BNSF and Arkema Tract A property)

- Lake Area Hydrologic Investigation (LAHI) conducted by SLLI in 2006 on the RP and ESCO properties (AMEC, 2007b)

- Groundwater monitoring events conducted by SLLI from 2002 through 2007 (AMEC, 2002; 2004; 2005; 2006b; 2007c)

- In-river sediment and groundwater investigation conducted by Siltronic in 2004 (MFA, 2005a)

- Supplemental investigation conducted by Siltronic in 2005 (MFA, 2005b)

- Gasco Siltronic groundwater source evaluation conducted by NWN in 2007 (Anchor, 2007)

- TZW sampling conducted by the LWG in 2005 (LWG, 2006c)

The most recent 1,2-DCB data for all hydrogeologic zones from 2002 to 2007 (including preliminary analytical results from the Stage 1 SCE beach area investigation) are shown in Figure 5, for the purpose of describing the general distribution of 1,2-DCB in groundwater, regardless of hydrogeologic zone or depth. Please note that analytical results from the Spring 2007 groundwater monitoring event and the July/August 2007 Stage 1 SCE beach investigation have not been validated, and must be considered preliminary and subject to change. These data are marked with an asterisk in Figure 5, as well as on the cross sections presented in Figure 3.

The lateral extent of the 1,2-DCB plume has been delineated and is drawn on Figure 5 based on comparison to a concentration of 130 micrograms per liter (µg/L), which is the Portland Harbor site-specific conservative SLV for fish consumption, as published in the updated Table 3-1 (July 2007) of the JSCS (DEQ/EPA, 2005). Although 1,2-DCB concentrations are elevated on and near the RP property, the distal end of the 1,2-DCB plume contains substantially lower concentrations that are up to two orders of magnitude less at the Willamette River than on RP property.

The vertical distribution of the 1,2-DCB plume is shown on a series of cross sections plotted on Figure 3. Cross sections B-B', A-A', and F-F' are drawn approximately normal to the river's edge and are arranged on Figure 3 to be viewed from upstream section B-B' to downstream section F-F'. The locations of the cross sections relative to the RP property are shown on Figure 3. The distribution of the 1,2-DCB shown on each cross section is discussed below:

- <u>Cross Section B-B'</u> – The 1,2-DCB concentrations are highest on the RP property and range in BST5TW/AL-5, from 6,200 µg/L in the Alluvium Zone at approximately 5 to 10 feet amsl, to 130 µg/L at approximately 35 feet bmsl within the DGZ where it occurs on the western wall and floor of the buried valley. Neither the Alluvium nor the DGZ contain 1,2-DCB exceeding a concentration of 1 µg/L at any location between the ESCO property and the Willamette River.

- Cross Section A-A' – As is the case for cross section B-B', the highest 1,2-DCB concentrations occur on RP property. Concentrations at monitoring well RP-04 range from 20,000 µg/L at 5 feet bmsl in the Alluvium Zone, to 3,100 µg/L in the DGZ where it occurs on the western edge of the buried valley at approximately 25 feet bmsl (RP-04-48, RP-04-56, and W-08-74 are completed in the DGZ). Farther north and hydraulically downgradient, 1,2-DCB is generally not detected in the upper part of the Alluvium Zone but, instead, occurs in the lowest 20 to 40 feet of the Alluvium Zone (W-09-86, W-11-I(60), RP-08-80), at the Alluvium Zone-DGZ contact (W-09-116 and RP-01-87), and in the underlying DGZ (W-11-B(122), ARK-03, RP-08-107, and RP-01-65). Cross section A-A' shows that 1,2-DCB concentrations near the Willamette River are lower than those detected at the RP property, and represent an overall decreasing trend from the upland to the river. 1,2-DCB is detected near the Willamette River in wells at RP-01, but is not detected at BNSF-03 at each of three sample intervals. As shown on Figure 5, 1,2-DCB detections exceeding 130 µg/L in beach area reconnaissance borings occur only at BNSF-2, and between ARK-11 and ARK-16. In these borings, 1,2-DCB detections are limited to the DGZ, and the Alluvium Zone-DGZ contact, except at two locations (ARK-12 and ARK-14) where 1,2-DCB was detected in the lower portion of the Alluvium Zone at approximately 5 feet bmsl.

- Cross Section F-F' – Like the other cross sections, cross section F-F', is oblique to the horizontal groundwater flow direction but is located farther hydraulically downgradient than cross sections B-B' and A-A.' Cross section F-F' shows that farther downgradient the 1,2-DCB plume occurs at the Alluvium Zone-DGZ contact (RP-06-87) or within the DGZ. The 1,2-DCB plume depth varies depending on the elevation of the buried basalt surface. Along this section, except at RP-06-89, 1,2-DCB is not detected in the Alluvium Zone in any monitoring well at concentrations exceeding 1 µg/L. In the Willamette River, 1,2-DCB was detected at concentrations exceeding the 130 µg/L SLV in two TZW samples obtained by LWG in 2005. Sample RP-03CTR, located outside the navigation channel, contained 1,2-DCB in a concentration of 640 µg/L (see cross section F-F'). Sample RP-03ETR, located within the navigation channel, contained 1,2-DCB at a concentration of 270 µg/L.

Review of the information for monitoring wells closest to the riverbank, as shown on cross sections B-B', A-A', and F-F', indicates that 1,2-DCB occurs primarily in groundwater in the DGZ and the lower part of the Alluvium adjacent to the DGZ. This is also shown in cross section C-C' (see Figure 3), which is drawn parallel to the edge of the Willamette River from the Arkema property downstream to the NWN/Gasco property.

As shown on cross section C-C', the southern boundary of the 1,2-DCB plume is located near the boundary between Arkema Lots 1 and 2, at depths equivalent to elevations of 20 to 35 feet bmsl. 1,2-DCB concentrations exceed 130 µg/L in the DGZ from the Arkema Lot 1 property north to SIL-03 on Siltronic property, then decrease to near or below the 130 µg/L SLV for the remainder of the Siltronic property northward to near the NWN/Gasco property boundary. These concentrations range in depth from as shallow as 5 feet bmsl in a focused area on Arkema property (near ARK-12 and ARK-14, see Figure 5), to between 40 to 80 feet bmsl on the southern portion of the Siltronic property. The northernmost part of the 1,2-DCB plume on Siltronic property is much deeper, occurring at elevations of approximately 165 bmsl, more than

100 feet below the bottom of the Willamette River Navigation Channel, near the northern boundary of the Siltronic property. No 1,2-DCB was detected at any depth beyond boring GS-05 on the NWN/Gasco property. The edge of the 1,2-DCB plume in groundwater, therefore, occurs just south of the boundary between Siltronic and NWN/Gasco property (see Figure 5).

Conceptual Hydrogeologic Model

Groundwater occurs beneath the RP property and surrounding properties in four hydrogeologic zones. The most relevant zones are the Alluvium Zone, the DGZ, and the Basalt Zone because groundwater in these zones contains 1,2-DCB and because groundwater in these zones flows toward the Willamette River. Differences in head at different depths are relatively small, indicating that flow is dominantly horizontal toward the river. Vertical flow is generally downward across these zones nearest the Tualatin Mountains, but can be locally upward, from the Basalt Zone to the DGZ, or from the DGZ to the Alluvium Zone, with increasing proximity to the Willamette River.

The DGZ's greater hydraulic conductivity, relative to the Alluvium and Basalt Zones, has resulted in a preferential migration pathway within the DGZ. This model differs from LWG assumptions that shallower groundwater flow systems will be the largest contributors to migration of constituents of potential concern to the Willamette River for the majority of sites because that is where most groundwater plumes within the Portland Harbor are located. The distribution of 1,2-DCB at the RP property and downgradient properties illustrates the significance of migration through the DGZ. In contrast, potential migration through the Alluvium Zone plays no significant role in the transport of 1,2-DCB or other RP-like constituents to the Willamette River.

The groundwater containing 1,2-DCB remains relatively shallow where the DGZ itself is relatively shallow as it follows the surface of the Basalt. The 1,2-DCB generally occurs in the DGZ at depths equivalent to elevations of 40 to 80 feet bmsl near the upstream and downstream sides of the railroad bridge (see cross section C-C' on Figure 3). The DGZ is the most relevant flow system contributing to migration of solute-phase constituents near the railroad bridge. Although some 1,2-DCB is present in the lower portion of the Alluvium just above the DGZ upstream of the railroad bridge, the concentrations are much lower than in the DGZ. Because of its lower hydraulic conductivity, the lower portion of the Alluvium is not a significant migration pathway. Downstream of the railroad bridge where the concentrations of 1,2-DCB in the Alluvium Zone are predominantly near or below detection limits, the Alluvium Zone is not a significant migration pathway.

The 1,2-DCB is found at greater depths downstream of the railroad bridge because the DGZ deepens in that direction and the vertical component of groundwater flow is downward. The buried valley deepens as it runs to the north and the DGZ follows the deepening ancient land surface. As cross section C-C' shows, the 1,2-DCB plume does not extend farther north into DAG encountered in the borings completed on NWN/Gasco property. This demonstrates that the presence of DAG alone does not by itself indicate the presence of 1,2-DCB in groundwater.

1,2-DCB is generally not detected in the Alluvium Zone above the DGZ downstream of the railroad bridge. The lower hydraulic conductivity in the Alluvium Zone, coupled with very low to not detected concentrations of 1,2-DCB indicate that RP-like constituents are not expected to migrate directly to the Willamette River via the Alluvium Zone in this area.

As discussed previously, TZW data developed by the LWG near the railroad bridge suggest that the distal end of the dissolved phase 1,2-DCB plume in the shallower part of the DGZ may have reached the Willamette River. However, the TZW data developed by Siltronic downstream of the railroad bridge indicates that 1,2-DCB is not present downstream of the bridge near the Siltronic-NWN/Gasco property boundary.

EVALUATION

This evaluation assesses the adequacy of the existing data sets to characterize potential discharge of groundwater from the RP property to the Willamette River, such that the Portland Harbor RI/FS may be completed. This evaluation further supports how discharge potentially occurring outside the defined AOPC in the navigation channel, will be addressed by upland source control as discussed in more detail in the NFA ISCM Work Plan (AMEC, 2007d).

The evaluation is organized into three informal regions of the Willamette River. The regions have been established based on the geologic, hydrogeologic, and chemical conditions in each region. The regions are identified on Figures 2, 3, 4, and 5. The evaluation of each region addresses: 1) the potential for 1,2-DCB in groundwater from the RP property to discharge to the Willamette River at concentrations above 130 µg/L; 2) the identification of potential data gaps; and 3) the need to fill any potential data gaps concurrent with ongoing LWG RI/FS activities.

Region 1 (Arkema Lot 1 through the Southern Portion of Siltronic Property)

Region 1 bounds the shallower part of the distal, dissolved-phase 1,2-DCB plume, and it extends from the upstream lateral boundary of the plume to the northern edge of a gravel-covered bench on the eastern wall of the buried valley (see cross section C-C’ on Figure 3). Within this region, LWG has mapped two discharge zones, one relatively well defined zone (based on discharge measurements and river sediment grain size) downstream of the railroad bridge, and one inferred zone (based primarily on one discharge monitoring point) upstream of the railroad bridge. Analytical results from TZW samples collected within each zone suggest that RP-like constituents are likely discharging to the Willamette River downstream of the railroad bridge. Upstream of the bridge, RP-like constituents also may be discharging to the Willamette River, but the evidence to support this statement is inconclusive. An evaluation of each mapped discharge zone is presented below.

Upstream of the Railroad Bridge

The analytical results for DGZ wells and for groundwater samples collected from temporary reconnaissance borings completed at the Alluvium Zone-DGZ contact south of the railroad bridge along the Arkema portion of Region 1 indicate that 1,2-DCB is present at concentrations exceeding the SLV of 130 µg/L in a limited area between ARK-16 (190 µg/L) to the southeast, and RP-01-65 (820 µg/L) to the northeast (Figure 5). 1,2-DCB also is detected above 130 µg/L in the lower portion of the Alluvium Zone on the Arkema Lot 1 property at RP-01-51 and in temporary borings completed on Arkema Tract A property (ARK-12 and ARK-14) at elevations of 5 to 15 feet bmsl. Based on preliminary data, the area on Arkema property where 1,2-DCB was detected during the Stage 1 SCE beach area investigation is bounded on both the upstream and downstream sides by low to nondetect concentrations of 1,2-DCB (BNSF-3 and ARK-17).

TZW samples collected by LWG from three locations in the Willamette River upstream of the railroad bridge indicate the maximum concentration of 1,2-DCB detected was 18 µg/L at RP07BTR (30 cm), located within the LWG inferred discharge zone. The moderate maximum discharge (6.7 cm/day) measured at this sampling location, coupled with the low 1,2-DCB concentration, does not in itself demonstrate discharge of 1,2-DCB from groundwater to the Willamette River. Nonetheless, the conceptual hydrogeologic model does suggest that groundwater discharge to the Willamette River may be occurring because positive discharge was measured at all three monitoring locations, and because sand lenses have been observed in multiple beach area reconnaissance borings adjacent to the Willamette River. Also note that the area over which discharge may be occurring is limited in extent (between ARK-11 and ARK-16 as shown on Figure 5).

SLLI's recently completed Stage 1 SCE beach area investigation complements the existing LWG TZW sampling by providing evidence that 1,2-DCB is present in groundwater beneath the western bank of the Willamette River between RP-01 and ARK-16. By applying the simplifying and conservative assumption that TZW in the upstream portion of this region contains 1,2-DCB at the same concentration detected in beach reconnaissance borings between ARK-11 and ARK-16, a potential data gap for the Portland Harbor RI/FS can be eliminated. Beyond ARK-16, further upstream, 1,2-DCB concentrations are well below the SLV, at less than 9.5 µg/L at the Alluvium-DGZ contact and less than 31 µg/L in the DGZ. Therefore, discharge of 1,2-DCB to the Willamette River at a concentration greater than 130 µg/L is unlikely because it is not present in groundwater above 130 µg/L. This would also be true for other RP-like constituents that are not present in groundwater above their respective SLVs.

Based on this discussion, SLLI concludes the following for the upstream portion of Region 1:

- Groundwater may be discharging to the Willamette River from the lower portion of the Alluvium Zone and the DGZ. Any groundwater from the Alluvium Zone would be expected to discharge at a much lower rate than groundwater from the DGZ based on the differences in hydraulic conductivities of these two units.
- The inferred discharge zone mapped by LWG where RP-like constituents may discharge to the Willamette River may not be fully delineated.
- It is not necessary to collect additional TZW data to fill this potential data gap for the Portland Harbor RI/FS because LWG can conservatively assume the 1,2-DCB concentrations in TZW are the same as, or less than, those detected in beach area reconnaissance borings.
- Additional data collection may be necessary to complete RD for sediment capping, but this potential data collection is not necessary for completion of the Portland Harbor RI/FS.

- Discharge may be occurring deeper in the Willamette River from the DGZ, within the navigation channel, but will be addressed by upland source control via implementation of the NFA ISCM as described in the NFA ISCM Work Plan (AMEC, 2007d).

Downstream of the Railroad Bridge

The analytical results for wells completed in the DGZ north of the railroad bridge along the Siltronic portion of Region 1 indicate that 1,2-DCB is present at concentrations exceeding the SLV of 130 µg/L, ranging from 240 µg/L (SIL-03) to 790 µg/L (RP-07-84) in wells completed at the riverfront (see cross section C-C' in Figure 3). In addition,1,2-DCB was detected in the off-shore discharge zone in TZW samples collected by LWG at concentrations ranging from approximately 3 µg/L (R2-RP-01, 30 cm) to 640 µg/L (RP-03-C, 30 cm). The relatively high maximum discharge (29 cm/day) recorded in the sand patch, and the higher 1,2-DCB concentrations in TZW samples collected there, indicate that solute-phase RP-like constituents may be discharging to the Willamette River within the discharge zone mapped by LWG.

The discharge zone is vertically aligned with the highest concentrations of 1,2-DCB at well clusters RP-07 and RP-24 (see cross section C-C' and F-F' on Figure 3), and the 1,2-DCB concentrations in the TZW are within the analytical error range of the highest concentrations detected in nearby upland monitoring wells. These two points are further supported by the direction of groundwater flow in the vicinity of these monitoring locations (northeast toward the river at RP-24 and east toward the river at RP-07 – see Figure 4) that results in migration of 1,2-DCB toward the mapped discharge zone.

Based on this discussion, SLLI concludes the following for the downstream portion of Region 1:

- Groundwater discharge to the Willamette River appears to be occurring primarily through the DGZ into sandy material in the river bottom, as supported by the analytical data on cross section F-F' (Figure 3) and on Figure 5.
- The maximum concentration in the groundwater discharge has been identified because it is downgradient of the location of maximum upland groundwater concentration in the same area. Furthermore, the maximum concentration in groundwater discharge occurs where the greatest discharge was measured in this section of the Willamette River.
- Groundwater discharge to the Willamette River from the lower portion of the Alluvium Zone may also be occurring but at a much slower rate as compared with the DGZ based on their respective hydraulic conductivities. However, no 1,2-DCB is detected in the Alluvium Zone. Therefore, neither 1,2-DCB nor other RP-like constituents not detected in the Alluvium Zone, are discharging to the Willamette River from the Alluvium Zone.
- The discharge zone identified by LWG is adequately mapped, based on the number of discharge monitoring locations downstream of the railroad bridge. However, 1,2-DCB concentrations within the discharge zone decrease with decreasing discharge, and decrease downstream.
- A portion of the sand patch is located within the navigation channel, but the highest discharge recorded within the sand patch does not occur in the channel. As previously stated, discharge occurring within the navigation channel will be addressed by upland source control (i.e., implementation of the NFA ISCM).

- Additional data collection may be necessary to complete RD for sediment capping, but this data collection is not necessary for completion of the Portland Harbor RI/FS.
- No in-river data gaps exist that would prevent the completion of the Portland Harbor RI/FS.

Region 2 (Northern Portion of Siltronic Property)

Region 2 encompasses that portion of the buried valley downstream of Region 1 where groundwater in the DGZ contains 1,2-DCB at or near the 130 µg/L SLV. Region 2 bounds the "deep" part of the 1,2-DCB in groundwater in the DGZ (see cross section C-C' on Figure 3). In this region, the 1,2-DCB detections occur at an approximate depth of 200 feet, which is an elevation of approximately 165 feet bmsl, more than 100 feet below the bottom of the Willamette River channel.

Groundwater discharge directly to the Willamette River in this region occurs through the Alluvium Zone. Although LWG has not conducted discharge monitoring or TZW sampling within Region 2, the concentrations of 1,2-DCB in TZW samples in Region 1 decreased downstream, toward Region 2 (LWG 2006c). Furthermore, TZW samples obtained by Siltronic in Region 2 did not detect any 1,2-DCB (MFA, 2005b).

Other chemical evidence of the relation of groundwater flow to the Willamette River in Region 2 can be obtained from cross sections showing the structure of a chlorinated solvent plume on the Siltronic property (MFA, 2005b). A series of three cross sections illustrates the location of trichlorethene, cis-1,2-dichlorethene, and vinyl chloride groundwater plumes from Siltronic property relative to the Willamette River channel. These cross sections show that on-shore groundwater, at depths equivalent to an elevation of 70 feet bmsl, flows upward, and discharges to the Willamette River. However, no 1,2-DCB is detected above 120 feet bmsl within the Alluvium Zone within Region 2, so no discharge of 1,2-DCB above 130 µg/L directly from the Alluvium Zone to the Willamette River is possible.

An evaluation of data within Region 2 indicates that no RI/FS data gaps exist as discussed below, along with other conclusions regarding Region 2:

- Groundwater discharge to the Willamette River that occurs in Region 2 is occurring primarily through the Alluvium Zone because the DGZ is at an approximate elevation of 165 feet bmsl, more than 100 feet below the bed of the Willamette River.
- 1,2-DCB is not detected in the Alluvium Zone at or above 130 µg/L at any riverfront or in-river boring location. Therefore, 1,2-DCB (or other RP-like constituents) are not discharging to the Willamette River from the Alluvium Zone.
- Discharge of 1,2-DCB in the DGZ directly to Willamette River is not occurring because the Alluvium Zone separates the DGZ from the river by at least 100 feet. This supported by the previous bullet which states that 1,2,-DCB is not detected in the Alluvium Zone above 130 µg/L.
- 1,2-DCB is not detected in any TZW samples collected by Siltronic within this region.
- No data gaps exist in the region for either the Portland Harbor RI/FS, or future RD.

- Implementation of the NFA ISCM will address the detections of 1,2-DCB in the DGZ in this region.

Region 3 (Northernmost Portion of Siltronic Property and NWN/Gasco Property)

Region 3 consists of the area bounding the northern side of the 1,2-DCB plume. 1,2-DCB is detected in Region 3 but only at its southern edge next to Region 2 and only at concentrations less than the 130 µg/L SLV. The 1,2-DCB concentrations in Region 3 were detected in samples from on-shore borings on the Siltronic and NWN/Gasco properties and from deep borings off-shore of the Siltronic property.

The 1,2-DCB detections were found only in deep samples (more than 100 feet below the Willamette River bottom) along the apparent floor of the ancient, buried valley. Note again that detections of 1,2-DCB are not in the DAG in this Region. Multiple samples collected within the DAG, which is part of the DGZ, did not contain 1,2-DCB above the method detection limit (GS-05 and GS-07 on cross section C-C', Figure 3, and Figure 5). In the off-shore Siltronic borings, 1,2-DCB was also detected only at depth and most often at drilling refusal. The maximum detected concentration was 94.4 µg/L in the sample obtained from a depth of 190.3 feet in boring GP-25. No 1,2-DCB was detected in off-shore samples obtained from elevations above 100 feet bmsl.

Based on this discussion, SLLI concludes the following for Region 3:

- No data gaps relative to the Portland Harbor RI/FS exist because 1,2-DCB is not detected in alluvial deposits of the Alluvium Zone at depths above an elevation of 100 feet bmsl, and because none of the detections at greater depths exceed the SLV of 130 µg/L SLV.
- SLLI will continue to monitor ongoing work being performed by NWN/Gasco for any indication that data gaps in this region might exist.

CONCLUSION

On the basis of the information provided above, there is no need to collect additional TZW data in order to complete the SCE for the RP Site, nor is there a need to collect TZW data in order for LWG to complete the Portland Harbor RI/FS. The extent of RP-like constituents, using 1,2-DCB as a model, is well understood, including the relationships between groundwater and its connection, via discharge, to the Willamette River. The NFA ISCM, once implemented, will reduce the concentrations of RP-like constituents in DGZ groundwater reaching the Willamette River.

If you have any questions or comments regarding this letter, please contact Roger Gresh at (503) 639-3400.

Sincerely,

AMEC Earth & Environmental, Inc.

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Project Manager

Michelle Peterson, R.G.
Project Geologist

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OREGON
MICHELLE L. PETERSON
NOVEMBER 30, 2007
#G1656
GEOLOGIST

Attachments:	Figure 1	Site Location Map
	Figure 2	Mapped Discharge Zones, Deep Alluvial Gravel (DAG) Occurrence, and Basalt Surface Contour Elevations
	Figure 3	Cross Sections (A-A', B-B', C-C', and F-F') Showing 1, 2-DCB Concentrations
	Figure 4	Deep Gravel Zone (DGZ) & Basalt Zone Groundwater Elevations (November 2006) and Approximate 1,2-DCB 130 µg/L Contour (Based on Most Recent Available Data, 2002-2007)
	Figure 5	1,2-DCB Concentrations for the RP Property and Surrounding Properties (Most Recent Available Data, 2002-2007)

MP/lp

c: S. Dearden, sanofi-aventis US, Inc.
R. Ferguson, SLLI
J. Benedict, CHBH&L
K. Koch, EPA

REFERENCES

AMEC, 2001. *Draft Groundwater Transport Evaluation Data Needs Report, RPAC - Portland Site*, prepared for Aventis CropScience, prepared by AMEC Earth & Environmental, submitted to Oregon Department of Environmental Quality, on April 16, 2001.

AMEC, 2002. *Focused Spring 2002 Groundwater Characterization Event Groundwater Monitoring Report, RPAC - Portland Site*, prepared for RPAC, prepared by AMEC Earth & Environmental, Inc. submitted to Oregon Department of Environmental Quality, July 31, 2002.

AMEC, 2003_. *Final Groundwater Characterization Report, RPAC - Portland Site,* prepared by AMEC Earth & Environmental, Inc. submitted to Oregon Department of Environmental Quality, March 28, 2003.

AMEC, 2004. *Spring 2004 Post-Characterization Groundwater Technical Memorandum,* prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, November 1, 2004.

AMEC, 2005. *Spring 2005 Post-Characterization Groundwater Event Technical Memorandum,* prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, December 21, 2005.

AMEC, 2006a. *Stage 1 Source Control Evaluation Technical Memorandum*, prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, May 19, 2006.

AMEC, 2006b. *Winter 2006 Groundwater Data Submittal*, prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, August 7, 2006.

AMEC, 2007a. *Stage 2 Source Control Evaluation Technical Memorandum;* prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, June 21, 2007.

AMEC, 2007b. *Lake Area Hydrologic Investigation Technical Memorandum*; prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, March 7, 2007.

AMEC, 2007c. *Summer 2006 Groundwater Data Submittal;* prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, June 13, 2007.

AMEC, 2007d. *Draft North Front Avenue Interim Source Control Measure Work Plan;* prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, July 10, 2007.

Anchor, 2007. *Phase I Report and Phase 2 Field Sampling Approach - Gasco Siltronic Groundwater Source Evaluation,* prepared by Anchor Environmental, LLC for Northwest Natural, May 2007.

Beeson, et. al, 1991. *Geologic Map of the Portland Quadrangle, Multnomah and Washington Counties, Oregon and Clark County, Washington*; State of Oregon Department of Geology and Mineral Industries Geological Map Series 75, 1991.

Freeze, R. A. and J. A. Cherry, 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, NJ.

Integral, 2006. *Work Plan, Engineering Evaluation/Cost Analysis, Arkema Removal Action, Portland, Oregon,* prepared by Integral Consulting, Inc., July 14, 2006.

LWG, 2004. *Portland Harbor RI/FS Programmatic Work Plan*, prepared by Integral Consulting Inc., Windward Environmental, LLC, Kennedy/Jenks Consultants, Anchor Environmental, LLC, and Groundwater Solutions. April 23, 2004.

LWG, 2006a. *Portland Harbor RI/FS, Field Sampling Plan, Transition Zone Water Sampling, Addendum 1, Sampling Plans for ExxonMobil, Gasco, Siltronic, and Arkema,* prepared by Integral Consulting, Inc. March 27, 2006.

LWG, 2006b. *Portland Harbor RI/FS, Field Sampling Plan, Transition Zone Water Sampling, Addendum 2, Sampling Plans for Kinder Morgan Linnton, ARCO, Rhone Poulenc, Willbridge, and Gunderson,* prepared by Integral Consulting, Inc. March 27, 2006.

LWG, 2006c. *Portland Harbor RI/FS, Round 2 Groundwater Pathway Assessment, Transition Zone Water, Site Characterization Summary Report*; prepared by Integral Consulting for Lower Willamette Group, submitted to the United States Environmental Protection Agency, August 7, 2006.

MFA, 2005a. *Results of In-River Sediment and Groundwater Investigation*; prepared by Maul Foster Alongi, Inc. for Siltronic Corporation, submitted to the Oregon Department of Environmental Quality, February 1, 2005.

MFA, 2005b. *Supplemental Investigation Report*; prepared by Maul Foster Alongi, Inc. for Siltronic Corporation, submitted to the Oregon Department of Environmental Quality, September 8, 2005.

Morgan, D. and McFarland, W., 1996. *Simulation Analysis of the Ground-Water Flow System in the Portland Basin, Oregon and Washington.* USGS Water-Supply Paper 2470-B.

Oregon Department of Environmental Quality (DEQ)/United States Environmental Protection Agency (EPA), 2005. *Portland Harbor Joint Source Control Strategy Final*, December 2005, Table 3-1 updated July 16, 2007.

Swanson, R.D., McFarland, W.D., Gonthier, J.B., and Wilkinson, J.W., 1993. *A Description of Hydrogeologic Units in the Portland Basin, Oregon and Washington.* USGS Water-Resources Investigations Report 91-4196.

Tolan, T.L. and Reidel, S.P., 1989. *Structure map of a portion of the Columbia River flood basalt province, in Reidel, S.P. and Hooper, P.R., eds, Volcanism and tectonism in the*

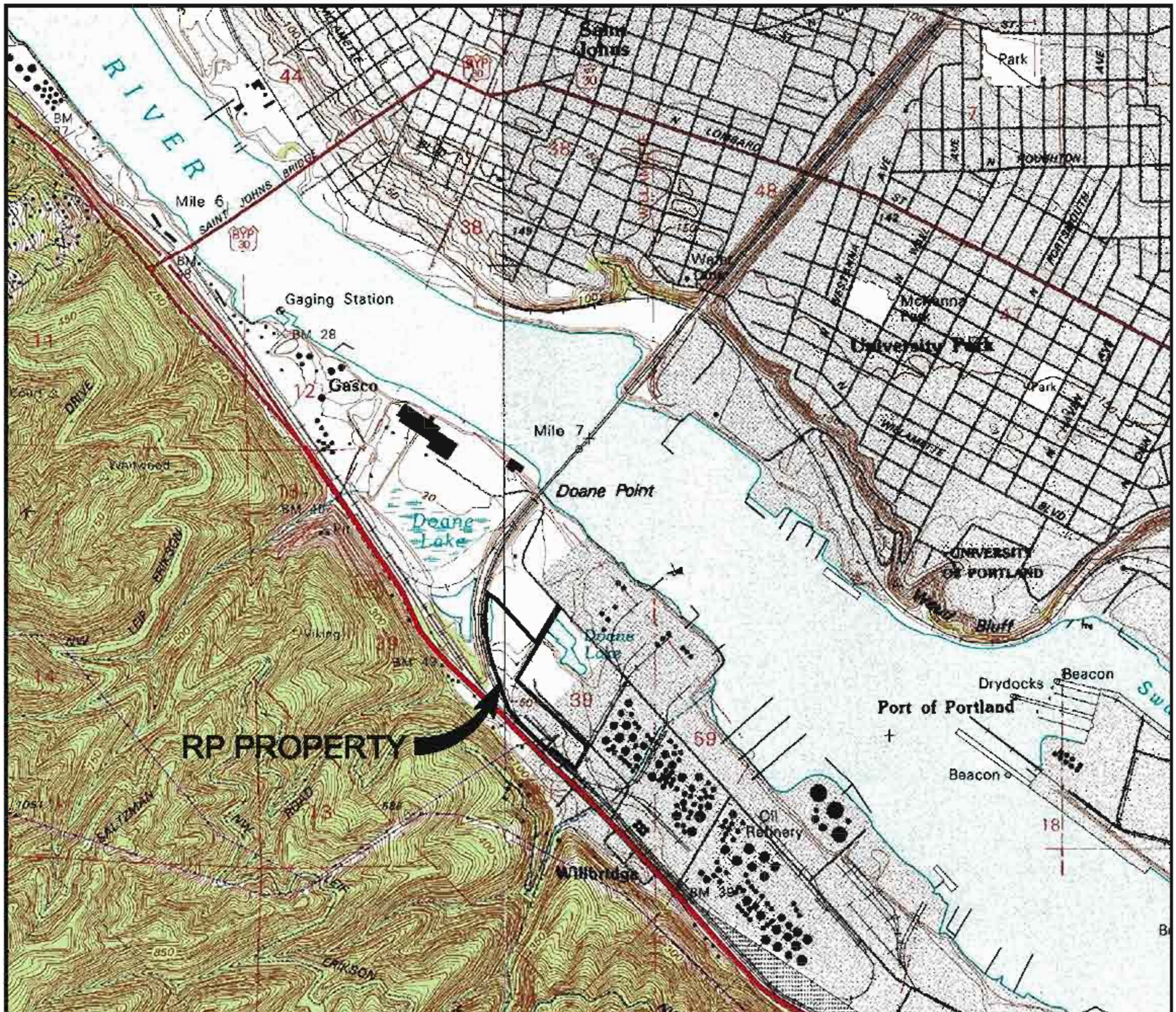
Columbia River flood-basalt province; Geological Society of America Special Paper 239, Plate 1, 1989.

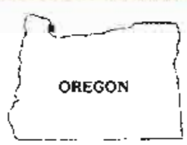
URS, 2001. *Portland NW CSO Force Main System River Crossing Evaluation, Portland, Oregon*, prepared for Bureau of Environmental Services, City of Portland, prepared by URS, January 2001.

LIMITATIONS

This document was prepared exclusively for SLLI by AMEC Earth & Environmental, Inc. The quality of information, conclusions, and estimates contained herein is consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions, and qualifications set forth in this report. The Evaluation of Groundwater Discharge to the Willamette River is intended to be used by SLLI for the RP - Portland Site, 6200 N.W. St. Helens Road, Portland, Oregon only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this document by any third party is at that party's sole risk.

ATTACHMENTS





QUADRANGLE LOCATION

PORTLAND, OR-WA
45122-E6-TF-024
1990

SCALE 1:24 000

KILOMETERS 1 .5 0 1 2
METERS 1000 0 1000 2000
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FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000

SOURCE: USGS QUAD SHEET: LINTON AND PORTLAND, OREG.

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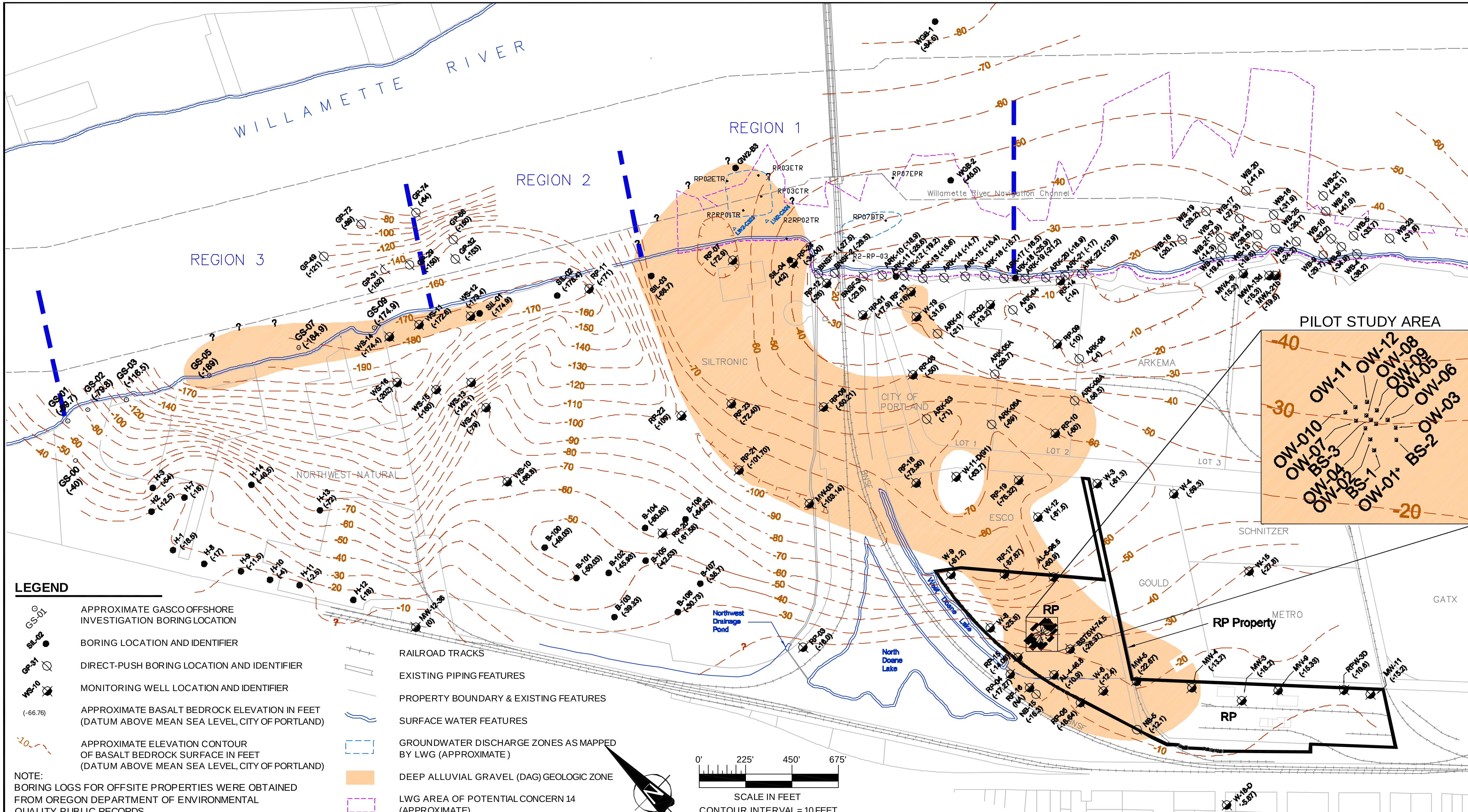
PROJECT: RP - PORTLAND SITE	DWN BY: DD/BRJ	DATUM: NAD83	DATE: SEPTEMBER 2007
TITLE: SITE LOCATION MAP	CHK'D BY: JF	REV. NO.: 1	PROJECT NO: 061M107030 P51 T4
	PROJECTION: UTM Zone 10N	SCALE: AS NOTED	FIGURE No. 1

K:\10000\10700\10703\Phase 51T4 Strategic Planning & Negotiations\DGZ White Paper\DWG\Figure 1 Site Location Map.dwg – Layout1 – Sep. 13, 2007 7:49am – brian.johnson



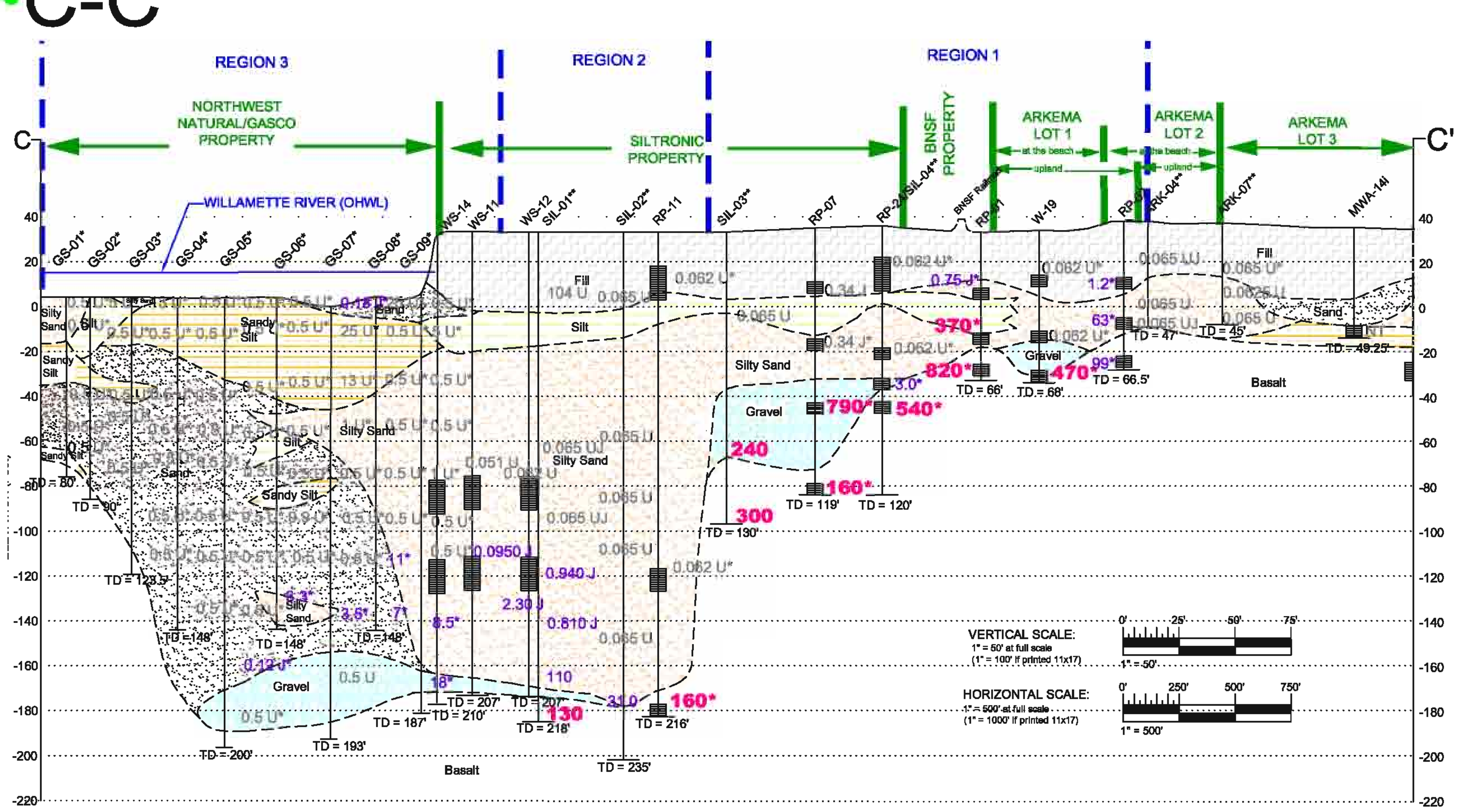
NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL EVALUATION OF GROUNDWATER DISCHARGE TO THE WILLAMETTE RIVER REPORT, SEPTEMBER 2007.

GASCO Offshore investigation boring locations are approximate and from the GASCO CSM document in PDF form, Figure 3, Page 135.

CLIENT:	SLLI
	AMEC Earth & Environmental 7376 S.W. Durham Road Portland, OR. U.S.A 97224
DWN BY:	PM
CHK'D BY:	MP
VERTICAL DATUM:	City of Portland
PROJECTION:	OR SP N., NAD83, Int. Ft
SCALE:	As Shown
PROJECT:	RP - PORTLAND SITE
TITLE:	MAPPED DISCHARGE ZONES, DEEP ALLUVIAL GRAVEL OCCURENCE, AND BASALT SURFACE CONTOUR ELEVATIONS
DATE:	SEPTEMBER 2007
PROJECT NO:	061M107030-P51 T4
REV. NO.:	1
FIGURE No.	2

K:\10000\10700\10703\Phase 51T4 Strategic Planning & Negotiations\DGZ White Paper\DWG\Figure 2 RP_Discharge_Zones with DAG and Basalt Contours.dwg – 11x17 w Basalt – Sep. 28, 2007 2:50pm – laura.mccoy

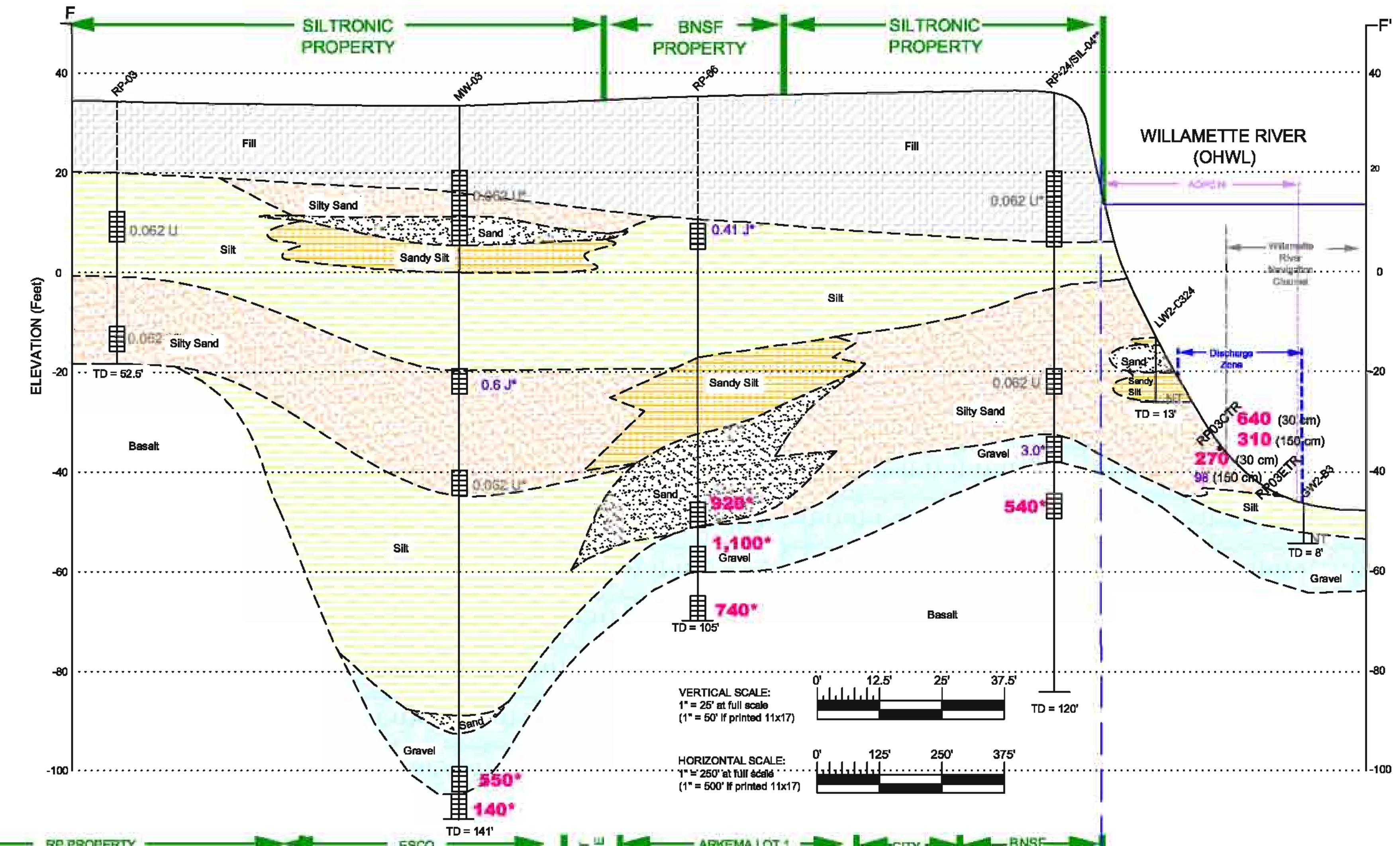
C-C'



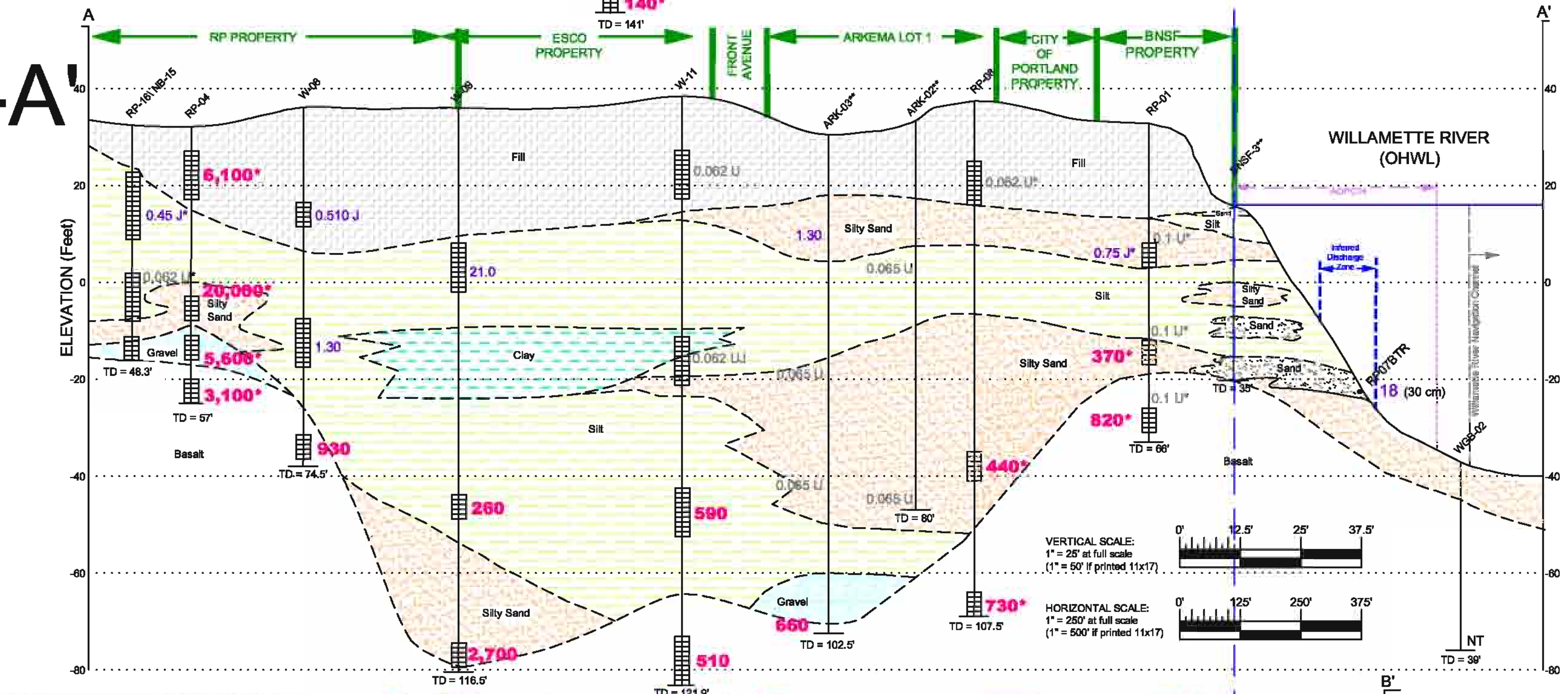
CROSS -SECTION LEGEND

- TD = 48.3' — Exploratory Boring and Identifier (TD=Total Boring Depth Below Ground Surface)
- TD = 107.5' — Monitoring Well Cluster, Identifier, and Screen Interval (TD=Total Boring Depth Below Ground Surface)
- INFERRED LITHOLOGIC CONTACT
- **DENOTES APPROXIMATED ELEVATION
- Property Locations (Approximate)
- LWG Discharge Zone Location (Approximate)
- AOPC14 LWG Area of Potential Concern (Approximate)
- Willamette River Navigation Channel (Approximate)
- 320 — Groundwater Concentration in ug/L above 130 ug/L
- 7.50 — Groundwater Concentration in ug/L below 130 ug/L
- 0.062 U — Constituent Not Detected at the Method Detection Limit in ug/L
- U — Not Detected at the Method Detection Limit
- J — Estimated Value
- * — Data Not Validated
- NT — Not Tested during the Period 2002-2007
- ug/L — micrograms per liter

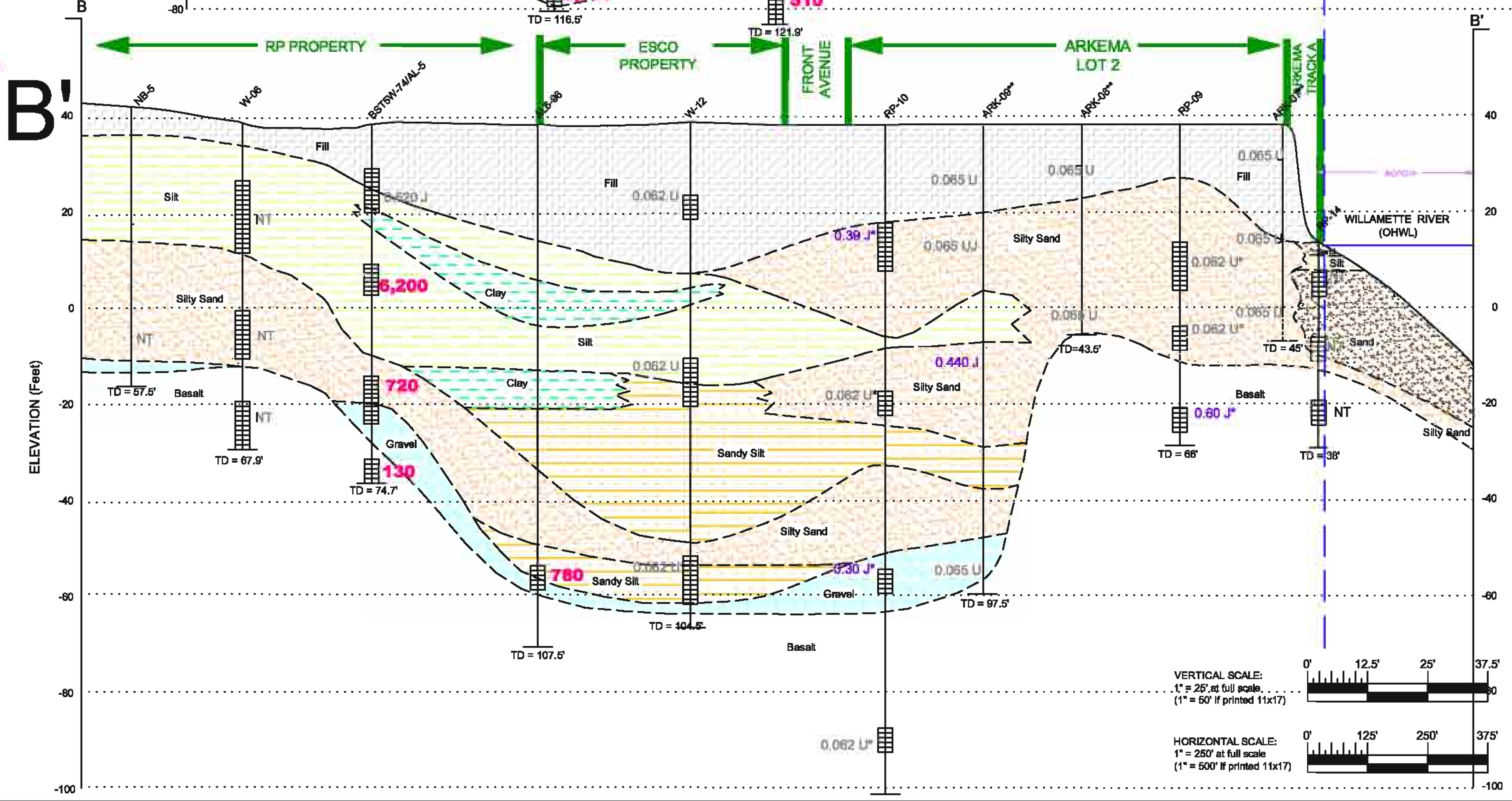
F-F'



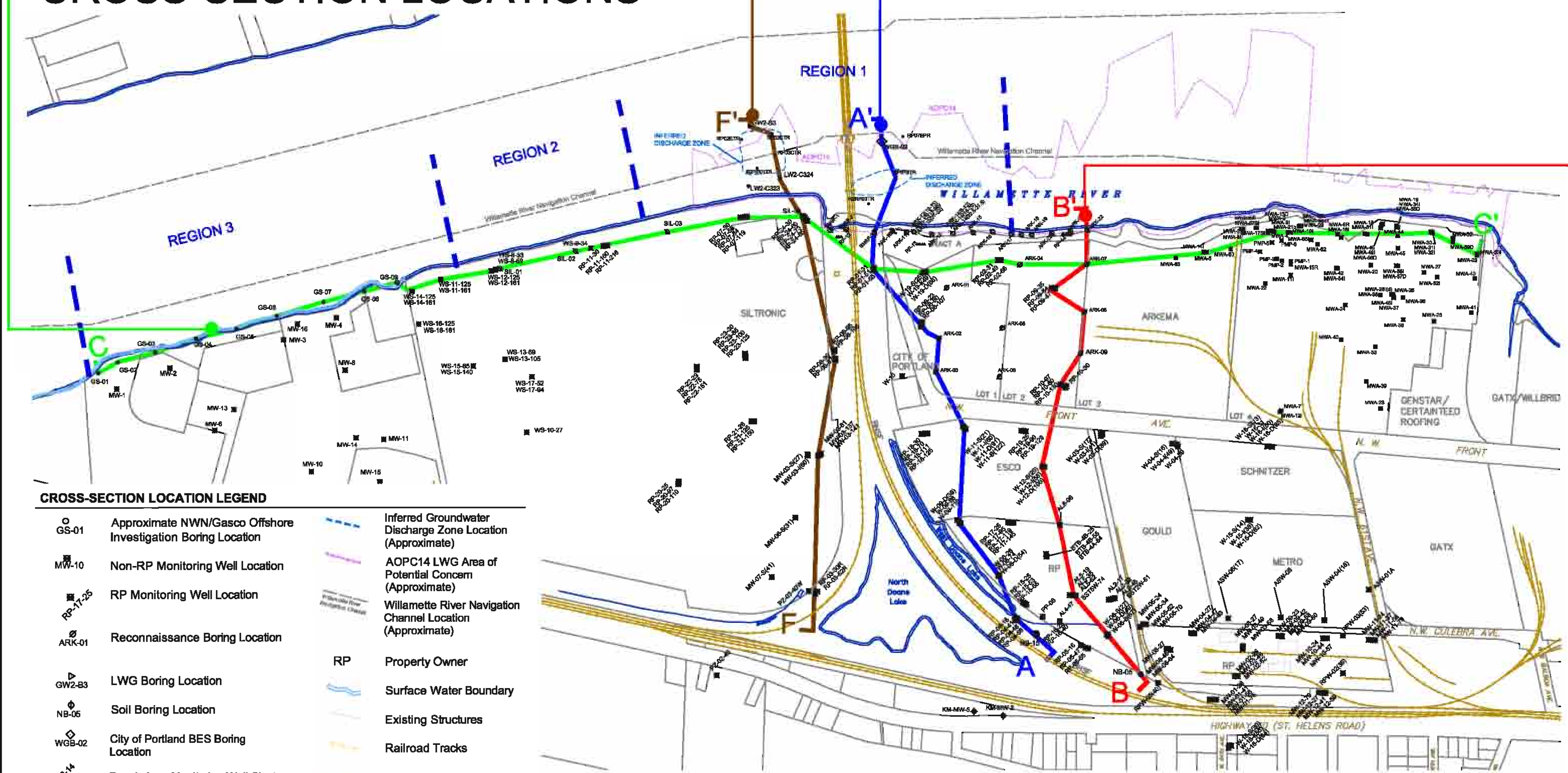
A-A'



B-B'



CROSS-SECTION LOCATIONS



CROSS-SECTION LOCATION LEGEND

- GS-01 — Approximate NWN/Gasco Offshore Investigation Boring Location
- MW-10 — Non-RP Monitoring Well Location
- RP-11-25 — RP Monitoring Well Location
- ARK-01 — Reconnaissance Boring Location
- GW2-63 — LWG Boring Location
- NB-05 — Soil Boring Location
- WGS-02 — City of Portland BES Boring Location
- Beach Area Monitoring Well Clusters
- Inferred Groundwater Discharge Zone Location (Approximate)
- AOPC14 LWG Area of Potential Concern (Approximate)
- Willamette River Navigation Channel Location (Approximate)
- RP — Property Owner
- Surface Water Boundary
- Existing Structures
- Railroad Tracks
- AMEC Lithologic Cross Section Location

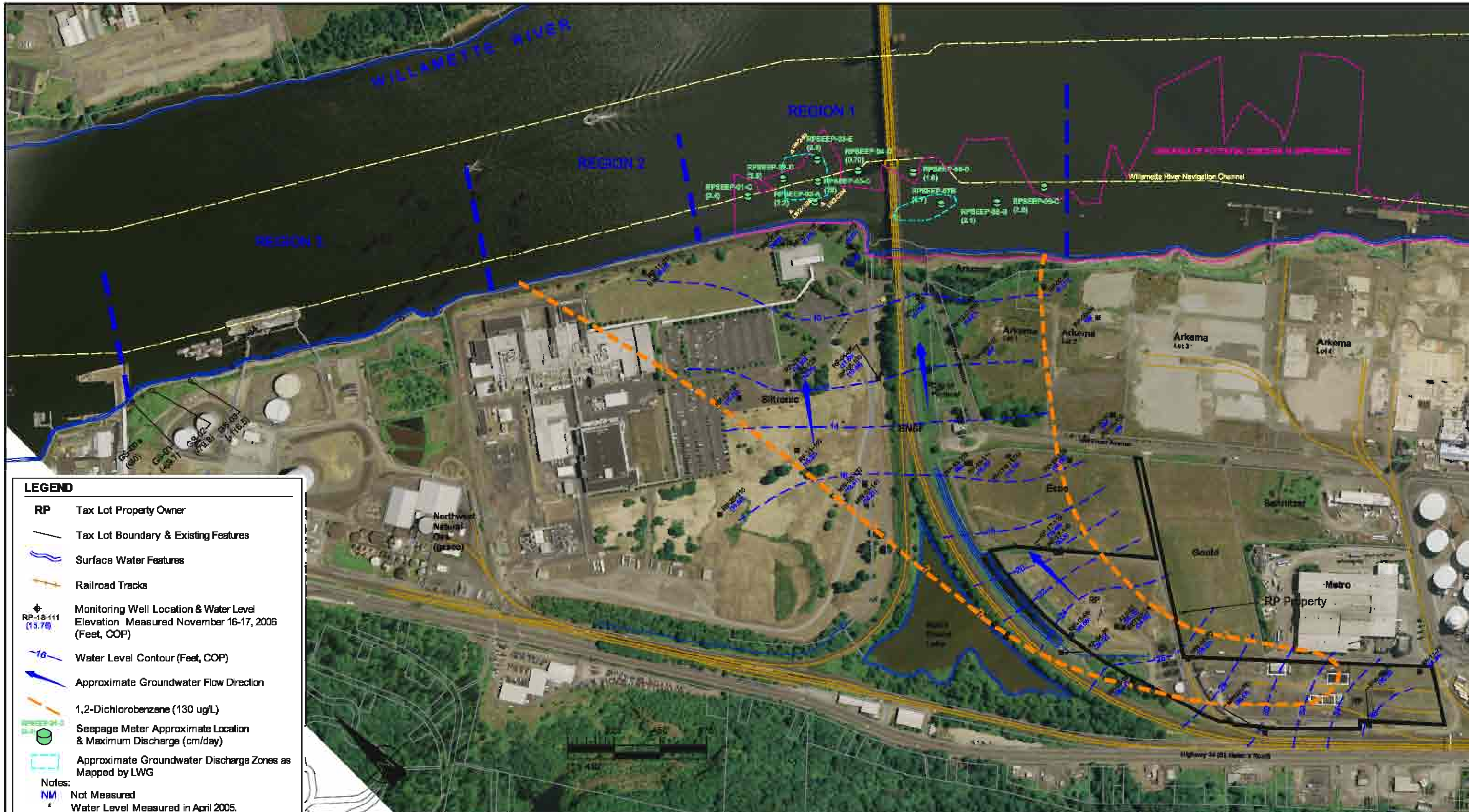
1" = 500' at full scale (1" = 1000' if printed 11x17)

NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL EVALUATION OF GROUNDWATER DISCHARGE TO THE WILLAMETTE RIVER REPORT

NOTE: STRATIGRAPHY BETWEEN DEPICTED BORINGS INTERPRETED FROM ADDITIONAL BORINGS NOT SHOWN ON THIS CROSS SECTION.

CLIENT: SLLI	DWN BY: LM	PROJECT: RP - PORTLAND SITE	DATE: SEPTEMBER 2007
AMEC Earth & Environmental, 7376 S.W. Durham Road, Portland, OR USA 97224	CHK'D BY: MP		PROJECT NO: 0-61M-10703-51 T4
	DATUM: City of Portland	TITLE: SELECTED CROSS-SECTIONS (A-A', B-B', C-C' & F-F') SHOWING 1,2-DCB CONCENTRATIONS (MOST RECENT AVAILABLE DATA, 2002-2007)	REV. NO.: 7
	PROJECTION: -		FIGURE No. 3
	SCALE: AS NOTED		

K:\10000\10700\10703\RP_Site_Cross_Sections\Cross_Sections_Under_Review_DO NOT USE\12_DCB_Cross Section Combination*.dwg – d SIZE – Sep. 28, 2007 2:33pm – laura.mccoy

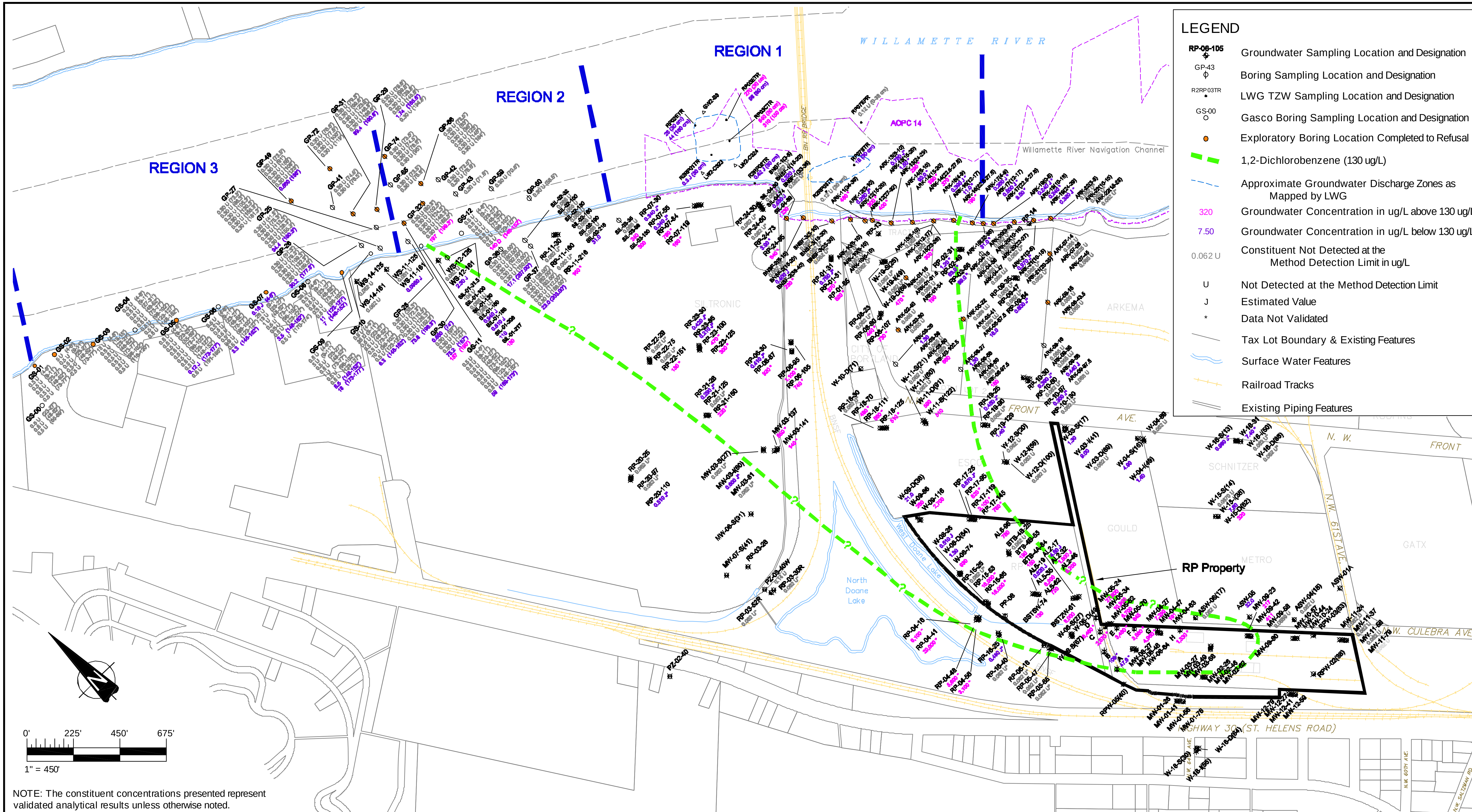


NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL EVALUATION OF GROUNDWATER DISCHARGE TO THE WILLAMETTE RIVER REPORT, SEPTEMBER 2007.

NOTE: 2006 Aerial from **Metro Data Resource Center**

CLIENT:	SLLI
AMEC Earth & Environmental 7376 S.W. Durham Road Portland, OR. U.S.A 97224	amec
DWN BY:	PM
CHK'D BY:	MP
DATUM:	CITY OF PORTLAND
PROJECTION:	OR SP N. Intl Ft.
SCALE:	1" = 450'
PROJECT:	RP - PORTLAND SITE
TITLE:	DEEP GRAVEL ZONE AND BASALT ZONE GROUNDWATER ELEVATIONS (NOVEMBER 2006) & APPROXIMATE 1,2-DICHLOROBENZENE 130 ug/L CONTOUR BASED ON MOST RECENT AVAILABLE DATA, 2002-2007
DATE:	SEPTEMBER 2007
PROJECT NO:	061M-107030 P51T4
REV. NO.:	0
FIGURE No.	4

K:\10000\10700\10703\Phase 51T4 Strategic Planning & Negotiations\DGZ White Paper\DWG\Figure 4 DGZ & BASALT ZONE GROUNDWATER 1,2 DCB.dwg – 11X17 – Sep. 28, 2007 3:05pm – laura.mccoy



NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL EVALUATION OF GROUNDWATER DISCHARGE TO THE WILLAMETTE RIVER REPORT, SEPTEMBER 2007.

CLIENT: SLLI

AMEC Earth & Environmental
7376 S.W. Durham Road
Portland, OR U.S.A. 97224

DWN BY: BRJ
CHK'D BY: -
DATUM: NAD83
PROJECTION: OR SP N. Int Ft.
SCALE: 1" = 450'

PROJECT: RP - PORTLAND SITE

TITLE: 1,2-DICHLOROBENZENE CONCENTRATIONS FOR THE RP PROPERTY AND SURROUNDING PROPERTIES, MOST RECENT AVAILABLE DATA, 2002-2007

DATE: SEPTEMBER 2007
PROJECT NO: 061M107030 P51T4
REV. NO.: 1
FIGURE No. 5

K:\10000\10700\10703\Phase 51T4 Strategic Planning & Negotiations\DGZ White Paper\DWG\Figure 5 12DCB Most Recent (2002-2007).dwg – All Zones – Sep. 28, 2007 2:45pm – laura.mccoy