U. S. EPA Region 10

Revised Draft Technical Memorandum Evaluation of Groundwater Flow and Contaminant Transport

Hamilton-LaBree Roads Superfund Site Chehalis, Washington

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Contents

Section 1 Introduction
1.1 Background 1-1
1.2 Purpose 1-2

Section 2 Conceptual Model
2.1 Hydrostratigraphy 2-1
2.2 Hydrogeologic Properties 2-2
2.3 Groundwater Recharge and Discharge 2-3
2.4 Groundwater Flow Directions 2-4
2.5 Site Contamination 2-4
2.6 Aquifer Transport Properties 2-5

Section 3 Numerical Groundwater Flow Model
3.1 Model Code 3-1
3.2 Model Area and Grid 3-1
3.3 Model Stratigraphy 3-1
3.4 Boundary Conditions 3-2
3.5 Flow Model Calibration 3-3
3.6 Sensitivity Analysis 3-4
3.7 Contaminant Transport Model Development 3-5

Section 4 Alternative Analysis
4.1 Simulation 1 - Hydraulic Containment 4-1
4.2 Simulation 2 - No Action 4-1
4.3 Simulation 3 - Source Removal 4-2

Section 5 Conclusions and Recommendations
5.1 Conclusions 5-1
5.2 Recommendations 5-2

Section 6 References 6-1

Figures

1-1	*Study Area Map*
1-2	*Site Location Map*
2-1	*Study Area Geology*
2-2	*Estimated PCE Plume Configuration*
3-1	*Grid Spacing at Site Properties*
3-2	*Layers 1 and 3 Bottom Elevations*
3-3	*Boundary Conditions*
3-4	*Calibration Summary*
3-5	*Layer 2 - Estimated Potentiometric Surface November 21, 2002*
3-6	*Calibrated Horizontal Hydraulic Conductivities*
3-7	*Sensitivity Analysis 1*
3-8	*Sensitivity Analysis 2*
3-9	*Comparison of Estimated and Field Data Plume*
4-1	*Estimated Capture Zone*
4-2	*Estimated PCE Plume: No Action - Current*
4-3	*Estimated PCE Plume: No Action - 5 Years*
4-4	*Estimated PCE Plume: No Action - 10 Years*
4-5	*Estimated PCE Plume: No Action - 20 Years*
4-6	*Estimated PCE Plume: No Action - 30 Years*
4-7	*Estimated PCE Plume: Source Removal - 5 Years*
4-8	*Estimated PCE Plume: Source Removal - 10 Years*
4-9	*Estimated PCE Plume: Source Removal - 20 Years*
4-10	*Estimated PCE Plume: Source Removal - 30 Years*

Tables

3-1	*Calibration Results*
3-2	*Calibrated Model Parameters*
3-3	*Groundwater Flow Summary*

Appendices

A-1	*Site Well Locations*
A-2	*Breen Property Stratigraphy*
A-3	*HRIA Stratigraphy: MW-600 to MW-608 Lithologic Logs*
A-4	*Soil Physical Properties*
A-5	*Berwick Creek Water Levels*
A-6	*Potentiometric Surface Map - Breen Property*
A-7	*PCE Concentration Cross Sections*

Section 1
Introduction

CDM Federal Programs Corporation (CDM) and Parametrix (CDM/Parametrix Team) has prepared a technical memorandum for the evaluation of groundwater flow and contaminant transport to support the remedial investigation/feasibility study (RI/FS) being performed for the Hamilton-Labree Roads Superfund Site (Site). The Site is located south of Chehalis, Washington in Lewis County. For this study, the Site includes the Hamilton Road Impact Area, the Breen Property and the impacted groundwater area. The evaluation was performed under Task Order 024 of the U.S. Environmental Protection Agency Region 10 Response Action Contract (RAC 10). A groundwater modeling effort, including fate and transport simulations, was required to evaluate the tetrachloroethylene (PCE) groundwater plume that originated onsite and has migrated downgradient. The report summarizes the site characteristics and documents the construction and calibration of the model. The report also presents the estimated capture zone of proposed extraction wells and two simulated contaminant transport alternatives: no action and source removal.

1.1 Background

The location of the Site is typically described as the intersection of Hamilton Road and Labree Road, west of Interstate 5, about 2 to 2.5 miles south of the main commercial district of Chehalis, Washington, within Lewis County. The Site includes the Breen property (located at the intersection of Hamilton Road North and Labree Road), the Hamilton Road Impact Area (HRIA), and the entire geographic area where PCE and related chemicals have been found in groundwater. This geographic area encompasses the area between and around the Breen property and the HRIA and extends more than a mile northwest of the intersection of Hamilton Road and Labree Road (URS 2004). The study area is shown in Figure 1-1 and the Site location map is presented in Figure 1-2. A figure that shows well locations throughout the Site is shown in Appendix A-1.

The HRIA portion of the Site is a roughly rectangular area approximately 3 acres in size, located immediately east of the United Rentals building on Hamilton Road North and extending eastward to the western edge of Interstate 5. The HRIA includes portions of the front parking lot of United Rentals, Hamilton Road North, and the grassy strip between Hamilton Road and Interstate 5 (owned by Lewis County and the State of Washington). Berwick Creek flows through the grassy strip from southeast to northwest. The geographic boundaries of the HRIA were estimated by observing where soil and groundwater samples were found to contain high concentrations of PCE (URS 2004).

Both the Breen property and the HRIA have been identified as areas that contribute PCE to the contaminant plume of the shallow aquifer. This shallow groundwater occurs in an aquifer (referred to as the "shallow aquifer") present from just below the

ground surface to approximately 50 feet below ground surface. The shallow aquifer is used as a water source by businesses and homeowners in the area, and PCE was found in some private wells starting in 1993. Groundwater in the shallow aquifer flows to the northwest, parallel to the Newaukum River valley (URS 2004).

Approximately 24 shallow-aquifer private wells are located in the vicinity of the HRIA, within about a mile of the intersection of Hamilton and Labree Roads and "downstream" (in terms of groundwater flow) of the HRIA. Of the properties supplied by these wells, the U.S. Environmental Protection Agency (EPA) connected all but seven to the City of Chehalis municipal water supply in 2002. PCE has not been detected in the private wells that remain unconnected to the municipal water supply (URS 2004).

After the discovery of PCE in private wells in 1993, the Washington State Department of Ecology performed several investigations to find the source of the contamination. Both the Breen property and the HRIA were identified as sources during these investigations. EPA took over the investigation work in July 2000, when the Site was designated a Superfund site. The initial work by EPA resulted in the connection of properties with contaminated wells to the City of Chehalis municipal water system in 2002. This action protected homeowners and workers in the area from the immediate risks from any PCE in the shallow aquifer. Work did not include, however, any attempt to cleanup the PCE in the shallow aquifer. An Engineering Evaluation/Cost Analysis (EE/CA) (2004) was prepared which considers alternatives that could be implemented to remove PCE from the shallow aquifer, to protect human health and the environment, and eventually to restore the shallow aquifer to a beneficial use (URS 2004).

1.2 Purpose

The objectives of the groundwater modeling task are to:

Develop a steady-state numerical model of the hydrogeologic system,

Build a solute transport model into the numerical model in order describe the fate and transport of dissolved PCE within the aquifer system to support an RI/FS

The model will provide decision support in the development and analysis of remedial alternatives including:

Estimate of the capture zone for the hydraulic containment alternative

The water quality impact of “No Action” and “Source Removal” alternatives

Section 2
Conceptual Model

The first step in preparing a numerical model is the preparation of a conceptual model. The conceptual model presents the modeler's understanding of the occurrence and movement of groundwater in the area of interest and is typically based on regional data, site-specific data and general hydrogeologic knowledge. The conceptual model focuses the calibration process and interpretation of model results by presenting a general understanding of the aquifer system.

The main components of a conceptual model are 1) hydrostratigraphy (including hydrogeologic properties and contaminant transport properties), 2) groundwater sources and sinks, and 3) groundwater flow directions.

2.1 Hydrostratigraphy

The Site lies within the Chehalis River Valley, at the southern end of the Puget Sound Lowland, an elongated structural basin that extends from the western drainage divide of the Cascade Range to the eastern drainage divide of the Olympic Mountains and north to the Frasier River in British Columbia. Pleistocene-age glaciations and subsequent Holocene-age alluvial processes that shaped the Chehalis lowlands left behind significant accumulations of glacial outwash, till, glacio-lacustrine deposits, and alluvium.

Two hydrostratigraphic units of interest have been identified to exist in the study area: alluvium underlain by glacial outwash. Additionally, fine-grained alluvial sediments underlie the outwash. Figure 2-1 presents the stratigraphy within the study area and cross sections in Appendix A-2 show the stratigraphy at the Breen property. Additionally, Appendix A-3 presents the lithologic logs for the nine newly installed wells (MW-600 - 608) at the HRIA.

Alluvium, the youngest geologic unit at the Site, consists of modern river and stream deposits of fine gravel, sand, and silt. This unit can vary in thickness from a few feet near the valley edges to several tens of feet in the Chehalis Valley interior. At the Site the formation is referred to as the silt cap and ranges from 0 to 10 feet below ground surface (bgs). The silt cap is primarily silt, containing sand lenses and stringers. In some cases, the silt grades to a silty sand or silty gravel at its contact with the underlying sand and gravel of the Vashon outwash (URS 2004). As shown in Appendices A-2 and A-3, the base of the silt cap occurs at an elevation of approximately 200 feet near the site properties. Figure 2-1 indicates that the base of the unit slopes to the west in the study area.

Vashon outwash gravel and sand underlies the alluvium (silt cap). The Vashon outwash onsite is referred to as the shallow aquifer. The shallow aquifer consists of fine-grained, poorly sorted sand to coarse gravel, with cobbles prevalent. The silt content of the sands and gravels varies substantially throughout the shallow aquifer, with some zones classified as silty sands and silty gravels and other zones classified as clean sands or gravels. At the Site, the shallow aquifer ranges from 10 to 47 feet bgs (URS 2004). As shown in Appendices A-2 and A-3, the base of the aquifer occurs at an elevation of approximately 157 feet near the HRIA and Breen property. Figure 2-1 indicates that the base of the unit slopes to the west in the study area.

Beneath the shallow aquifer, fine-grained alluvial sediments overlay glaciolacustrine deposits of glacial Lake Chehalis. These deposits are described as blue-green silt or clayey silt in the EE/CA field investigation auger borings, but have been logged as a clay in some locations by other investigators; this aquitard is widespread in the Chehalis River Valley and is reported to be more than 100 feet thick. Onsite this deposit begins at an approximate depth of 47 feet. The thickness is reported to be more than 100 feet and little to no groundwater movement occurs across this low permeability unit (Dames and Moore 1994). At locations far downgradient from the HRIA, the available hydrogeologic data are less plentiful, and it was not possible to develop a detailed picture of hydrogeologic conditions (URS 2004).

2.2 Hydrogeologic Properties

Within the HRIA study area, the shallow aquifer exhibits the characteristics of a confined or leaky confined or semiconfined aquifer. The silt cap of the shallow aquifer is relatively thin (1 to 13 feet thick within the HRIA study area) while the basal aquitard is reported to be more than 100 feet thick (Dames and Moore 1994). Little leakage probably occurs between the deep and shallow aquifers. The silt cap and the silt/clay basal aquitard exhibit vertical hydraulic conductivities less than the 2.3×10^{-2} ft/day (8×10^{-6} cm/s), based on laboratory testing performed on samples collected during the EE/CA (URS 2004). The results of vertical conductivity tests are shown in Appendix A-4.

The sand and gravel of the shallow aquifer beneath the HRIA underlies the silt cap and extends to a depth of about 47 feet bgs (as measured from near the United Rentals building). Logged soil types within the sand and gravel typically range from fine-grained, poorly sorted sand to coarse gravel, with cobbles prevalent. The silt content of the sands and gravels varies substantially throughout the shallow aquifer, with some zones classified as silty sands and silty gravels and other zones classified as clean sands or gravels (URS 2004).

Three sources provide horizontal hydraulic conductivity values for the shallow aquifer. Results of two short term tests performed at MWR-10 and MWR-11 suggest a horizontal conductivity value of 125 ft/day (E&E 2000). Two pumping tests conducted as part of the EE/CA investigation at MW-602 and 605 (with several observation wells) suggest a range of horizontal conductivities from 8.8 to 139 ft/day

(URS 2004). The maximum value is approximately one order of magnitude greater than the average value. The large conductivity is noted to be parallel to the Berwick Creek in the HRIA source area. Lastly, in a regional study, the horizontal hydraulic conductivity was estimated to be 75 ft/day (Ecology 2005).

The effective porosities of the silt cap and the aquifer are shown in Appendix A-4. Effective porosities for the silt cap range from 7.5 to 12.9 % and for the aquifer range from 11.2 to 36%.

2.3 Groundwater Recharge and Discharge

The main source of recharge to the aquifer system is precipitation. Regional data indicate an average annual precipitation for the area of approximately 46 inches (Ecology 2005). Using a relationship as described for adjacent Thurston County, the amount of recharge to the aquifer is estimated to range from 15 (low permeability material) to 28 (high permeability material) inches per year (USGS 1998). The recharge chart developed for Thurston County is based on the results of a U.S. EPA runoff-rainfall model. In addition, the chart also shows recharge estimates based on precipitation-recharge estimates for King County, Washington. The results of the two methods are similar.

Locally, the aquifer is mapped to discharge to the Newaukum River (Ecology 2005). However, it is also recognized that the river may have losing reaches or be losing during low precipitation periods (Ecology 2005).

Some data are available on the interaction between the Berwick Creek surface water and adjacent groundwater Farallon (2003) . Water levels at Berwick Creek and adjacent well locations are presented in Appendix A-5. As shown in the appendix, water is measured to be lost from the creek at locations SW-5 through SW-9. These locations are within approximately 1,300 feet from the HRIA. One location, SW-10, suggests water being gained by the stream from the aquifer in November 2003. SW-10 is located approximately 2,300 feet downgradient from the HRIA.

No other significant discharge points (e.g., production wells) are known to be operating in the vicinity of the Site. The seven private wells downgradient of the Site are not considered significant discharge points since the withdrawal of groundwater at the home wells is minimal compared to the amount of groundwater flowing in the aquifer. Using an estimated average flow of 300 g/d for each home, the seven wells withdraw groundwater at a rate of 2,100 g/d, or 1.5 g/m. In the area of the homes, the rate of groundwater flowing through the aquifer is estimated to be approximately 200 g/m under ambient conditions. The rate is estimated using specific discharge in the aquifer between the Newaukum River and the Dillenbaugh-Berwick Creek confluence. Since the estimated groundwater withdrawal rate is less than one percent of the flow within the aquifer, the wells are considered to be insignificant to the movement of groundwater and contaminants.

2.4 Groundwater Flow Directions

Groundwater elevation contours for November 21, 2002 are shown in Appendix A-6. The pattern of groundwater elevation contours based on this data set is similar to other data sets (URS 2004). Groundwater levels in the monitoring wells fluctuate an average of 3 to 5 feet per year between the high groundwater levels recorded in the winter and spring, and the low groundwater levels observed in the summer and fall months (Farallon 2003). Groundwater levels from September 5, 2002 were approximately 1.5 feet lower than the November levels. The groundwater gradient and direction of flow in September and November 2002 (Farallon 2003) was consistent with other groundwater level monitoring events conducted at the Site during previous investigations by Ecology (1999) and EPA (E&E, 2001, 2002).

The equipotential surface presented in the appendix shows a local groundwater flow direction to the southwest beneath the apparent NAPL zone and a flow direction due west beneath the northwestern hotspot. The southwesterly groundwater flow direction beneath the apparent NAPL zone becomes more westerly downgradient of the NAPL zone, and the groundwater flow direction appears westerly downgradient of the United Rentals building. The flow direction becomes northwesterly farther downgradient. At a distance from the Site, water level measurements are limited and the direction of flow into or from the creeks and the river was not measured.

The overall groundwater gradient beneath the NAPL zone, calculated based on the groundwater elevations collected at MW-9 and MWR-11 on November 26, 2003, is 0.0063 ft/ft. A localized steeper gradient is apparent immediately downgradient of Hamilton Road. The gradient in this area is approximately 0.016 ft/ft, which is approximately twice as steep as the overall gradient throughout the source area. At greater distances downgradient of the Site, groundwater flow direction is primarily to the northwest and gradients are approximately 0.003 ft/ft (URS 2004).

Monitoring well pairs MW-17/MW-18, MW-20/MW-21, and MW-22/MW-23 had no significant vertical gradient when measured within the shallow aquifer (Farallon 2003). Therefore, the vertical gradients are considered to be insignificant to the movement of groundwater and contaminants.

2.5 Site Contamination

The source contaminant at the Site is PCE, and no evidence has been found to indicate the PCE being mixed with any other contaminant. Some breakdown compounds of PCE are present, including trichloroethene (TCE) and 1,2-dichloroethene (1,2-DCE), but at much lower concentrations than PCE and with a much lower frequency of detection. PCE has contaminated the silt cap above the shallow aquifer in the bed and banks of Berwick Creek near the HRIA and has contaminated the groundwater of the shallow aquifer. Dissolved PCE (but not PCE NAPL) has reached the aquitard at the base of the shallow aquifer and has contaminated the upper 1 to 2 feet of the aquitard at relatively low concentrations (URS 2004).

Dissolved PCE has migrated a substantial distance downgradient of the HRIA source area and has commingled with PCE plumes from other areas at the Site. PW 3 was identified to be contaminated in 1993 and is located approximately 400 feet from the release location in Berwick Creek along a groundwater flow line. The latest possible PCE release time has been estimated to be 1990 (URS 2004). Contaminant concentrations at PW 3 have continued to increase since sampling in 1993, indicating that contaminant concentrations have not reached a dynamic equilibrium between dissolution from NAPL and attenuation downgradient (URS 2004).

PCE concentrations greater than 1,000 ug/L have not been detected southwest of the United Rentals building in the southern portion of the HRIA study area (i.e., from the southwestern hotspot). PCE concentrations less than 1,000 ug/L have been detected substantially farther downgradient of this area. These detections may record PCE plumes from other sources commingled with the other plume originating at the HRIA. Dissolved PCE in groundwater appears to have migrated west of the northwestern hotspot at concentrations in the range of 1,000 to 1,200 ug/L, based on recent data from the site-wide sampling program.

PCE concentrations in groundwater from the sampling event of November 2003 were contoured to estimate the plume distribution across the Site. This date was chosen since it appeared to be the most extensive sampling data set. The plume is shown in Figure 2-2. Also, cross sections that were prepared for the EE/CA show the depth of the PCE plume and are presented in Appendix A-7. PCE concentrations are also shown for the Breen property in Appendix A-2.

2.6 Aquifer Transport Properties

PCE is adsorbed on sites within the aquifer matrix, limiting their mobility in groundwater. This adsorption may occur on sites such as natural organic carbon coatings on aquifer materials, but may also occur to a lesser degree on inorganic surfaces such as clay or iron minerals. The chemical characteristic that defines the degree to which the chemical are adsorbed is the organic carbon partitioning coefficient (Koc), which is reported in numerous sources for the chemicals of interest. This coefficient defines the degree to which a chemical will partition onto the solid phase adsorption sites. At concentrations observed at the site, this process is assumed to be linear, instantaneous and reversible. A bulk measure of the adsorption capacity of the aquifer material may be estimated using the Koc and the organic carbon concentration in the soil. This term is described as the soil – water partitioning coefficient (Kd). Kd may be estimated by multiplying the fraction of organic carbon present in the soil by the Koc value for the chemical of interest.

Once Kd has been estimated for the chemicals of interest and the aquifer material at the site, the velocity of the contaminants may be estimated. These equilibrium sorption processes have the effect of slowing movement of contaminants relative to

the groundwater velocity. The ratio of the velocity of the groundwater to that of the contaminant front is referred to as the retardation factor, R. A value of 1 for R indicates that the contaminant moves at the same velocity as groundwater. The R value can be estimated from the following equation:

$$R = 1 + \frac{Kd * Density}{TotalPorosity}$$ Where:

R – Ratio of average groundwater velocity to average contaminant velocity

Kd – soil water partitioning coefficient

Density – dry bulk density of aquifer soil

Total Porosity – total porosity of aquifer material

The organic carbon content, bulk density and total porosity of the silt cap and the aquifer has been estimated from samples collected at several borings advanced in the HRIA (URS 2004). The values are presented in Appendix A-4.

The total porosities for the silt and the aquifer material are assumed to be 20% and 36%, respectively. The total porosity of the silt may be higher than 20%. As shown in Appendix A.4, the maximum measured value was 42.3%. However, transport results due to the difference of 20% compared to 42.3% are negligible, since the silt is predominantly unsaturated and groundwater concentrations of interest are located in the aquifer.

This data indicate that averages for the total organic carbon concentrations, porosity and bulk density of the silt cap are 5180 mg/kg, 20 % and 1.51 gm/ml, respectively. The Koc value for PCE, reported on an EPA website is 238 ml/gm. Using these values, the retardation factor for PCE in the silt cap is estimated to be 10.3. The data indicate that the averages for the total organic carbon concentrations, porosity and bulk density in the aquifer are 350 mg/kg, 36% and 1.62 g/ml, respectively Using these values, the retardation factor for PCE in the aquifer is estimated to be 1.4. This low capacity for adsorption of PCE on the aquifer matrix will result in rapid flushing of the aquifer, once the source of additional mass contribution from the silt cap is eliminated.

PCE may readily degrade under the proper biogeochemical conditions in aquifers to create the principal degradation products TCE, cis-1,2-DCE, and vinyl chloride. Degradation of PCE to the daughter products requires the presence of reducing conditions in groundwater. However, since negligible PCE daughter product concentrations have been reported at wells at the HRIA, biodegradation is assumed to

not be an active fate process. For example, the PCE concentration at MW-601 was detected at 83,500 ug/l and the detected TCE and DCE concentrations are 96J and 500 UJ ug/l, respectively (URS 2004). Historical documentation suggests some minimal biodegradation is occurring by the presence of the daughter products TCE and cis-1,2-DCE in some groundwater samples (URS 2004). However the overall geochemistry of the aquifer is unfavorable for biodegradation (URS 2004).

Lastly, the effect of dispersion spreads contaminant mass beyond the region it would normally occupy due to advection alone. Dispersion occurs in three directions (longitudinal, transverse and vertical). Longitudinal dispersivity is the largest and transverse and vertical are commonly considered to be one and two orders of magnitude lower, respectively. Longitudinal dispesivity is defined as

$$\text{Dispersivity} = 0.83\ (\log\ (\text{plume length}))^{2.414}$$

where length is in meters (Xu and Eckstein 1995).

Therefore, using a plume length of 5, 400 ft (1,646 m), longitudinal dispersivity is 45.7 ft. Transverse and vertical dispesivity is suggested to be 4.6 and 0.5 ft, respectively.

Section 3
Numerical Groundwater Model

The numerical model was developed from information and data used to construct the conceptual model. The six main components of developing a numerical model are: developing a conceptual model and parameter estimates (Section 2), choosing a model code, defining a model grid, assigning boundary conditions, performing a model calibration, and conducting a sensitivity analysis to confirm the final model parameters.

3.1 Model Code

The flow code MODFLOW-96 (McDonald and Harbaugh 1989) and the solute transport program MT3DMS (Zheng and Wang 1998) were used to perform the modeling activity. The groundwater modeling package Groundwater Vistas, Version 4.18, (Environmental Simulations, Inc. 2004) was used as the graphical user interface to pre- and post-process the model files produced by MODFLOW and MT3DMS. Groundwater Vistas was chosen since it has the capabilities to simulate three-dimensional flow in layered units as found at the Site, and the proposed site remedies may be incorporated into the model.

3.2 Model Area and Grid

The numerical groundwater model domain represents approximately 12 square miles located in Lewis County, Washington. The model extends vertically from 300 to 150 ft NGVD (1929). The grid was rotated 37^0 to the northwest so that the principal axis was parallel to the valley walls. The lateral extent of the model is congruent to the study area, which is shown in Figure 1-1. The lateral extent was chosen so that standard hydrogeologic boundaries (e.g., a river) were available to be selected as model boundaries and so that the boundaries were located at significant distances so that they would not adversely impact water levels at the Site. The model coordinate system is Washington State Plane, NAD 83, South Zone (horizontal).

The model grid utilizes a non-uniform spacing with a total of 217 rows and 144 columns. At the Site, the model grid spacing is a minimum at 10 feet by 10 feet. The maximum grid spacing occurs at the model edges. The maximum row and column spacing is 395 and 350 feet, respectively. The grid spacing at the Site is shown on Figure 3-1.

3.3 Model Stratigraphy

The model was divided into three layers to represent the hydrostratigraphic layers above the basal silt.

Model Layer 1 = Silt cap - silt that contains sand lenses and stringers; in some cases, the silt grades to a silty sand or silty gravel at its contact with the underlying sand and gravel of the shallow aquifer

Model Layers 2 and 3= Sand and Gravel aquifer - fine-grained, poorly sorted sand to coarse gravel, with cobbles prevalent. The silt content of the sands and gravels varies substantially throughout the shallow aquifer, with some zones classified as silty sands and silty gravels and other zones classified as clean sands or gravels

The aquifer was represented by two layers of equal thickness. The aquifer unit was represented by two layers to allow for refinement. The two layers do not represent two hydrostratigraphic units.

The top of layer 1 was set at 300 feet NGVD, which was estimated to be the highest elevation within the model domain. The bottom elevation of layer 1 was set at 200 ft NGVD at MW-602 at the HRIA. This elevation was the average value for the silt base in the source area. A slope of 0.0045 at W32^{0}N was applied to the base of layer 1 to represent the sloping plane as seen in regional data. Additionally, at the Dillenbaugh Creek and the Berwick Creek, in the area downgradient of the surface water measurement locations, the base of layer 2 was set at 170 ft NGVD. This depth allowed for all reaches of the creeks to exist in layer 1. The layer 2 bottom was set half way between the bottoms of layers 1 and 3. The bottom of layer 3 was at 167 ft NGVD at MW-602. A slope of 0.00076 at W38^{0}N was applied to the base of layer 3 to represent the sloping plane as seen in regional data.

Figure 3-2 shows the bottom elevations of layers 1 and 3, respectively.

3.4 Boundary Conditions

Boundary conditions are added to a model to account for areas where groundwater enters or leaves the system. The three types of boundary conditions used in numerical modeling are specified head, specified flux and mixed boundary conditions. Specified flux and mixed boundaries were used in the current modeling effort.

The specified flux boundary condition was implemented using recharge (a positive flux) and no flow (no flux). When used, production wells (a negative flux) are also considered flux boundary conditions. Head dependant (or mixed) boundary conditions were implemented using river boundaries.

The Newaukum River, Dillenbaugh Creek and Berwick Creek were simulated with the River package of MODFLOW. The stage elevations of the surface water bodies were based on topography from USGS. However, the stage elevations of the Berwick Creek in the reach by the site were based on site measurements made on November 21, 2002.

The conductance of a river bed is defined as:

$$C = (KWL)/D$$

Where C is the conductance of the bed; K is the hydraulic conductivity of the bed material; W is the width of the bed; L is the length of the surface water body in the model cell; and D is the thickness of the bed material. The value of K used to calculate C was 1 ft/day for the two creeks to represent the silty material common to the bed. The value of K used to calculate C for the Newaukum River is 10 ft/day for the two creeks to represent the silts, sands and gravels reported in the river bed (Ecology 2005).

No flow boundary cells were assigned to the model on the west side of the Newaukum River, since the river is assumed to be serving as a groundwater divide. Data collected in September 2005 indicate that the Newaukum River is gaining (Ecology 2005). Also, groundwater elevation measurements from the Newaukum River valley suggest groundwater flows into the river from both sides of the water body (Ecology 2005). Therefore, the river was used as a boundary within the model. Also, no flow boundaries were assigned to the model in areas to the east to represent the relatively low permeable bedrock at the valley wall.

The river and no-flow boundaries for the three model layers are shown in Figure 3-3.

Recharge was applied to layer 1 at a rate of 15 in/yr. However, the rate was ultimately adjusted to 12 in/yr to reach a more acceptable calibration.

3.5 Flow Model Calibration

The flow model was calibrated by comparing the computed groundwater levels with the levels measured in the field on November 21, 2002. This data set was selected for evaluation because it has the most available points, the best distributed locations, the nearest to steady-state condition values, and surface water elevations from Berwick Creek. The water levels are presented in Table 3-1.

Figure 3-4 presents a summary of the model calibration results. The figure shows a graph of observed values compared to model values. If a model is perfectly calibrated, the points would lie on a 45 degree line bisecting the graph. As shown in the figure, all points are near the line, which indicates reasonable calibration.

Additionally, the model was considered calibrated when the residual mean and residual standard deviation was within five percent and 10 percent, respectively, of the observed range in heads and the computed potentiometric surface was equivalent to the observed surface. As shown in the Table 3-1, the residual mean is -0.61 (four percent of the range in heads) and the residual standard deviation is less than five percent of the range in heads. Also, the model-estimated potentiometric surface for the shallow aquifer is presented in Figure 3-5. As shown in the figure, the surface is similar to the potentiometric surface developed from data collected in the field. The final calibrated horizontal hydraulic conductivities are shown in Figure 3-6 and the final calibrated model parameters are summarized in Table 3-2.

Computed and measured vertical hydraulic gradients are also commonly matched in the calibration process. However, virtually no vertical gradient was measured nor computed. The data for well clusters MW-17/MW-18, MW-20/MW-21 and MW-

22/MW-23 in Table 3-1 illustrate the minimal or non-existent vertical gradients observed in the field and computed by the model. Therefore, a rigorous vertical gradient evaluation was not part of the calibration process.

The calibration tolerances of residual mean and residual standard deviation were met. Also, the estimated horizontal hydraulic gradient is similar to the gradient based on field measurements. Therefore, the calibration is considered acceptable for the purpose of using the model to estimate groundwater flow and contaminant transport for the RI/FS. However, as presented in Table 3-1, 19 of the 23 water level estimates are greater than the observed water levels, which suggests a bias in the data. This bias should be evaluated, and addressed, if deemed necessary, if the model is used for future site work (e.g., remedial design).

Lastly, Table 3-3 presents a summary of flow rates for the model, model layers and an area beneath the HRIA. The water volumetric budget is important in analyzing the modeling results. As shown in the table, the inflow and outflow rates for the entire model are equivalent, thus the water budget is balanced. The budgets for Layers 1 and 2 indicate that recharge is applied to these two layers. In the model, Layer 2 receives recharge where Layer 1 is dry. The budget for Layer 3 illustrates that water is lost and gained at equal rates through the layer's top. The equal rates are expected since Layer 3 is the bottom layer and water is not lost or gained at the model base. Beneath the site, water is lost to the saturated zone from Berwick Creek. Surface water loss is expected in this area where creek water elevations are higher than the aquifer groundwater elevations. Also, in the HRIA area the flow analysis indicates water being lost from Layer 1 to the aquifer at a rate of 82 g/m and the rate of groundwater flowing beneath the Site is approximately 100 g/m.

3.6 Sensitivity Analysis

A sensitivity analysis was performed as part of the modeling task. The analysis considered the sensitivity of the model to changes in conductivities of the silt cap and shallow aquifer hydraulic, recharge, conductance of creek beds and stage of creek beds. The sensitivity analysis for each parameter except creek stage, was performed by multiplying each parameter by a range of factors (0.5, 0.75, 1, 1.5 and 2) and maintaining the other parameters constant. Figure 3-7 compares the parameter multipliers to the sum of squared residuals and Figure 3-8 compares the parameter changes to the sum of the squared residuals. Model-sensitive parameters are those with large changes along the curve; conversely, a flat curve indicates that the model is not sensitive to the parameter. A parameter curve that has a minimum sum of squared residuals at a multiplier of 1 indicates that the parameter value is acceptable. Since the parameter curves at or near a multiplier of 1 are at a minimum, the model parameter values are validated.

As shown in the figures, the most sensitive parameters are the horizontal hydraulic conductivity of the aquifer, recharge and the stage of Dillenbaugh Creek east of the confluence of the Berwick Creek.

The sensitivity analysis was performed on the hydrogeologic zones as developed in the calibrated model. The model is based on available data and hydrogeologic

interpretation. The calibrated zones do not represent a unique solution. If additional data are collected or made available the model may be refined to incorporate those additional data. Also, since the study area stratigraphy is complex and the data points are limited, then the interpretation of the hydrogeology may differ.

3.7 Contaminant Transport Model Development

After the flow model was calibrated, a mass transport model was developed. The conceptual model transport parameter values were accordingly added to the hydrostratigraphic units of the flow model. A 10 ft x 10 ft contaminant source of 83, 500 ug/l was added to the center of the HRIA impact area in Layer 2 since this concentration is the highest reported in a recent (November 2003) sampling event for the source area (URS 2004). The model parameters are summarized in Table 3-2.

The source area at the HRIA was considered to be the area of interest because the PCE concentrations at the HRIA are an order of magnitude greater than the concentrations detected near the Breen property. Additionally, for the HRIA a historical summary is available and a significant amount of data has been collected so that information on the origin and extent of this source is accessible. No source was added at the Breen property since a definitive source area and concentration have not been identified at that location. Due to the elevated concentrations, the HRIA has been selected as the source area of interest and is the focus of remedial action. Therefore, the model considered the HRIA as the area of interest for the RI/FS and further investigations.

The model simulation was operated for a time interval of 13 years or from 1990 to 2003. The referenced concentrations were detected in samples collected in 2003. The source at the property is speculated to have started in 1990 (URS 2004). Mass was considered when developing the transport model. The contaminant mass within the model appears to be within the speculated range of 100 to 700 gallons (URS 2004). The cross sectional area (A) of the source that is parallel to the flow velocity in the model is 10 ft x 20 ft = 200 ft2. Also, the following values are from the model

Kh = 135 ft/d
ne = 0.36
I= 0.003

Therefore, flux (Q) through the source zone is Kh x I x A = 0.42 gpm = 2, 291 l/d.
A source concentration of 83,500 ug/l and a flux of 2, 291 l/d translate to a mass flux of 1.9 x 108 ug/d or 69.4 kg/yr. Over a 13 year period, 902 kg of contaminant mass would occur in the aquifer. A mass of 902 kg of PCE is approximately 150 gallons. A volume of 150 gallons is within the speculated contaminant mass range of 100 – 700 gallons.
Dispersivity (longitudinal, transverse and vertical) was adjusted (increased) until the estimated plume configuration best approximated the plume based on measured data. The ultimate dispersivity values were not allowed to exceed twice the estimated value of the conceptual model.

If sufficient data were available, point concentrations could be used to calibrate the mass transport model. However, no rigorous calibration involving a comparison of

point concentrations over time was performed. This type of calibration was believed to be impractical for a number of reasons including the initiation date of the source is speculative, the volume of waste is unknown, only one data point (MW-25) defines most of the downgradient edge of the plume and another source may be contributing to the plume. Figure 3-9 compares the configuration of the model estimated plume and the plume based on field data.

Section 4
Alternative Analysis

The numerical model was used to analyze three alternatives for the FS: Hydraulic Containment, No Action and Source Removal. Since hydraulic containment involved only implementing the flow model plus the advective travel time code MODPATH, that simulation is presented first. The transport model was used to evaluate the No Action and Source Removal alternative, therefore, those two alternatives are presented second and third.

4.1 Simulation 1 - Hydraulic Containment

The first simulation involved simulating the withdrawal of groundwater from eight wells at a rate of eight gpm per well as proposed in the EE/CA (URS 2004). The wells were added as analytic elements in the model with fully penetrating screens. Well logs indicate that the screens are exposed to almost the entire thickness of the aquifer.

The estimated capture zone is shown in Figure 4-1. As shown in the figure, complete capture of the area within the treatment zone is achieved with the extraction well array and pumping rates.

4.2 Simulation 2 - No Action

The second simulation involved estimating the transport of the contaminant plume if a No Action remedial alternative was implemented. The same 10 ft x 10 ft source was included in the simulation at the HRIA as described for the model development. No source was added at the Breen property since no definitive source concentration or location has been reported. Also, the plume configuration as estimated by field data from November 2003 was included in the model as initial concentrations.

The initial concentrations are shown in Figure 4-2. The simulation results are shown in a 30-year time sequence in Figures 4-3 through 4-6. As shown in the figures, the model estimates the plume to expand slightly to the north and south and minimal transport down the valley (to the west). The model estimates that the plume will migrate to the Dillenbaugh Creek. If additional data from near the plume extent were available to incorporate into the model (e.g., creek and river stage elevations, creek and river bed conductivities, aquifer hydraulic conductivity, etc.) that additional data may result in a plume that migrates elsewhere. For example, a lower river stage may result in groundwater flowing to the river or higher conductivities may result in lower groundwater levels, thus continued migration down the valley.

4.3 Simulation 3 - Source Removal

The last simulation involved removing the source and reducing the concentrations in the HRIA treatment zone by 85%. In this simulation, the source was not included and the initial concentrations of the field data plume were reduced in the treatment zone by 85%.

The simulation results are shown in a 30-year time sequence in Figures 4-7 through 4-10. As shown in the figures, the plume continues to migrate toward Dillenbaugh Creek after the source is removed. Five years after the source is removed, PCE concentrations at the HRIA treatment zone are estimated to be below 5 ug/l. After 10 years elapses, the 5 ug/l tail of the plume has migrated to a point west of Labree Road. After 20 years elapses the plume is on the west side of Dillenbaugh Creek and by 30 years, only a small amount of groundwater with PCE concentrations above 5 ug/l remains.

As noted previously, if additional data from near the plume extent were available to incorporate into the model (e.g., creek and river stage elevations, creek and river bed conductivities, aquifer hydraulic conductivity, etc.) that additional data may result in a plume that migrates elsewhere. Also, if transport properties at the distal reaches of the plume differ from that collected near the site (and used in the model) source the plume estimates may be different.

Section 5
Conclusions and Recommendations

Based on the findings of the hydrogeological analysis, several conclusions and recommendations were developed to assist in evaluating the movement of groundwater and the PCE contaminant plume. A three dimensional flow model coupled with an advective pathline code and a contaminant transport code were used to estimate responses to three FS alternatives.

The groundwater model and associated information presented herein are intended for use in an RI/FS. The information can be used in order to gain insight into the remedial alternatives and to guide additional data collection and analysis that may be performed to support a remedial design.

The model was prepared using available data. In areas within the model domain insufficient data are a potential issue. Additional data that may be collected and analyses performed are identified. Additional data will refine the model and improve accuracy and decrease the uncertainty of the groundwater flow and contaminant transport estimates. In areas of sparse data, multiple lithologic scenarios may be employed to provide numerical solutions; however, the model represents a single scenario. The effect on simulated capture zones imposed by hydrogeologic assumptions necessitated in zones of insufficient data have been quantified by performing a sensitivity analysis on the hydraulic parameters of some of the distal areas of the model domain.

5.1 Conclusions

Only a minimal thickness of the silt cap lies within the saturated zone. The base of the silt cap at the HRIA lies at approximately 200 ft NGVD, and groundwater level elevations in this range from approximately 201 to 203 feet NGVD.

The shallow aquifer beneath the study area is heterogeneous. Horizontal hydraulic conductivity estimates range from 8.8 to 139 ft/day. A value of 135 ft/day was used to meet model calibration tolerances.

The most sensitive flow model parameter after recharge and the horizontal conductivity of the aquifer was the stage of the Dillenbaugh Creek reach that is east of the confluence with Berwick Creek.

Appreciable amounts of hydrogeologic and transport data are available from locations near the site properties. However, at distances from the properties, the amount of available data is limited. In these areas of limited data (west of Labree Road), approximately 75% (estimated from area of plume) of the PCE plume occurs.

No or negligible biodegradation is occurring since minimal concentrations of PCE daughter products are detected in wells with exceedingly high concentrations of PCE.

A well defined source area and related concentrations have not been delineated at the Breen property.

The model estimates that groundwater flow discharges to the Dillenbaugh Creek downgradient from the site properties near the current mapped limit (based on field data) of the plume.

Under the No Action Alternative, the groundwater plume is estimated to expand slightly at the lateral extents and migrate to the Dillenbaugh Creek near the plume's leading edge. Under the Source Removal Alternative, PCE concentrations in groundwater are expected to drop below 5 ug/l in the treatment area within 5 years after the source is removed and treatment area concentrations are reduced by 85%.

5.2 Recommendations

The model shall be used to provide an understanding of groundwater flow and contaminant transport for the RI/FS. The model should be refined with additional data (e.g., data that may be collected in a pre-design investigation) prior to being used for other project activities (e.g., remedial design).

A source should be investigated and delineated for the Breen property.

Additional data should be collected in areas west of Labree Road. These data include, but are not limited to, surface water elevations, groundwater elevations, conductivity of surface water body beds and aquifer hydrogeologic conductivity. Additionally, surface water elevations and bed conductivity measurements should be collected on Dillenbaugh Creek that is east of the confluence with Berwick Creek.

Section 6
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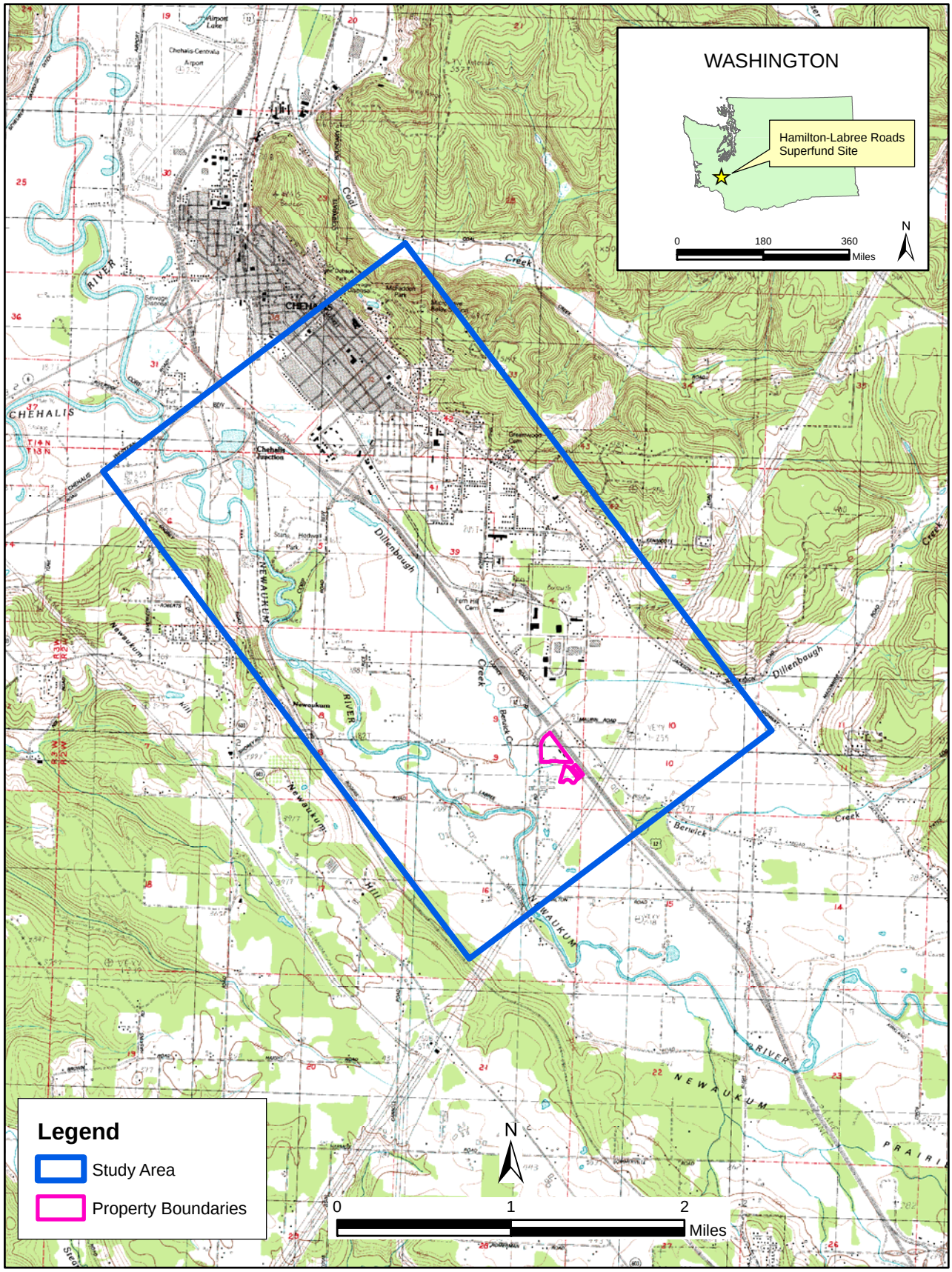

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Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 1-1
Study Area Map

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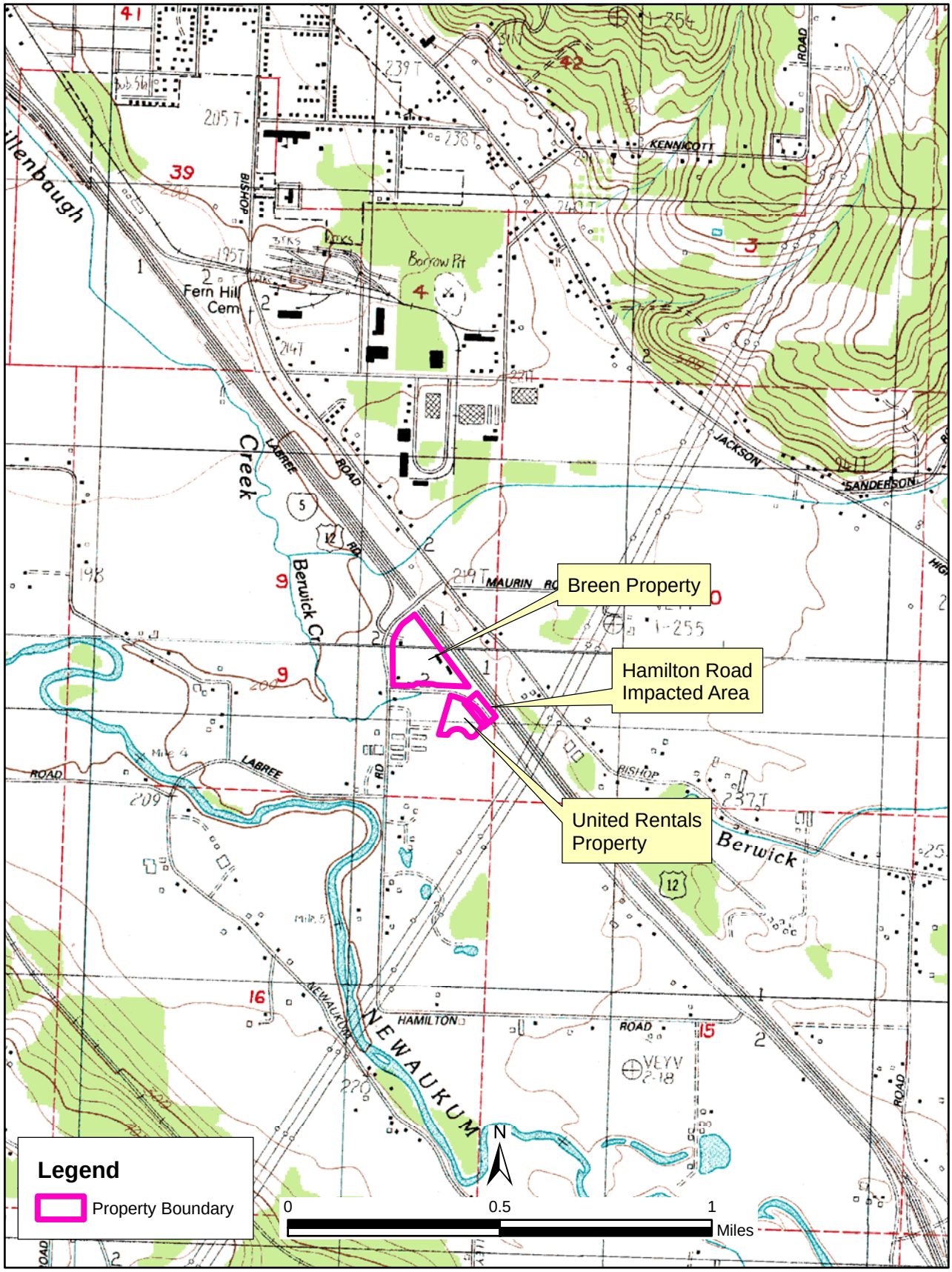

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Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 1-2
Site Location Map

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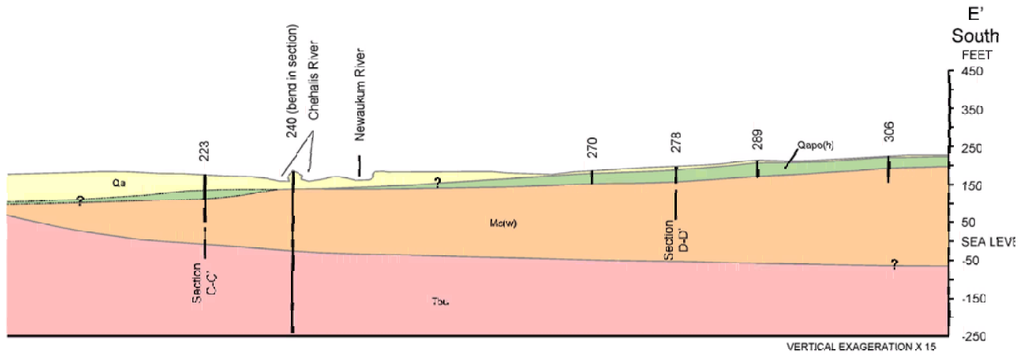

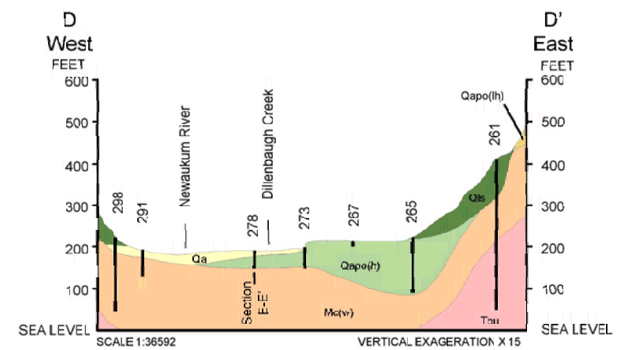

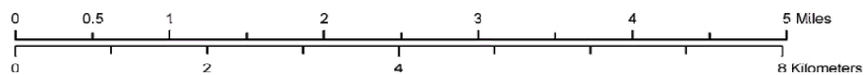

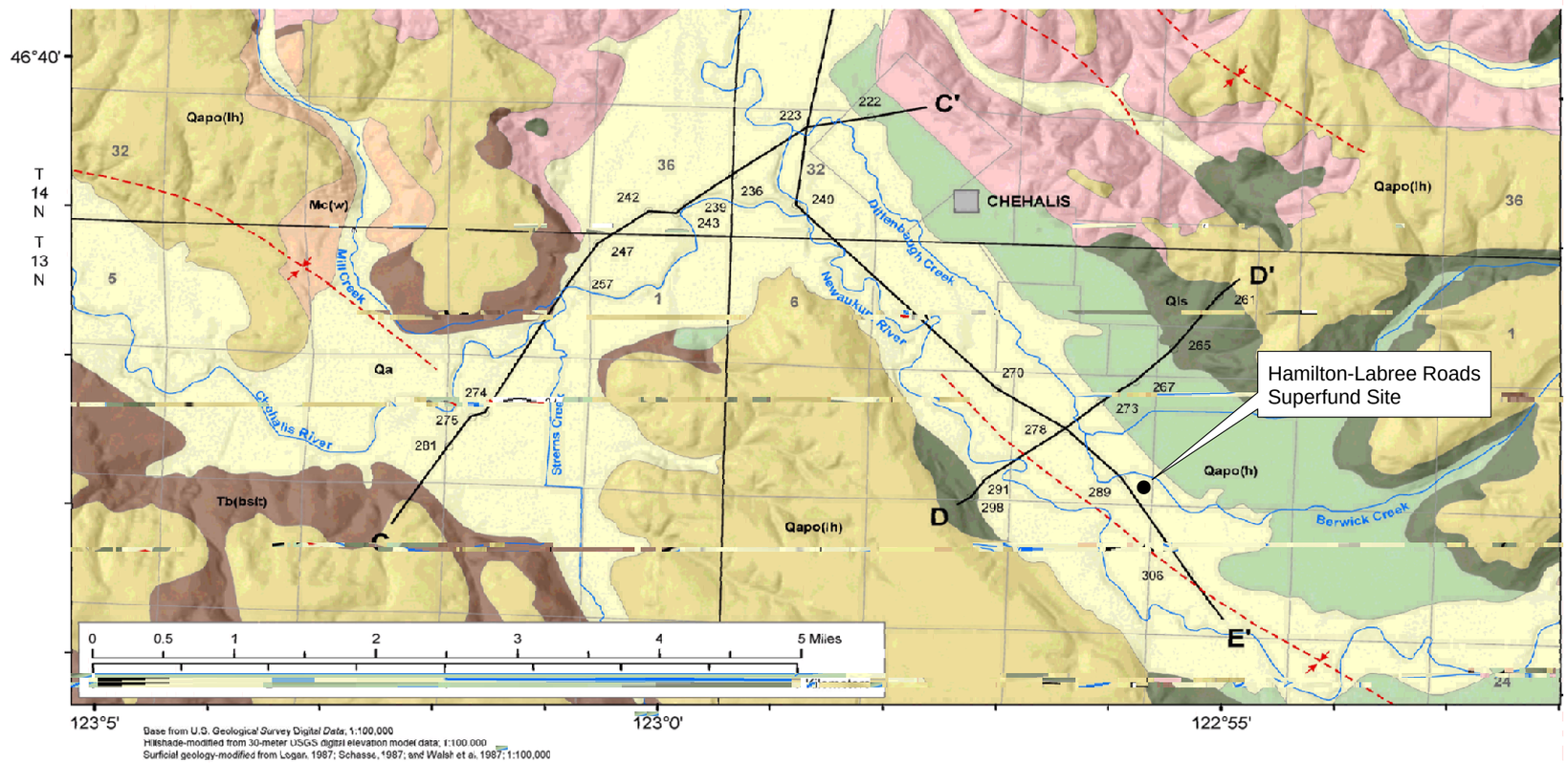

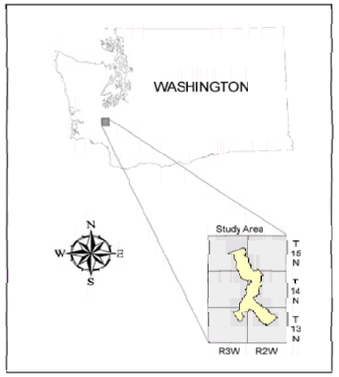

EXPLANATION

- CROSS SECTION WELL AND MAP ID (see plate B)
- A — A' CROSS SECTION TRACE
- AXIS OF ANTICLINE
- AXIS OF SYNCLINE

SURFICIAL HYDROGEOLOGIC UNITS

- Qa Quaternary alluvium
- Qls Quaternary landslide debris
- Qgo(g) Outwash sand and gravel
- Qapo(h) Hayden Creek Drift, Pre-Frasier outwash
- Qapo(lh) Logar Hill Formation Pre-Frasier outwash deposits
- Mc(w) Miocene continental sediments
- Tb(bslt) Miocene volcanic rocks
- Tbu Miocene to Eocene age bedrock, undifferentiated

Source: Washington State Department of Ecology. 2005. Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer.

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Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 2-1
Study Area Geology

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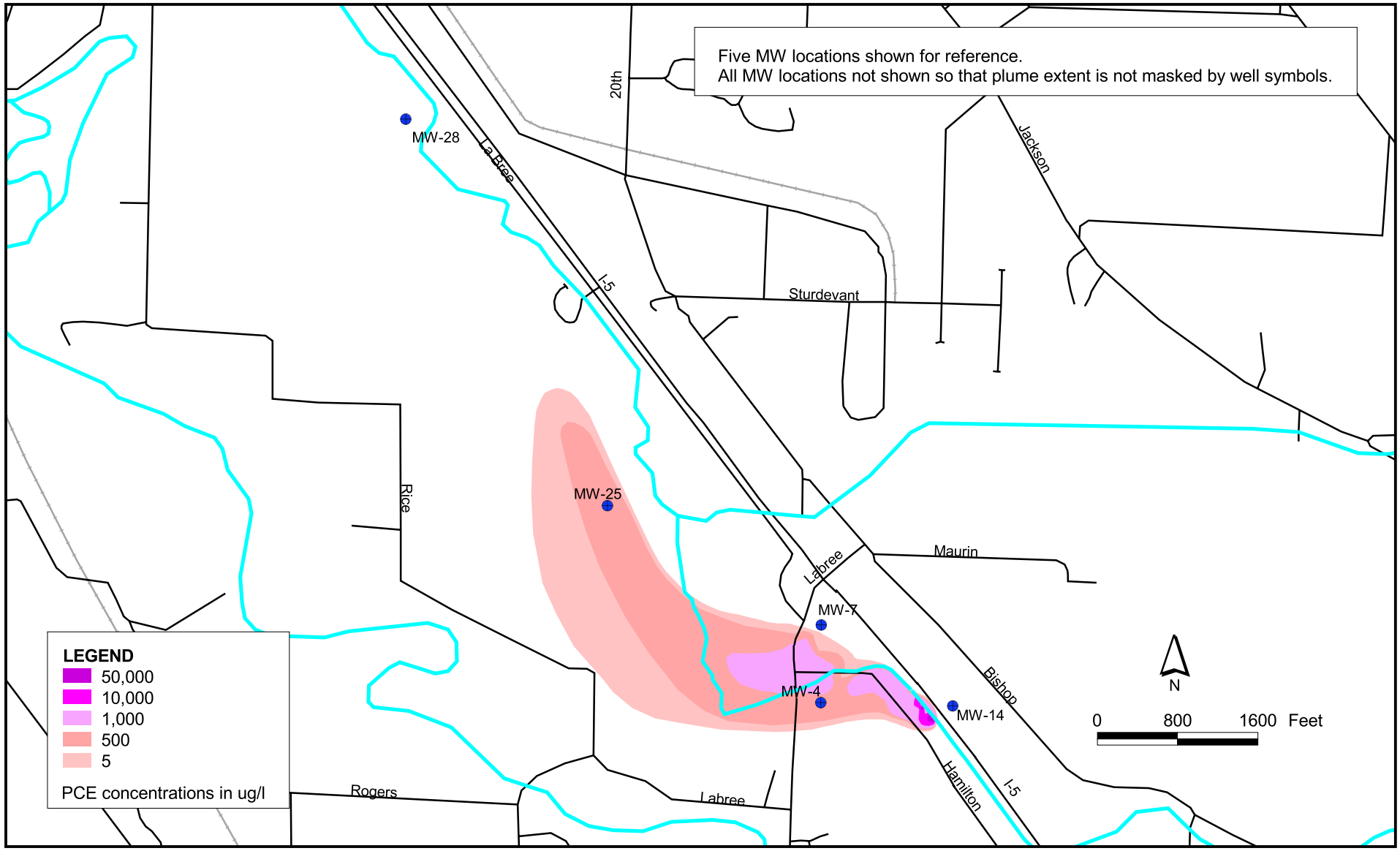

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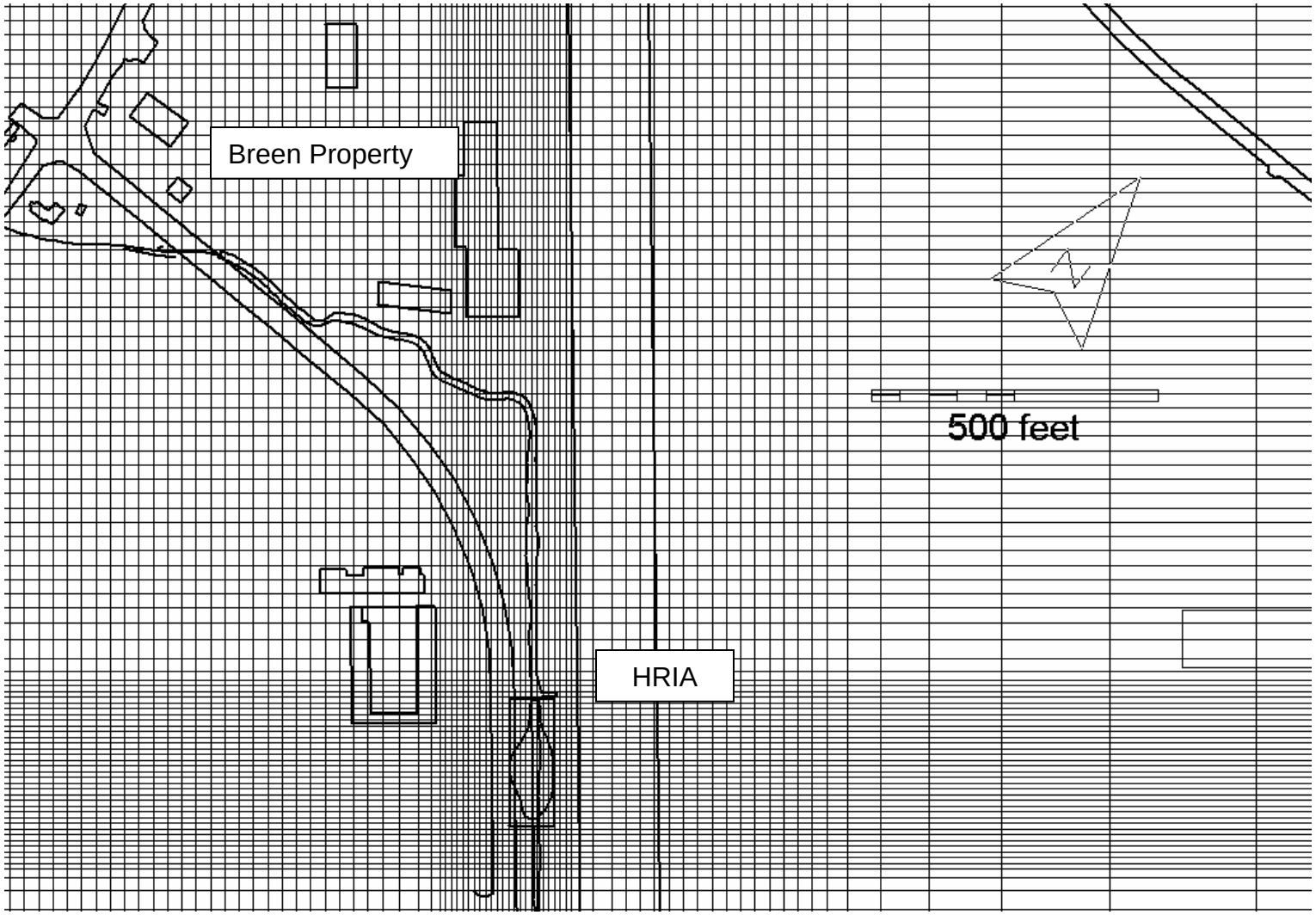
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 2-2
Estimated PCE Plume Configuration



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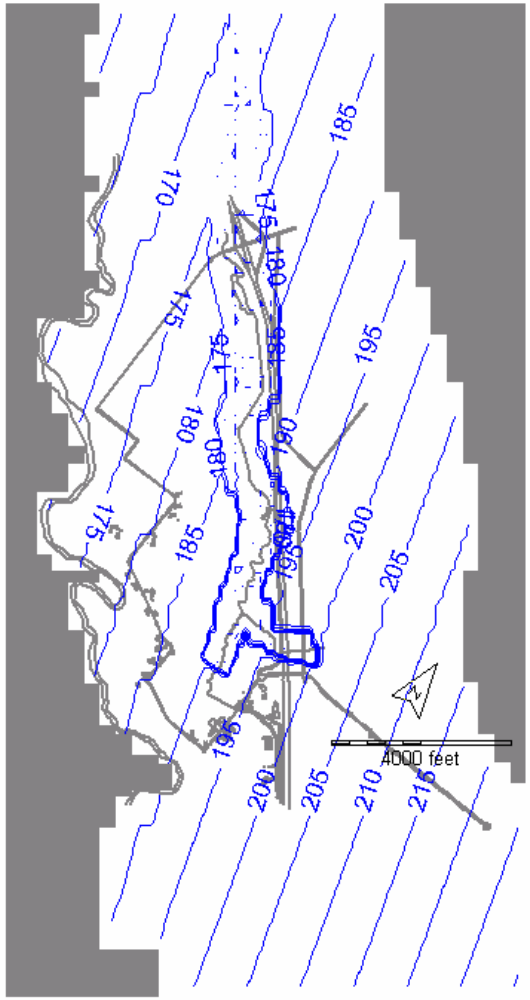
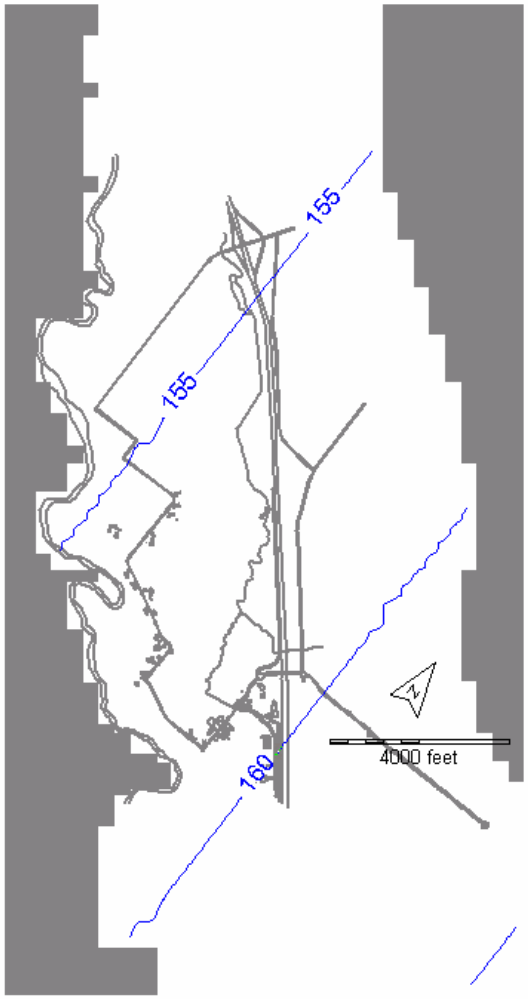
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-1
Grid Spacing
at Site Properties



Layer 1

Layer 2 elevation is at midpoint between Layer 1 and 3 elevations



Layer 3

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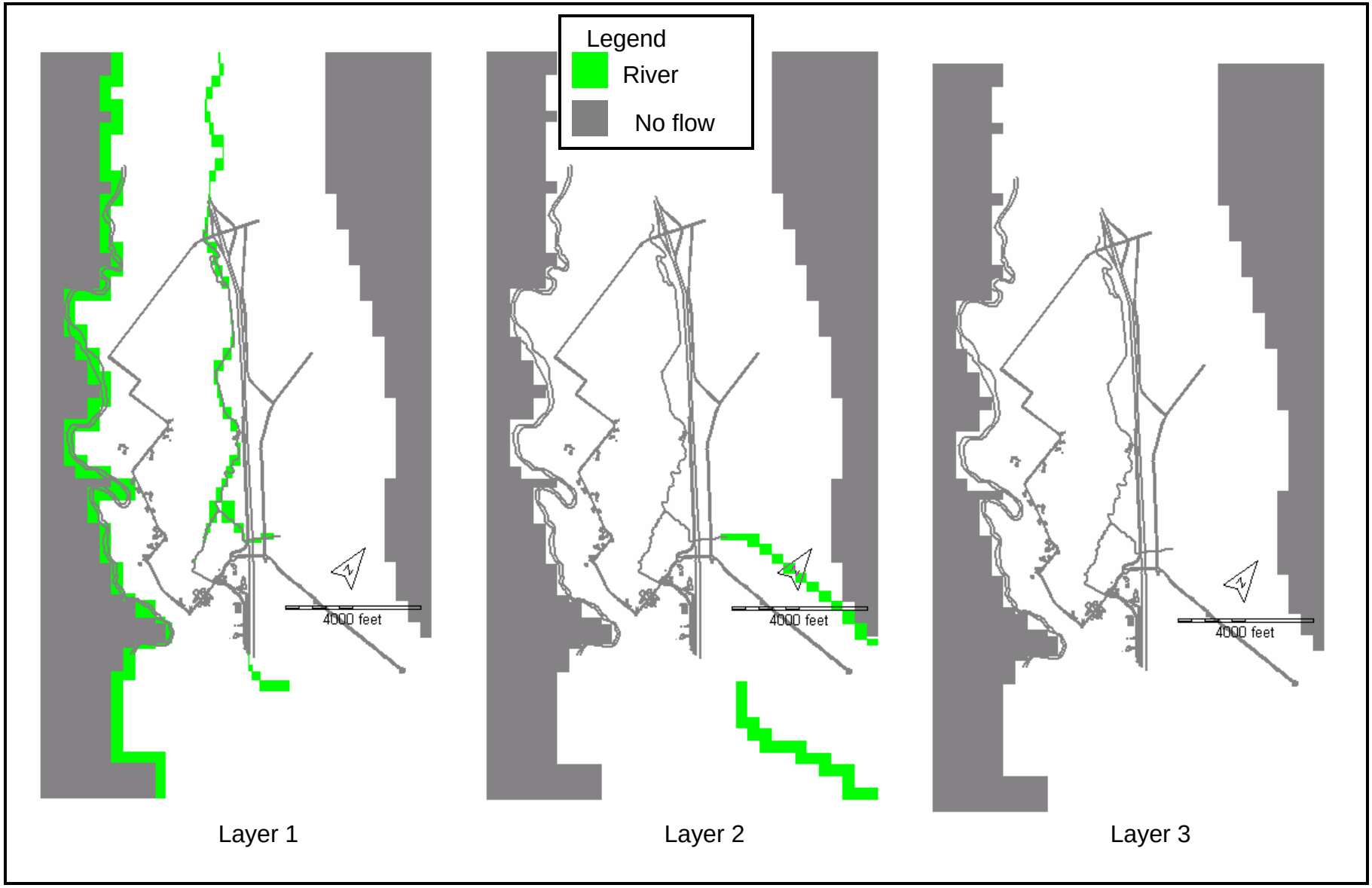
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-2
Layers 1 and 3
Bottom Elevations



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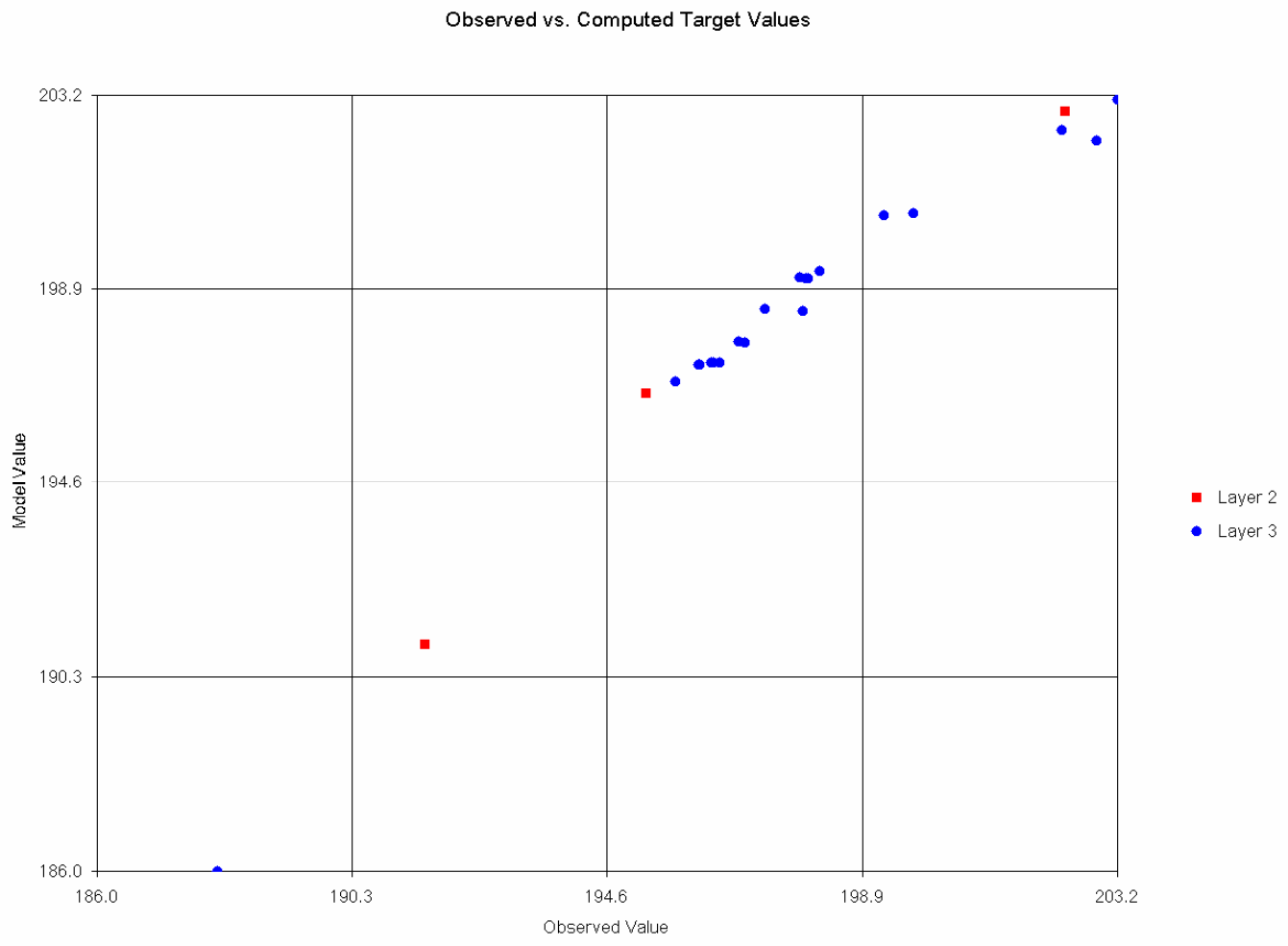
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-3
Boundary Conditions



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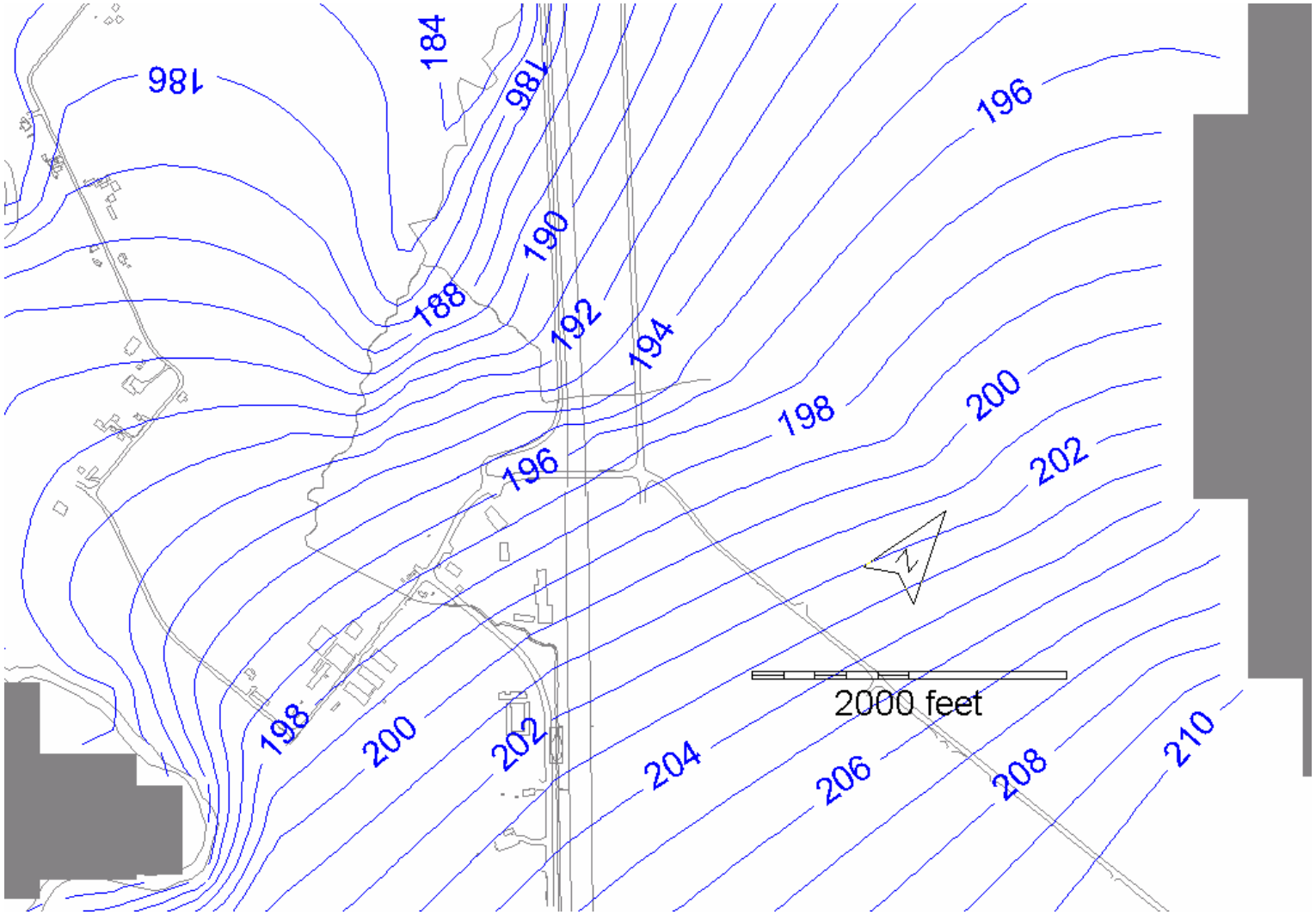
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-4
Calibration Summary



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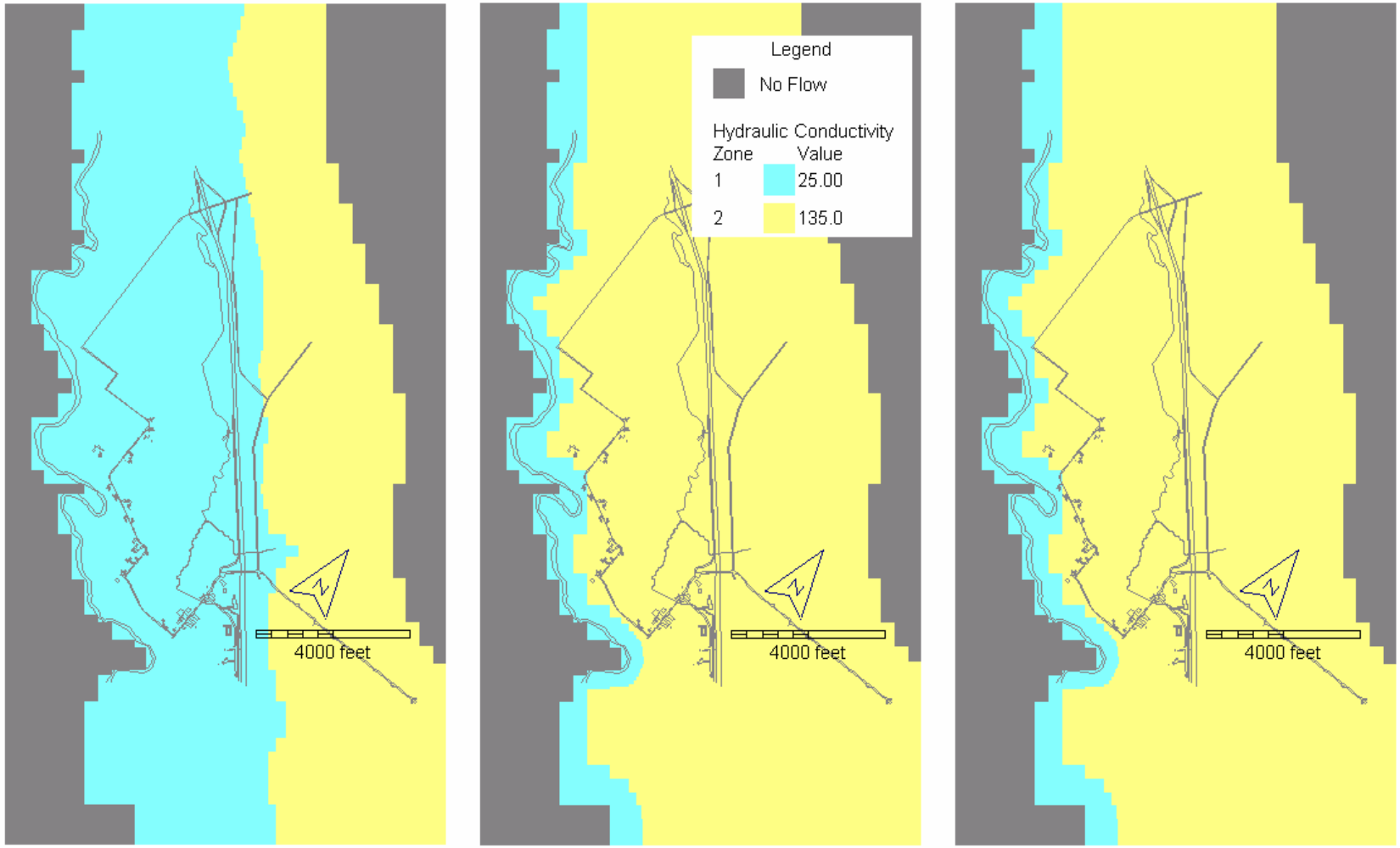
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-5
Layer 2 - Estimated Potentiometric Surface
November 21, 2002



Layer 1 Layer 2 Layer 3

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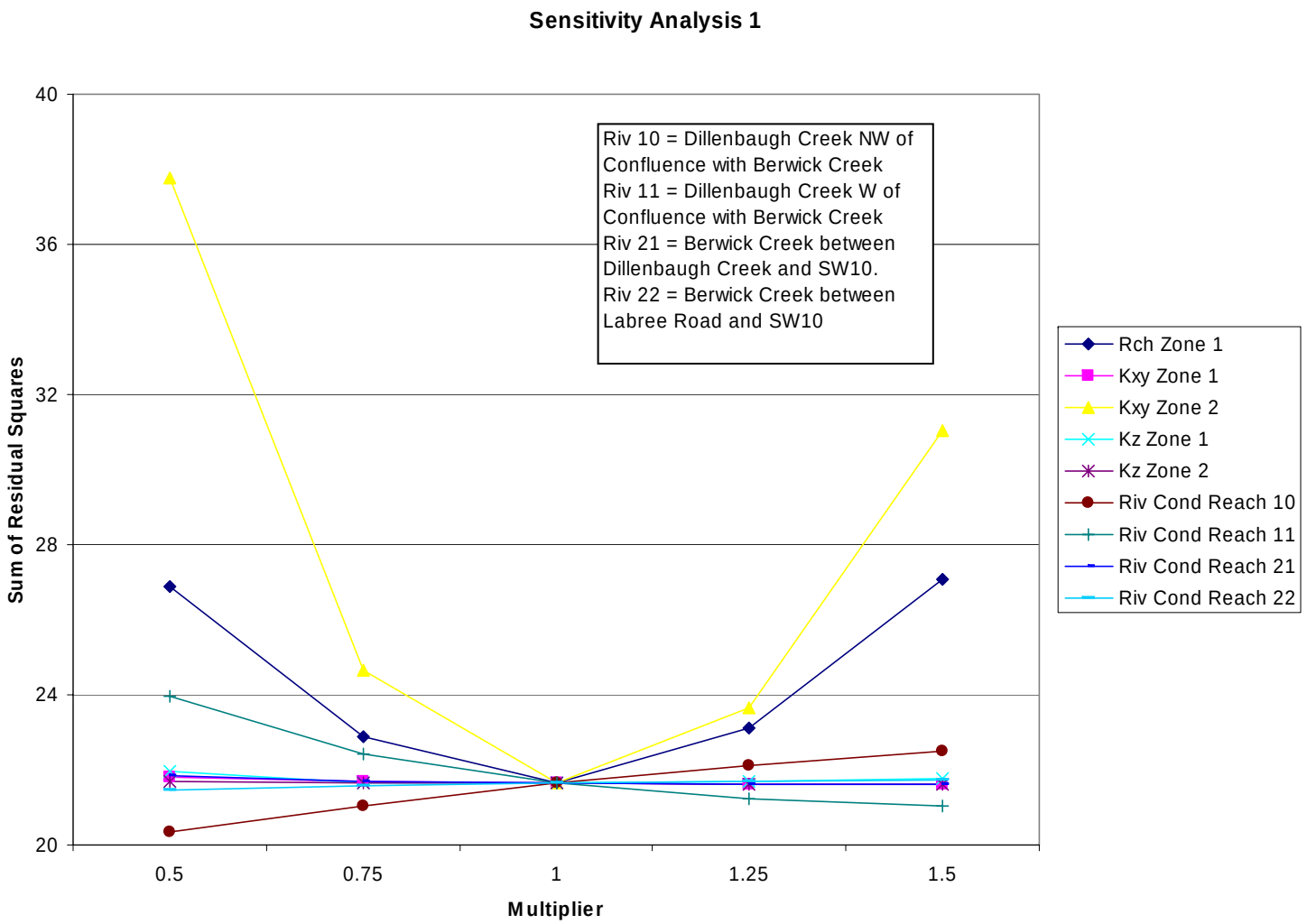
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-6
Calibrated Horizontal
Hydraulic Conductivities



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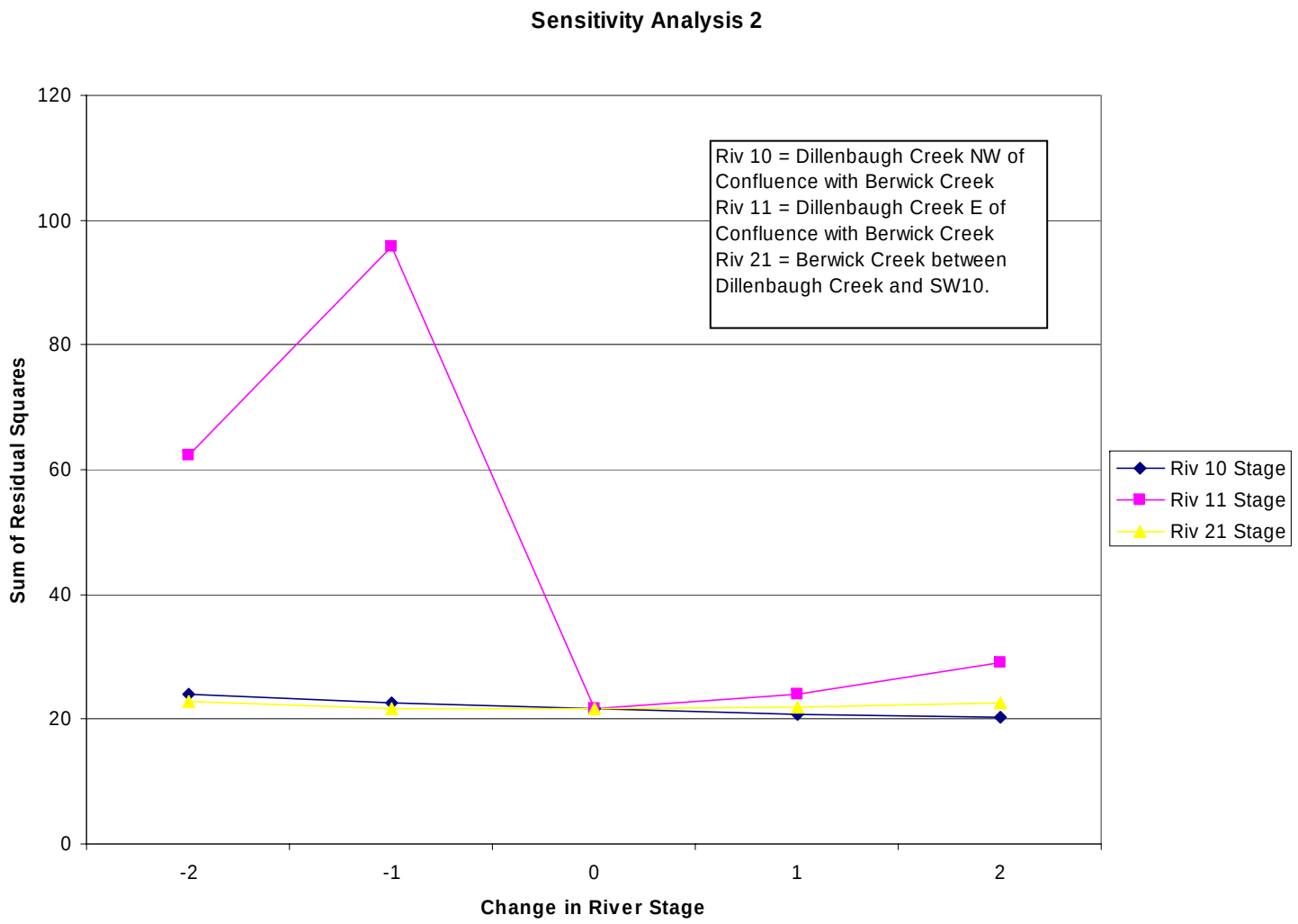
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-7
Sensitivity Analysis 1



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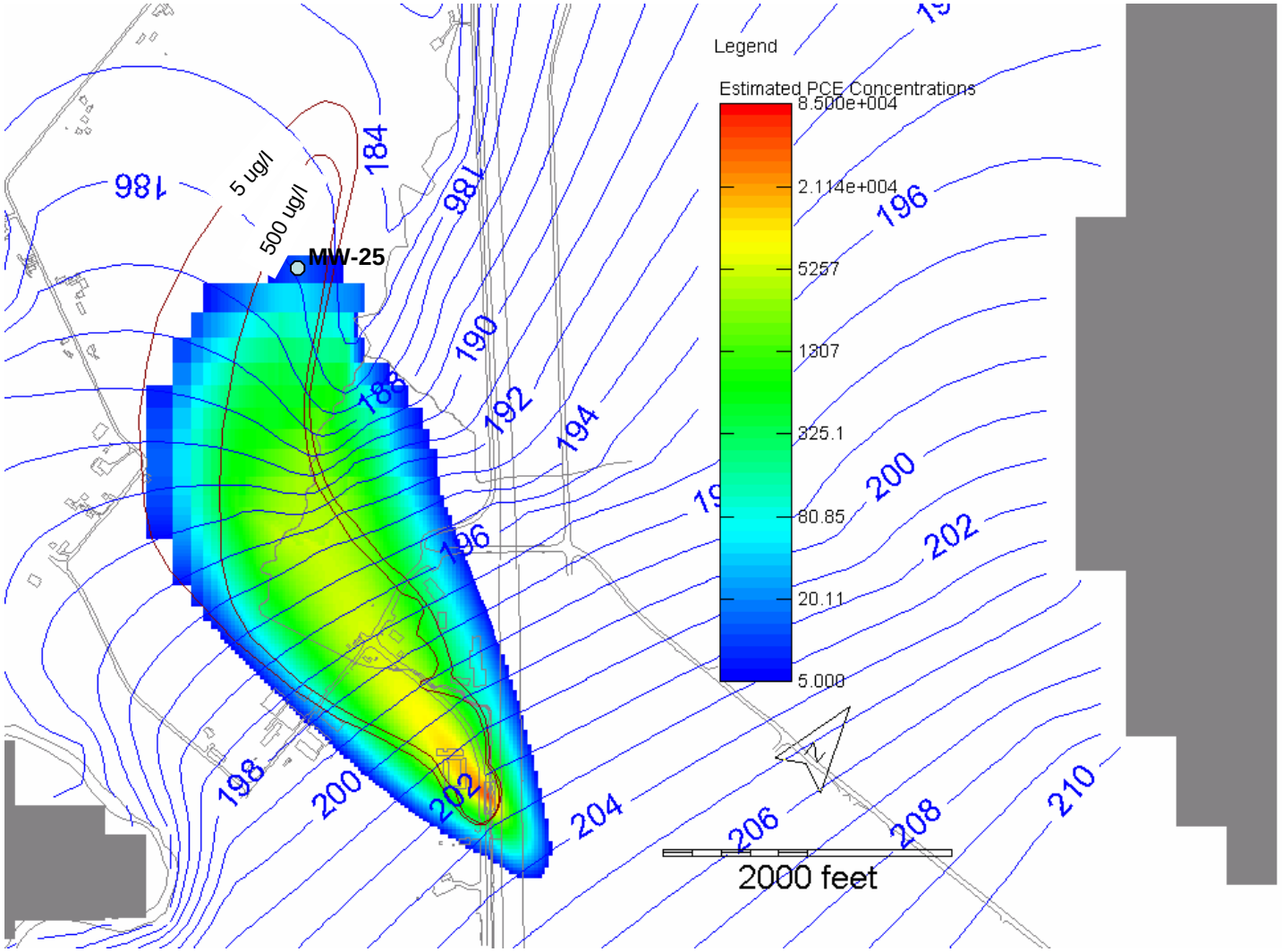
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 3-8
Sensitivity Analysis 2



13 Years after Source Addition

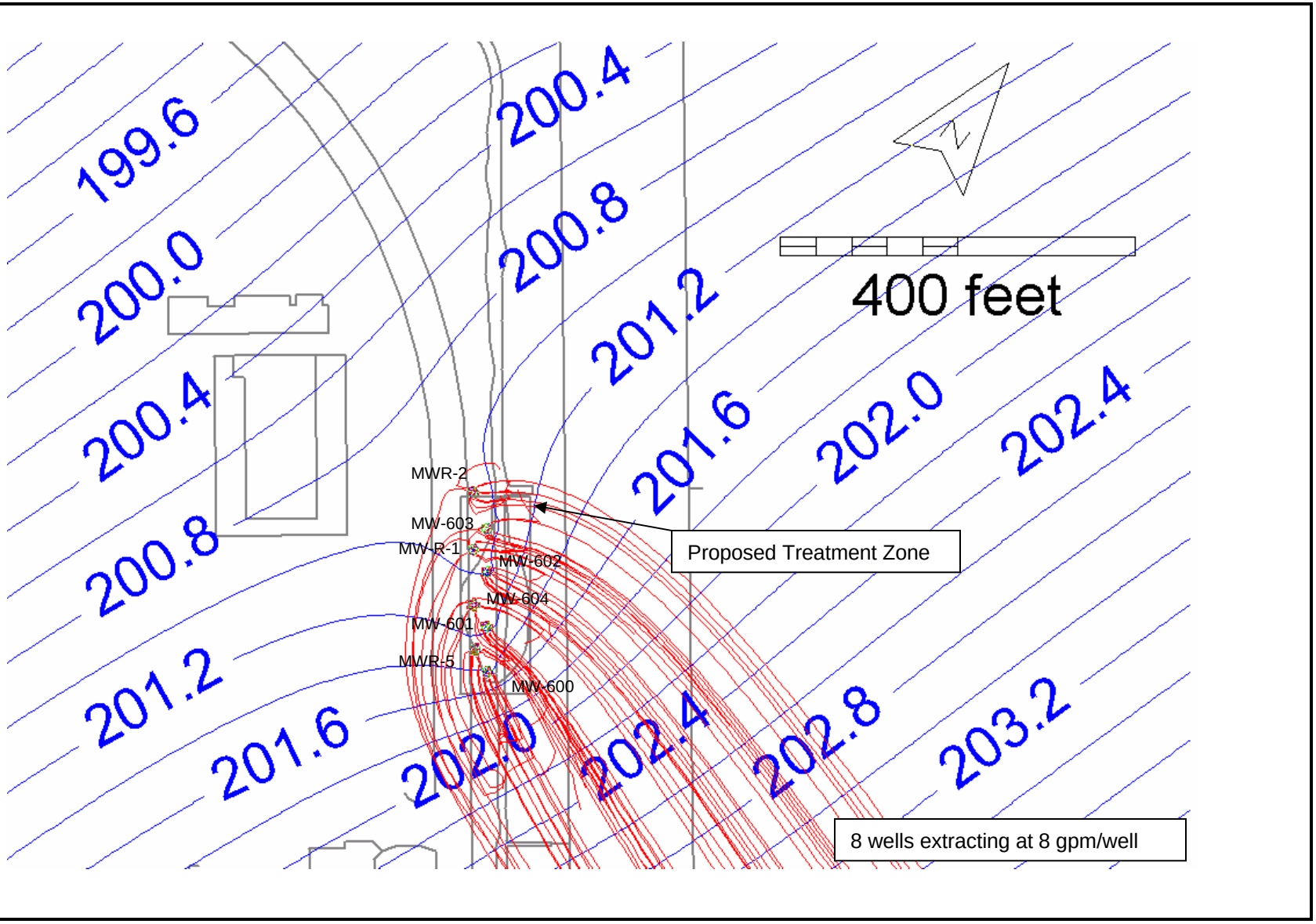
CDM

Hamilton-Labree Roads Site

Chehalis, Washington

Figure 3-9

Comparison of Estimated and Field Data Plume



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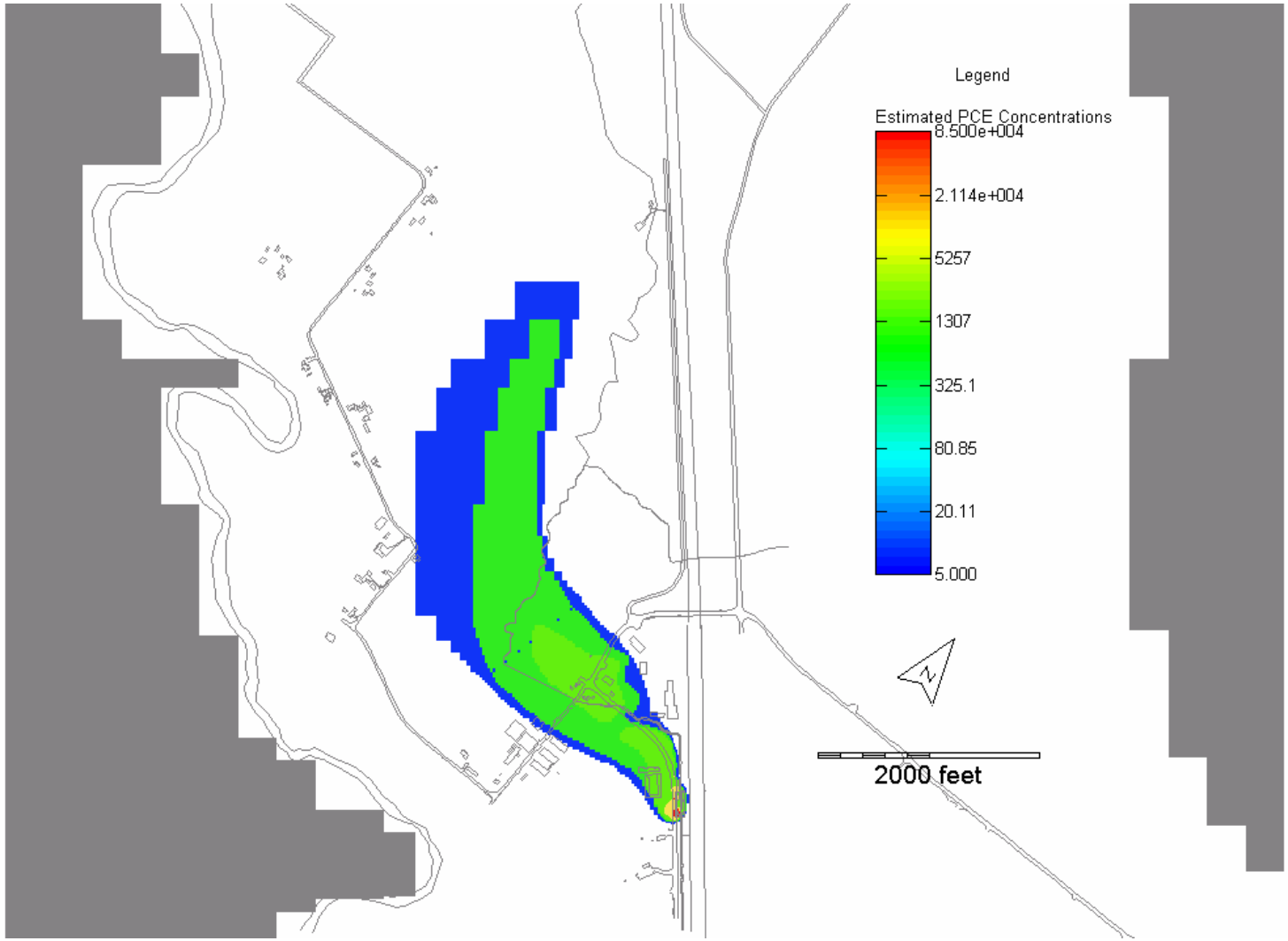
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-1
Estimated Capture Zone



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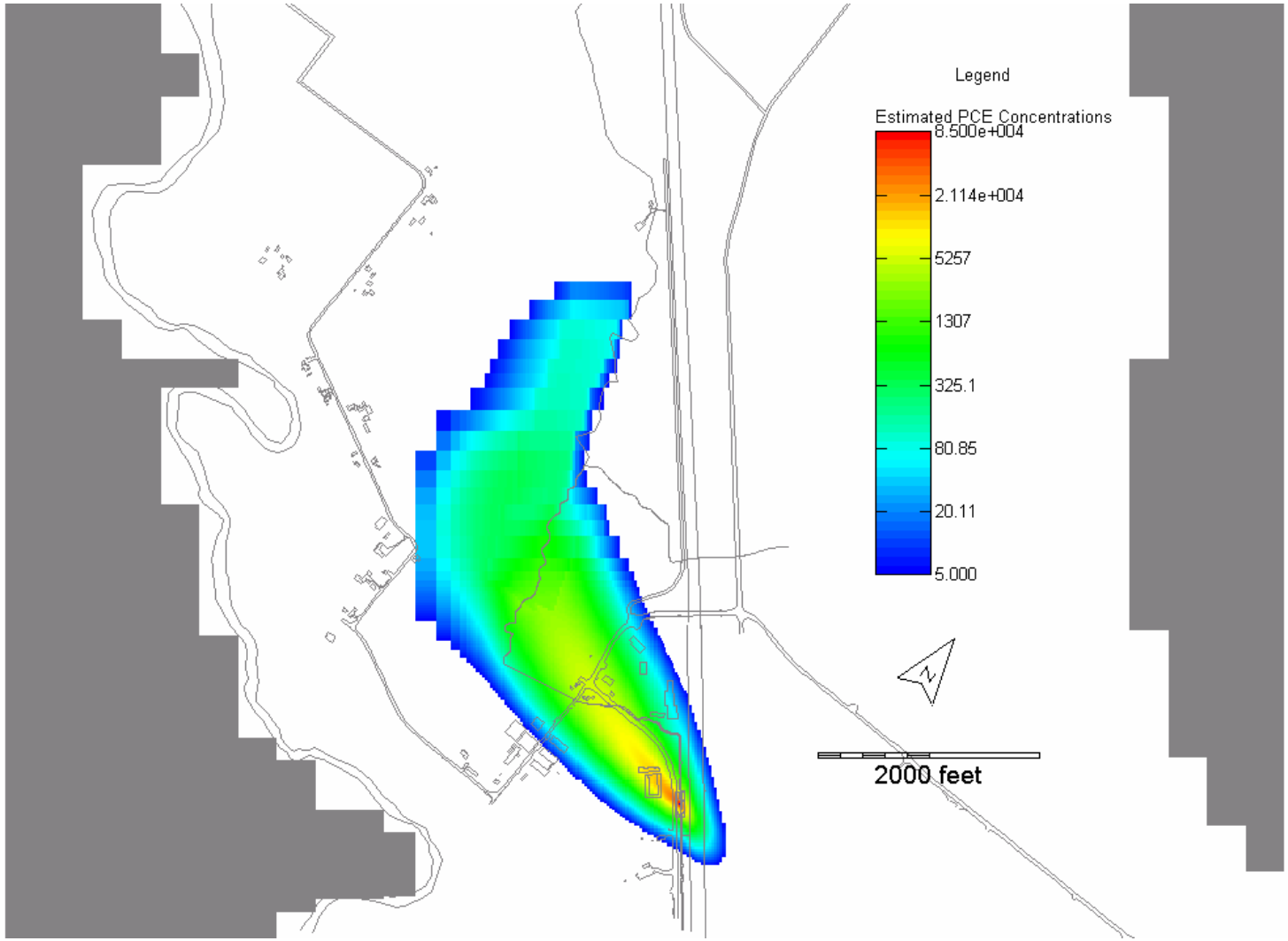
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-2
Estimated PCE Plume
No Action – Current



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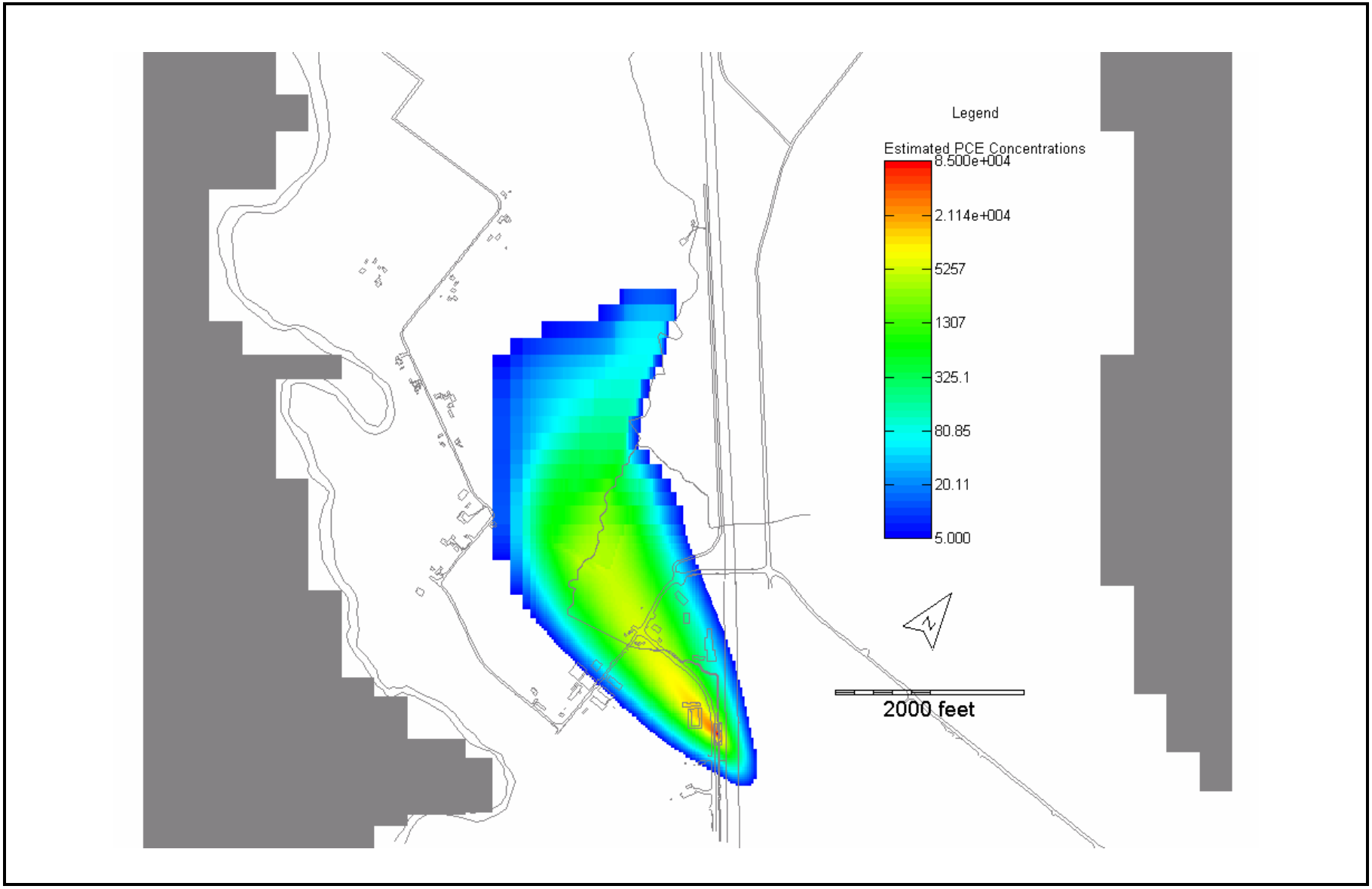
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-3
Estimated PCE Plume
No Action – 5 Years



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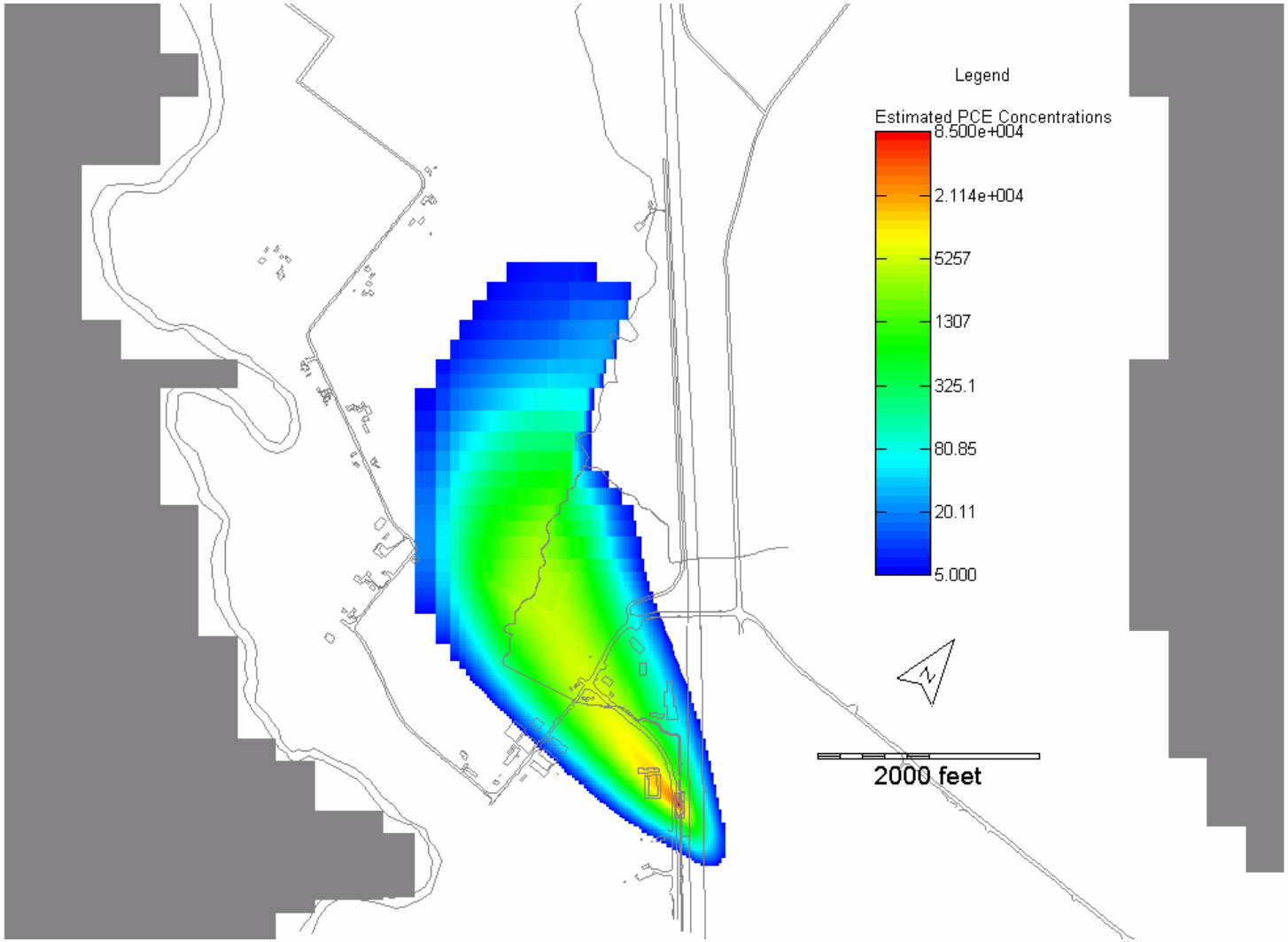
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-4
Estimated PCE Plume
No Action – 10 Years



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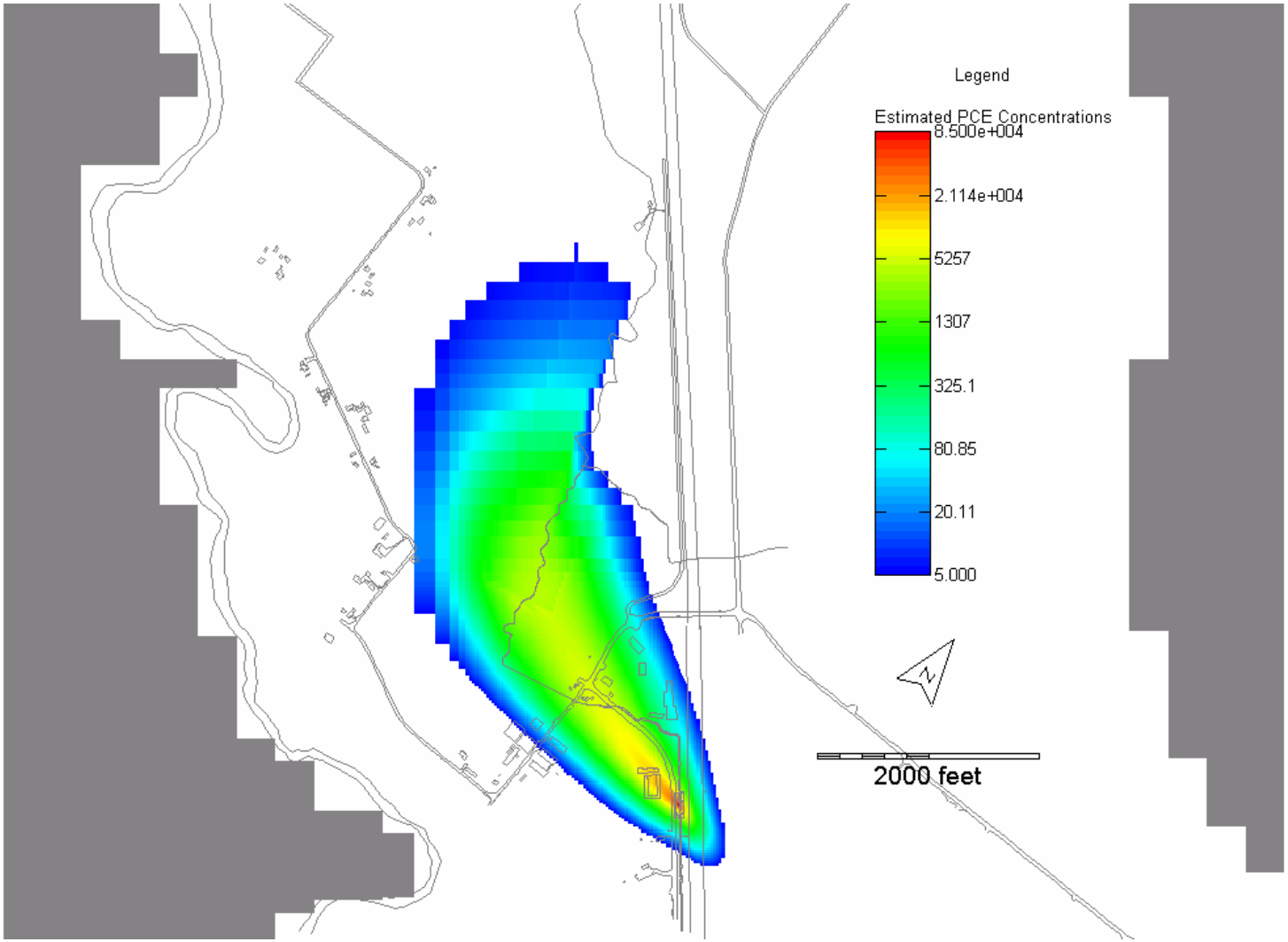
Hamilton-Labree Roads Superfund Site
Chehalis, Washington

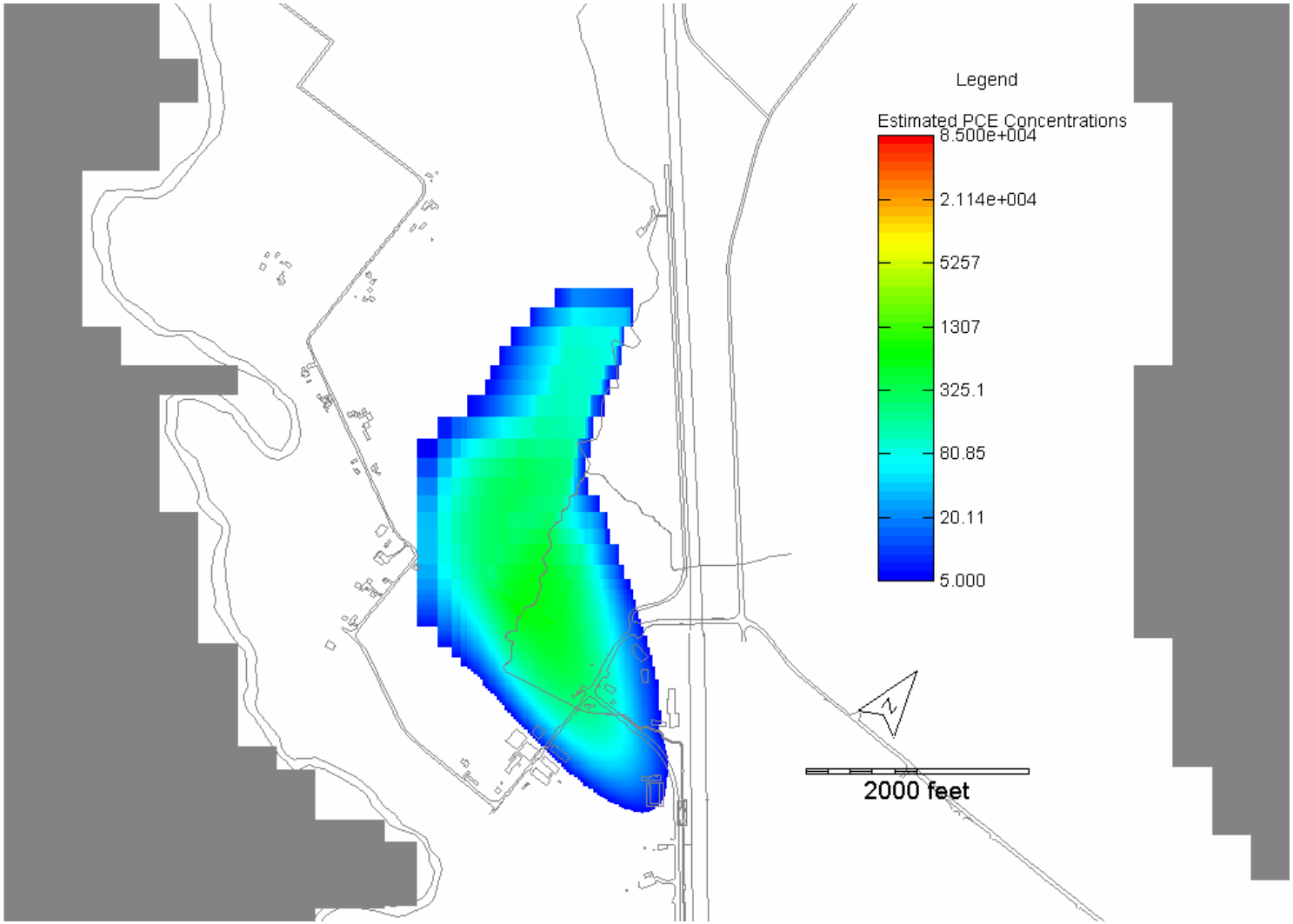
Figure 4-5
Estimated PCE Plume
No Action – 20 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

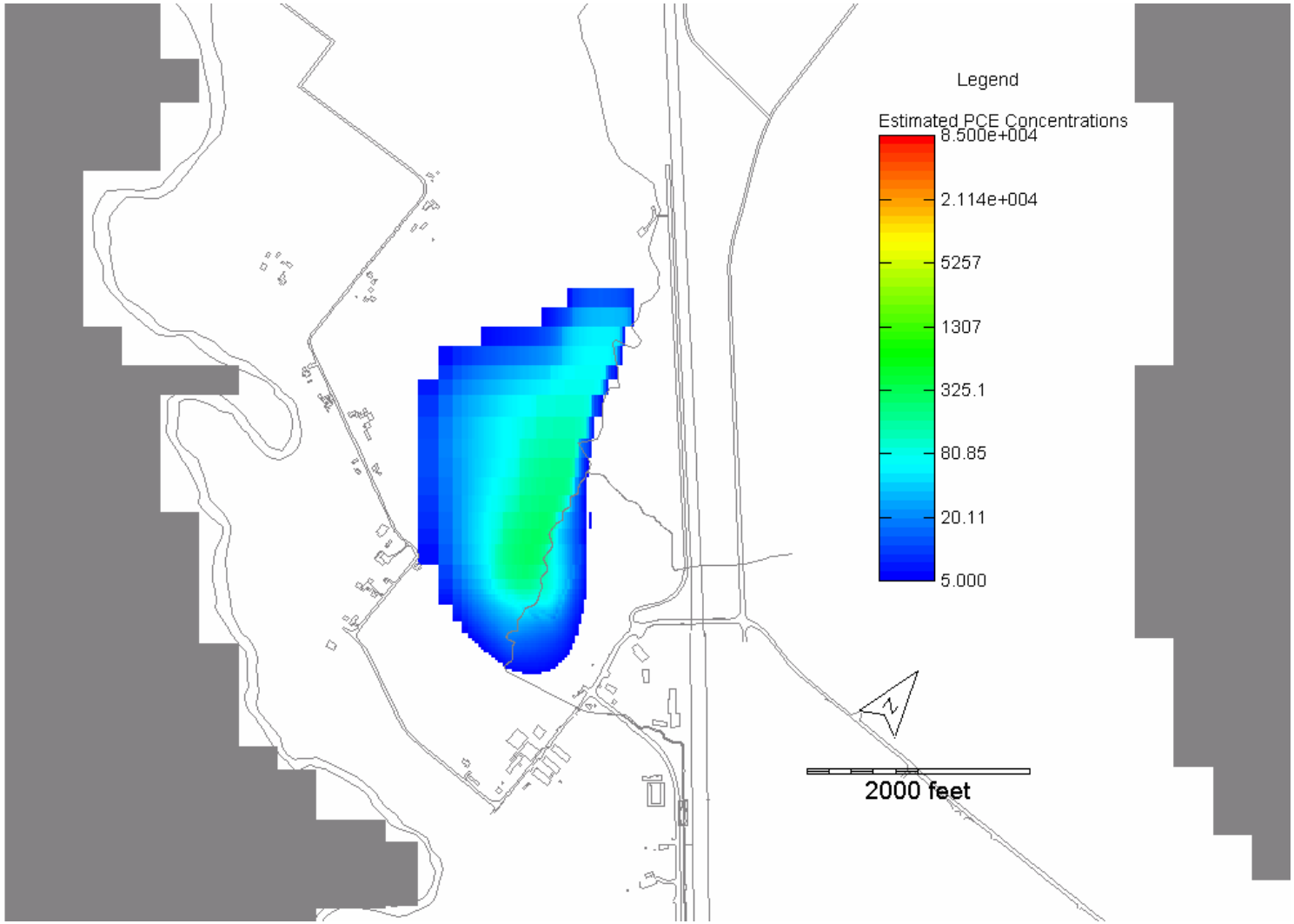
Figure 4-6
Estimated PCE Plume
No Action – 30 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

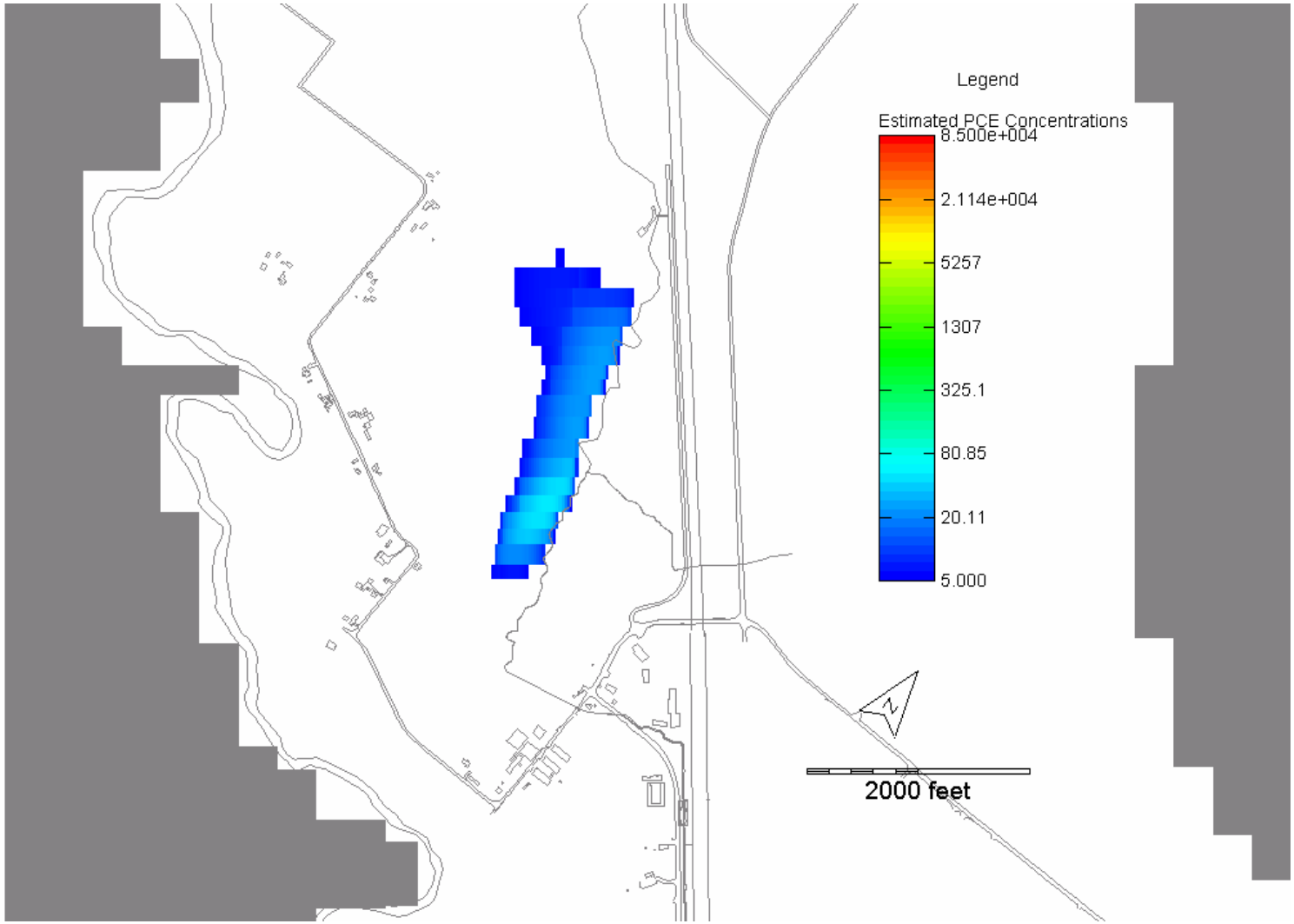
Figure 4-7
Estimated PCE Plume
Source Removal – 5 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

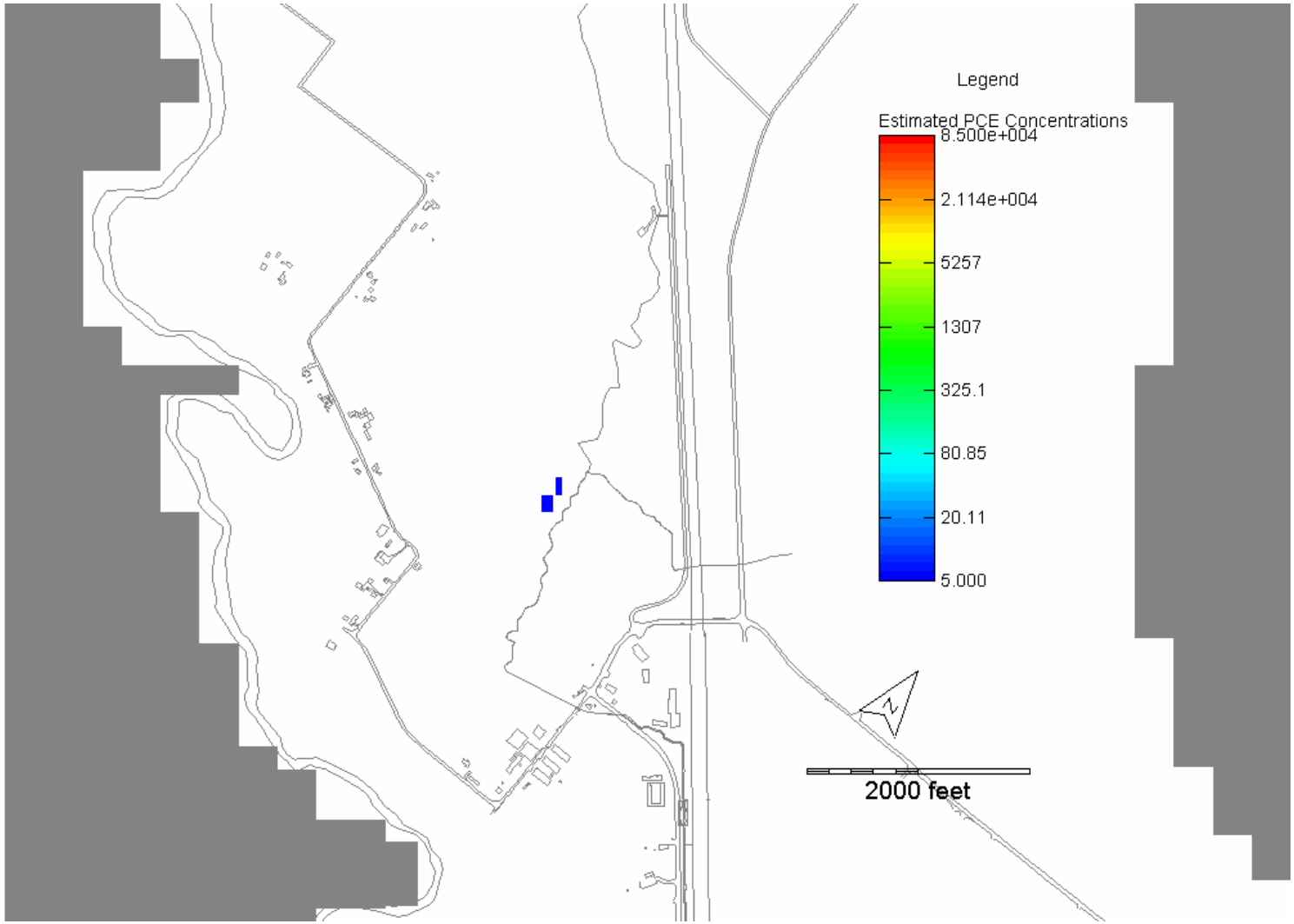
Figure 4-8
Estimated PCE Plume
Source Removal – 10 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-9
Estimated PCE Plume
Source Removal – 20 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-10
Estimated PCE Plume
Source Removal – 30 Years

Table 3-1 Calibration Results

Well ID	E	N	Layer	Observed	Computed	Weight	Residual
MW-1	1029437	480422	3	197.88	198.40	1	-0.52
MW-2	1029121	480103	3	196.91	197.70	1	-0.79
MW-3	1029678	479641	3	199.25	200.51	1	-1.26
MW-4	1029116	479577	3	197.25	198.45	1	-1.20
MW-5	1029765	479879	3	199.75	200.58	1	-0.83
MW-6	1029417	479947	3	197.84	199.14	1	-1.30
MW-7	1029121	480351	3	196.35	197.25	1	-0.90
MW-8	1029055	479933	3	196.8	197.72	1	-0.92
MW-9	1030186	479555	3	202.24	202.41	1	-0.17
MW-10	1030285	479425	2	202.3	202.84	1	-0.54
MW-11	1030229	479815	3	202.83	202.18	1	0.65
MW-14	1030432	479547	3	203.19	203.08	1	0.11
MW-17	1029088	480272	3	196.49	197.27	1	-0.78
MW-18	1029087	480265	3	196.38	197.27	1	-0.89
MW-19	1028934	480162	3	195.75	196.83	1	-1.08
MW-20	1028929	479938	3	196.14	197.21	1	-1.07
MW-21	1028930	479931	3	196.15	197.22	1	-1.07
MW-22	1029354	479784	3	197.94	199.12	1	-1.18
MW-23	1029355	479777	3	197.98	199.13	1	-1.15
MW-24	1029346	479605	3	198.18	199.30	1	-1.12
MW-25	1026991	481544	3	188.03	186.01	1	2.02
PW-7	1028717	479797	2	195.24	196.59	0.1	-0.13
PW-21	1027000	479741	2	191.52	191.02	0.1	0.05

Residual Mean	-0.61
Res. Std. Dev.	0.75
Sum of Squares	21.64
Abs. Res. Mean	0.86
Min. Residual	-1.30
Max. Residual	2.02
Range	15.16
Std/Range	0.05

Water Levels collected November 21, 2002 (Farallon 2003)

Table 3-2 Calibrated Model Parameters

	Kxy (ft/d)	**Kz** (ft/d)	**n_e** %	**n** %	**Kd** ml/g	ρ_b g/ml	α_L ft	α_T ft	α_V ft
Silt Cap	25	3	20	20	1.2	1.51	1	0.1	0.01
Aquifer	135	14	36	36	0.083	1.62	90	9	0.9

Kxy = horizontal hydraullic conductivity
Kz = vertical hydraulic conductivity
n_e = effective porosity
n = total porosity
Kd = soil/water partition coefficient
ρ_b = bulk density
α_L = longitudinal dispersivity
α_T = tranverse dispersivity
α_V = vertical dispersivity

Table 3-3 Groundwater Flow Summary

Area of Interest	Inflow	Outflow
Entire Model		
Surface Water Bodies	528	3040
Recharge	2512	0
Layer 1		
Bottom	2438	1048
Surface Water Bodies	127	2839
Recharge	1322	0
Layer 2		
Top	1048	2438
Bottom	1672	1672
Surface Water Bodies	402	202
Recharge	1189	0
Layer 3		
Top	1672	1672
Site-specific Zone		
Flow from Berwick Creek Reach into Layer 1	38	N/A
Flow from Layer 1 into Layer 2/3	82	N/A
Flow from Layer 2/3 into Layer 1	3.5	N/A
Flow beneath site in aquifer to downgradient areas	99	N/A

1. Flows are in gpm
2. The site-specific zone is defined by an area that extends from near MW-10 north 540 feet to the bend in the Berwick Creek. The area starts at Berwick Creek (inclusive) and extends 330 feet to the west.
3. N/A- not applicable, item does not refer to outflow
4. Layer 1 is the silt cap and Layers 2/3 represent the aquifer

Appendix A-1
Site Well Locations

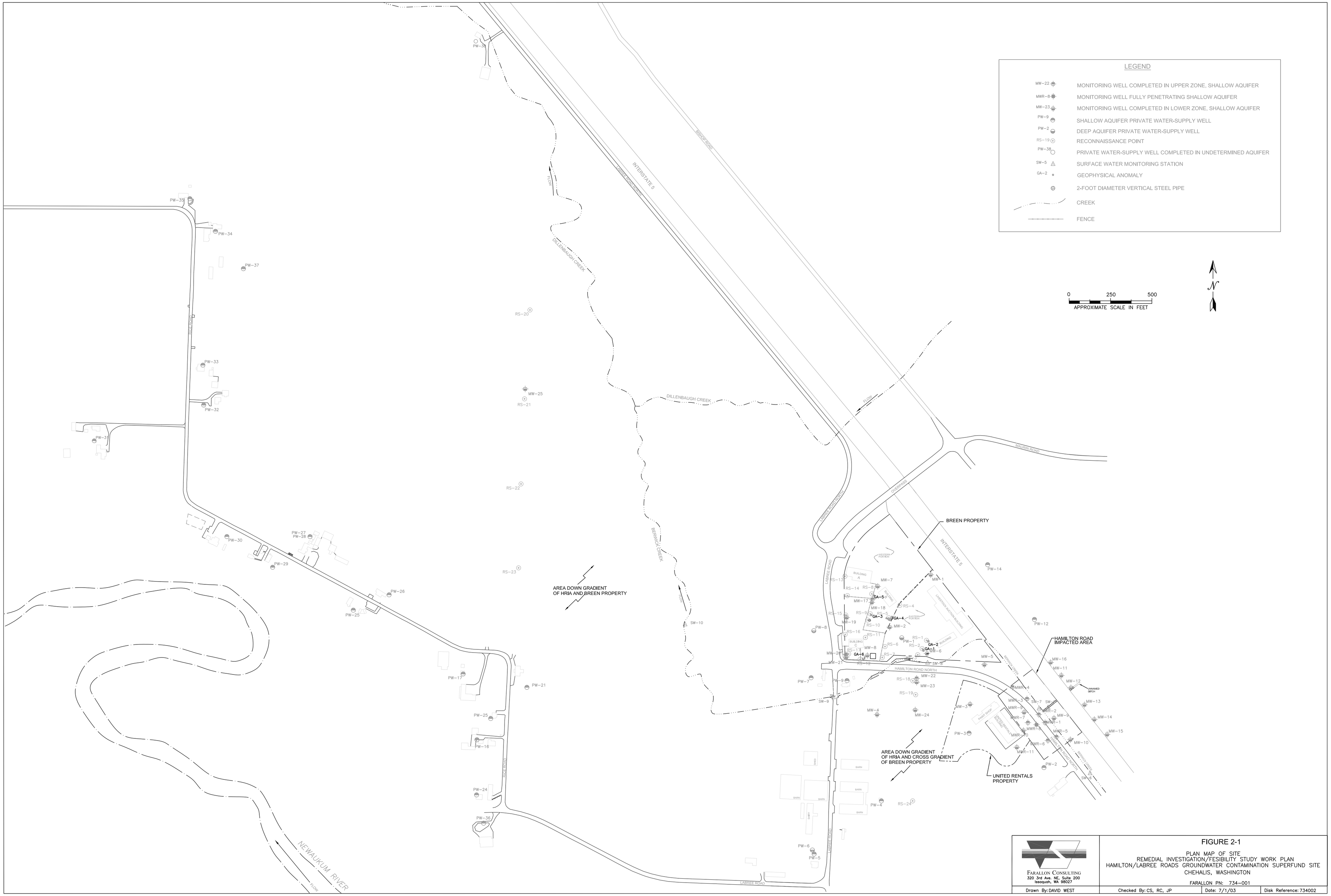


FIGURE 2-1

PLAN MAP OF SITE
REMEDIAL INVESTIGATION/FESIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

Appendix A-2
Breen Property Stratigraphy

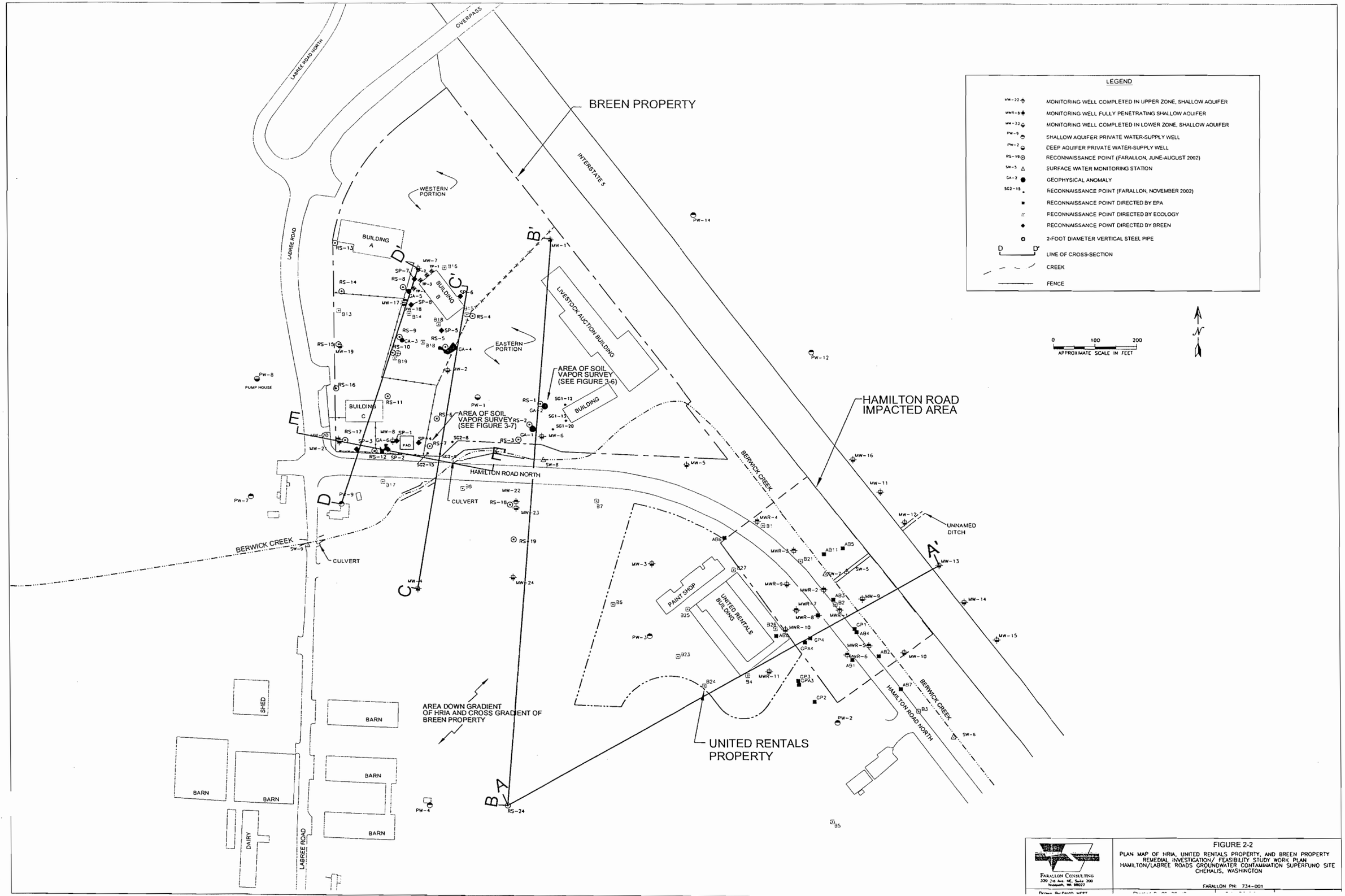


FIGURE 2-2

PLAN MAP OF HRIA, UNITED RENTALS PROPERTY, AND BREEN PROPERTY
REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

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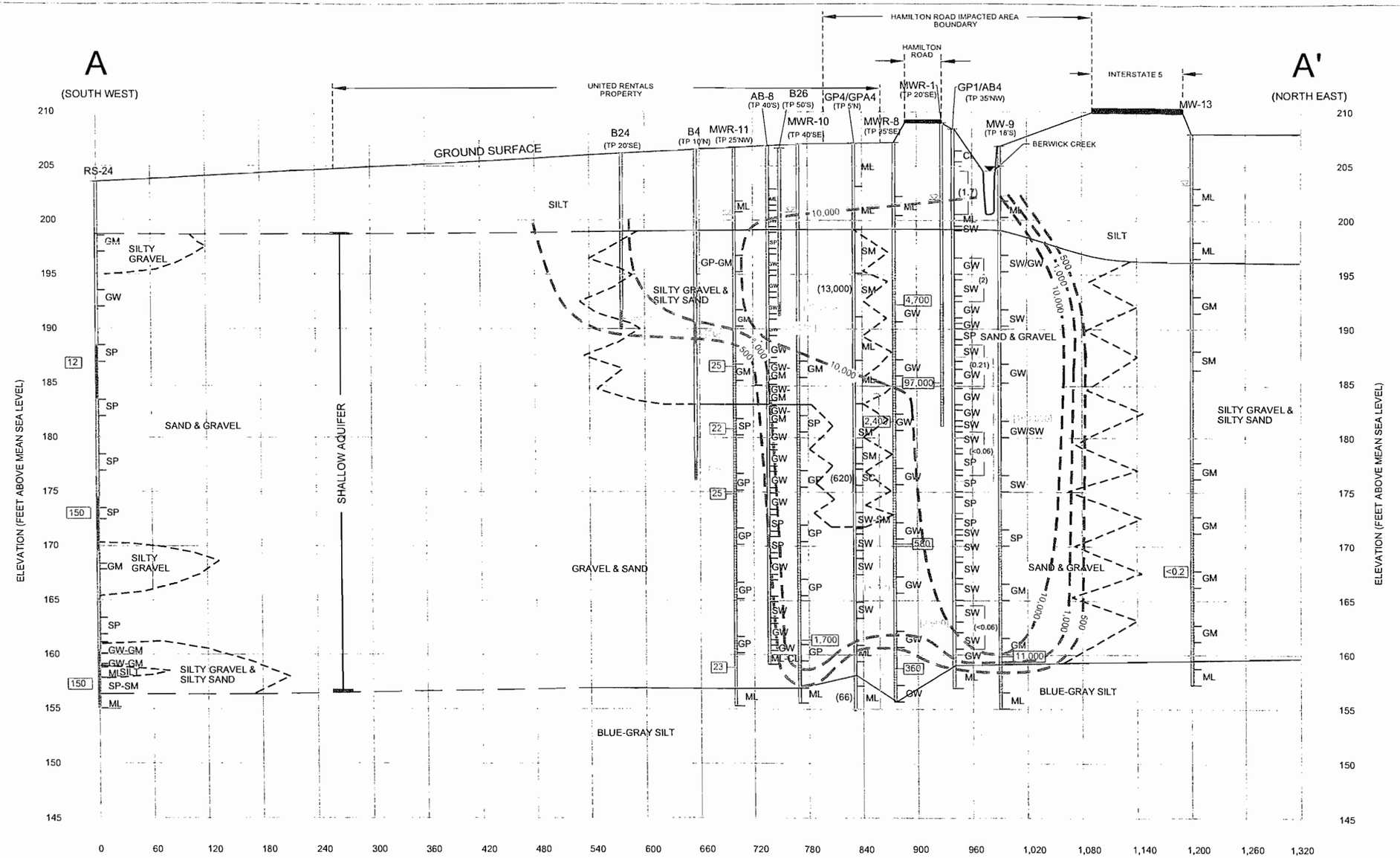
Issaquah, WA 98027

FARALLON PN: 734-001



LEGEND

MW-4 (TP72'S) — BORING LOCATION TRANSPOSED (TP) IN FEET, NORTH (N), SOUTH (S), EAST (E), OR WEST (W) TO CROSS SECTION LINE.

SOIL SAMPLE INTERVAL

BLANK CASING

POTENTIOMETRIC SURFACE, INFERRED WHERE (DASHED) (NOVEMBER, 2002)

GEOLOGIC CONTACT, INFERRED WHERE QUERIED

TEMPORARY WELL SCREEN INTERVAL

WELL SCREEN INTERVAL

BOTTOM OF WELL/BOREHOLE

(2) = CONCENTRATION OF TETRACHLOROETHENE (PCE) IN SOIL IN MICROGRAMS PER KILOGRAM (ug/kg)

[1,46 0.56] = CONCENTRATION OF PCE IN GROUNDWATER RECONNAISSANCE SAMPLE IN MICROGRAMS PER LITER (ug/l)

97,000 = CONCENTRATION OF PCE IN GROUNDWATER SAMPLE (ug/l)

▼ = DENOTES SURFACEWATER ELEVATION (NOVEMBER 2002)

MW-18 = MONITORING WELL LOCATION

RS-12 = RECONNAISSANCE POINT (FARALLON, JUNE-AUGUST 2002)

B17 = RECONNAISSANCE POINT DIRECTED BY ECOLOGY

GM = SILTY GRAVEL, SILTY GRAVEL WITH SAND

GW/GP = GRAVEL, GRAVEL WITH SAND

GW-GM, GP-GM = GRAVEL WITH SILT, GRAVEL WITH SILT AND SAND

GW = GRAVEL (WELL GRADED)

GP = GRAVEL (POORLY GRADED)

SP/SW = SAND, SAND WITH GRAVEL

SM = SILTY SAND, SILTY SAND WITH GRAVEL

SP-SM, SW-SM = SAND WITH SILT, SAND WITH SILT AND GRAVEL

ML = SILT, SANDY SILT, GRAVELLEY SILT

NOTE: LOCATION OF LINE OF CROSS SECTION SHOWN ON FIGURE 4. THE POTENTIOMETRIC SURFACE IS NEARLY PARALLEL TO THE LINE OF CROSS-SECTION FROM RIGHT TO LEFT.

SCALE (IN FEET) 5' 0' 0' 60'

FARALLON CONSULTING

Drawn By: DAVID WEST

FIGURE 2-3

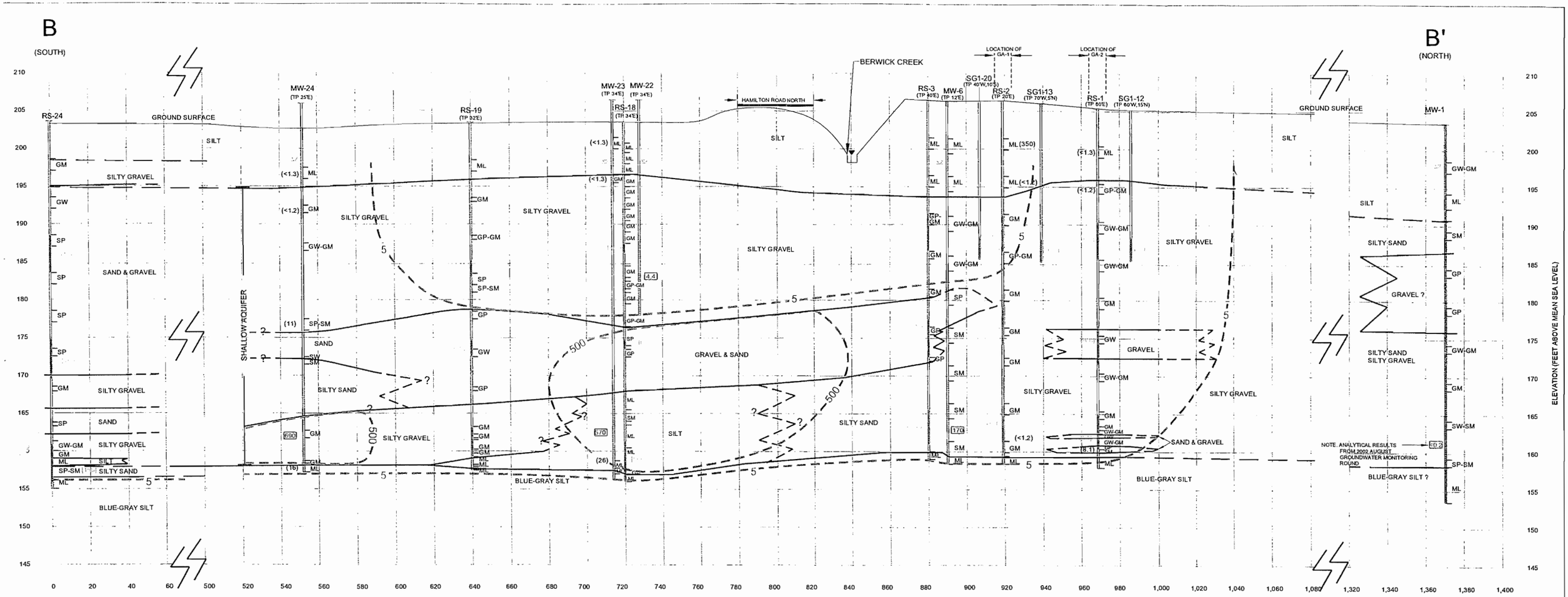
CROSS SECTION A-A'

REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN

HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE

CHEHALIS, WASHINGTON

FARALLON PN: 734-001



LEGEND

MW-4 (TP72'S) — BORING LOCATION TRANSPOSED (TP) IN FEET, NORTH (N), SOUTH (S), EAST (E), OR WEST (W) TO CROSS SECTION LINE.

SOIL SAMPLE INTERVAL

BLANK CASING

POTENTIOMETRIC SURFACE, DASHED WHERE INFERRED (NOVEMBER, 2002)

GEOLOGIC CONTACT, INFERRED WHERE QUERIED

TEMPORARY WELL SCREEN INTERVAL

WELL SCREEN INTERVAL

BOTTOM OF WELL/BOREHOLE

(16) = CONCENTRATION OF TETRACHLOROETHENE (PCE) IN SOIL IN MICROGRAMS PER KILOGRAM (ug/kg)

(<1.3) = CONCENTRATION OF PCE IN GROUNDWATER RECONNAISSANCE SAMPLE IN MICROGRAMS PER LITER (ug/l)

[4.4] = CONCENTRATION OF PCE IN GROUNDWATER SAMPLE (ug/l)

▼ = DENOTES SURFACEWATER ELEVATION (NOVEMBER 2002)

5 = ISOCONCENTRATION CONTOUR LINE

GA-4 = GEOPHYSICAL ANOMALY

MW-18 = MONITORING WELL LOCATION

RS-12 = RECONNAISSANCE SOIL BORING LOCATION

SG1-20 = RECONNAISSANCE SOIL BORING LOCATION, NOVEMBER 2002

GW = SILTY GRAVEL, SILTY GRAVEL WITH SAND

GW/GP = GRAVEL, GRAVEL WITH SAND

GW-GM, GP-GM = GRAVEL WITH SILT, GRAVEL WITH SILT AND SAND

GW = GRAVEL (WELL GRADED)

GP = GRAVEL (POORLY GRADED)

SP/SW = SAND, SAND WITH GRAVEL

SW = SILTY SAND, SILTY SAND WITH GRAVEL

SP-SM, SW-SM = SAND WITH SILT, SAND WITH SILT AND GRAVEL

ML = SILT, SANDY SILT, GRAVELLEY SILT

NOTE: LOCATION OF LINE OF CROSS SECTION SHOWN ON FIGURE 4

SCALE (IN FEET) 5' 0' 0' 20'

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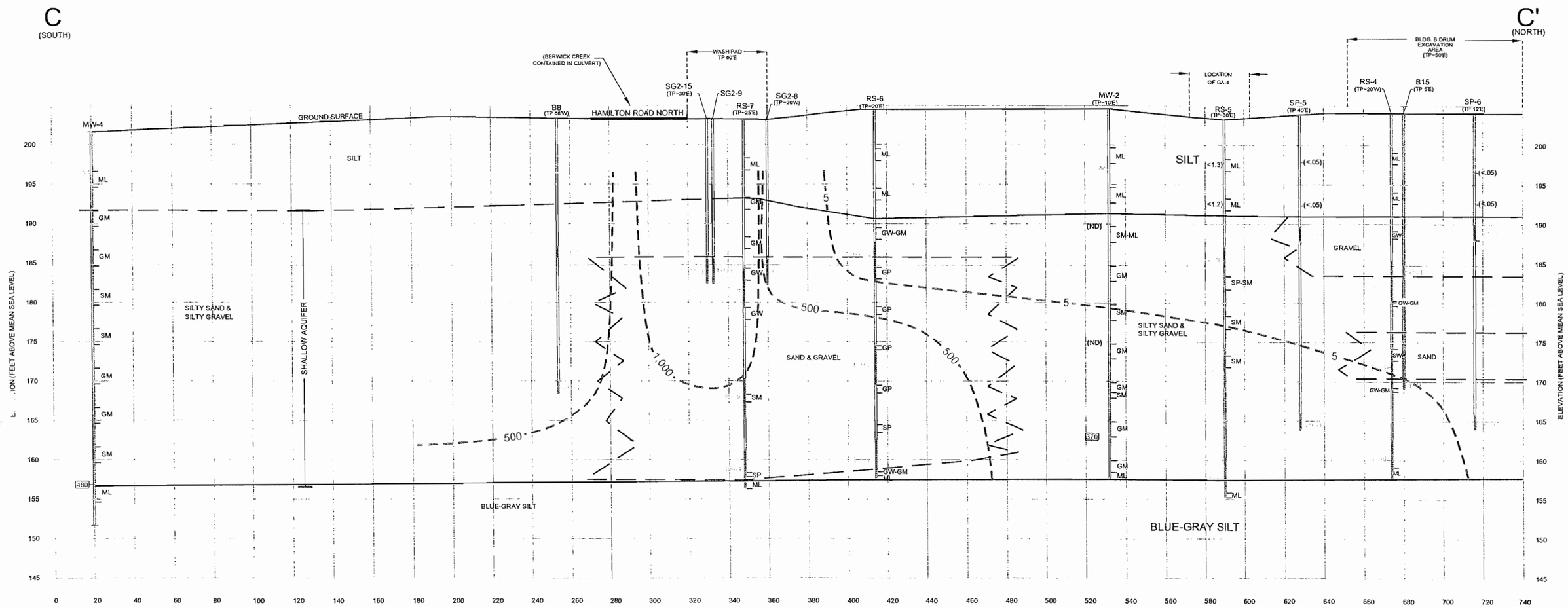
Issaquah, WA 98027

FIGURE 2-4
CROSS SECTION B-B'
REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

FARALLON PN: 734-001

Drawn By: DAVID WEST	Checked By: CS, RC, JP	Date: 7/1/03	Disk Reference: 734002



LEGEND

MW-4 (TP72'S) — BORING LOCATION TRANSPOSED (TP) IN FEET, NORTH (N), SOUTH (S), EAST (E), OR WEST (W) TO CROSS SECTION LINE.

SOIL SAMPLE INTERVAL

BLANK CASING

POTENTIOMETRIC SURFACE, DASHED WHERE INFERRED (NOVEMBER, 2002)

GEOLOGIC CONTACT, INFERRED WHERE QUERIED

TEMPORARY WELL SCREEN INTERVAL

WELL SCREEN INTERVAL

BOTTOM OF WELL/BOREHOLE

(<1.3) = CONCENTRATION OF TETRACHLOROETHENE (PCE) IN SOIL IN MICROGRAMS PER KILOGRAM (ug/kg)

(1,450) = CONCENTRATION OF PCE IN GROUNDWATER RECONNAISSANCE SAMPLE IN MICROGRAMS PER LITER (ug/l)

320 = CONCENTRATION OF PCE IN GROUNDWATER SAMPLE (ug/l)

▼ = DENOTES SURFACEWATER ELEVATION (NOVEMBER 2002)

5 = ISOCONCENTRATION CONTOUR LINE

GA-4 = GEOPHYSICAL ANOMALY

MW-18 = MONITORING WELL LOCATION

RS-12 = RECONNAISSANCE POINT (FARALLON, JUNE-AUGUST 2002)

B17 = RECONNAISSANCE POINT DIRECTED BY ECOLOGY

SG2-9 = RECONNAISSANCE POINT (FARALLON, NOVEMBER 2002)

SP-5 = RECONNAISSANCE POINT DIRECTED BY BREEDN

GW = SILTY GRAVEL, SILTY GRAVEL WITH SAND

GW/GP = GRAVEL, GRAVEL WITH SAND

GW-GM, GP-GM = GRAVEL WITH SILT, GRAVEL WITH SILT AND SAND

GW = GRAVEL (WELL GRADED)

GP = GRAVEL (POORLY GRADED)

SP/SW = SAND, SAND WITH GRAVEL

SM = SILTY SAND, SILTY SAND WITH GRAVEL

SP-SM, SW-SM = SAND WITH SILT, SAND WITH SILT AND GRAVEL

ML = SILT, SANDY SILT, GRAVELLEY SILT

NOTE: LOCATION OF LINE OF CROSS SECTION SHOWN ON FIGURE 4

SCALE (IN FEET) 0' 5' 20'

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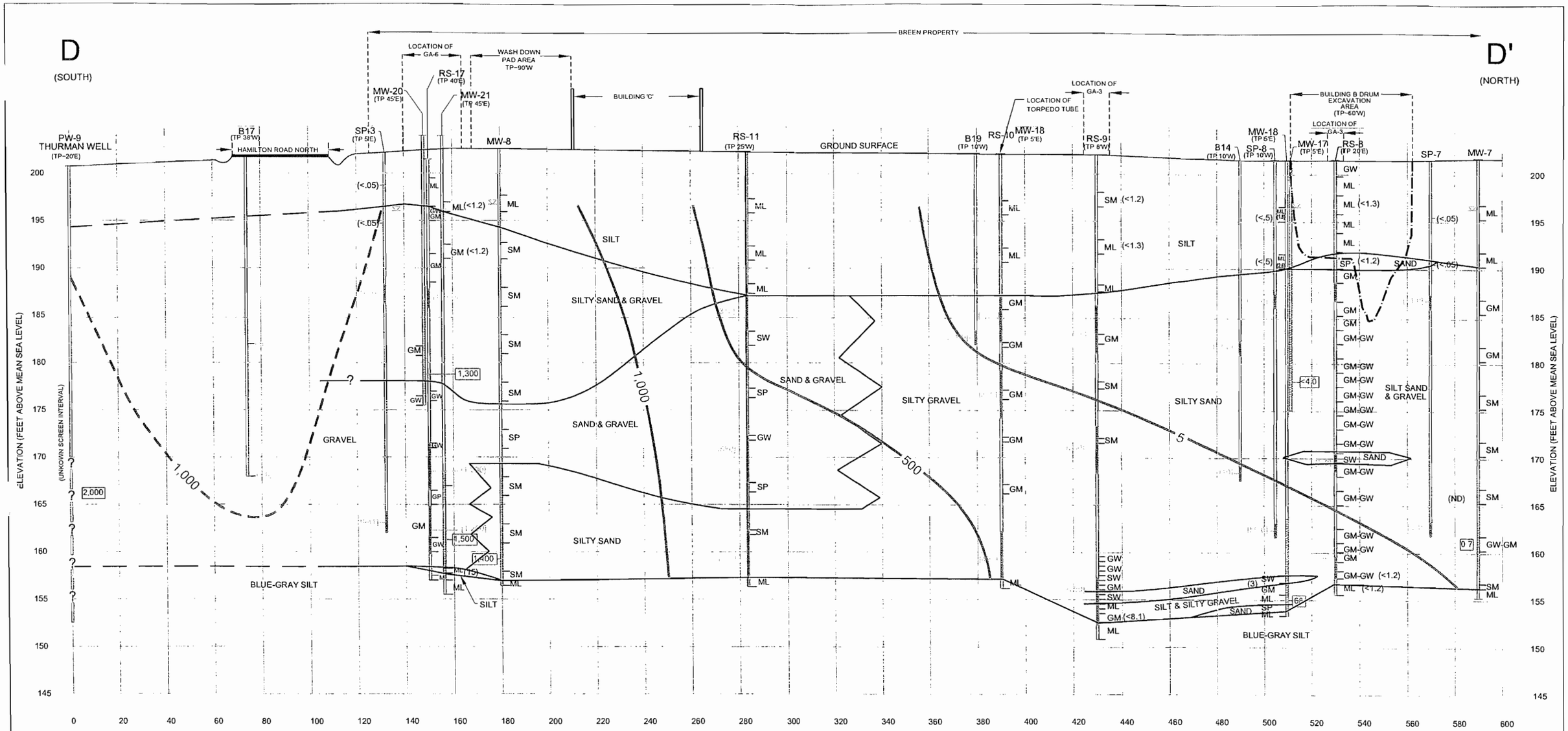
FIGURE 2-5
CROSS SECTION C-C'
REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

FARALLON PN: 734-001

Drawn By: DAVID WEST	Checked By: CS, RC, JP	Date: 7/1/03	Disk Reference: 734002



LEGEND

MW-4 (TP72S) — BORING LOCATION TRANSPOSED (TP) IN FEET, NORTH (N), SOUTH (S), EAST (E), OR WEST (W) TO CROSS SECTION LINE.

SOIL SAMPLE INTERVAL

BLANK CASING

POTENTIOMETRIC SURFACE, DASHED WHERE INFERRED (NOVEMBER, 2002)

GEOLOGIC CONTACT, INFERRED WHERE QUERIED

TEMPORARY WELL SCREEN INTERVAL

WELL SCREEN INTERVAL

BOTTOM OF WELL/BOREHOLE

(3) = CONCENTRATION OF TETRACHLOROETHENE (PCE) IN SOIL IN MICROGRAMS PER KILOGRAM (ug/kg)

(1,400) = CONCENTRATION OF PCE IN GROUNDWATER RECONNAISSANCE SAMPLE IN MICROGRAMS PER LITER (ug/l)

2,000 = CONCENTRATION OF PCE IN GROUNDWATER SAMPLE (ug/l)

5 = ISOCONCENTRATION CONTOUR LINE

GA-4 = GEOPHYSICAL ANOMALY
MW-18 = MONITORING WELL LOCATION
RS-12 = RECONNAISSANCE SOIL BORING
B17 = SOIL BORING

GM = SILTY GRAVEL, SILTY GRAVEL WITH SAND
GW/GP = GRAVEL, GRAVEL WITH SAND
GW-GM, GP-GM = GRAVEL WITH SILT, GRAVEL WITH SILT AND SAND
GW = GRAVEL (WELL GRADED)
GP = GRAVEL (POORLY GRADED)
SP/SW = SAND, SAND WITH GRAVEL
SM = SILTY SAND, SILTY SAND WITH GRAVEL
SP-SM, SW-SM = SAND WITH SILT, SAND WITH SILT AND GRAVEL
ML = SILT, SANDY SILT, GRAVELLEY SILT

NOTE: LOCATION OF LINE OF CROSS SECTION SHOWN ON FIGURE 4

SCALE (IN FEET) 5' 0' 0' 20'

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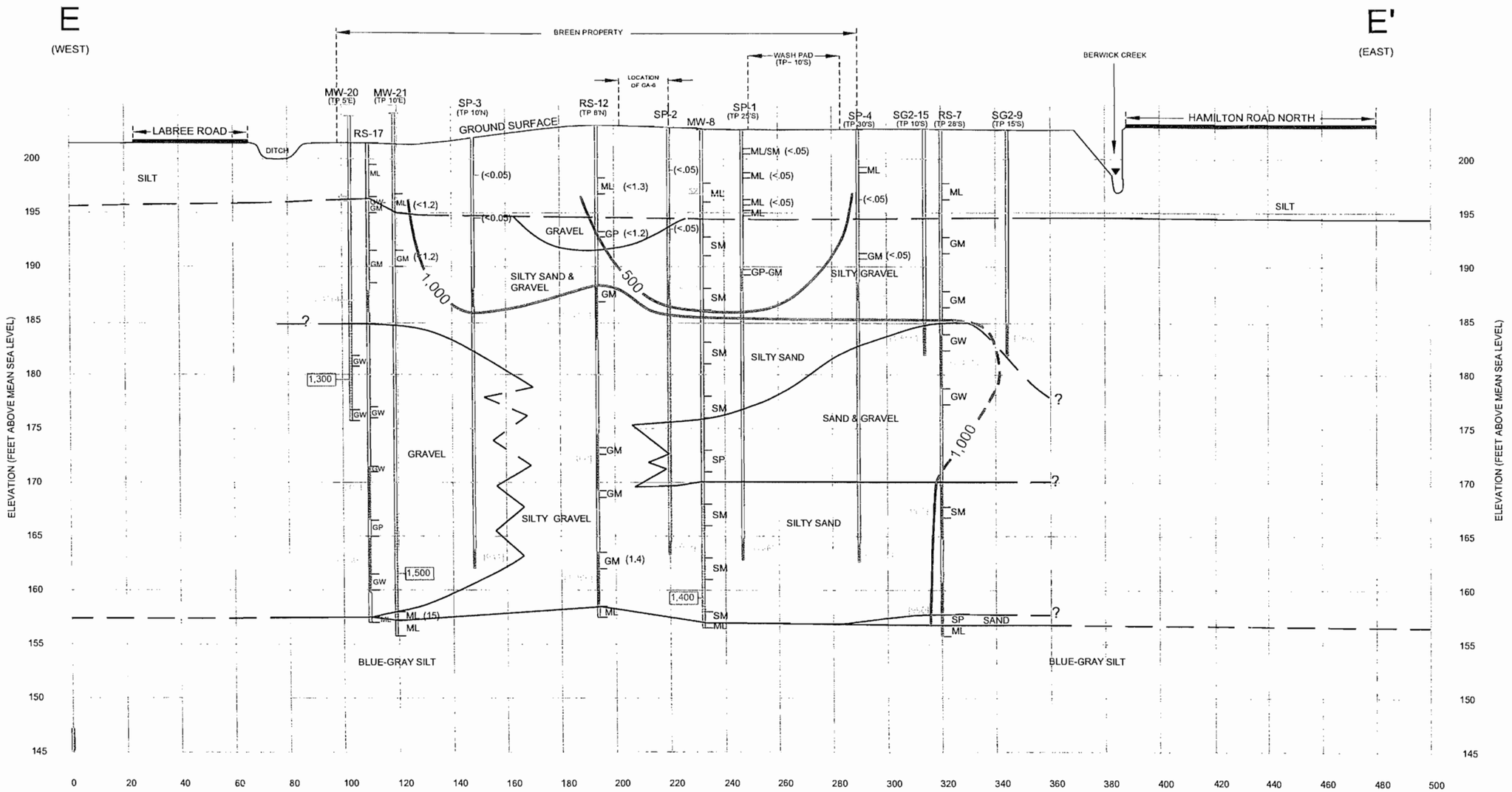
FIGURE 2-6
CROSS SECTION D-D'
REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

FARALLON PN: 734-001



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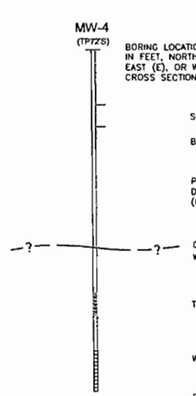

BORING LOCATION TRANSPOSED (TP) IN FEET, NORTH (N), SOUTH (S), EAST (E), OR WEST (W) TO CROSS SECTION LINE.

SOIL SAMPLE INTERVAL

BLANK CASING

POTENTIOMETRIC SURFACE, DASHED WHERE INFERRED (NOVEMBER, 2002)

GEOLOGIC CONTACT, INFERRED WHERE QUERIED

TEMPORARY WELL SCREEN INTERVAL

WELL SCREEN INTERVAL

BOTTOM OF WELL/BOREHOLE

(1.4) = CONCENTRATION OF TETRACHLOROETHENE (PCE) IN SOIL IN MICROGRAMS PER KILOGRAM (ug/kg)

[2,400] = CONCENTRATION OF PCE IN GROUNDWATER RECONNAISSANCE SAMPLE IN MICROGRAMS PER LITER (ug/l)

1,500 = CONCENTRATION OF PCE IN GROUNDWATER SAMPLE (ug/l)

▼ = DENOTES SURFACEWATER ELEVATION (NOVEMBER 2002)

5 = ISOCONCENTRATION CONTOUR LINE

GA-6 = GEOPHYSICAL ANOMALY
MW-18 = MONITORING WELL LOCATION
RS-12 = RECONNAISSANCE SOIL BORING
SP-4 = STRATA PROBE SOIL BORING

GM = SILTY GRAVEL, SILTY GRAVEL WITH SAND
GW/GP = GRAVEL, GRAVEL WITH SAND
GW-GM, GP-GM = GRAVEL WITH SILT, GRAVEL WITH SILT AND SAND
GW = GRAVEL (WELL GRADED)
GP = GRAVEL (PDORLY GRADED)
SP/SW = SAND, SAND WITH GRAVEL
SM = SILTY SAND, SILTY SAND WITH GRAVEL
SP-SM, SW-SM = SAND WITH SILT, SAND WITH SILT AND GRAVEL
ML = SILT, SANDY SILT, GRAVELLEY SILT

NOTE: LOCATION OF LINE OF CROSS SECTION SHOWN ON FIGURE 4

SCALE (IN FEET)
5'
0'
0'
20'

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FIGURE 2-7
CROSS SECTION E–E'
REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

FARALLON P.N: 734-001

Drawn By: DAVID WEST | Checked By: CS, RC, JP | Date: 7/1/03 | Disk Reference: 734002

Appendix A-3
HRIA Stratigraphy
MW-600 to MW-608 Lithologic Logs

Project: Hamilton-Labree/EPA **Project Location: Chehalis, WA** **Project Number: RAC WA 100**	**Log of Boring MW-600** Sheet 1 of 2

Date(s) Drilled	**11/3 to 11/5/2003**	Logged By	**J. Rapp**	Checked By	**M. Meyer**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**Tacoma Pump and Drilling**	Total Depth Drilled (FT BGS)	**49.5**
Drill Rig Type	**Foremost**	Sampler Type	**Split Spoon/Dames and Moore**	Surface Elevation	**207.60**
Groundwater Level (feet bgs)	**5.04 on 11/21/03**	Drill Bit Size/Type	**6.25-inch ID auger**	Top of PVC Elevation	**209.20**
Diameter of Hole (inches)	**10** Diameter of Well (inches) **4**	Type of Well Casing	**Sch 80 CPVC**	Screen Perforation	**0.010"**
Type of Sand Pack	**10/20 Silica**	Type and Depth of Seal(s)	**Well screen (7-35'); Filter sand (5-36'); Bentonite chips (2-5', 36-49'); Cement surface compl. (0-2')**		
Comments	**Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.**				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				ml		Light to medium olive-brown SILT - dry grading to wet, soft, non-plastic					Depth of silt contact based on log of boring GP-503
205												
	5											
200					gm		Dark reddish-brown silty sandy GRAVEL - dry to slightly damp, 60% subangular gravel, rock fragments, 20% fine sand, 20% silt					
	10											
195												
	15	X	600	8,11,16	gw-sw		Gray-brown sandy GRAVEL to gravelly SAND - wet, dense, 50% subrounded to subangular gravel, 40-45% mostly fine sand		0.0		1400 1405	03444036
190												
	20											
185												
	25	X		10,10,10	gw		Gray-brown sandy GRAVEL - wet, medium dense, 50% subrounded to subangular gravel, 40% fine to		0.0		1427	

URS

Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-600

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25		A				coarse sand, weathered granite at 25'				1430	03444037
180												
			B	5,8,12	sw		Gray-brown gravelly SAND - wet, medium dense, mostly fine to medium sand, 20% subrounded to subangular gravel, some silt		0.0		1508	
			600B								1510	03444038
											1515	03444052 (PTS)
	30		C	5,7,10	sp		Gray-brown SAND - wet, mostly fine to medium sand, increasing gravel at 31.5'		0.0		1520	
											1525	03444039
			D	7,13,14			Same as above - dense, increasing subrounded to subangular gravel, rock fragments and weathered granite at 32.5'		0.0	0.0	1535	
175											1537	03444040
			E	7,11,12	sw-gw		Gray-brown gravelly SAND to sandy GRAVEL - wet, medium dense, 50% fine to medium sand, 40% subrounded to angular gravel, 10% silt, oxidized yellow-brown, reddish-gray volcanics at 34'				1550	
											1555	03444041
	35		GW-1						0.0	0.0	0915	03444042
			F	11,16,20	gw		Gray-brown sandy GRAVEL - wet, dense, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt				0955	
170											1000	03444043
			G	8,11,13							1010	
											1020	03444044
	40											
			GW-2								1045	03444045
			H	9,13,14	gm		Same as above grading to silty GRAVEL - moist, dense, some reddish-brown silt			0.0	1100	
165											1112	03444047
			I	7,12,15	gw		Gray-brown sandy GRAVEL - wet, dense, 60% subrounded to subangular gravel, 40% fine sand, weathered granite				1115	
											1120	03444048
	45											
			GW-3								1130	03444049/03444046
			J	2,3,4	ml		Bluish-green SILT - very moist, stiff, low plasticity, trace fine to medium sand				0945	
160											0950	03444050
			K	2,3,5							1005	
											1015	03444051
	50						Boring terminated at 49.5 feet bgs on 11-5-03					
155												
	55											
50												

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Project: Hamilton-Labree/EPA **Project Location: Chehalis, WA** **Project Number: RAC WA 100**	**Log of Boring MW-601** Sheet 1 of 2

Date(s) Drilled	11/10/03	Logged By	J. Rapp	Checked By	M. Meyer
Drilling Method	Hollow Stem Auger	Drilling Contractor	Tacoma Pump and Drilling	Total Depth Drilled (FT BGS)	47.5
Drill Rig Type	Foremost	Sampler Type	Split Spoon/Dames and Moore	Surface Elevation	207.30
Groundwater Level (feet bgs)	4.84 on 11/21/03	Drill Bit Size/Type	6.25-inch ID auger	Top of PVC Elevation	208.71
Diameter of Hole (inches)	10 / Diameter of Well (inches) 4	Type of Well Casing	Sch 80 CPVC	Screen Perforation	0.010"
Type of Sand Pack	10/20 Silica	Type and Depth of Seal(s)	Well screen (7-40'); Filter sand (5-40'); Silica grout (2-5', 40-49'); Cement surface compl. (0-2')		
Comments	Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				ml		Light olive-brown SILT - damp, soft, non-plastic, vegetation, roots					
205												
	5	■	601	1,2,3					0.0		0930 0940	03464000
200					gw		Gray-brown sandy GRAVEL - wet, medium dense, 60% subrounded to subangular gravel, 35% mostly fine sand, trace silt					8' Contact/description between silt and gravel based on lithology from GP-502, adjusted for elevation
	10											
195												
	15	■	A	8,15,15	gw		Gray-brown sandy GRAVEL - wet, dense, 60% subrounded to subangular gravel, 35% mostly fine sand, trace silt		0.0	4.7	1025 1030	03464001
190												
	20											
185												
	25											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-601

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25											
180												
		Physical	B	6,7,7	gw		Gray-brown sandy GRAVEL - wet, medium dense, 50% subrounded to subangular gravel, 35% fine to medium sand, 15% silt		0.0		1120 1122	03464002
	30			11,12,13	sw-gw		Gray-brown gravelly SAND to sandy GRAVEL - wet, dense, 50% fine to coarse sand, 50% subrounded to subangular gravel, slightly silty		0.0	5.7	1130	
			C								1135	03464003
175			D	6,7,12			Same as above - grading to sandy GRAVEL at 32.5'		0.0	4.5	1135 1140	03464004
			E	8,28,30	gw sp		Gray-brown sandy GRAVEL - wet, medium dense, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt,			4.8	1146	
	35		GW-1				Gray-brown SAND - wet, very dense, mostly medium sand, trace subrounded gravel, increasing gravel at 34'				1150 1305	03464005 03464006
170			F	8,14,17	sw-gw		Gray-brown gravelly SAND to sandy GRAVEL - wet, dense, 45% mostly fine sand, 45% subrounded to subangular gravel, mottled yellow to dark gray				1315 1325	03464007
			G	8,13,14	sp-sw		Gray-brown gravelly SAND - wet, dense, mostly medium sand, some fine subrounded gravel,				1330	
	40				gw		Gray-brown sandy GRAVEL - wet, medium dense, mostly subrounded to subangular gravel, fine sand				1335	03464008
			GW-2								1425	03464009
165			H	9,14,15	sp-sw		Gray-brown gravelly SAND - wet, dense, mostly medium sand, some fine subrounded gravel,				1445 1450	034640010
		Physical	I	20,13,7	gw		Gray-brown sandy GRAVEL - wet, medium dense, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt,				1455 1458 1500	034640011
	45		GW-3 J	9,7,8							1535	03464012
		Physical	K L	1,2,3	ml		Bluish-green SILT - very moist, medium stiff, low to medium plasticity, trace fine to medium sand				1540 1542 1543 1545	034640013 034640014 034640015
160							Boring terminated at 47.5 feet bgs on 11-11-03					
	50											
155												
	55											
	60											

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Project: Hamilton-Labree/EPA **Project Location: Chehalis, WA** **Project Number: RAC WA 100**	**Log of Boring MW-602** Sheet 1 of 2

Date(s) Drilled	11/11 to 11/12/2003	Logged By	J. Rapp	Checked By	M. Meyer
Drilling Method	Hollow Stem Auger	Drilling Contractor	Tacoma Pump and Drilling	Total Depth Drilled (FT BGS)	49.0
Drill Rig Type	Foremost	Sampler Type	Split Spoon/Dames and Moore	Surface Elevation	206.80
Groundwater Level (feet bgs)	4.06 on 11/24/03	Drill Bit Size/Type	6.25-inch ID auger	Top of PVC Elevation	208.03
Diameter of Hole (inches)	10 — Diameter of Well (inches) 4	Type of Well Casing	Sch 80 CPVC	Screen Perforation	0.010"
Type of Sand Pack	10/20 Silica	Type and Depth of Seal(s)	Well screen (7-40'); Filter sand (5-41'); Bentonite chips (2-5', 41-49'); Cement surface compl. (0-2')		
Comments	Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				ml		Grass Surface					
205							Light olive-brown SILT - moist grading wet, soft, non-plastic, fine sand					
	5		Physical 602 Metals	4,5,6					0.0		1510	03464018
											1512	03464018/03464041
200					gm		grades to silty GRAVEL at 6.5'					
	10											
195			A Physical	7,12,17	gw		Gray-brown sandy GRAVEL - wet, medium dense, 60% subrounded to subangular gravel, 30% fine to coarse sand, 10% silt		0.0		1540 1542 1550	 03464019 03464021
			GW-1								0755	03464020
	15		B Physical	6,8,10			Same as above - wet, medium dense, 60% subrounded to subangular gravel, 40% mostly fine sand with some medium to coarse		0.0	14.5	0810 0815	03464022 03464022
190												
	20											
185												
	25											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-602

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25											
180												
	30		C									
		Physical		8,18,15	gw-sw		Gray-brown sandy GRAVEL to gravelly SAND - wet, medium dense, 50% subrounded to subangular gravel, 45% fine to coarse sand, 5% silt		0.0	32	0855 0900 0910	03464023 03464023
175			D	5,17,26	sp-sw		Gray-brown SAND - wet, mostly medium sand, occasional subrounded gravel, rock fragments		0.0	47	0920	03464024
			E	6,17,24	sw		Gray-brown gravelly SAND - wet, medium dense, 50% fine to coarse sand, 30% weathered granite fragments, 15% subrounded to subangular gravel, 5% silt		0.0	4.1	0930 0935	03464025
	35		GW-2								0955	03464026
170			F	3,5,8			Same as above - no weathered granite, sand is mostly medium to coarse, fine subrounded gravel, slightly silty		0.0	3.1	1020 1025	03464027
			G	7,12,13			Same as above - yellow-brown fine sand, compact, very silty		0.0	0.0	1030 1040	03464028
	40		GW-3								1120	03464029/03464039
165												
	45											
160			H	7,6,7,8	ml		Bluish-green SILT - damp, stiff, low to medium plasticity, trace fine to medium sand				1617	03464030
			I								1619	03464031
		Physical									1620	03464031
							Boring terminated at 49 feet bgs on 11-12-03					
	50											
155												
	55											
150												

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Project: Hamilton-Labree/EPA **Project Location: Chehalis, WA** **Project Number: RAC WA 100**	**Log of Boring MW-603** Sheet 1 of 2

Date(s) Drilled	11/13 to 11/17/2003	Logged By	E. Lillywhite	Checked By	M. Meyer
Drilling Method	Hollow Stem Auger	Drilling Contractor	Tacoma Pump and Drilling	Total Depth Drilled (FT BGS)	48.0
Drill Rig Type	Foremost	Sampler Type	Split Spoon/Dames and Moore	Surface Elevation	206.40
Groundwater Level (feet bgs)	3.82 on 11/24/03	Drill Bit Size/Type	6.25-inch ID auger	Top of PVC Elevation	207.79
Diameter of Hole (inches)	10 / Diameter of Well (inches) 4	Type of Well Casing	Sch 80 CPVC	Screen Perforation	0.010"
Type of Sand Pack	10/20 Silica	Type and Depth of Seal(s)	Well screen (7-37'); Filter sand (4-38'); Bentonite chips (2-5', 38-48'); Cement surface compl. (0-1')		
Comments	Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				ml		Olive-gray SILT - dry, non-plastic, some fine sand					0-5' Lithologic description based on log of GP-500
205							Gray sandy SILT - wet, loose					
							Light olive-gray SILT - stiff, slightly moist, mottled, oxidized					
	5	■	603A Physical	41,33, 50/5.5"			Light gray SILT - damp, stiff, non-plastic, some subrounded to subangular gravel 0.25 to 0.5", trace oxidation		0.0	0.0	1510	03464037 03464037
200					gw-gm		Gray-brown silty sandy GRAVEL - moist, fine sand, subrounded to subangular gravel					
	10											
195												
	15	X	B	65,50/0.5"	gw		Gray-brown sandy GRAVEL - wet, medium dense, 60% subrounded to subangular gravel, 30% fine to medium sand, 10% silt		0.0	0.0	1548	03464038
190												
	20											
185												
	25											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-603

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25											
			C	11,50/5.5"			Same as above - cobble in shoe, dense		0.0	0.0	1031	03464042
			Physical									03464042
180												
	30		D	18,48,50/6"	sp		Gray-brown SAND - wet, dense, 70% mostly fine to medium sand, 20% subrounded to subangular gravel, 10% silt		0.0	0.0	1137	03464043
175				20,20,30	gw		Gray-brown sandy GRAVEL - wet, medium dense, 85% subrounded to subangular gravel, 15% fine to coarse sand, trace silt, oxidized at 32.25'		0.0	0.0	1229	
			E									03464044
				8,8,8					0.0	0.0	1541	
			F									03464045
			GW-1									03464046
	35		G	2,2,11	gm		Gray-brown silty GRAVEL - wet, medium dense, 50% subrounded to subangular gravel, 25% fine sand, 25% silt, partial cementation		0.0	0.0	0849	03464047
170			H	5,25,20	gw		Gray-brown sandy GRAVEL - wet, medium dense to dense, 90% subrounded to subangular gravel, 10% fine to medium sand, grades to silty GRAVEL		0.0	0.0	1312	03464048
			I									03464049
			Physical	10,20,54	gm		Gray-brown silty GRAVEL - wet, 40% silt, 40% subrounded to subangular gravel, 20% fine to coarse sand		0.0	0.0	1334	03464100
			J									03464100
	40		GW-2								1505	03464101
165			K	10,22,31			Same as above - wet, loose to medium dense, 50% subrounded to subangular gravel, 40% silt, 10% fine to medium sand, grades siltier		0.0	0.0	1522	03464102
			L	15,35, 50/4.5"	sp		Gray-brown SAND - wet, medium dense, mostly fine to coarse sand		0.0	0.0	1550	03464103
			M		gm		Gray-brown silty GRAVEL - wet, medium dense, 35% subrounded to subangular gravel, 30% fine to coarse sand, 30% silt					03464104
			GW-3									03464105
	45		N	6,6,8	ml		Same as above - wet, medium dense, 50% subrounded to subangular gravel (1/4-1/2"), 40% silt, 10% fine sand		0.0	0.0	0830	03474200
			O									03474201
160			P				Bluish-green SILT - damp, stiff to hard, non-plastic, trace very fine sand, occasional wood fragments 45.5-46'		0.0	0.0	48	03474202
			Physical	10,12,14								03474203
			Q									03474203
							Boring terminated at 48 feet bgs on 11-17-03					
	50											
155												
	55											
150												

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-604

Date(s) Drilled	10/28 to 10/29/03	Logged By	J. Rapp	Checked By	M. Meyer
Drilling Method	Hollow Stem Auger	Drilling Contractor	Tacoma Pump and Drilling	Total Depth Drilled (FT BGS)	51.0
Drill Rig Type	Foremost	Sampler Type	Split Spoon/Dames and Moore	Surface Elevation	209.30
Groundwater Level (feet bgs)	4.55 on 11/25/03	Drill Bit Size/Type	6.25-inch ID auger	Top of PVC Elevation	209.06
Diameter of Hole (inches)	10 / Diameter of Well (inches) 4	Type of Well Casing	Sch 80 CPVC	Screen Perforation	0.010"
Type of Sand Pack	10/20 Silica	Type and Depth of Seal(s)	Well screen (7-37'); Filter sand (4-37'); Bentonite chips (1-4', 37-51'); Cement surface compl. (0-1')		
Comments	Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch. Sampling performed 10/28 and 10/29, well installed 11/19/03.				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				fill		Gravel surface and FILL					
205	5				ml		Dark gray SILT - moist, description based on cuttings					
200	10				gw		Gray-brown sandy GRAVEL - wet, 60% subrounded to subangular gravel, 30% fine to coarse sand					
195	15		604	8,13,10			Same as above - wet, medium dense, 60% subrounded to subangular gravel, 30% fine to coarse sand, 10% silt			31.0	1112 1152	 03444000
190	20											
185	25		A 604A Metals	14,20,17			Same as above - dense, rock fragments			25.0	1430 1432 1050	 03444001 03444053
180	30		B	50/6"			Same as above - very dense, rock fragments				1120	03444002

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-604

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	30										1133	
			C	11,17,14	sw		Gray-brown gravelly SAND - wet, dense, 70% fine to coarse sand, 30% fine subrounded gravel				1135	03444003/03444004
			D	10, 50/4"			Same as above - dense, rock fragments, 60% sand			4.0	1150 1155	03444005
			E	5,7,12			Same as above- medium dense, 70% sand, trace silt				1209	
175										0.2	1215	03444006
	35		GW-1								1255	03444007
			F	4,11,15	gw		Gray-brown sandy GRAVEL - wet, dense, 60% subrounded to subangular gravel, 30% fine to medium sand, some coarse sand, 10% silt			4.0	1340 1345	03444008
			G 604G Metals	15,19,22			Same as above - wet, very dense, 60% subrounded to subangular gravel, 30% fine to coarse sand			0.8	1405 1410 1415	03444009 03444054
170												
	40		GW-2		gm		Gray-brown silty sandy GRAVEL - wet, dense, 50% subrounded to subangular gravel, 35% fine to coarse sand, 15% silt, yellow-brown oxidation				1450	03444010
			H	10,12,13							1510	
			I	6,10,14	sw		Gray-brown gravelly SAND - wet, medium dense, 70% fine to coarse sand, 30% fine subrounded gravel, rock fragments			0.4 1.1	1520 1530 1535	03444011 03444012
165												
	45		GW-3									
			J	10,31,21	sw-gw		Gray-brown gravelly SAND to sandy GRAVEL - wet, dense, 50% fine to medium sand, 45% fine subangular gravel, rock fragments, weathered volcanics, oxidized yellow-brown			0.1	1605 0855 0900	03444013 03444014
			K	7,8,4	gm-sm		Gray-brown silty GRAVEL to silty SAND - wet, medium dense, 40% subrounded to subangular gravel, 40% fine to coarse sand, 20% silt, yellow-brown oxidation				0914 0916 0918 0935 0919 0940	03444015 03444016 03444017 03444018
160			L M	3,4,5	ml							
	50		N 604N Metals				Bluish-green clayey SILT - moist, stiff, low to medium plasticity, trace to some fine to medium sand				0945	03444055
							Boring terminated at 51 feet bgs on 10-19-03					
155	55											
150	60											
145	65											
140	70											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-605

Date(s) Drilled	11/17 to 11/18/2003	Logged By	E. Lillywhite	Checked By	M. Meyer
Drilling Method	Hollow Stem Auger	Drilling Contractor	Tacoma Pump and Drilling	Total Depth Drilled (FT BGS)	50.0
Drill Rig Type	Foremost	Sampler Type	Split Spoon/Dames and Moore	Surface Elevation	207.90
Groundwater Level (feet bgs)	4.22 on 11/24/03	Drill Bit Size/Type	6.25-inch ID auger	Top of PVC Elevation	207.23
Diameter of Hole (inches)	10 — Diameter of Well (inches) 4	Type of Well Casing	Sch 80 CPVC	Screen Perforation	0.010"
Type of Sand Pack	10/20 Silica	Type and Depth of Seal(s)	Well screen (10-35'); Filter sand (7-37'); Bentonite chips (2-7', 37-50'); Cement surface compl. (0-1')		
Comments	Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				Fill		FILL, Gravel					0-12' Lithologic description based on log of GP-506
205												
	5				ml-cl		Light olive-gray clayey SILT - damp, medium soft, medium plasticity, trace fine sand, mottled gray-brown, oxidized					
200					ml		Same as above - increasing sand and gravel at 9'					
	10				gw-sw		Red-brown sandy GRAVEL - slightly wet, subrounded to subangular gravel median size 1", fine to medium sand, some silt/clay					
195		■ ■ ■	605A Physical	34,27,26	sw		Gray-brown gravelly SAND - wet, very dense, 60% fine to coarse sand, 35% subrounded to subangular gravel, 5% silt			0.0	0951	03474204 03474204
	15											
190												
	20											
185												
	25											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-605

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25		B	6,50/5"			Same as above - mostly fine to medium sand, decreasing gravel			0.0	1156	03474205
180			C Physical	11,43,49	sm		Gray-brown silty SAND - wet, very dense, 60% fine to medium sand, 35% silt, trace subrounded to subangular gravel, partially cemented			0.0	1302	03474206 03474206
	30		D	5,12,11	sp		Gray-brown SAND (SP) - wet, medium dense, fine to medium sand, 10% silt				1310	03474207
			E	12,24,33						0.0	1319	03474208
175			F		sp-gp		Gray-brown SAND and GRAVEL - wet, very dense, mostly medium sand, 40% subrounded gravel, 15% silt, partial cementation					03474209
			G	33,36,50/3"	sp					0.0	1330	
			H		ml		Gray-brown SILT - very dense, damp, stiff, nonplastic					03474210
	35		GW-1		gm		Gray-brown silty GRAVEL - wet, dense, 60% subrounded to subangular gravel, 20% fine to coarse sand, 20% silt					03474211 03474212
			I	11,24,50/5"	sp		Gray-brown SAND (SP) - wet, fine to coarse sand grading to fine to medium sand, trace subrounded to subangular gravel, trace silt			0.0	1440	03474213
170			J Physical	36,50/5"	sm-gm		Gray-brown silty SAND to silty GRAVEL - wet, very dense, 40% subrounded to subangular gravel, 40% silt, 20% fine to coarse sand, grading less silty at 38'			0.0	1452	03474214 03474213
			GW-2									03474215
	40		K	25,23,17			Same as above - slightly cemented, oxidized 40.5-41'			0.0	1546	03474216
			L	26,50/4"	sp		Gray-brown SAND - wet, medium dense to dense, mostly fine to medium sand with trace coarse, 5% silt			0.0	1600	03474217
165			GW-3									03474218
	45		M	19,36,44			Same as above - some oxidized sand, increasing fine sand and silt content			0.0	0819	03474219
			N	16,50/6"			Same as above - with coarse sand, gravel 0.25-1"			0.0	0831	03474220
160			O	5,9,11	ml		Brown SILT (ML) - damp, hard, non-plastic, oxidized, contacts			0.0	0858	03474221/03474222
			P Q Physical	9,17,19			Bluish-green SILT (ML) - damp to dry, stiff to hard, trace very fine sand, non-plastic			0.0	0913	03474223 03474224
	50		R									03474224
							Boring terminated at 50 feet bgs on 11-18-03					03474225
155												
	55											
150												

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Project: Hamilton-Labree/EPA **Project Location: Chehalis, WA** **Project Number: RAC WA 100**	**Log of Boring MW-606** Sheet 1 of 2

Date(s) Drilled	**10/30/03**	Logged By	**J. Rapp**	Checked By	**M. Meyer**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**Tacoma Pump and Drilling**	Total Depth Drilled (FT BGS)	**49.5**
Drill Rig Type	**Foremost**	Sampler Type	**Split Spoon/Dames and Moore**	Surface Elevation	**208.70**
Groundwater Level (feet bgs)	**5.71 on 11/6/03**	Drill Bit Size/Type	**4.25-inch ID auger**	Top of PVC Elevation	**206.83**
Diameter of Hole (inches)	**8** Diameter of Well (inches) **4**	Type of Well Casing	**Sch 40 PVC**	Screen Perforation	**0.010"**
Type of Sand Pack	**10/20 Silica**	Type and Depth of Seal(s)	**Well screen (20-40'); Filter sand (18-40'); Bentonite chips (2-16', 40-49.5'); Cement surface compl. (0-2')**		
Comments	**Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.**				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				fill		FILL - Sand and Gravel					0-8' Lithologic description based on log of GP-511
					ml		Light olive-brown clayey SILT - moist, medium soft, mottled reddish-brown, trace fine sand, roots					
205							Light olive brown to reddish-brown SILT - moist, stiff, increasing gravel with depth, grading to GM 7-8'					
	5											
					gm		increasing gravel and sand based on drilling observations					
200				2,3,2	sw		Gray-brown gravelly SAND - wet, loose, 70% fine to medium sand, 25% subrounded to subangular gravel, 5% silt		0.0	4.0	1407	
	10											
195												
	15		Physical	5,3,2	gw		Gray-brown sandy GRAVEL - wet, loose, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt		0.0	2.2	1420 1422	03444019
190												
	20											
185												
	25											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-606

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25		Metals	6,8,9	gm-sm		Gray-brown silty sandy GRAVEL - wet, medium dense, subrounded to subangular gravel, fine to coarse sand, oxidized yellow-brown		0.0	0.4	1432	03444040
180												
	30		606	10,16,17	gm		Gray-brown silty GRAVEL - moist, dense, 50% subrounded to subangular gravel, 35% fine sand, 15% silt		0.0	5.1	1443	
			A	7,20,18	gw		Gray-brown sandy GRAVEL- wet, dense, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt, yellow-brown oxidized fine sand and silt		0.0	7.4	1445 1455 1505	03444020 03444021
175			GW-1								1525	03444022/03444028
	35		B	8,6,5	sp		Gray-brown SAND - wet, mostly fine to medium sand, trace gravel, trace silt		0.0	37	1532 1533	 03444023
			C D	8,13,16	sp-sm		Gray-brown silty SAND - wet, dense, mostly fine to medium sand, increasing coarse sand and gravel at 37.5', rock fragments		0.0	24	1540 1535 1542	03444024 03444025
170			E	8,15,18	gm		Gray-brown silty GRAVEL - moist, dense, 50% subrounded to subangular gravel, 35% fine sand, 15% silt, oxidized yellow-brown fine sand and silt		0.0	8.5	1546 1548	 03444026
	40		GW-2								1610	03444027
			F Physical	5,9,16	sw-gw		Gray-brown SAND and GRAVEL - wet, dense, 50% subrounded to subangular gravel, 50% fine to medium sand, slightly silty			0.0	1625 1627 1630	 03444029 03444034
165			G	8,18,18						0.0	1642 1645	 03444030
	45		GW-3								1655	03444031
			H	2,3,4	ml		Reddish-brown grading to bluish-green SILT (ML) - very moist, stiff, low to medium plasticity, trace fine to medium sand			0.0	1706 1710	 03444032
160			Physical I	2,3,3						0.0	0810 0815 0817	 03444035 03444033
	50						Boring terminated at 49.5 feet bgs on 10-30-03					
155												
	55											

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Project: Hamilton-Labree/EPA **Project Location: Chehalis, WA** **Project Number: RAC WA 100**	**Log of Boring MW-607** Sheet 1 of 2

Date(s) Drilled	**10/21 to 10/22/2003**	Logged By	**J. Rapp**	Checked By	**M. Meyer**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**Tacoma Pump and Drilling**	Total Depth Drilled (FT BGS)	**49.0**
Drill Rig Type	**Foremost**	Sampler Type	**Split Spoon/Dames and Moore**	Surface Elevation	**207.20**
Groundwater Level (feet bgs)	**6.04 on 11/7/03**	Drill Bit Size/Type	**4.25-inch ID auger**	Top of PVC Elevation	**206.88**
Diameter of Hole (inches)	**8** Diameter of Well (inches) **2**	Type of Well Casing	**Sch 40 PVC**	Screen Perforation	**0.010"**
Type of Sand Pack	**10/20 Silica**	Type and Depth of Seal(s)	**Well screen (20-40'); Filter sand (18-41'); Bentonite chips (16-18', 40-49'); Silica grout (2-16'); Cement surface compl. (0-2')**		
Comments	**Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.**				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	0				Fill		FILL - Sand and Gravel					0-8.5' Lithologic description based on log of GP-509
205					cl-ml		Gray silty CLAY to clayey SILT- medium soft, damp, low to medium plasticity					
					ml		Light olive brown SILT - slightly moist, stiff, nonplastic, some fine sand					
	5											
					ml		Gray-brown SILT with gravel - increasing gravel to 2"					
200				2,6,9	gw		Brown sandy GRAVEL - wet, medium dense, rock fragments, fine to coarse sand, 10% silt to fine sand		0.0	0.0	1515	
	10											
195												
	15			6,11,11			Same as above - wet, medium dense, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt		0.0	0.0	1530	
190												
	20											
185												
	25											

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Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-607

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25			5,7,9	sw		Gray-brown gravelly SAND (SW) - wet, medium dense, 60% fine to coarse sand, 30% subrounded to subangular gravel, 10% silt					
180												
	30		607	7,13,16					0.0	0.0	0850	03434250
			A	11,12,15			Same as above - wet, dense, 65% fine to coarse sand, 25% subrounded to subangular gravel, 10% silt				0925	03434251
175			B	12,12,13	gw		Gray-brown sandy GRAVEL - wet, dense, 50% subrounded to subangular gravel, 40% fine to coarse sand, 10% silt				1425	03434252
			C	12,14,16	sw		Gray-brown gravelly SAND - wet, dense, 70% fine to coarse sand, 25% subrounded to subangular gravel, 5% silt				1430	03434253
	35		GW-1									
			D	8,21,32					0.0	0.0	1450 1515	03434254 03434255
170			E	12,14,16							1544	03434256/03434257
			GW-2		sw-gw		Gray-brown gravelly SAND to sandy GRAVEL (SW-GW) - wet, dense, 50% fine to coarse sand, 50% subrounded to subangular gravel				1610	03434258
	40		F	12,16,17					0.0	0.0	1620	03434259
165			G	8,11,14							1635	03434260
	45		GW-3								1645	03434261
				10,7,8			Same as above - bluish-green silt in sample shoe					
160			H I								1658	03434262
			J	2,3,3	ml		Bluish-green SILT - very moist, medium stiff, low to medium plasticity, trace fine to medium sand				1700 1712	03434263 03434264
							Boring terminated at 49 feet bgs on 10-22-03					
	50											
155												
	55											
50												

URS

Project: Hamilton-Labree/EPA Project Location: Chehalis, WA Project Number: RAC WA 100	**Log of Boring MW-608** Sheet 1 of 2

Date(s) Drilled	10/24/2003	Logged By	J. Rapp	Checked By	M. Meyer
Drilling Method	Hollow Stem Auger	Drilling Contractor	Tacoma Pump and Drilling	Total Depth Drilled (FT BGS)	47.5
Drill Rig Type	Foremost	Sampler Type	Split Spoon/Dames and Moore	Surface Elevation	205.90
Groundwater Level (feet bgs)	5.90 on 11/8/03	Drill Bit Size/Type	4.25-inch ID auger	Top of PVC Elevation	205.59
Diameter of Hole (inches)	8 — Diameter of Well (inches) 2	Type of Well Casing	Sch 40 PVC	Screen Perforation	0.010"
Type of Sand Pack	10/20 Silica	Type and Depth of Seal(s)	Well screen (26-46'); Filter sand (24-47'); Bentonite chips (22-24', 47-47.5'); Silica grout (2-22'); Cement surface compl. (0-2')		
Comments	Split spoon and Dames/Moore samplers driven with 300-lb hammer. Groundwater samples collected with hydropunch.				

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
205	0				ml		Reddish-brown SILT (ML) - damp, medium soft, some fine sand, increasing gravel and clay at 4'					0-8' Lithologic description based on log of GP-518
					ml		Same as above - subrounded to subangular gravel					
200	5				gw-sw		Gray-brown sandy GRAVEL to gravelly SAND - slightly wet, loose, 45% subrounded to subangular gravel, 45% fine to coarse sand, 10% silt					
				3,2,3	gw		Gray-brown sandy GRAVEL - wet, loose, 60% subrounded to subangular gravel, 25% fine to coarse sand, 15% silt				1625	
195	10											
190	15			6,8,15	gw		Gray-brown sandy GRAVEL - wet, medium dense, 60% subrounded to subangular gravel, 30% fine to coarse sand, 10% silt				1632	
185	20											
	25											

URS

Project: Hamilton-Labree/EPA
Project Location: Chehalis, WA
Project Number: RAC WA 100

Log of Boring MW-608

Elevation, feet (NGVD)	Depth, feet	SAMPLES Type	Number	Blows per 6-inch Interval	USCS Code	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	PID (ppm)	Headspace PID (ppm)	Drilling Rate (24-hr clock)	REMARKS/ SAMPLE TRACKING NUMBERS
	25			4,8,12	sw-gw		Gray-brown sandy GRAVEL to gravelly SAND (GW-SW) - wet, medium dense, 50% fine to coarse sand, 45% subrounded to subangular gravel, 5% silt			2.1	0905	
180												
	30			11,18,24	gw		Same as above - dense, weathered gravel, various colors			1.4	0918	
175			608								0920	03434265
			A	7,14,12	gw		Gray-brown sandy GRAVEL - wet, medium dense, 50% subrounded to subangular gravel, 40% fine to coarse sand, 10% silt, oxidized		0.0	0.7	0940 0942	03434266
			B	7,12,11					0.0		0957 0959	03434267
	35		GW-1				Same as above - wet, dense, 60% subrounded to subangular gravel, 35% fine to coarse sand, 5% silt			0.9	1020	03434268
170				11,12,11					0.0		1028	
			C (FD)								1020	03434269/03434270
			D	11,17,18			Same as above - dense, dark brown, rock fragments, yellow-brown oxidized sand			0.7	1040 1045	03434271
	40		GW-2								1100	03434272
165			E	7,9,13	sw		Gray-brown gravelly SAND - wet, medium dense, 60% fine to medium sand, 35% subrounded to subangular gravel, 5% silt				1110 1115	03434273
			F	17,20,15			Same as above - dense, dark gray, rock fragments			0.2	1120 1125	03434274
	45		GW-3								1145	03434275
160			G H	2,3,3	ml		Bluish-green SILT - very moist, medium stiff, low to medium plasticity, 10% fine to medium sand				1155 1157 1200	03434276 03434277
							Boring terminated at 47.5 feet bgs on 10-24-03					
	50											
155												
	55											
150												

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Appendix A-4
Soil Physical Properties

Results And Summary of Soil Physical Properties Analyses

Location ID	Depth (ft bgs)	Moisture Content (% wt)	Density (g/cc)		Porosity (%Vb)			Pore Fluid Saturations (% Pv)		Total Organic Carbon (mg/kg)	Effective Permeability to Water (millidarcy)	Effective Hydraulic (cm/s)	Mean Grain Size Description
			Bulk	Grain	Total	Air Filled	Effective	Water	NAPL				
602	5.0	24.7	1.45	2.60	44.3	8.5	7.5	80.9	ND<0.1	15,800	0.296	2.82E-07	Silt
603	5.5	21.2	1.47	2.64	44.4	13.3	13.9	70.0	ND<0.1	2,950	0.925	8.81E-07	Medium sand
601	5.5	20.5	1.61	2.61	38.4	5.1	8.7	86.6	0.1	1,400	0.141	1.34E-07	Silt
602	13.0	22.2	1.53	2.64	41.9	8.0	12.9	81.0	ND<0.1	11,000	1.28	1.21E-06	Silt
605	13.0	18.1	1.64	2.70	39.4	9.4	17.4	76.1	ND<0.1	<100	38.1	3.62E-05	Gravel
602	15.5	19.9	1.57	2.68	41.6	10.5	19.1	74.9	ND<0.1	3,400	3.29	3.14E-06	Coarse sand
652	16.0	14.6	1.75	2.71	35.2	9.1	15.6	74.1	ND<0.1	2,350	9.81	9.31E-06	Gravel
601	16	16.8	1.76	2.70	35.1	5.6	17.6	84.2	ND<0.1	690	15.9	1.51E-05	Gravel
604	16.1	11.6	1.75	2.71	35.6	14.3	22.1	59.9	ND<0.1	<100	127	1.21E-04	Gravel
606	16.1	17.8	1.74	2.71	35.7	4.6	20.1	86.4	0.8	420	58.3	5.62E-05	Gravel
603	25.7	10.5	1.46	2.68	45.6	30.0	30.1	34.2	ND<0.1	<100	238	2.25E-04	Medium sand
601	28.5	22.8	1.42	2.67	46.9	14.4	36.0	66.7	2.5	380	0.476	4.58E-07	Medium sand
605	29.0	14.3	1.73	2.72	36.3	11.3	17.6	69.0	ND<0.1	600	22.1	2.09E-05	Coarse sand
600	29.1	31.6	1.27	2.64	51.8	11.6	33.7	77.6	ND<0.1	280	182	1.77E-04	Fine sand
602	30.5	24.5	1.44	2.66	46.0	10.7	23.5	76.3	0.5	<100	50.1	4.81E-05	Fine sand
605	37.5	17.2	1.63	2.68	39.1	10.7	14.0	72.0	0.7	760	3.92	3.73E-06	Coarse sand
603	38.0	13.3	1.71	2.73	37.2	14.1	23.0	62.1	ND<0.1	280	646	6.13E-04	Medium sand
652	38.0	14.0	1.66	2.69	38.5	14.9	16.3	61.3	ND<0.1	2,200	117	1.11E-04	Gravel
606	42.6	11.0	1.79	2.63	32.1	12.4	21.0	61.5	ND<0.1	560	32.7	3.12E-05	Gravel
601	43.5	17.5	1.79	2.69	33.3	1.7	11.2	95.0	ND<0.1	180	471	4.54E-04	Medium sand
603	47.0	41.9	1.12	2.62	57.3	8.2	16.5	85.7	ND<0.1	4,650	0.599	5.66E-07	Silt
601	47	31.9	1.33	2.68	50.5	8.3	7.1	83.6	ND<0.1	4,300	1.15	1.11E-06	Silt
652	47.5	30.5	1.19	2.61	54.4	17.8	16.7	66.8	0.6	4,750	0.152	1.45E-07	Silt
602	48.5	35.9	1.23	2.60	52.5	8.3	6.6	84.2	ND<0.1	2,400	0.322	3.08E-07	Silt

Location ID	Depth (ft bgs)	Moisture Content (% wt)	Density (g/cc)		Porosity (%Vb)			Pore Fluid Saturations (% Pv)		Total Organic Carbon (mg/kg)	Effective Permeability to Water (millidarcy)	Effective Hydraulic (cm/s)	Mean Grain Size Description
			Bulk	Grain	Total	Air Filled	Effective	Water	NAPL				
606	48.6	30.9	1.40	2.60	46.2	2.9	14.0	93.6	ND<0.1	1,700	1.44	1.40E-06	Silt
605	49.5	29.2	1.38	2.60	47.1	6.4	14.8	86.4	ND<0.1	1,100	0.511	4.83E-07	Silt
Mean value 0-13 ft		22.1	1.5	2.6	42.3	8.7	10.74	79.6	0.1	7,790	0.700	6.3E-07	Silt cap
Mean value 13-31 ft		18.4	1.6	2.7	40.8	11.9	22.99	70.8	1.3	756	67.7	6.5E-05	Sand/gravel aquifer
Mean value 31-40 ft		14.8	1.7	2.7	38.2	13.2	17.08	65.2	0.7	1,080	256	2.4E-04	Sand/gravel aquifer
Mean value 40-45 ft		14.3	1.8	2.7	32.7	7.0	16.09	78.2	ND<0.1	370	252	2.4E-04	Sand/gravel aquifer
Mean value 45-50 ft		33.4	1.3	2.6	51.3	8.6	12.62	83.4	0.6	3,150	0.700	6.7E-07	Silt aquitard
											Overall mean:	1.20E-04	Sand/gravel aquifer
											Overall max:	6.13E-04	
											Overall min:	4.58E-07	

Notes:
Maximum NAPL saturation = 2.5%.
Minimum measurable NAPL saturation = 0.1%.
Overall mean NAPL saturation = 0.9%.
cm/s – centimeter per second
ft bgs – feet below ground surface at sampling location
g/cc – gram per cubic centimeter
max – maximum
mg/kg – milligram per kilogram
min – minimum
NAPL – nonaqueous-phase liquid
ND< – not detected at a concentration greater than that shown
% wt – percent by weight
% Vb – percent of bulk volume
% Pv – percent of pore volume

Appendix A-5
Berwick Creek Water Levels

Table 3-6
Surface Water Elevation and Stream Gauging Summary for Berwick Creek - September and November 2002
RI/FS Work Plan
Hamilton Labree Roads Groundwater Contamination Superfund Site
Chehalis, Washington
Farallon PN: 734-001

Surface Water Monitoring Station	Date Monitored	Stream Gauge Elevation (feet)[1]	Stream Height (feet)[2]	Surface Water Elevation (feet)	Estimated Groundwater Elevation[3]	Elevation Head Difference (feet)[4]	Flow Rate (cfm)	Flow Rate (gpm)	Channel Depth (feet)[5]
SW-5	9/5/02	209.08	4.32	204.76	201.00	-3.76	0.0	0	2.46
	11/21/02	209.08	4.50	204.58	202.20	-2.38	1.2	<50	2.22
SW-6	9/5/02	209.88	5.13	204.75	201.11	-3.64	0.0	0	2.40
	11/21/02	209.88	5.19	204.69	202.30	-2.39	0.6-4.2	<50	2.60
SW-7	9/5/02	208.77	3.98	204.79	200.90	-3.89	6.0	<50	4.11
	11/21/02	208.77	4.18	204.59	202.18	-2.41	0.0	0	3.91
SW-8	9/5/02	205.00	6.18	198.82	196.42	-2.40	65.0	500	0.37
	11/22/02	205.00	5.88	199.12	198.00	-1.12	190.0	1,400	0.91
SW-9	9/5/02	204.49	7.46	197.03	195.00	-2.03	116.0	870	0.43
	11/22/02	204.49	7.16	197.33	196.00	-1.33	170.0	1,250	0.70
SW-10	9/5/02	196.14	4.13	192.01	192.00	-0.01	0.0	0	2.09
	11/21/02	196.14	4.04	192.10	193.00	0.90	6.0	<50	2.20

NOTE:

[1] Surveyed elevation of top of stream gauge to vertical datum NGVD 29, in feet above mean sea level.

[2] Height measured in feet from top of stream gauge to water surface.

[3] Groundwater elevation estimated from corresponding well or groundwater contour.

[4] A head difference is calculated by subtracting the groundwater elevation from the surface water elevation. A negative value indicates potential for surface water discharge to groundwater. Positive value indicates potential for groundwater discharge to surface water

[5] Channel depth in feet, measured in center of channel from water surface to bottom of channel.

cfm = cubic feet per minute

gpm = gallons per minute

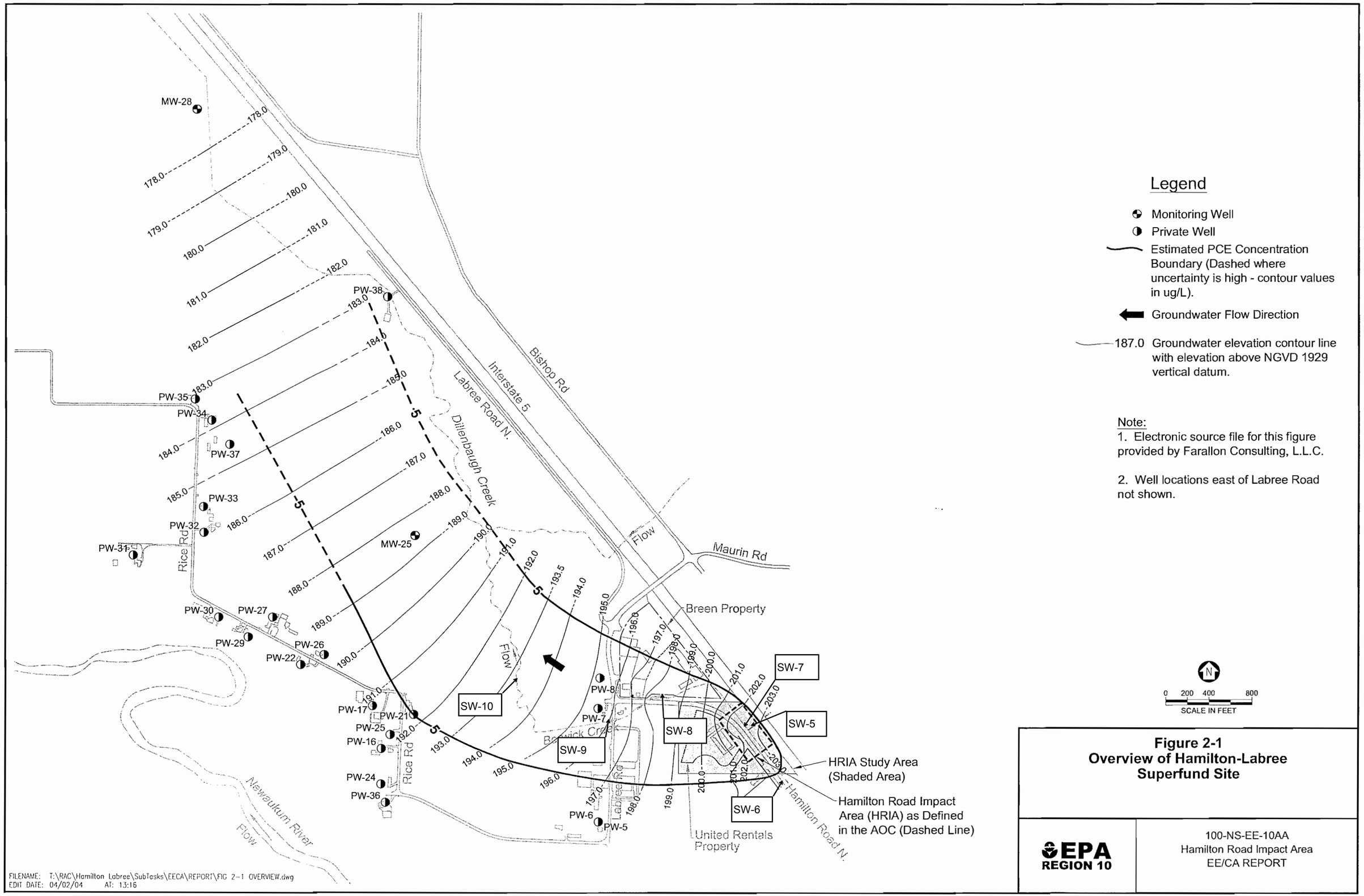

Figure 2-1
Overview of Hamilton-Labree Superfund Site

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Appendix A-6
Potentiometric Surface Map
Breen Property

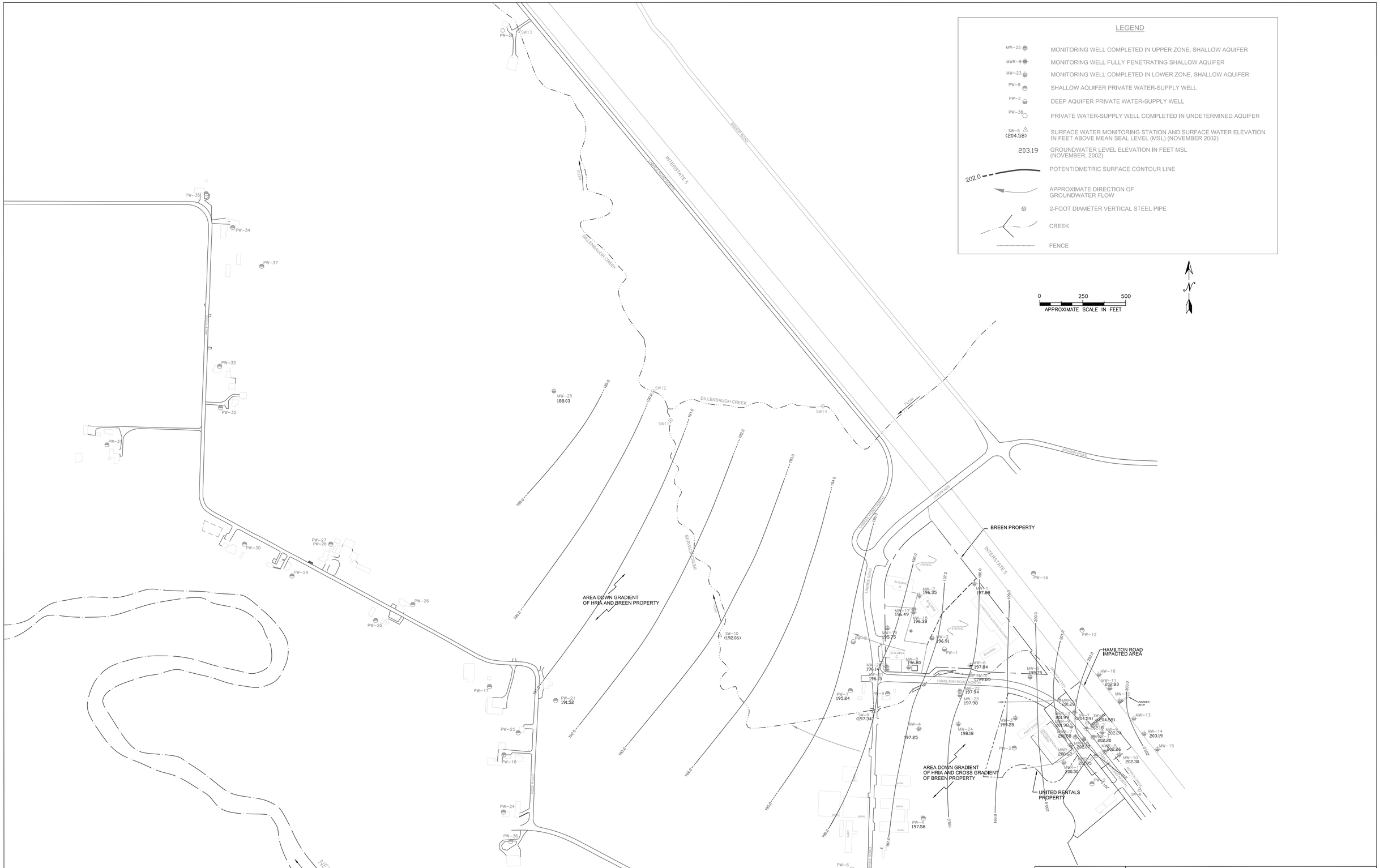
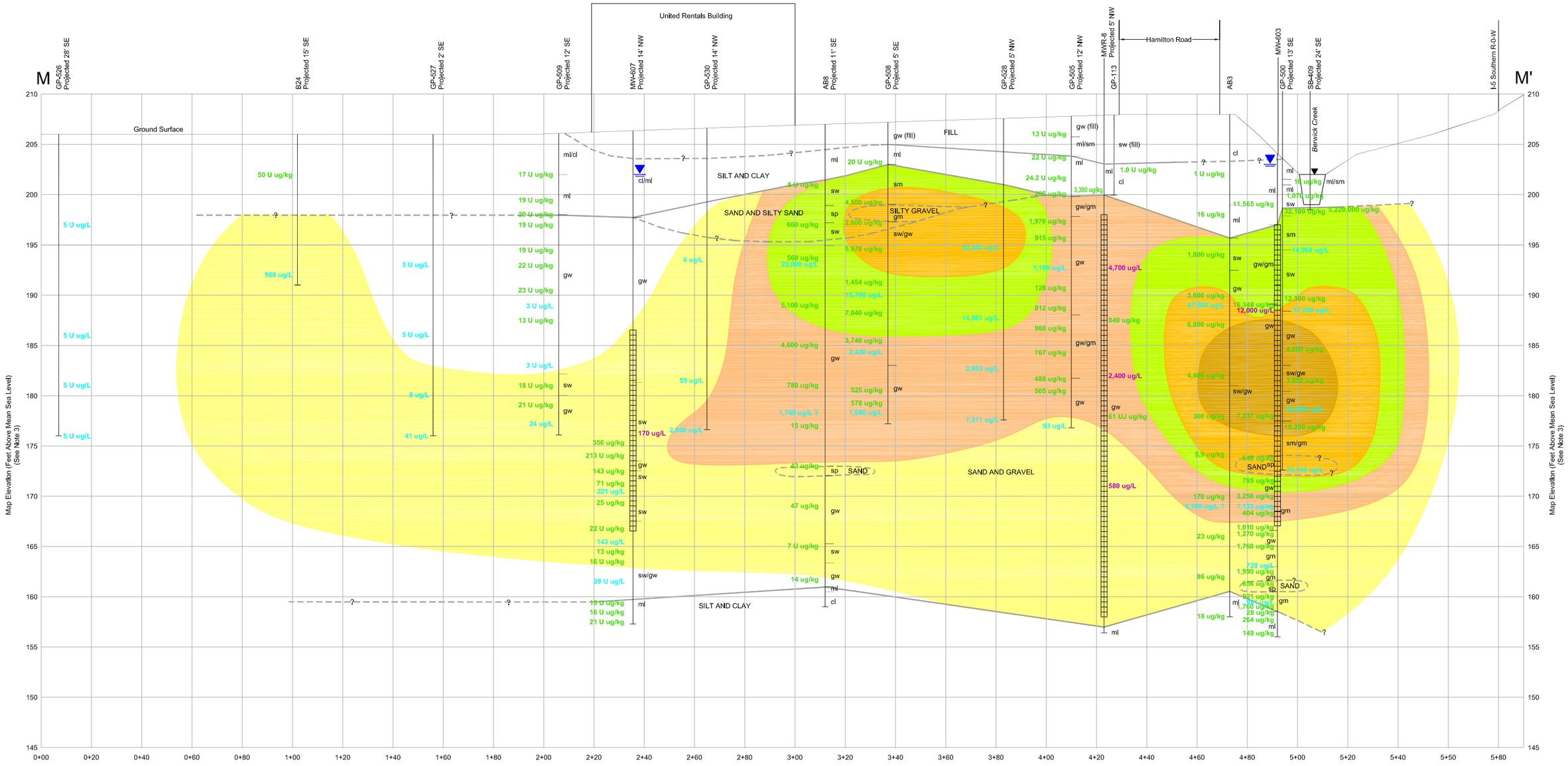


FIGURE 2-9

POTENTIOMETRIC SURFACE CONTOUR MAP FOR SHALLOW AQUIFER–NOVEMBER 2002
REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN
HAMILTON/LABREE ROADS GROUNDWATER CONTAMINATION SUPERFUND SITE
CHEHALIS, WASHINGTON

FARALLON PN: 734–001

Appendix A-7
PCE Concentration Cross Sections



LEGEND

PCE Concentration in Groundwater

- >100,000 ug/L
- 50,000 - 100,00 ug/L
- 25,000 - 50,000 ug/L
- 10,000 - 25,000 ug/L
- 1,000 - 10,000 ug/L
- 5 - 1,000 ug/L

MW-600 Projected 17' SE — Sample Location With Distance and Direction of Projection Onto Section.

Potentiometric Groundwater Surface Elevation Measured 12/1/03. Corrected to Map Elevations From Ground Survey Elevations (See Note 3).

988 ug/kg — Analytical Result of Soil Sample Collected at Depth of Numerical Value.

14,561 ug/L — Analytical Result of Discrete Groundwater Sample From Temporary Sample Device.

4,700 ug/L — Analytical Result of Groundwater Sample From Screened Well Collected With Sampling Device at Depth of Numerical Value.

J	Concentration Value Reported as "Estimated"
U	Not Detected Above Concentration Value Shown
ug/L	Micrograms Per Liter
ug/kg	Micrograms Per Kilogram
gm	Silty Gravel
gw	Well-Graded Gravel
sw	Well-Graded Sand
sp	Poorly Graded Sand
ml	Silt, Low Plasticity
cl	Clay, Low Plasticity

NOTES:
1. All analytical results shown are validated data rounded to the nearest whole number.
2. Soil type designations are field determined.
3. Elevations are based on interpolation from Lewis County PUD topographic data, not site-specific ground surveys.
4. No records are available that document the depth of the discrete water samples collected in AB3 and AB8. The depths of these samples have been interpreted based on the analytical results at adjacent sampling locations.

VERTICAL 0 1 2 3 4 5
HORIZONTAL 0 5 10 15 20
SCALE IN FEET

PLATE 2
Cross-Section M-M'

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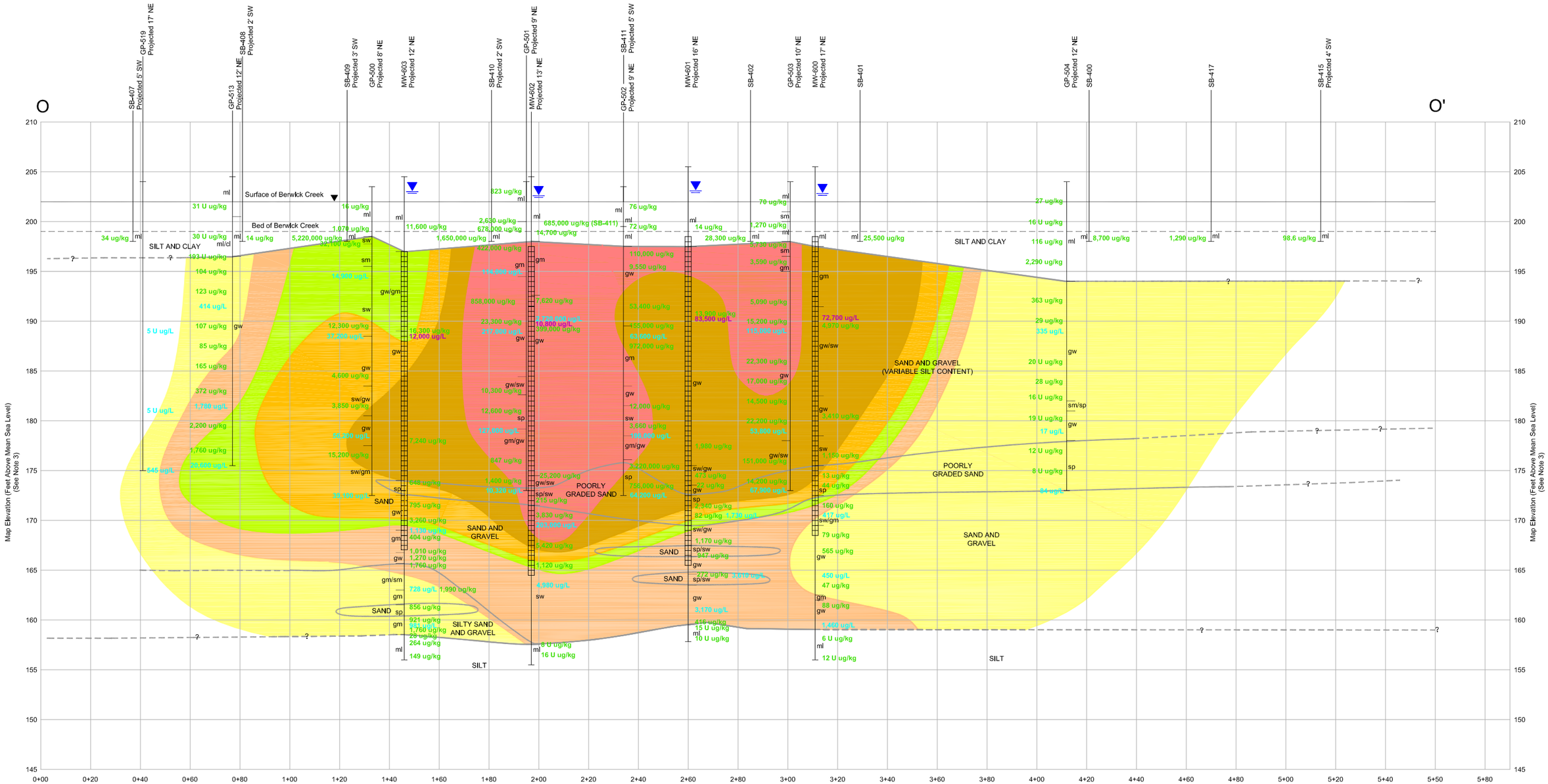

LEGEND

PCE Concentration in Groundwater

- >100,000 ug/L
- 50,000 - 100,000 ug/L
- 25,000 - 50,000 ug/L
- 10,000 - 25,000 ug/L
- 1,000 - 10,000 ug/L
- 5 - 1,000 ug/L

MW-600 Projected 17' SE — Sample Location With Distance and Direction of Projection Onto Section.

Potentiometric Groundwater Surface Elevation Measured 12/1/03. Corrected to Map Elevations From Ground Survey Elevations (See Note 3).

988 ug/kg — Analytical Result of Soil Sample Collected at Depth of Numerical Value.

14,561 ug/L — Analytical Result of Discrete Groundwater Sample From Temporary Sample Device.

4,700 ug/L — Analytical Result of Groundwater Sample From Screened Well Collected With Sampling Device at Depth of Numerical Value.

J	Concentration Value Reported as "Estimated"
U	Not Detected Above Concentration Value Shown
ug/L	Micrograms Per Liter
ug/kg	Micrograms Per Kilogram
gm	Silty Gravel
gw	Well-Graded Gravel
sw	Well-Graded Sand
sp	Poorly Graded Sand
ml	Silt, Low Plasticity
cl	Clay, Low Plasticity

NOTES:
1. All analytical results shown are validated data rounded to the nearest whole number.
2. Soil type designations are interpretations based on field characterization of discrete soil samples.
3. Elevations are based on interpolation from Lewis County PUD topographic data, not site-specific ground surveys.
4. The groundwater sample from the installed well MW-602 exhibits a lower PCE concentration than nearby discrete groundwater samples. This lower value was not used for contouring on this cross-section.

VERTICAL 0 1 2 3 4 5
HORIZONTAL 0 5 10 15 20
SCALE IN FEET

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PLATE 4
Cross-Section O-O'

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