Final Site-Wide Groundwater Remedial Investigation Kaiser Trentwood Facility Spokane Valley, Washington

Volume I

Prepared for
Kaiser Aluminum Washington, LLC

May 2012
2644-114

HARTCROWSER

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Kaiser Trentwood Facility
Spokane Valley, Washington

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FINAL SITE-WIDE GROUNDWATER REMEDIAL INVESTIGATION
KAISER TRENTWOOD FACILITY
SPOKANE VALLEY, WASHINGTON

1.0 INTRODUCTION

This report presents the results of the Site-Wide Groundwater Remedial Investigation (RI) conducted on behalf of Kaiser Aluminum Washington, LLC. (Kaiser) at its Trentwood Facility (Facility) located at East 15000 Euclid Avenue in Spokane Valley, Washington. The general location of the Facility is shown on Figure 1-1.

This RI was conducted pursuant to the requirements outlined in Task VII of Exhibit B to Agreed Order No. DE 2692 between Kaiser and the Washington State Department of Ecology (Ecology), dated August 16, 2005. The Agreed Order requires Kaiser to complete a RI to evaluate the nature and extent of contamination and a Feasibility Study (FS) to evaluate potential remedial actions at the Facility.

This document is the RI report for groundwater at the Facility. A RI report for soil is provided under separate cover (Hart Crowser 2012). The RI report for soil includes a detailed discussion of the nature and extent of contamination in the soil and source control actions that have been conducted at the Facility. A FS will be completed for the Facility once the soil and groundwater RIs are reviewed and accepted by Ecology.

1.1 PURPOSE

The primary purpose of the Groundwater RI is to:

- Characterize the hydrogeologic regime underlying the Facility;
- Characterize the nature, extent, and magnitude of contamination in groundwater at the facility;
- Evaluate contaminant fate and transport and assess contaminant migration; and
- Support the development and analysis of groundwater remedial alternatives for the Facility in the FS.

1.2 REPORT ORGANIZATION

This report is presented in two volumes. Volume I includes the text, tables, figures, plates, and DVDs, as well as Appendices A through E. Volume II includes Appendix F. The main text of the report is organized using one section for each primary technical aspect. Tables and figures are numbered to correspond to and are presented at the end of their respective section. References are presented at the end of the technical discussions in Section 8.0. Appendix-specific references are presented at the end of each appendix. Where appropriate, cross references are made between sections rather than duplicating tables or figures. Primary report sections consist of the following:

- **1.0 INTRODUCTION.** Presents the purpose and scope of this project.
- **2.0 BACKGROUND.** Presents a summary of the Facility location, physical setting, ecological setting, Facility history, and interim groundwater remedial measures completed or in place at the Facility.
- **3.0 GROUNDWATER INVESTIGATIONS.** Presents a summary of the general methods, tools, and tests used in recent and historical groundwater investigations at the Facility.
- **4.0 HYDROGEOLOGY AND SURFACE WATER.** Presents a summary of the regional and local geology and hydrogeology in the vicinity of the Facility and the chemical characteristics of surface water and groundwater.
- **5.0 NATURE AND EXTENT OF GROUNDWATER CONTAMINATION.** Presents a discussion of the surface water and groundwater sampling results at the Facility and identifies chemicals of potential concern in groundwater.
- **6.0 CONTAMINANT FATE AND TRANSPORT.** Presents a discussion of the aspects of each chemical of potential concern relevant to fate and transport at the Facility.
- **7.0 GROUNDWATER CONCEPTUAL MODEL.** Presents an evaluation of the contaminant transport pathways and the physical-chemical properties of the contaminants of concern present at the Facility.
- **8.0 REFERENCES.** Lists references cited in the report.

Supporting information and data tables are presented in appendices.

In general, data and information presented in the 2003 Groundwater RI/FS are not repeated in this document but that earlier document is referenced as appropriate. To aid in reviewing this RI document a copy of the 2003 Groundwater RI/FS, is included on a DVD in electronic format. In addition, a copy of this updated Groundwater RI is also included in electronic format on the same DVD. A second DVD containing new laboratory certifications for data generate since 2003 Groundwater RI/FS is also enclosed.

Appendices A through E follow the DVDs in Volume I.

- **Appendix A** presents a tabular summary of monitoring well construction details completed at the Facility as well as boring logs and well completion diagrams completed since the 2003 Groundwater RI/FS.
- **Appendix B** presents an electronic copy of the surface water, groundwater, and free phase petroleum levels measured at the Facility.
- **Appendix C** presents the configuration, development, and use of the PCB transport groundwater model developed for the Remelt/Hot Line PCB plume.
- **Appendix D** presents the colloid study report.
- **Appendix E** presents the PCB/Groundwater concentration and trend analysis.

The following appendix is presented under separate cover in Volume II.

- **Appendix F** presents a summary of the chemical water quality review and an electronic copy of the chemical database is presented on the DVD in Volume I.

1.3 LIMITATIONS

Work for this project was performed, and this report prepared, in accordance with generally accepted professional practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Kaiser Aluminum Washington, LLC. for specific application to the referenced property. This report is not meant to represent a legal opinion. No other warranty, express or implied, is made.

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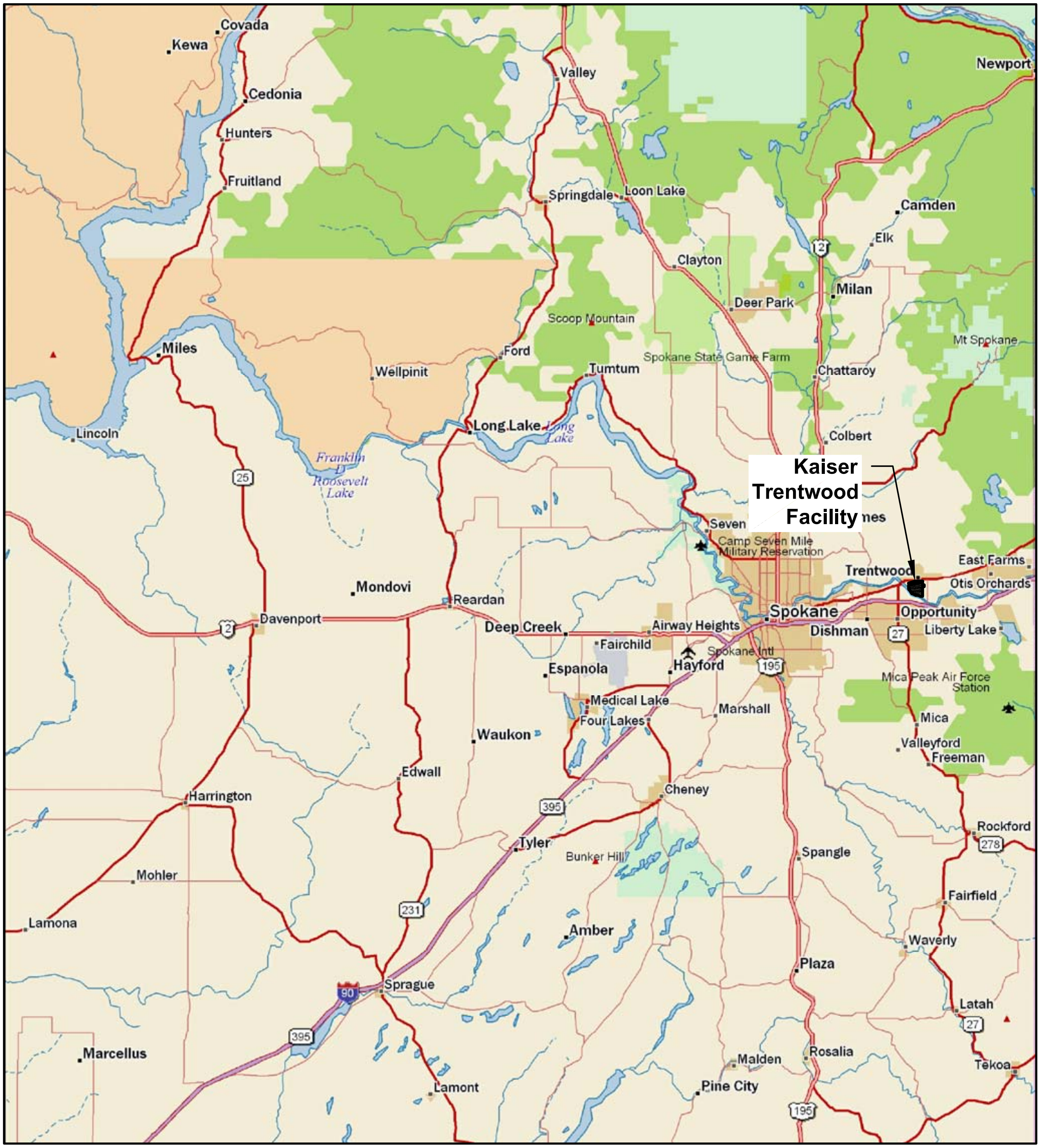
Regional Map



Source: Base map prepared from DeLorme Topo 7.0, 2007.

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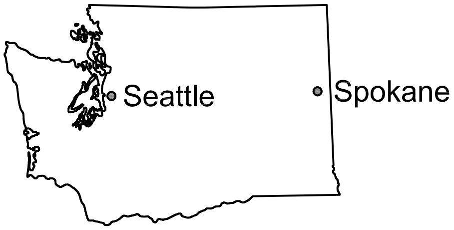

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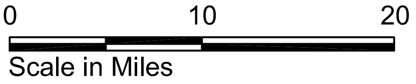

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Figure 1-1

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TABLE

FIGURES

2.0 BACKGROUND

2.1 SITE DESCRIPTION

The Facility is situated north and east of the Spokane River, west of Sullivan Road, and south of Highway 290 (Trent Road) in the City of Spokane Valley, Washington. As shown on the Vicinity Map (Figure 2-1), the Facility is located in Township 25 North, Range 44 East (Willamette Meridian), Section 2 (Southern 1/2), Section 3 (Southeast 1/4), Section 10 (Northeast 1/4), and Section 11 (Northern 1/2).

The Kaiser Trentwood property is approximately 512 acres in area and includes a northern and southern parcel (Figure 2-1). The northern parcel is undeveloped and is separated from the southern parcel by a narrow strip of land owned by the Inland Empire Land Company. Kaiser's industrial and support operations are located on the southern parcel. For the purpose of this report, we defined the Facility to be the southern parcel.

The Facility has approximately 2.5 million square feet of building space (SAIC 1993) and is zoned as heavy industrial. Properties to the east of the Facility are zoned heavy industrial and commercial, whereas properties to the north are zoned residential and commercial. Properties south and west of the Spokane River are zoned commercial.

2.2 PHYSICAL SETTING

2.2.1 Surface Topography

The northern and eastern portions of the Facility are characterized by relatively flat topography with ground surface elevations typically on the order of 2000 to 2010 feet (NGVD29), which is about 3.8 feet lower than the NAVD88 datum used in our Base Map for this report. The ground surface slopes downward toward the Spokane River on the south and west portions of the Facility. The Spokane River is incised roughly 60 feet below the surrounding land surface (Figure 2-2). A bedrock outcrop (Pines Road Knoll) located across the Spokane River to the west is the highest topographic feature in the immediate area (Figure 2-1).

2.2.2 Soils

There are two local soil types mapped in the project area—Garrison gravelly loam and river wash soils (Donaldson and Giese 1968).

The Garrison series consists of very deep, somewhat excessively drained soils formed in glacial outwash with a component of loess and volcanic ash in the upper part. Garrison soils are located on outwash terraces and terrace escarpments and have slopes of 0 to 90 percent.

River wash soils are located along the banks of the Spokane River and consist of long, narrow areas of sand, gravel, and boulders. Some areas are barren of vegetation and others support scattered trees and shrubs. Overflow and alteration by severe erosion and deposition are frequent (Donaldson and Giese 1968).

2.2.3 Climate

In general, the Spokane area has the characteristics of a mild, arid climate during the summer months and a cold, coastal-type climate in the winter. Figure 2-3 and Table 2-1 presents the monthly average temperatures and precipitation for the Spokane area from 1890 to 2005 (Western Regional Climate Center 2009).

The normal July maximum ambient temperature is 83.9 degrees Fahrenheit (F) and the minimum is 55.8 F, whereas the normal January maximum temperature is 33.0 F and minimum is 21.7 F. Extremes range from 108 F to –30 F, but temperatures of more than 95 F and less than –10 F are rare.

The average annual precipitation is 16.1 inches with nearly 41 inches of annual snowfall. Approximately 70 percent of the total annual precipitation falls between the first of October and the end of March.

2.3 ECOLOGICAL SETTING

The Facility is situated in the transition zone between the Okanogan Highlands and the Columbia Basin. The Facility contains both terrestrial and river environments. The riparian area adjacent to the river serves as a transition between the river and terrestrial environments, which are described below. The area near the property supports a variety of plant, animal, and fish species. Figure 2-4 presents a habitat map for the Facility and nearby areas. Additional discussion of the Ecological setting for the Facility is presented in the Human Health and Terrestrial Ecological Risk Assessment (Pioneer 2012).

2.3.1 Terrestrial Environment

Vegetation Communities

The property contains a distinctive upland environment dominated by a meadow steppe plant community. This community is dominated by the Idaho fescue/snowberry (*Festuca idahoensis*/*Symporicarpus albus*) association (Gilpin 2007). This association is dominated by Idaho fescue, snowberry, bluebunch wheatgrass (*Agrophyron spicatum*), Merrill's bluegrass (*Poa ampla*), western groundsel (*Senecio exaltata*), arrowleaf balsamroot (*Balsamorhiza sagittata*), lupine (*Lupinus* sp.), camas (*Camassia* sp.), and western hawkweed (*Hieracium albertinum*). In addition, a variety of native and naturalized species are present throughout the meadow steppe plant community. These species include, but are not limited to, clover (*Trifolium* sp.) and bedstraw (*Gallium* sp.). A variety of non-native and/or invasive species also present on the property, include pigweed (*Amaranthus* sp.), tumbleweed (*Salsola* sp.), horseweed (*Conyza* sp.), and cheatgrass (*Bromus tectorum*).

The upland plant community nearest to the Spokane River transitions to a forested Ponderosa pine (*Pinus ponderosa*) association (Gilpin 2007). Common overstory tree species include Ponderosa pine, Douglas fir (*Pseudotsuga menziesii*), Western white pine (*Pinus monitcola*), Western larch (*Larix occidentalis*), grand fir (*Abies grandis*), and black cottonwood (*Populus balsamifera*). The shrub layer is dominated by snowberry, serviceberry (*Amelanchier alnifolia*), juniper (*Juniperus* sp.), low Oregon-grape (*Mahonia repens*), rose (*Rosa* sp.), ninebark (*Physocarpus* sp.), chokecherry (*Prunus virginiana*), black hawthorn (*Crataegus douglasii*), and mock orange (*Philadephus lewisii*).

The riparian plant community located immediately adjacent to the Spokane River is dominated by black cottonwood, hardhack (*Spiraea douglasii*), and a variety of willows (*Salix* sp.) including, but not limited to, coyote willow (*S. exigua*), Pacific willow (*S. lasiandra*), and Scouler's willow (*S. scouleriana*) according to Spokane County Conservation District (2005). Thickets of willow dominate the river banks in many areas. In addition, reed canarygrass (*Phalaris arundinacea*) is common along the banks of portions of the river. In general, the riparian zone on the property extends landward approximately 30 feet beyond the ordinary high water mark (OHWM) line within the northwestern portion of the Facility and extends approximately 100+ feet beyond the OHWM within the southwestern portion of the Facility.

Wildlife

A variety of wildlife has been documented using the Facility for feeding, breeding, shelter, and access to the river. Several species of wildlife use both the terrestrial and river environments, primarily for feeding, creating difficulties in distinguishing species use in these environments. Therefore, wildlife use is discussed in the context of species that use both environments, as well as water-dependent species.

Ungulate or hoofed species either documented as using the property or known to occur in the vicinity and, therefore, likely to use the property include mule deer (*Odocoileum hemionus*), white-tailed deer (*O. virginianus*), and Shira's Moose (*Alces alces shirasi*). Small to medium sized carnivores observed on or adjacent to the property include river otter (*Lutra canadensis*), beaver (*Castor canadensis*), and coyote (*Canis latrans*). Small to medium carnivores that are likely to occur in the area include badger (*Taxidea taxus*). Small herbivores observed on the property include yellow-bellied marmot (*Marmota flaviventris*), ground squirrel (*Spermophilus* sp.), and chipmunk (*Eutamias* sp.). Small herbivores likely to occur on the property include blacktailed jackrabbit (*Lepus californicus*) and cottontail rabbit (*Sylvilagus* sp.). Two common omnivores either observed or likely to occur in this area of the state include raccoon (*Procyon lotor*) and black bear (*Ursus americanus*) (Gilpin 2007).

Avian species documented as using the property and adjacent habitats include red-tailed hawk (*Buteo jamaicensis*), red-winged blackbird (*Agelaius phoeniceus*), Canada goose (*Branta canadensis*), and mourning dove (*Zenaida macroura*) (Spokane County Conservation District 2005), as well as common and smaller species, such as teal, vireo, nuthatch, wren, waxwing, sparrow, warbler, magpie, finch, and crossbill. Species likely to occur on or adjacent to the property include American wigeon (*Anas americana*), mallard (*Anas platyrhynchos*), canvasback (*Aythya valisineria*), redhead (*Aythya americana*), sage grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), ruffed grouse (*Bonasa umbellus*), and California quail (*Calipepla californica*) (Gilpin 2007).

The Northern leopard frog (*Rana pipiens)* may occur on the property. Bat species likely to occur in the area include the pallid bat (*Antrozous pallidus*) and the little brown bat (*Myotis lucifugus*).

2.3.2 River Environment

The river environment comprises the Spokane River between River Mile (RM) 86 and 87. River flow is directly influenced by releases from the Idaho Post Falls

Dam (RM 101) located downstream from Lake Coeur d'Alene (Ecology 2008). Spokane Falls are located approximately 10 miles (RM 74) downstream and serve as a natural barrier to anadromous fish migration. In addition, Little Falls Dam (RM 29) and the Grand Coulee Dam on the Columbia River also serve as fish passage barriers for migrating anadromous fish populations.

The section of the river channel located west of the Facility is moderately to highly incised and contains little floodplain habitat (Spokane Conservation District 2005). The dominant river substrate consists of cobbles and boulders. In general, the current is swift along this portion of the river. The reach of the Spokane River located south of the Facility contains a larger floodplain as a result of less incisement.

Fish

Fish use within this reach of the Spokane River is relatively limited because of downstream fish passage barriers. Resident populations of trout (*Oncorhyncus* and *Salvenlinus* sp.), whitefish (*Propsium* sp.), suckers (*Catostimus* sp.), and carp (*Cyprinus* sp.) are currently or historically present within this reach of the river (Serdar and Johnson 2006). Of these species, rainbow trout (*Oncorhynchus mykiss*) and largescale suckers (*Catostomus marcocheilus*) are the most common species documented in the river (Serdar and Johnson 2006). In addition to rainbow trout, brown trout (*Salmo trutta*) and cutthroat trout (*Oncorhynchus clarki*) are documented as occurring adjacent to the Facility.

Historically, sculpin (*Cottidae*) occurred from Post Falls (RM 101) to the Seven-Mile Bridge (RM 62). Currently few sites along the Spokane River provide suitable conditions for sculpin (MacCoy and Maret 2003). Whitefish are generally absent from this reach of the river (Serdar and Johnson 2006).

2.4 FACILITY BACKGROUND

This section presents a brief summary of the Facility history, significant operational features, regulatory history, and previous remedial investigation reports. The major features at the Facility are shown on Figure 2-5. See Section 2 of the 2003 Groundwater RI/FS (on the enclosed DVD) for more details on the history and development of Kaiser's operations.

The Facility is an aluminum sheet, plate, and coil rolling mill. There are four general manufacturing steps conducted at the Facility. In the first step, aluminum ingots are created. Aluminum from off-site sources, including recycled aluminum and scrap, are melted and cast into ingots in the Remelt Area (also called Casting). From the Remelt Area, the ingots are heated in soaking pits to achieve desired temperature and homogenization.

The second step in the manufacturing process is the rolling process. The Hot Line is the first step in the rolling process. Here the ingots are passed through rollers to produce a flattened sheet or plate and coils of aluminum. The aluminum is then annealed (if desired) before being sent to the Cold Mill. In the Cold Mill, additional rolling of the aluminum coil is conducted to achieve the desired thickness.

The third step is heat treatment. Heat treating of sheet, plate, or coil stock (finishing operations) occurs at the Furnace Process Lines, vertical heat-treat furnaces, and the Salem furnace. Other plate operations include stretching, flattening, and rolling to final gauge.

The final step in the manufacturing process is preparation of the product for delivery to the customer. Packaging of the final product occurs in the Packaging and Shipping area.

2.4.1 Facility History

The Facility was originally constructed in 1942 to provide aluminum for the manufacture of fighter planes and bombers used in the World War II effort. Kaiser took control of the site in 1946. Throughout the decades, Kaiser has updated the machinery and operations at the Facility to diversify its products and keep pace with the changes in technology and client needs.

2.4.2 Potential Sources of Groundwater Contamination

Selected Facility operations and features that may have been potential source areas of groundwater contamination are shown on Figure 2-5 and briefly discussed below. This discussion is based on historical source area investigations and a RCRA Facility Assessment (RFA) of the Facility conducted by SAIC (1993) for the EPA in 1993. Since the 1980s, Kaiser has completed a variety of source control actions at the Facility. A detailed discussion of source area investigation and source control actions are discussed in the Soil RI (Hart Crowser 2012).

Remelt and Hot Line Areas. Aluminum ingots are cast and rolled in the Remelt and Hot Line areas, respectively.

Historically, polychlorinated biphenyl (PCB)-containing hydraulic oil was used in the casting hydraulic cylinder operations due to their non-flammable characteristics. The type of PCB in the hydraulic oil is characterized as Aroclor 1242/1248. Hydraulic oil from leaks and spills likely entered the soil and cooling water discharge system and is believed to be the primary potential source of PCBs at the Facility.

Cold Mill and Finishing Areas. Areas of the Cold Mill and Finishing Operations that may have been potential source areas for groundwater contamination include the following:

- Cold Mills (Nos. 1, 2, 3, and 5);
- Coolant and Chromium Transfer Lines;
- Electrical Grounding Pit;
- Continuous Can Process Line (CCPL);
- Coater Line Tank; and
- Transformer Yard.

Currently, the No. 1 Cold Mill is being used for cold rolling operations, which uses an oil-based coolant to facilitate the rolling process. Prior to the 1980s, an oil-based coolant was used.

Transfer lines were used to transport waste oils, spent coolant, and chromium-containing wastewater from the Cold Mill and Finishing area to accumulation tanks or the Wastewater Treatment area (Hart Crowser 2003). The waste oil and spent coolant transfer lines connecting the Oil House and the Cold Mill ran north-south outside the north side of the building toward former underground storage tanks (USTs) located near the Oil House.

Oil House and Tank Farm Areas. The Oil House was constructed with the original plant in 1942 and has historically served as the central point where coolant and lubricating oils arrive at the Facility for storage and eventual distribution to the different work areas within the plant. The Oil House has also served in the past as a central management area for storage of used oils within the plant. The Tank Farm area was constructed with above-ground tanks east of the Oil House in 1989 to support the additional Cold Milling operations and to replace the USTs.

Numerous USTs and associated systems were located around the Oil House and Tank Farm area. Oil products stored in USTs included diesel and gasoline and process oils such as PCB-containing hydraulic oil, Kensol (an aluminum rolling lubricant), mineral oil, Stoddard solvents, and kerosene.

Areas of the Oil House and Tank Farm areas studied during previous investigations include the following:

- 500-Gallon Diesel UST;
- Oil House Drum Storage and French Drain Area;
- Oil House Tank;
- 20,000-Gallon Gasoline UST;
- Tank Farm; and
- Eight Miscellaneous USTs.

Truck Shop Tank. The Truck Shop area is used for vehicle maintenance and includes cleaning, repair, and office areas. The Truck Shop had a cleaning area that consisted of an enclosed steam-cleaning pad and an underground sump tank. The sump tank was taken out of service and releases were investigated as described in the Soil RI Report (Hart Crowser 2012). The sump tank remains in place and is located east of the steam cleaning pad and connected to the pad through a pipe running east beneath the office structure. The function of the sump tank was to collect wastewater, oil, and cleaning-related material from the Truck Shop area before it is pumped to the Oil Reclamation Building (ORB). The sump tank was installed in 1973 and is estimated to have a capacity of 1,500 to 2,000 gallons.

Oil Reclamation Building. The ORB receives oily wastewaters from the rolling mills and other locations throughout the Facility. The ORB is an original 1942 concrete structure that is segmented into nine compartments containing tanks that are approximately 50 percent below surrounding grade with a combined storage capacity of about 230,000 gallons. In 2006 and 2008, the ORB area was upgraded with spill containment structures as described in the Soil RI Report (Hart Crowser 2012).

The original function of the ORB was believed to have been to collect, settle, and process oil/emulsion waste from the Hot Line Rolling Mills, to allow some amount of recycling and also to remove a portion of the oils prior to discharge.

With the installation of the Wastewater Treatment system, the purpose of the ORB changed to providing emulsion coolant storage/surge capacity and solids removal. Historically, the ORB overflowed to the surrounding soil, but improvements were made to the ORB with the installation of level sensors and instrumentation connecting to the Wastewater Treatment distribution control system to allow the automated closing of influent valves to reduce the chance of overflow of the ORB.

ORB to Wastewater Transfer Lines. Underground transfer lines formerly carried oily wastewater emulsion from the ORB to the Wastewater Treatment area. The G1 through G3 Transfer Lines are currently not in operation. Significant historical investigation and cleanup activities have been conducted along the G1 (original line), G2 (second generation), and G3 (third generation) transfer lines associated with leaks that were discovered in the past as detailed in the Soil RI Report (Hart Crowser 2012). The current transfer line (G4) is an above-ground, heat-traced piping system that was installed in 2005.

Wastewater Treatment Operations. Two primary wastewater streams are generated and treated at the Facility—sanitary wastewater and industrial wastewater. Sanitary and industrial wastewaters are treated in separate treatment systems located on the western portion of the Facility. Treated wastewater from both treatment systems are further processed through the Wastewater Lagoon and final Trace Oil Filtration System prior to being released to the Spokane River under a National Pollutant Discharge Elimination System (NPDES) Permit.

Sanitary wastewater receives secondary treatment and disinfection in the sanitary wastewater treatment system. This secondary treatment system operates at a nominal flow of 40,000 gallons per day (gpd) and is comprised of two parallel primary clarifiers, a trickling filter, and a chlorine contact chamber.

The primary function of the industrial wastewater treatment system is to remove solids and oils from production wastewater. It operates at a nominal flow of 60,000 gpd. The industrial wastewater treatment system consists of an oil/water acidification/break tank (wastewater is acidified and heated to break the oil/water emulsion), several oily water separation tanks, a pH neutralization tank, a clarifier, and a multimedia filter. Treated wastewater is discharged to the Wastewater Treatment Lagoon and Trace Oil Filtration System for polishing.

The 2.5-acre Wastewater Treatment Lagoon was constructed in the 1970s with a PVC liner. It has a nominal holding capacity of 6 million gallons and receives approximately 9 million gallons per day (MGD) of water from five general sources: 1) stormwater; 2) secondary-treated sanitary wastewater; 3) industrial wastewater treatment plant discharges; 4) contact cooling water; and 5) non-contact cooling water (accounts for more than 75 percent of water to the lagoon). The lagoon was cleaned to remove accumulated sludge and the PVC Liner was repaired as necessary in 2008 under Ecology Order No. 2868. Flows from the lagoon are further polished through the Trace Oil Filtration System.

Areas in the Wastewater Treatment area that have undergone investigation include the Field-Constructed Tanks, the Hydrogen Sulfide Scrubber, the MEK Tank, and the Hoffman Tank.

The Field-Constructed Tanks consist of two concrete 225,000-gallon above-ground storage tanks (ASTs) that were constructed in 1942 to store fuel oil for plant operations and a 588,000-gallon capacity steel AST that was constructed in 1950. The tanks were cleaned and decommissioned in 1989 and removed in 2008. Impacts near the Field-Constructed Tanks were discovered that same year when sampling was conducted on an area-wide basis within the Wastewater Treatment area.

The Hoffmann Tank was used as an oily wastewater flow-through process tank until the mid- to late 1980s when it was taken off-line. The Hoffman Tank along with the nearby MEK Tank were removed in 1990 and impacted soils identified during the removal were cleaned up to the maximum extent practicable in 1991. After the removal activities were completed, a cover was installed in 1991 to reduce the potential for residual petroleum contaminants in soil that had to be left in place from migrating to groundwater.

In early April 1998, total petroleum hydrocarbon (TPH) contamination in soil was discovered when Kaiser was excavating soil to construct a Hydrogen Sulfide Scrubber Building to remove odors from the wastewater treatment plant. After the cleanup actions were completed to the extent possible, the Hydrogen Sulfide Scrubber Building was constructed and surrounding areas were paved to reduce the potential for stormwater infiltration in the area. The impacted soil encountered within the scrubber excavation is believed to be associated with the historical releases from the former Hoffman Tank area located about 20 feet northeast of the Scrubber Building (Hart Crowser 1998).

Discharge Ravines. Prior to the construction of the Wastewater Treatment system in 1973, wastewater discharges from the Facility were handled by two discharge ravines located west and south of the plant. The West Discharge Ravine (WDR) is located north and northwest of the wastewater lagoon and started near the former sanitary wastewater treatment system. The South Discharge Ravine (SDR) is located directly south of the plant where an open channel section of the ravine starts at the south fence line and runs generally north-south through Washington State Department of Parks property toward the Spokane River.

The WDR handled wastewaters originating from the casting operations, ORB, Hot Line, and associated areas on the north and west areas of the plant. The SDR handled wastewater discharges from areas of the plant located east of the Hot Line and the southern areas of the plant. A source removal action was completed in the WDR in 2008 (see Hart Crowser 2008 and 2012).

Closed Solid Waste Landfills. Currently, no solid waste disposal occurs at the Facility. Historically, the following three solid waste landfills were used at the Facility; however, these former landfills have been closed.

- **East Landfill.** The East Landfill was used from 1962 to 1969 for disposal of approximately 100,000 tons of black dross generated at the Facility. In the process of melting aluminum in the remelt furnaces, a layer of aluminum oxide collects on the surface of the melt and is known as "skim" or "white dross" and contains approximately 50 percent metallic aluminum. The metallic aluminum in the skim was recovered in a rotary barrel furnace containing sodium and potassium salts. Periodically, the salt layer became saturated with aluminum oxide and was disposed of and replaced with fresh salt. This spent salt/aluminum oxide mixture is called "black dross." This landfill also received some construction rubble and miscellaneous debris.

- **West Landfill.** Approximately 250,000 cubic yards of uncompacted solid waste were disposed of in the 13-acre West Landfill from about 1965 until it was closed in 1980. Wastes included construction debris, wood, paper, scrap metal, brick, and miscellaneous trash. Trench depths at the landfill were approximately 8 feet.

- **South Landfill.** Little information is available concerning historical use of this landfill. Based on available information, the South Landfill is about 2 acres in area and was used from 1965 to 1972 for disposal of construction debris and other inert wastes.

Groundwater monitoring wells have been installed in the vicinity of each of the landfills.

2.4.3 Regulatory History

Kaiser Trentwood submitted Part A of its Resource Conservation and Recovery Act (RCRA) Permit Application to the United States Environmental Protection Agency (EPA) on November 13, 1980 (EPA ID number WAD009067281). On

November 4, 1994, the EPA authorized Ecology to implement corrective action at treatment, storage, and disposal (TSD) facilities within the state. Subsequent to this authorization, the state has also received authorization to use the Model Toxics Control Act (MTCA - Chapter 70-105D RCW) and its implementing regulations (Chapter 173-340 WAC) as the corrective action authority under the state Dangerous Waste regulations (WAC 173-303-646[3]).

Corrective action requirements (WAC 173-303-646[1]) apply to TSD facilities seeking a permit. Kaiser filed a Part A application as a protective measure and concluded that a final Part B Dangerous Waste Permit was not necessary for Kaiser to conduct these operations. Other operations listed in the Part A Dangerous Waste Permit do not appear to have occurred. Facility records do not indicate that dangerous waste containers were stored for longer than 90 days. However, at the request of Ecology, Kaiser is complying with the corrective action requirements so that interim status can be terminated at the Facility at some time in the future. Currently, no TSD facility activities requiring a permit are conducted at the Facility, and Kaiser does not foresee the need for a final Part B TSD facility permit.

In response to Ecology's request, Kaiser expressed a willingness to implement a Corrective Action Remediation Work Plan in partial fulfillment of the RCRA/dangerous waste corrective action requirements (Kaiser 1994). In December 1994, Ecology identified Kaiser as a potentially liable person (PLP) under MTCA authority (Ecology 1994a). In January 1995, Kaiser responded to Ecology's PLP letter and acknowledged its status as a PLP without admitting liability and reserving future rights and defenses allowed by law. Ecology responded with a final determination of PLP status in March 1995 (Ecology 1995). Both prior to and after 2005, Kaiser implemented a series of investigations and cleanup activities. In August 2005, Kaiser and Ecology signed an Agreed Order (No. DE 2692) to complete a site-wide RI/FS in general accordance with requirements in MTCA.

2.4.4 Previous RI Reports

This Groundwater RI report presents the outcome of work completed at the Facility through the end of December 2008. It is the third update to the initial draft Groundwater RI/FS report submitted to Ecology in September 1996 (Hart Crowser 1996c). The first update to the Groundwater RI/FS was submitted to Ecology in July 2001 (Hart Crowser 2001) and the second in July 2003 (Hart Crowser 2003). This updated report presents a compilation and interpretation of data describing groundwater conditions beneath the Facility. It also includes an evaluation of the operating Interim Remedial Measure (IRM), including ongoing pilot testing and other remedial alternatives. The purpose of the IRM is to provide protection to human health and the environment using permanent solutions to the maximum extent practicable. This report has been developed to support a selection of a remedy under applicable regulations.

The 2003 Groundwater RI/FS was based on data collected through December 2002. Considerable new information has been collected resulting in changes to the monitoring well network and an increased understanding of site groundwater conditions. The most significant change has been the installation of shallow and deep nested well pairs in the Hot Line area and along the downgradient Facility boundary. Many of the changes are the direct result of verbal and written comments provided by Ecology. Specific comments on the 2001 Draft RI/FS were provided by Ecology in a letter to Kaiser dated July 1, 2002. Kaiser responded to these comments in a letter dated October 2, 2002, to which Ecology responded in a letter dated October 14, 2002.

2.5 INTERIM REMEDIAL MEASURE (IRM)

This section discusses the groundwater IRM implemented at the Facility. The IRM has been phased in over the past 14 years in an attempt to meet the following three basic objectives:

- Prevent downgradient migration and spreading of free phase petroleum and associated PCBs and dissolved hydrocarbons identified near the Oil House and the Wastewater Treatment areas;
- Recover free phase petroleum; and
- Enhance biodegradation of dissolved and residual hydrocarbons in the source areas.

2.5.1 Basic and Enhanced System

The IRM is focused on groundwater contamination and free phase petroleum recovery in the Oil House and the Wastewater Treatment areas. The location of the IRM activities are shown on Figure 2-5. Refer to Figure 3-1 for specific IRM well locations. The primary components of the groundwater IRM system are:

- Groundwater extraction wells to depress the water table beneath free phase petroleum accumulations;
- Skimming wells and belt skimmers to extract free phase petroleum;

- Special deep observation wells to monitor for potential downward migration of petroleum hydrocarbons near the groundwater extraction wells; and

- Enhanced oxygenation systems for promoting biodegradation.

Oil House IRM. The IRM used for groundwater containment and free phase petroleum recovery at the Oil House began operations in 1993 and was expanded in 2000. Four extraction wells, two injection wells, four skimmer wells, and one deep monitoring well were installed to enhance product recovery and biodegradation. Currently, one extraction well (OH-EW-1) is pumping, with two skimmer wells operating when free phase petroleum is present.

Wastewater Treatment IRM. The IRM used for groundwater containment and free phase petroleum recovery at the Wastewater Treatment area began operations in 1993 and was expanded in 2000. Three extraction wells, one recirculation well, four skimmer wells, and one deep monitoring well were installed to enhance product recovery and biodegradation. Currently, two extraction wells (WW-EW-1 and WW-EW-2) and the recirculation well (WW-UVB-1) are operating, with two skimmer wells operating when free phase petroleum is present.

2.5.2 System Performance

The performance of the IRM was evaluated by monitoring groundwater and free phase petroleum levels in observation wells in the Oil House and Wastewater Treatment areas and by computer modeling. The IRM systems were shown to meet project objectives with respect to containment, product recovery, and enhanced biodegradation. Migration and spreading of the contaminant plumes in the Wastewater and Oil House areas have been eliminated through hydraulic control. The extent and thickness of free phase petroleum have declined with time. Finally, the IRM has effectively increased dissolved oxygen concentrations in the source areas, which in turn enhances the rate of aerobic biodegradation of residual hydrocarbons.

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Table 2-1 - Monthly Average Climate Statistics

Month	Average Maximum Temperature	Average Minimum Temperature	Average Total Precipitation	Average Total Snow Fall	Average Snow Depth
January	33	21.7	1.99	12.9	3
February	39.1	25.1	1.54	7.5	2
March	48.2	30.5	1.39	3.4	0
April	58.2	36.5	1.11	0.5	0
May	67	43.7	1.42	0.1	0
June	74.3	50.1	1.2	0	0
July	83.9	55.8	0.55	0	0
August	82.7	54.6	0.63	0	0
September	72.4	46.6	0.8	0	0
October	59.2	37.6	1.17	0.2	0
November	42.9	29.9	2.08	5.3	0
December	34.7	24.3	2.2	11	2
Annual	58	38	16.08	40.9	1

Notes:

Period of Record is from Spokane Airport between January 1890 and December 2005.

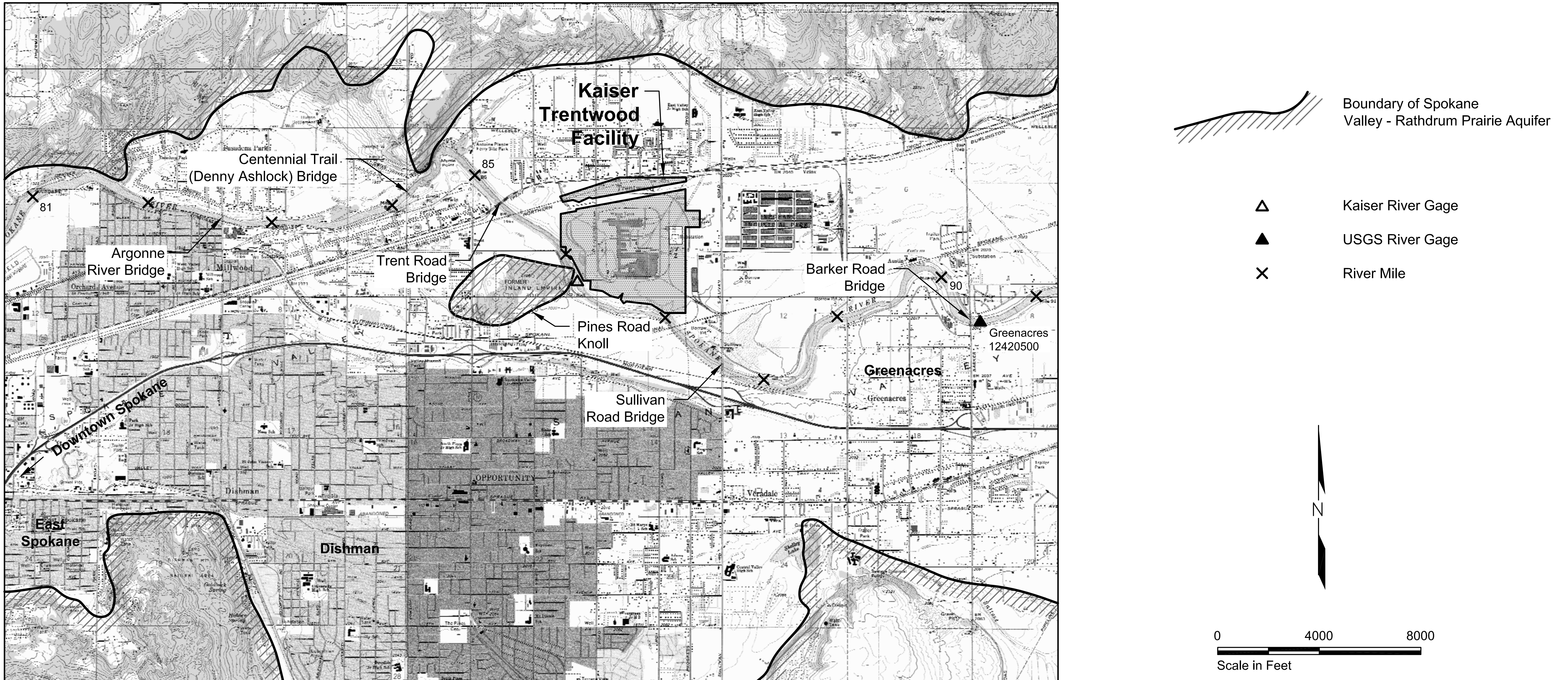
Temperature is in degrees Fahrenheit.

Precipitation statistics are in inches.

Average snow depth are in feet.

Data from Western Regional Climate Center (2009)

Vicinity Map



Note:
Base map prepared from USGS 7.5 minute quadrangle maps of Spokane NE and Greenacres, Washington, dated 1986 and Freeman and Spokane SE, Washington, dated 1973.

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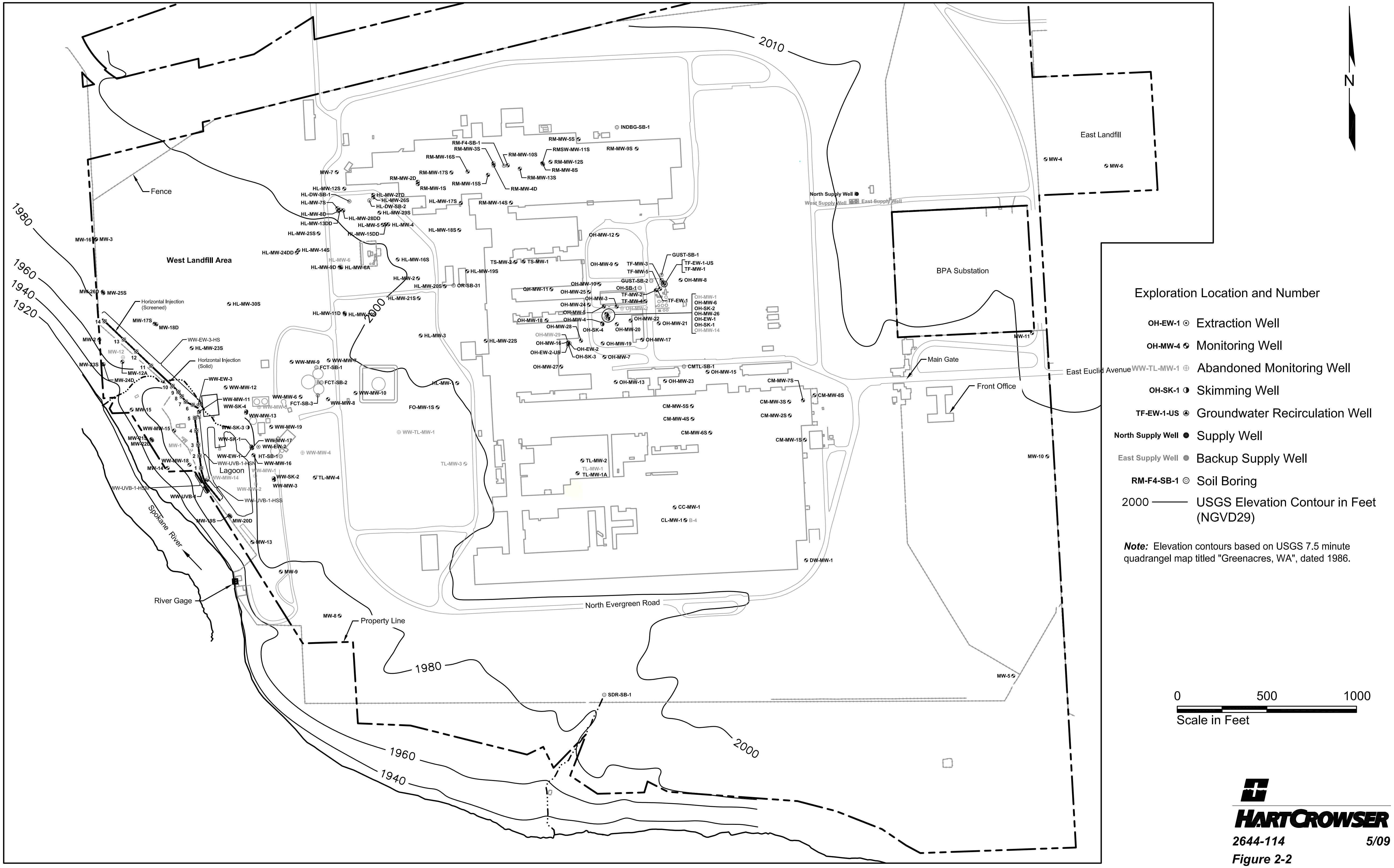
Figure 2-1

Facility Elevation Contour Map



Note: Elevation contours based on USGS 7.5 minute quadrangel map titled "Greenacres, WA", dated 1986.

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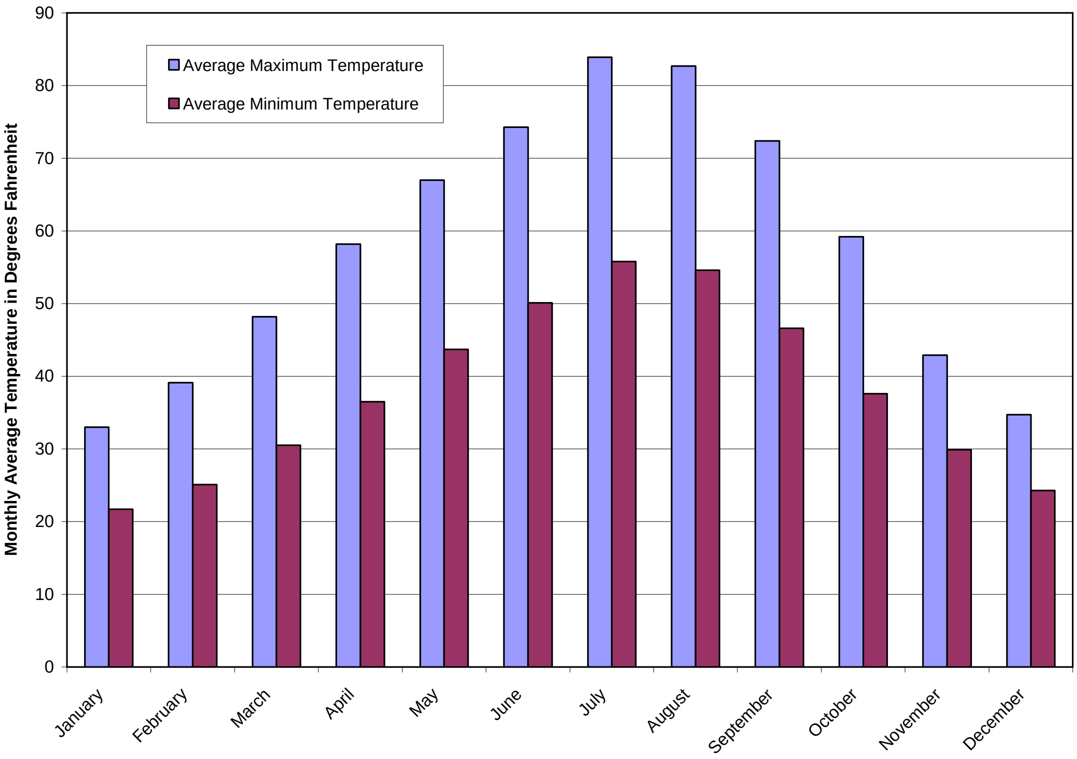
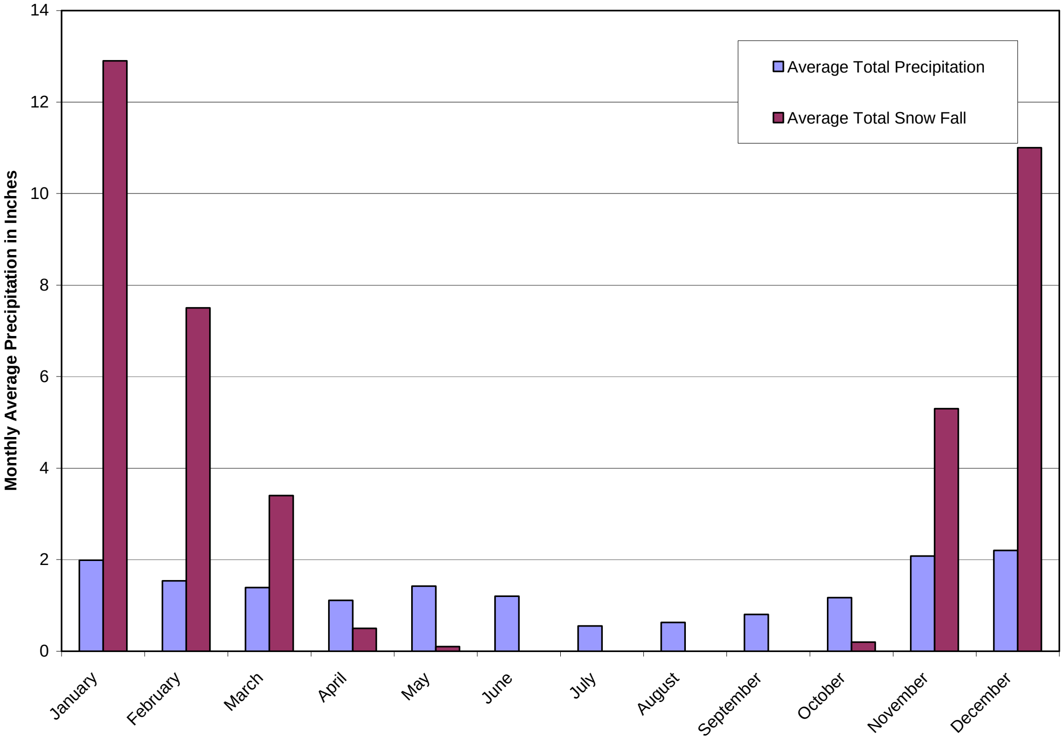
Figure 2-2

Monthly Average Temperature and Precipitation
Spokane Airport, 1890 to 2005

Temperature



Precipitation



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Data from Western Regional Climate Center (2009)

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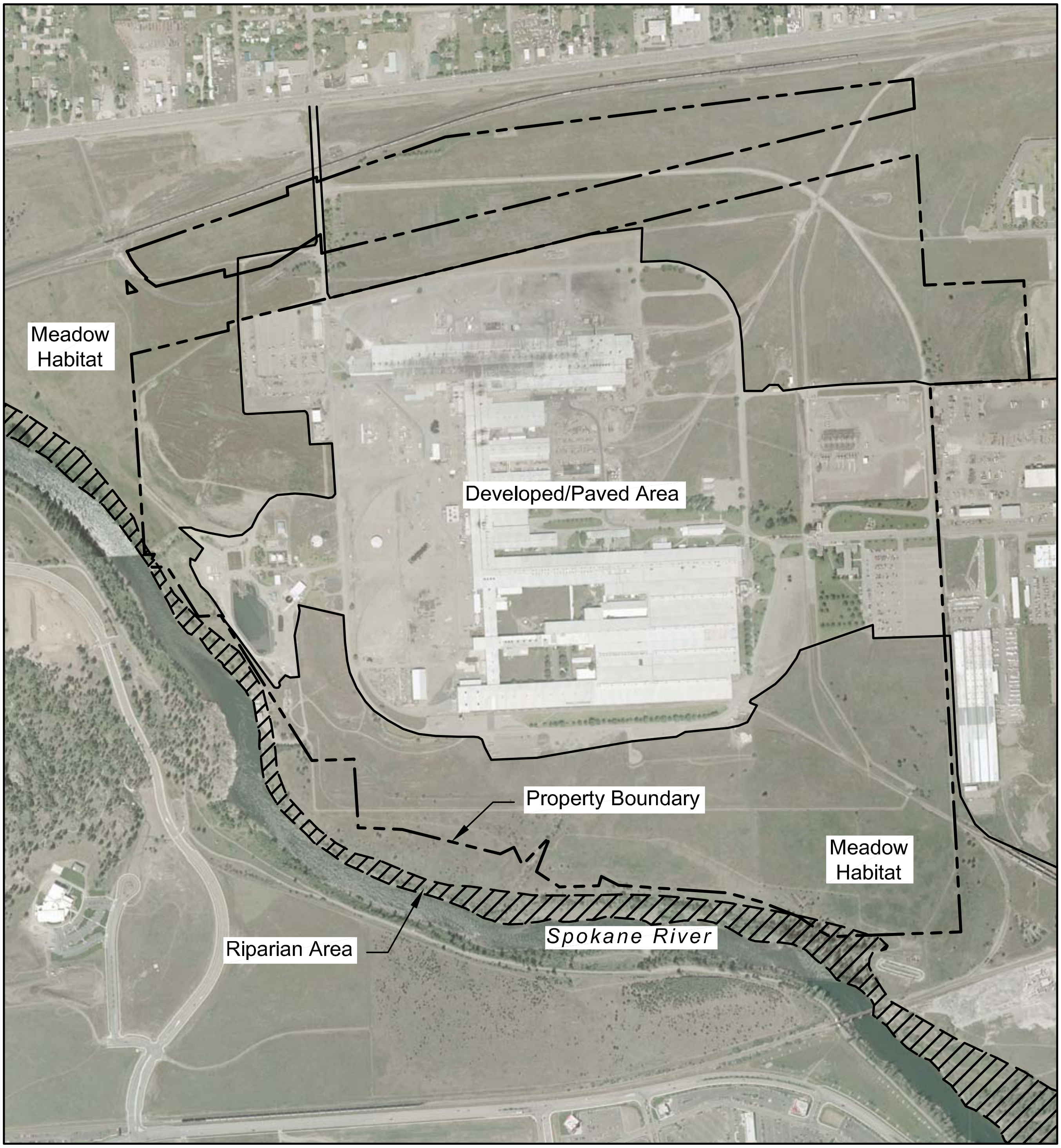
Figure 2-3

Habitat Map - Kaiser and Surrounding Area



Note: Some overlap of meadow habitat and developed area.

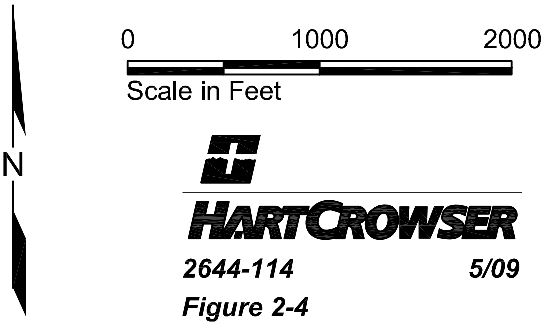


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Figure 2-4

Facility Map Showing Significant Features

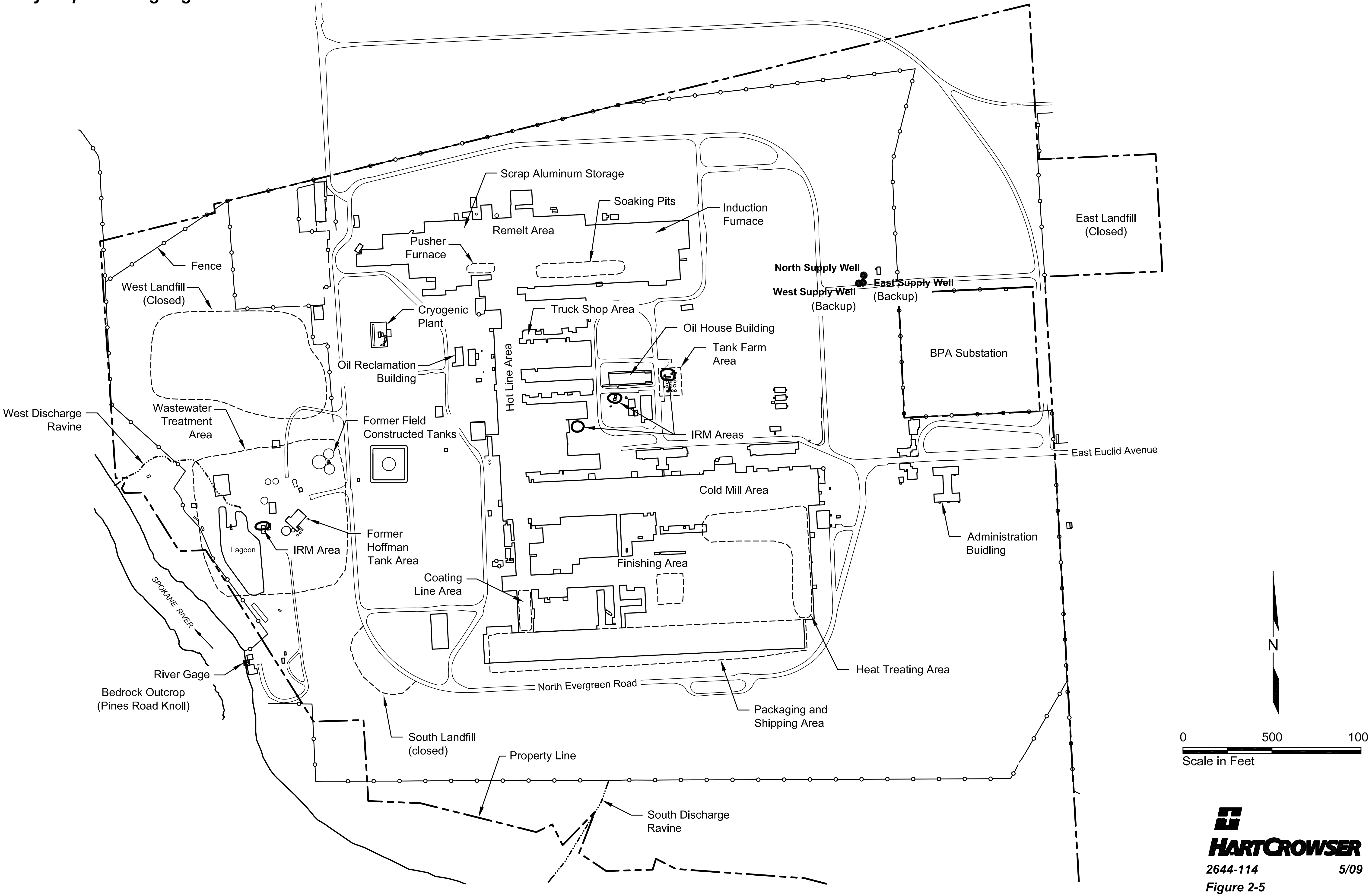

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Figure 2-5

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3.0 GROUNDWATER INVESTIGATION METHODS

Groundwater investigations have been conducted nearly continuously since 1979 to monitor and remediate contaminant releases on the Facility. Since the 2003 Groundwater RI/FS, Kaiser has continued to investigate groundwater quality at the Facility with a focus on the Remelt and Hot Line areas where a groundwater PCB plume has been identified. This section describes the general methods, tools, and tests used in recent and historical groundwater investigations at the Facility.

3.1 GROUNDWATER WELLS

There have been 167 groundwater wells installed on the Facility since 1979. Groundwater well locations are presented on Figure 3-1 and Plate 1, which is a larger scale version of Figure 3-1. A compilation of boring and well construction logs completed since the 2003 Groundwater RI/FS are included in Appendix A. Boring and well logs from earlier explorations are contained in the 2003 Groundwater RI/FS found on DVD in this report. Details of monitoring, extraction, and skimming well construction for all Facility wells are summarized in Table A-1.

3.1.1 Well Nomenclature

Groundwater wells at the Facility have been numbered to reflect their location and well type. Well nomenclature begins with a prefix reflecting the site location (CC-Continuous Can Process Line, CL-Chrome Line, CM-Cold Mill, DW-Dry Well, FO-Fuel Oil, HL-Hot Line, MW-Perimeter Wells, OH-Oil House, RM-Remelt, TF-Tank Farm, TL-Transfer Line, TS-Truck Shop, and WW-Wastewater Treatment areas), well type (MW-monitoring well, EW-extraction well, and SK-skimming well), and location number (e.g., OH-MW-01). Perimeter wells are located along the perimeter of the Facility including upgradient of the mill and along the western border, downgradient of the Facility.

Wells with an "A" after the number denote a replacement well for an abandoned well (e.g., HL-MW-6A replaced well HL-MW-6). Abandonments are generally due to improper screen intervals or wells with damaged casings. Wells with a "US" (i.e., upper screen) after the number identify the well as a vertical well screened above the water table operating as part of the oxygen enhancement pilot system (OH-EW-02-US and TF-EW-01-US). Wells with an "S" after the number identify shallow screen intervals (i.e., water table completions) and those with a "D" or "DD" after the number identify deep and very deep screen intervals, respectively.

3.1.2 Groundwater Wells Installed to Date

The construction of monitoring wells at the Facility began in 1979 with the installation of seven wells (MW-1 through MW-7) to assess the impact of the on-site landfills. Since then, there have been 160 groundwater wells installed to supply water to the production process, evaluate the nature and extent of contamination, and assist remediation efforts at the Facility. Of the 167 wells, 14 wells were abandoned with 3 wells were installed as replacements, 4 wells were lost or cannot be located in the field, and one well is known to have been destroyed during recent excavation work (TL-MW-3). Groundwater wells that are currently functional include 129 monitoring wells, 9 extraction wells, 8 product recovery (skimmer) wells, and 3 water supply wells. Of these wells 4 extraction wells, 7 skimmer wells, and 1 supply well are currently in operation. Table 3-1 presents the average annual groundwater pumping rates for the extraction wells and North Supply well at the Facility.

3.1.3 Groundwater Well Construction Details

Air rotary was the primary drilling method for completing borings and installing groundwater wells at the Facility. During air rotary drilling, subsurface soil conditions were logged by a combination of drill cuttings and/or split-spoon sampling. In September 2006, the preferred drilling method switched from air rotary to sonic drilling methods. Sonic drilling has the advantage of allowing the collection of continuous high quality soil samples and generating less water and soil cuttings requiring disposal.

As shown in Table A-1, 136 monitoring wells were constructed using polyvinyl chloride (PVC) for the casing and screen. The water supply, extraction, skimmer, and nine other monitoring wells were constructed using steel casings. The inside casing diameter for monitoring wells range from 2 to 6 inches, extraction wells range from 7 to 24 inches, and skimmer wells range from 4 to 12 inches.

The majority of the monitoring wells were constructed to be screened across the water table. There are 21 deep monitoring wells (HL-MW-5, MW-3, OH-MW-14, OH-MW-26, WW-MW-16, WW-MW-17, and wells with a “D” and “DD” nomenclature) that are screened at depths ranging from 15 to 140 feet below the water table. The purpose of the deep wells is to evaluate vertical gradients, define the vertical distribution of constituents of potential concern, and to act as early warning wells to warn of constituent being drawn down by extraction well pumping. Shallow and deep wells have screen lengths ranging from 2 to 30 feet and 5 to 20 feet, respectively.

Nine large extraction wells were constructed with screen lengths that range from 20 to 65 feet with some wells being screened across the water table to 30 feet below the water table. The extraction wells were designed and installed as part of the containment and oxygen enhancement wells to provide oxygenated water to the upper part of the aquifer for groundwater remediation. The 2003 Groundwater RI/FS (Section 5.3) presents a detailed discussion of the biodegradation enhancement system of dissolved and residual hydrocarbons in the Oil House and Wastewater Treatment areas. Currently three of the extraction wells (OH-EW-1, WW-EW-1, and WW-EW-2) also supply water to the production process or are discharged directly to the river, depending on needs in the mill. As of fall 2008, extraction wells OH-EW-1, WW-EW-1, WW-EW-2, and WW-UVB-1 are currently in operation.

Four skimming wells (OH-SK-1, OH-SK-2, OH-SK-3, and WW-SK-1) were installed between 1993 and 1995 to recover free phase product from the top of the water table. In 2001, three additional skimming wells (WW-SK-2, WW-SK-3, and WW-SK-4) were installed in the Wastewater Treatment area and one additional skimming well (OH-SK-4) was installed in the Oil House area. The skimmer wells were constructed with screen lengths that range from 15 to 30 feet with the screens spanning the water table. The skimmer wells are monitored frequently for free phase hydrocarbons by Kaiser personnel and are activated when free phase hydrocarbons are present.

3.2 SURVEYING

The elevation data presented in this report are referenced to the vertical datum of NAVD88 and the horizontal datum is referenced to Washington State Plane North Zone NAD83/91, in feet. Groundwater well screen, top of casing, and ground surface elevations are provided in Table A-1.

The groundwater well's top of casing measuring point, ground surface, and X and Y coordinates were surveyed at various times at the Facility. The need for surveying depended on whether new wells were added or wells were modified or repaired.

Prior to 2007, the elevation data were referenced in the NGVD29 vertical datum. In March 2007, Adams and Clark (licensed land surveyors) completed a groundwater well resurvey of the Facility converting the groundwater wells measuring point elevations to the NAVD88 vertical datum. The conversion between the two datums is defined as adding 3.8 feet to NGVD29 elevation to get the corresponding NAVD88 elevation. A total of 47 wells were surveyed by Adams and Clark. This included surveying newer wells as well as older wells that were originally surveyed using the NGVD29 vertical datum to provide a correction factor. The elevations of the remaining wells were converted to the new datum by adding the correction factor (3.8 feet) to the old datum.

3.3 WATER LEVEL MEASUREMENTS AND FREE PHASE PETROLEUM THICKNESS MONITORING

The depth to water level and free phase petroleum thickness data have been measured using a combination of electronic water level indicators and oil-water interface probes since 1989 and these data are provided in Appendix B.

Facility-wide water level and free phase petroleum monitoring from 2003 to 2005 have been conducted two to seven times a year in approximately 105 groundwater wells. Since 2007, water level and free phase petroleum monitoring is being conducted on a quarterly basis in approximately 116 monitoring and skimmer wells. The data are used to assess groundwater conditions and fluctuations, and changes in free phase petroleum thickness over time.

3.4 GROUNDWATER QUALITY SAMPLING AND ANALYSIS

Groundwater sampling and analysis have been conducted at the Facility since 1989. Groundwater sampling activities at the Facility have been governed by the Sampling and Analysis Plans (SAP) and Quality Assurance Project Plans (QAPP) reviewed and approved by Ecology. Table 3-2 summarizes the number of analyses performed on each groundwater well for individual chemical parameters.

3.4.1 Historical Groundwater Sampling and Analysis

The parameters historically analyzed at the Facility have included PCBs, total petroleum hydrocarbons (TPH), semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), total suspended solids (TSS), chloride, nitrate, and various total and dissolved metals (Table 3-2). Groundwater samples for dissolved metals analysis were field filtered using a 0.45 micrometer (µm) filter. Water quality parameters were typically measured prior to sampling and include pH, temperature, conductivity, dissolved oxygen, oxygen reduction potential (ORP or redox), and turbidity. Groundwater was sampled using stainless steel bailers, polyethylene bailers, or dedicated submersible pumps.

In 1995, a site-wide Groundwater Monitoring Plan (Hart Crowser 1995b) was developed and implemented to provide more consistency and continuity between monitoring events. The groundwater monitoring program, or SAP and QAPP, was revised again in May 1999, May 2003, and December 2005 to reflect changes in the monitoring well network and to adjust the monitoring based on what had been learned regarding groundwater quality over the years (Hart Crowser 1999, 2003, and 2005b).

3.4.2 Current Groundwater Sampling and Analysis

A new SAP was implemented in January 2007 (Hart Crowser 2007a). The governing rationales for the sampling schedule included evaluation of proximity of each well to other wells, sampling parameters, sampling frequency, and value of additional data to the ongoing RI/FS. In general, there are three classes of wells that are monitored:

- **Protection Wells.** These wells are located at or near the downgradient property line and provide information on groundwater quality downgradient of source areas immediately upgradient from the Spokane River. These wells generally have more frequent monitoring.

- **Performance Wells.** These wells are located throughout the Facility and are used to assess migration or increase/decrease of the dissolved and free phase hydrocarbon plumes and the Remelt Groundwater PCB plume. Monitoring frequency and parameters vary depending on the wells location and plume stability based on existing groundwater quality data.

- **Operation Wells.** These wells are used to monitor the effects of the ongoing Interim Remedial Measure (IRM). Operation monitoring wells are used to measure groundwater elevations and free phase product plumes as well as monitoring water quality from the IRM extraction and early warning wells.

Currently there are about 83 wells that are sampled on an annual, biannual, or quarterly basis for selected analytes. The analytes include ultra-low level PCBs, TPH, SVOCs, VOCs, TSS, chloride, nitrate, nitrite, total and dissolved arsenic, and dissolved metals. Groundwater is sampled using dedicated polyethylene bailers, dedicated Grundfos submersible pumps, dedicated Whaler electric submersible pumps, or portable stainless steel submersible pump. Currently, there are 57 wells with dedicated Grundfos pumps and 4 wells with dedicated electric pumps.

Metals Groundwater Sampling

Periodically, wells have been sampled for total metals, however, in general, filtered samples were used to analyze for dissolved metals. A summary of total metals data from groundwater samples is presented in Table 3-3. With few exceptions in the early years of monitoring, samples from monitoring wells were analyzed using filtered samples, while samples from pumping wells were analyzed for total metals. Anything that was discharged to the river, to a production process, or to the Kaiser drinking water supply (e.g., North Supply Well) has been analyzed for total metals.

Prior to the installation of dedicated sampling pumps most wells were either sampled with bailers or portable submersible pumps. Samples collected using bailers for metal analysis tend to be have high biased metal concentrations due to entrained suspended inorganic and biogenic solids. For purposes of consistency with historical sampling practices, dissolved metals analysis has continued.   This is consistent with SAP/QAPP procedures since at least 1995, including those documents reviewed and approved by Ecology since the signing to the Agreed Order in 2005.

3.5 AQUIFER TESTS

In January 1999, Hart Crowser performed pumping tests on wells WW-UVB-1 (one test) and WW-EW-3 (two tests) to evaluate groundwater mounding and dissolved oxygen distribution associated with the oxygen enhancement system in the Wastewater Treatment area and to estimate aquifer hydraulic properties. Appendix F of the 2003 Groundwater RI/FS details the pumping test methods and analyses (enclosed on CD).

WW-UVB-1 pumping test was conducted over a period of 48 hours using a temporary pump, operating at a constant rate of 820 gallons per minute (gpm). The purpose of this test was to determine the degree of drawdown and/or mounding resulting from groundwater recirculation, monitor changes in dissolved oxygen concentrations in five nearby wells, and estimate aquifer hydraulic properties.

Two pumping tests were conducted at WW-EW-3 (one for the upper screen and one for the lower screen) over a period of 24 hours using a temporary pump, operating at a constant rate of 1,280 gpm. The purposes of these tests were to determine the degree of drawdown that could be produced by this pumping well using four nearby wells to monitor groundwater elevations and estimate aquifer hydraulic properties. These data were used to evaluate the potential for this well to provide hydraulic control (capture) of site groundwater.

A groundwater tracer test using a non-partitioning tracer, sodium bromide, was performed between April 25 and 30, 2001, in the Wastewater Treatment area (Appendix H of the 2003 Groundwater RI/FS). The objective of the bromide tracer test was to estimate groundwater flow direction and velocity of the aquifer underlying the Wastewater Treatment area and evaluate the oxygen enhancement system's area of influence.

3.6 SITE-WIDE GROUNDWATER MODEL

A groundwater flow model was developed to aid in understanding the groundwater conditions beneath the Facility (Appendix C of the 2003 Groundwater RI/FS). The model was first developed, calibrated, and verified in 1996. The model has been periodically updated as additional data became available or site conditions changed (e.g., installation of additional pumping wells). For the 2003 Groundwater RI/FS, the model was used to support the analysis of remedial alternatives. The groundwater flow model, as needed, will be used to evaluate cleanup alternatives during the development of the Facility Feasibility Study (FS).

3.7 POLYCHLORINATED BIPHENYL (PCB) GROUNDWATER TRANSPORT MODEL

A new transient, two-dimensional PCB congener and colloid transport model, ***RATLIM2D_PCB***, was developed to evaluate PCB transport in the shallow aquifer at the Facility. It is not designed to predict the extent of groundwater capture zones. The site-wide, three dimensional Kaiser groundwater model discussed in Section 3.6 is designed to predict groundwater capture zones. The model was developed to provide an important computational tool that was used to analyze the October 2007 and April 2008 congener data sets and advanced the understanding of the key PCB transport mechanisms at the Facility. In addition to congener data, the model used many types of hydrogeologic and chemical data that have been collected during previous site investigations (e.g., soil organic carbon, hydraulic conductivity, hydraulic gradient, physical colloid characterization, etc.).

RATLIM2D_PCB contains two modules: groundwater flow and PCB congener and colloid transport models. The analytical flow model is based on the superposition of Dupuit-Forchheimer solutions (Bear 1979) for flow to one or more wells and the effects of a regional hydraulic gradient. The PCB congener and colloid transport model is a sophisticated and comprehensive analysis tool that incorporates many chemical transport mechanisms. The model simulates the transport of all 209 PCB congeners simultaneously, both as aqueous-phase (i.e., dissolved in groundwater) and colloidal (sorbed to mobile colloids flowing with the groundwater) fractions. See Section 6.3 and Appendix C for detailed information and results of this model.

3.8 GEOPHYSICAL SURVEY

A geophysical survey was completed at the Facility in 1994 (Appendix O of the 2003 Groundwater RI/FS) using seismic refraction methods. The purpose of the survey was to help define the depth and configuration of the water table and the underlying bedrock using the seismic velocities of the subsurface materials. The survey consisted of three 1,508-foot-long seismic refraction lines and concluded that the bedrock surface occurs at depths of 200 to 350 feet below ground surface beneath the Facility (see Figure 4-4).

3.9 SURFACE WATER INVESTIGATIONS

The Spokane River (RM 86 to 87) bounds the Facility to the west and south. A staff gage (River Gage) is located at approximate RM 86.3, near the two river pumping stations. The River Gage is visually measured daily by Kaiser personnel and during each groundwater monitoring event to monitor river water levels during groundwater sampling.

The Facility is currently using a mixture of river water and groundwater for its production process water supply. Two river pumping stations are located south of the Wastewater Treatment area. The River Gage is located outside of the north river pumping station (Figure 3-1). The Facility currently uses the south river pumping station where river water is sampled from the pump intake line located inside the pumping station. The river water is sampled quarterly and analyzed for hardness, total dissolved solids, alkalinity, chloride, nitrate, nitrite, and sulfate to characterize the production process water.

3.10 GRAIN SIZE ANALYSIS

Twenty-nine soil samples were collected from 12 monitoring well borings during drilling at the Facility for grain size analysis by sieve method. Eighteen soil samples were analyzed for moisture content, and porosity was calculated using the following weight-volume relationship.

$$n = \frac{\gamma}{Gs\,\gamma w(1+W)}$$

where:

n is the porosity;

γ is the saturated weight;

γ w is the weight of water;

W is the moisture content; and

Gs is the specific gravity of the soil.

3.11 REMELT SOURCE AREA CHARACTERIZATION SAMPLING AND ANALYSIS

Soil sampling and analysis in the Remelt area was performed to provide additional PCB source area information. Soil samples collected were analyzed for PCBs and TPH. There were 119 soil samples collected from 14 borings in the Remelt area prior to the wells being installed and from borings INDBG-SB-1 and RM-F4-SB-1. Investigations focused on the Remelt casing pit areas and the Induction Furnace area (Figure 2-5).

3.12 GROUNDWATER COLLOID ASSESSMENT

In 2004 and 2005, three laboratory bench-scale (i.e., jar test) studies and a groundwater colloids assessment were performed to provide information on colloidal transport and to assess potential remedial alternatives for the groundwater PCB plume in the Remelt and Hot Line areas (Hart Crowser 2004 and 2005a).

The jar tests were conducted to assess the effectiveness of several vendor-supplied water treatment chemicals to remove low concentrations of PCBs from the groundwater. The purpose of groundwater colloid assessment was to evaluate the size and nature of colloidal material in the groundwater since it is likely that PCBs detected in the groundwater in the Remelt and Hot Line areas are transported in colloidal suspension. In August 2004, 6 liters of groundwater from well HL-MW-5 were submitted to Materials and Chemistry Laboratory, Inc. (MCL) to characterize the sample for particle size analysis and chemical composition using a Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS). MCL's (2005) detailed colloid report is presented in Appendix D.

3.13 ANALYTICAL METHODOLOGY

Appendix F provides data validation summary of the chemical analyses performed on groundwater samples from January 2003 to October 2008. The following chemical analyses were performed on select groundwater samples identified in the SAPs (Hart Crowser 1999, 2003, 2005b, and 2007).

- Total Petroleum Hydrocarbons (TPH) following Washington State methodology.
    - Hydrocarbon Identification by Method NWTPH-HCID modified for the Kaiser site.
    - Diesel- and motor oil-range petroleum hydrocarbons by Method NWTPH-Dx.
    - Gasoline-range petroleum hydrocarbons by Method NWTPH-Gx.
- Polychlorinated Biphenyls (PCBs) by EPA Method 8082.
- Ultra-Low Level PCBs with solid phase extraction by EPA Method 8082 modified.
- PCB congeners by EPA Method 1668A.
- Semivolatile Organic Compounds (SVOCs) by EPA Method 8270C.
- Polycyclic Aromatic Hydrocarbons (PAHs) by Selected Ion Monitoring (SIM) following EPA Method 8270C - SIM.
- Volatiles by EPA Method 8260B.
- Total Suspended Solids (TSS) by EPA Method 160.2 or SM 2540 D.
- Nitrate, nitrite, and nitrate plus nitrite by EPA Method 300.0 or 353.2.
- Chloride and sulfate by EPA Method 300.0.
- Alkalinity by Method SM 2320B or EPA Method 310.
- Sulfide by EPA Method 376.2.
- Hardness by Method SM 2340C or EPA Method 130.2.
- Total Dissolved Solids (TDS) by Method SM 2540C or EPA Method 160.1.
- Total and Dissolved Organic Carbon, (TOC) and (DOC), by EPA Method 415.1.
- Dissolved and total metals by EPA Methods 200.7, 200.8, 6010B, and 6020. Mercury was prepared and analyzed following EPA Method 7470A.

Modifications for petroleum hydrocarbons and PCBs methodologies are described below.

3.13.1 Petroleum Hydrocarbon Analytical Methodology

Petroleum hydrocarbons in groundwater were analyzed using the following methods:

- TPH using EPA Method 418.1 (infrared spectrometry) from 1989 to August 1992.
- EPA Method 8015 modified, which analyzes for petroleum hydrocarbons using a gas chromatography analysis and a flame ionization detector was used from June 1991 to June 1997.
- NWTPH-HCID based on EPA Method 8015 modified was used from December 1991 through the present (October 2008). Constituents were quantified for gasoline-, stoddard/mineral spirit-, diesel/fuel oil-, kerosene/jet fuel-, Kensol-, Bunker C-, and heavy oil-range petroleum hydrocarbons.
- NWTPH-Gx and NWTPH-Dx from May 2005 through present (October 2008). Constituents were quantified for gasoline-, stoddard/mineral spirit-, diesel/fuel oil-, kerosene/jet fuel-, and heavy oil-range petroleum hydrocarbons.

Detections limits for petroleum hydrocarbons have varied over time with the general trend of lower detection limits with time.

NWTPH-HCID (Modified). NWTPH-HCID (Modified) is a qualitative and semi-quantitative analytical method for petroleum hydrocarbon identification. The TPH-HCID (Modified) method is used to identify petroleum products containing components for C_7 to above C_{37}. Petroleum products applicable for this method include gasoline, mineral spirits, Stoddard solvent, kerosene, jet fuels, diesel, fuel oils, kensol, and heavy oils. Kensol and castor oil were added as additional reference standards. Kensol was added because of the release of virgin Kensol product at the Facility and the use of this rolling oil throughout the Facility. Castor oil was added as a reference standard in March 2005. Castor oil is a vegetable oil used as a releasing agent in the casting/remelt area. Other non-petroleum synthetic oils may have been used in hydraulic formulations at the site, which may have included Pydraul. Early formulations of Pydraul included a mixture of PCBs and phosphate esters. Castor oil is the only non-petroleum oil that has been individually identified and quantified by NWTPH-HCID. Because castor oil has never been identified in groundwater it is not reported in the laboratory data sheets. If the analyst were to identify castor oil in a future groundwater sample it would be quantified as castor oil and reported as such.

NWTPH-Gx and NWTPH-Dx. NWTPH-Gx and NWTPH-Dx (Ecology 1997) are qualitative and quantitative analytical methods for volatile and semivolatile petroleum products, respectively. Petroleum products applicable for NWTPH-Gx include gasoline, mineral spirits, and Stoddard solvent. The retention time range (window) at a minimum includes toluene (C_7) through naphthalene (C_{10}). Petroleum products applicable for NWTPH-Dx include kerosene, jet fuels, diesel, fuel oils, and heavy oils. The retention time range (window) is required to be adjusted to incorporate the majority of petroleum product(s) identified in samples.

Qualitative Analysis - Identification

The three petroleum analytical methods discussed above are applicable for identification by pattern matching ("fingerprinting") and rely heavily on the experience of the analyst for petroleum hydrocarbon identification. Sample petroleum hydrocarbon products are identified by comparison to one or more chromatogram of hydrocarbon standards, depending on the chromatographic pattern of the sample contaminant. The petroleum product(s) are matched to reference product chromatograms, generated the same day as the sample analysis, by pattern recognition. Chromatograms containing individual chromatographic peaks not associated with known petroleum hydrocarbon or solvent mixtures are listed as "Unknown." Although petroleum hydrocarbon identification is completed by comparison to reference standards, the following are typical carbon chain ranges for the specific petroleum reference standards:

- Gasoline - C7 through C12
- Mineral Spirits/Stoddard Solvents - C7 through C12
- Kerosene/Jet Fuel - C10 through C18
- Diesel/Fuel Oil - C12 through C24
- Kensol - C16 through C20
- Bunker C - C12 through C37
- Motor Oil - C24 through C37

Castor oil can overlap with heavy oils. Quantification of castor oil began in March 2005. A unique pattern was observed in 2005 not matching the petroleum reference standards. Castor oil was known to be used on the Site and a reference standard was provided from a pure castor oil sample, to identify and quantify the castor oil present in the soils. Prior to 2005, castor oil may have been quantified as heavy oil. It is also possible that if castor oil is comingled with heavy oil it may be quantified as heavy oil. In general, since 2005 when castor oil started being quantified as a unique hydrocarbon, detections of castor oil have been observed in soil without the presence of other petroleum hydrocarbons. Castor oil has not been identified in groundwater.

Other synthetic oils (e.g., Pydraul with phosphate esters) can overlap with heavy oils. If these synthetic oils were present in mixtures with other heavy oils they would have likely been quantified as heavy oil. If synthetic oils were present but not as a mixture, a unique pattern would have been observed in the chromatogram and the chemist would have likely worked to identify the peak (as done with castor oil) to be able to quantify and identify the synthetic oil, or the analyst may have reported the detection as "unknown".

Figure 3-2 details hydrocarbon ranges for petroleum hydrocarbon components and analytical methods.

Quantitative Analyses – Integration

Quantitative analyses for NWTPH-Dx and NWTPH-Gx include comparing sample chromatogram to a series of calibration standards to quantify the component concentration(s). Calibration standards include a five-point calibration curve and are sufficiently low to provide the necessary reporting limits. The integration range for individual petroleum components is based on ranges for reference and calibration standards as discussed above.

A semi-quantitative analysis is completed under NWTPH-HCID (Modified) and includes estimating the concentration from a one-point calibration. Occasionally this calibration was not performed and results are presented either as a detection (D) or as not detected (ND) above the reporting limit.

Screening Level Comparison

The groundwater screening levels for petroleum hydrocarbons are based on MTCA Method A cleanup Levels (Table 5-2). Groundwater screening levels are available for gasoline (0.8 mg/L), diesel (0.5 mg/L), and heavy oil (0.5 mg/L). For the purpose of groundwater screening level comparisons, petroleum hydrocarbons ranges were separated into gasoline, diesel, and heavy oil. Gasoline includes the combination of gasoline- and Stoddard/mineral spirit-range petroleum hydrocarbons, diesel includes the combination of diesel/fuel oil-, kerosene/jet fuel-, and Kensol-range petroleum hydrocarbons, and heavy oil includes the combination of Bunker C-, and heavy oil-range petroleum hydrocarbons (Figure 3-3). Individual petroleum hydrocarbon ranges are discussed in Section 5.

3.13.2 Polychlorinated Biphenyls (PCBs) Analytical Methodology

Between 1990 and 2003, groundwater samples were analyzed for PCBs by gas chromatography with a flame ionization detector (FID) using EPA Method 8080. Since 2003, PCBs were analyzed using EPA Method 8082. EPA Method 8082 uses a capillary column gas chromatography with electron capture detection (GC/ECD).

Using EPA Methods 8080 and 8082, PCBs are quantified as Aroclors based on commercial mixtures of PCBs. Aroclors are mixtures of PCB cogeners selected for their chemical properties. The Aroclors are identified by their characteristic peak patterns matching a standard sample for each Aroclors. The limitation of this method is the varying congener ratios within a given commercial mixture due to batch-to-batch production variability which, in turn, may lead to congener calculation error. Also, a significant bias resulting in an overestimation of PCB measurements may occur if the PCB pattern in the sample does not match that of the standards. Accurate PCB determinations can be made if the chromatographic pattern of both the standards and the samples are similar. However, if the pattern differs, the original Aroclor may be misidentified and/or improperly quantified. The composition of congeners can varying in groundwater samples because of mixing from difference sources, and differences in mobility and sorption rates. Therefore, the final pattern in a sample is often highly modified and may not resemble the original commercial formulation or mixture of formulations.

Detection limits for PCBs have varied with a trend for detection limits to become lower over time. Since 2001, groundwater samples have been analyzed using low level and ultra low level detection methodology, which have typical reporting limits of 0.02 to 0.005 ug/L, respectively.

Selected groundwater samples collected in October 2007 and April 2008 were analyzed for congeners of PCB using EPA Method 1668A. EPA Method 1668A is used to analyze individual PCB congeners by high resolution gas chromatography with high resolution mass spectrometry (HRGC/HRMS) using isotope dilution. The method includes all 209 PCB congeners, however, about 30 percent of PCB congeners co-elute and are represented as pairs, triplets, and even quadruplets. PCB congener reporting limits are presented in Table 3-4 and range from 0.501 to 9.63 picograms per liter (pg/L) with most reporting limits below 1 pg/L. This table also presents the number of samples analyzed and the number of times each congener was detected in groundwater samples.

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Table 3-1 - Groundwater Extraction and Supply Well Pumping Rates

Year	OH-EW-01	WW-EW-01	WW-EW-02	WW-EW-03	WW-UVB-01	North Supply Well
2002	1.27	5.03	5.06	2.38	2.49	0.26
2003	1.17	3.57	5.76	1.48	0.66	0.26
2004	1.26	4.17	7.62	0.00	0.00	0.26
2005	1.13	3.19	5.10	0.00	0.00	0.26
2006	1.27	4.42	7.14	1.56	0.00	0.26
2007	1.29	2.31	6.40	1.10	1.67	0.26
2008	1.28	4.42	7.32	1.17	3.35	0.26

Notes:

Pumping rates are average annual rates in million gallons per day.

WW-EW-03 was shut down in the summer of 2008.

Table 3-2 - Groundwater Sampling and Analysis Summary

Sheet 1 of 5

Well Number	TPH-HCID	TPH-G	TPH-Dx	VOCs	SVOCs	PCBs	Copper and Zinc	Heavy Metals (a)	Iron and Manganese	Antimony	Arsenic	Chromium	Mercury	Conventionals (b)
CC-MW-01				1		1			1	1	1	1		1
CL-MW-01				1										
CM-MW-01S	12	6	6	11	11	11		9	8	8	10	9	8	12
CM-MW-02S	12	6	6	11	12	12		8	8	8	10	8	8	12
CM-MW-03S	12	6	6	11	12	12		8	8	8	10	8	8	12
CM-MW-04S	12	6	6	11	12	12		8	8	8	10	8	8	12
CM-MW-05S	12	6	6	11	11	12		8	8	8	10	8	8	12
CM-MW-06S	12	6	6	11	12	12		8	8	8	10	8	8	12
CM-MW-07S	12	6	6	11	12	12		9	8	8	10	9	8	12
CM-MW-08S	12	6	6	11	12	12		9	8	8	10	9	8	12
FO-MW-01S	7	7	7	7	6	1								7
HL-MW-01	29			3		4			3	2	4			12
HL-MW-02	20	8	8	8	8	12			1	2	2			25
HL-MW-03	19			2		4			3	1	3			9
HL-MW-04	40			3		43			1	1	1			46
HL-MW-05	29					34								36
HL-MW-06	1					1								2
HL-MW-06A	23	10	10	10	10	30		7	8	8	8	7	6	38
HL-MW-07S	15			1		26								28
HL-MW-08D	15					20								22
HL-MW-09D	15					20								22
HL-MW-10S	15			1		19								19
HL-MW-11D	8					10								11
HL-MW-12S	8					12								12
HL-MW-13DD	8			1		14								14
HL-MW-14S	8			1		18								18
HL-MW-15DD	8					12								12
HL-MW-16S	8					18								18
HL-MW-17S	9	1	1			20								20
HL-MW-18S	10					15								15
HL-MW-19S	11	10	10	10	10	1		6	10	10	10	6	6	5
HL-MW-20S	10	9	9	9	9			5	9	9	9	5	5	4
HL-MW-21S	11	10	10	10	10			6	10	10	10	6	6	4
HL-MW-22S	11	9	9	9	9			7	10	10	10	7	6	4
HL-MW-23S	8	8	8	8	8	11		5	8	8	8	5	3	11
HL-MW-24DD	8	8	8	8	8	8		6	8	8	8	6	3	8
HL-MW-25S	8	7	7	8	8	11		5	8	8	8	5	3	11
HL-MW-26S	8	8	8	8	8	11		6	8	8	8	6	3	11

Table 3-2 - Groundwater Sampling and Analysis Summary

Well Number	TPH-HCID	TPH-G	TPH-Dx	VOCs	SVOCs	PCBs	Copper and Zinc	Heavy Metals (a)	Iron and Manganese	Antimony	Arsenic	Chromium	Mercury	Conventionals (b)
HL-MW-27D	8	8	8	8	8	8		5	8	8	8	5	4	8
HL-MW-28DD	8	8	8	8	8	8		8	8	8	8	8	2	8
HL-MW-29S	5	5	5	5	5	6		5	5	5	5	5		6
HL-MW-30S	5	5	5	6	5	6		5	5	5	5	5		6
MW-01	15			16		14	2	2		3	3	2	2	16
MW-02	14			16	1	14	2	2		3	3	2	2	30
MW-02D	12					14								3
MW-02S	12					14								4
MW-03	17			19	1	17	1	1		2	4	1	1	18
MW-04	2			1		1	1	1		2	2	1	1	43
MW-05	1			2	1	2	2	2		3	3	2	2	17
MW-06														22
MW-07	20					22				1	1			39
MW-08	34			27		38			4	5	35	1		45
MW-09	42			40		44			6	5	35	5		54
MW-10	1					1			5	6	25			16
MW-11	2			2		1			1	1	1			1
MW-12	12			8		13			1		6			16
MW-12A	25			19		33		1	5	4	28	1		35
MW-13	23			23		26			6	4	27	5		32
MW-14	26			21		29			6	4	40			38
MW-15	28			23		35			6	4	32			42
MW-16	28			30	7	31			6	4	32			37
MW-17S	19			18	7	26		2	5	5	18	2		28
MW-18D	15			8		19			4	4	18			22
MW-19S	17			17	7	19		1	5	5	17	2		21
MW-20D	11			13	4	13			4	4	13	1		15
MW-21S	18			18	7	24		1	5	5	18	1		25
MW-22D	12			9		14			4	4	22			15
MW-23S	17			16	7	24			4	4	18			25
MW-24D	17			9		24			4	4	20			25
MW-25S	19	1	1	18	7	25			4	4	18			26
MW-26D	15			9		17			4	4	17			18
N Supply				1						1	2	1	1	20
OH-EW-01	49			1	1	50	1	1		1	26	1	1	59
OH-EW-02	2					2								3
OH-MW-01				3			2	2		3	3	2	2	
OH-MW-02				3			2	2		3	3	2	2	

Table 3-2 - Groundwater Sampling and Analysis Summary

Well Number	TPH-HCID	TPH-G	TPH-Dx	VOCs	SVOCs	PCBs	Copper and Zinc	Heavy Metals (a)	Iron and Manganese	Antimony	Arsenic	Chromium	Mercury	Conventionals (b)
OH-MW-03	1			5		2	2	2	1	4	4	2	2	15
OH-MW-04	1			5		2	2	2	1	4	4	2	2	9
OH-MW-05	1			4		1	2	2	1	4	4	2	2	4
OH-MW-06				3		1	2	2		3	3	2	2	8
OH-MW-07	5			2		5				1	1			6
OH-MW-08	5	1	2	5	2	4			3	4	4			6
OH-MW-09	4			2		4				1	1			4
OH-MW-10	9	1	2	4	3	3			3	4	4			25
OH-MW-11	4			3		3			1	2	2			3
OH-MW-12	2			2		1			1	2	2			1
OH-MW-13	25	7	8	2		1			1	2	2			8
OH-MW-14	2			2		1			1	2	2			1
OH-MW-15	2			1		1			1	1	1			2
OH-MW-16	2			2		3			1	1	1			6
OH-MW-17	17			2		2			1	1	1			6
OH-MW-18	27	8	8	2		4			1	1	1			31
OH-MW-19	2			2		2			1	1	1			3
OH-MW-20	2			2		2			1	1	1			4
OH-MW-21	3			1		3			1	1	1			3
OH-MW-22	1			1		1			1	1	1			1
OH-MW-23	1			1		1			1	1	1			2
OH-MW-24	4	2	2	4	2	4			3	3	3			3
OH-MW-25	3	2	2	3	2	3			3	3	3			2
OH-MW-26	33					34					1			49
OH-MW-27	6													26
OH-MW-28														4
OH-SK-01				1		1								1
OH-SK-02														1
OH-SK-03														2
RM-MW-01S	5					18								18
RM-MW-02D	5	1	1			12								12
RM-MW-03S	6	1	1			19								19
RM-MW-04D	5					12								12
RM-MW-05S	5					12								12
RM-MW-08S	9	1	2			17								17
RM-MW-09S	8	1	1			16								16
RM-MW-10S	9	1	2			18								18
RM-MW-11S	1													

Table 3-2 - Groundwater Sampling and Analysis Summary

Well Number	TPH-HCID	TPH-G	TPH-Dx	VOCs	SVOCs	PCBs	Copper and Zinc	Heavy Metals (a)	Iron and Manganese	Antimony	Arsenic	Chromium	Mercury	Conventionals (b)
RM-MW-12S	8	1	2			16								16
RM-MW-13S	8	1	2			16								16
RM-MW-14S	9					9								9
RM-MW-15S	8					9								9
RM-MW-16S	8					9								9
RM-MW-17S	8					9								9
RMSW-MW11S	7	1	2			8								8
TF-EW-01	1					1								1
TF-MW-01	3	2	2	2	2	3			2	2	2			3
TF-MW-02	3	2	2	2	2	1			2	2	2			2
TF-MW-03	3	2		2		1								6
TF-MW-04	2	2	2	2	2	3			2	2	2			2
TF-MW-05	1					1								2
TL-MW-01	1			1					1	1	1	6		
TL-MW-01A												26		18
TL-MW-02							1	1	1	2	2	10	1	1
TL-MW-03	11			2		4	1	1	1	2	2	9	1	12
TL-MW-04	6			2		4	1	1	3	2	3	11	1	8
TS-MW-01S	7	7	7	6	11	7		6	10	10	10	6	6	7
TS-MW-02S	7	7	7	6	11	7		6	10	10	10	6	6	7
W Supply				1	1	1	1	1		1	1	1	1	1
WW-EW-01	49					52					31			57
WW-EW-02	28					30					27			30
WW-EW-03	4					1					1			2
WW-MW-01	1			3		2	2	2		3	3	2	2	2
WW-MW-02	3			5		3	2	2	1	4	5	2	2	3
WW-MW-03	6			9		7	2	2	3	4	11	2	2	19
WW-MW-04				3			2	2		3	3	2	2	
WW-MW-05	1			4			2	2	1	4	4	2	2	
WW-MW-06	1			4	1	1	2	2	1	4	4	2	2	
WW-MW-07	4	2	2	2	2	3	2	2	3	4	6	2	2	3
WW-MW-08	22	7	7	4	2	3			2	1	3			23
WW-MW-09	7	2	2	2	2	7			3	2	4			7
WW-MW-10	6			3		4			3	2	4			6
WW-MW-11	3			1		4			3	1	3			20
WW-MW-12	28	1	1	9	7	11		3	10	8	10	3	3	36
WW-MW-13						1								
WW-MW-14	2			2		2			1	1	1			2

Table 3-2 - Groundwater Sampling and Analysis Summary

Well Number	TPH-HCID	TPH-G	TPH-Dx	VOCs	SVOCs	PCBs	Copper and Zinc	Heavy Metals (a)	Iron and Manganese	Antimony	Arsenic	Chromium	Mercury	Conventionals (b)
WW-MW-15	40	6	7	22		22			3	1	8			47
WW-MW-16														21
WW-MW-17	42	1				45					1			62
WW-MW-18	32			32		27		1	7	5	25	1		47
WW-MW-19	4								2		2			8
WW-SK-01														4
WW-TL-MW-1	1		1											
WW-UVB-01														5

Notes:

Values represent the number of analyses performed for the specified well from the time the well was installed. Blank indicates no analyses conducted for this analyte in this well.

(a) Includes one of more the following: Barium, Cadmium, Lead, Selenium, and Silver.

(b) Conventionals include Total Suspended Solids (TSS), Dissolved Oxygen (DO), Total Alkalinity, Total Hardness, Total Dissolved Solids, Total Organic Carbon, Total Sulfide, Chloride, Fluoride, Nitrate, Nitrite, and Sulfate. For the purpose of this summary,

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
HL-MW-01	HL-MW-1	3/30/2000	Iron	20	U	ug/L	
HL-MW-01	HL-MW-1	3/30/2000	Manganese	5	U	ug/L	
HL-MW-01	HL-MW-1	3/30/2000	Arsenic	5	U	ug/L	
HL-MW-03	HL-MW-3	3/30/2000	Iron	20	U	ug/L	
HL-MW-03	HL-MW-3	3/30/2000	Manganese	5	U	ug/L	
HL-MW-03	HL-MW-3	3/30/2000	Arsenic	5	U	ug/L	
MW-01	MW-1	12/2/1989	Cadmium	5	U	ug/L	
MW-01	MW-1	12/2/1989	Chromium	10	U	ug/L	
MW-01	MW-1	12/2/1989	Silver	10	U	ug/L	
MW-01	MW-1	12/2/1989	Antimony	30	U	ug/L	
MW-01	MW-1	12/2/1989	Arsenic	2	U	ug/L	
MW-01	MW-1	12/2/1989	Beryllium	5	U	ug/L	
MW-01	MW-1	12/2/1989	Copper	20	U	ug/L	
MW-01	MW-1	12/2/1989	Lead	3	U	ug/L	
MW-01	MW-1	12/2/1989	Mercury	0.5	U	ug/L	
MW-01	MW-1	12/2/1989	Selenium	2		ug/L	
MW-01	MW-1	12/2/1989	Thallium	2	U	ug/L	
MW-01	MW-1	12/2/1989	Zinc	10	U	ug/L	
MW-01	MW-1	12/2/1989	Nickel	10	U	ug/L	
MW-01	MW-1	5/10/1990	Cadmium	0.3	U	ug/L	
MW-01	MW-1	5/10/1990	Chromium	20	U	ug/L	
MW-01	MW-1	5/10/1990	Silver	20	U	ug/L	
MW-01	MW-1	5/10/1990	Antimony	23		ug/L	
MW-01	MW-1	5/10/1990	Arsenic	5	U	ug/L	
MW-01	MW-1	5/10/1990	Beryllium	10	U	ug/L	
MW-01	MW-1	5/10/1990	Copper	20	U	ug/L	
MW-01	MW-1	5/10/1990	Lead	5	U	ug/L	
MW-01	MW-1	5/10/1990	Mercury	0.5	U	ug/L	
MW-01	MW-1	5/10/1990	Selenium	5	U	ug/L	
MW-01	MW-1	5/10/1990	Thallium	5	U	ug/L	
MW-01	MW-1	5/10/1990	Zinc	20	U	ug/L	
MW-01	MW-1	5/10/1990	Nickel	30	U	ug/L	
MW-02	MW-2	12/2/1989	Cadmium	5	U	ug/L	
MW-02	MW-2	12/2/1989	Chromium	10	U	ug/L	
MW-02	MW-2	12/2/1989	Silver	10	U	ug/L	
MW-02	MW-2	12/2/1989	Antimony	30	U	ug/L	
MW-02	MW-2	12/2/1989	Arsenic	3		ug/L	
MW-02	MW-2	12/2/1989	Beryllium	5	U	ug/L	
MW-02	MW-2	12/2/1989	Copper	20	U	ug/L	
MW-02	MW-2	12/2/1989	Lead	3	U	ug/L	
MW-02	MW-2	12/2/1989	Mercury	0.5	U	ug/L	
MW-02	MW-2	12/2/1989	Selenium	2	U	ug/L	
MW-02	MW-2	12/2/1989	Thallium	2	U	ug/L	
MW-02	MW-2	12/2/1989	Zinc	10		ug/L	
MW-02	MW-2	12/2/1989	Nickel	10	U	ug/L	
MW-02	MW-2	5/10/1990	Cadmium	0.3	U	ug/L	
MW-02	MW-2	5/10/1990	Chromium	20	U	ug/L	
MW-02	MW-2	5/10/1990	Silver	20	U	ug/L	
MW-02	MW-2	5/10/1990	Antimony	21	J	ug/L	
MW-02	MW-2	5/10/1990	Arsenic	5	U	ug/L	
MW-02	MW-2	5/10/1990	Beryllium	10	U	ug/L	
MW-02	MW-2	5/10/1990	Copper	20	U	ug/L	
MW-02	MW-2	5/10/1990	Lead	5	U	ug/L	
MW-02	MW-2	5/10/1990	Mercury	0.5	U	ug/L	
MW-02	MW-2	5/10/1990	Selenium	5	U	ug/L	
MW-02	MW-2	5/10/1990	Thallium	5	U	ug/L	
MW-02	MW-2	5/10/1990	Zinc	20	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
MW-02	MW-2	5/10/1990	Nickel	30	U	ug/L	
MW-02	MW-2D	12/2/1989	Cadmium	5	U	ug/L	
MW-02	MW-2D	12/2/1989	Chromium	10	U	ug/L	
MW-02	MW-2D	12/2/1989	Silver	10	U	ug/L	
MW-02	MW-2D	12/2/1989	Antimony	30	U	ug/L	
MW-02	MW-2D	12/2/1989	Arsenic	2		ug/L	
MW-02	MW-2D	12/2/1989	Beryllium	5	U	ug/L	
MW-02	MW-2D	12/2/1989	Copper	20	U	ug/L	
MW-02	MW-2D	12/2/1989	Lead	3	U	ug/L	
MW-02	MW-2D	12/2/1989	Mercury	0.5	U	ug/L	
MW-02	MW-2D	12/2/1989	Selenium	2	U	ug/L	
MW-02	MW-2D	12/2/1989	Thallium	2	U	ug/L	
MW-02	MW-2D	12/2/1989	Zinc	10	U	ug/L	
MW-02	MW-2D	12/2/1989	Nickel	10	U	ug/L	
MW-03	MW-3	5/10/1990	Cadmium	0.3	U	ug/L	
MW-03	MW-3	5/10/1990	Chromium	20	U	ug/L	
MW-03	MW-3	5/10/1990	Silver	20	U	ug/L	
MW-03	MW-3	5/10/1990	Antimony	20	J	ug/L	
MW-03	MW-3	5/10/1990	Arsenic	5	U	ug/L	
MW-03	MW-3	5/10/1990	Beryllium	10	U	ug/L	
MW-03	MW-3	5/10/1990	Copper	20	U	ug/L	
MW-03	MW-3	5/10/1990	Lead	5	U	ug/L	
MW-03	MW-3	5/10/1990	Mercury	0.5	U	ug/L	
MW-03	MW-3	5/10/1990	Selenium	5	U	ug/L	
MW-03	MW-3	5/10/1990	Thallium	5	U	ug/L	
MW-03	MW-3	5/10/1990	Zinc	20	U	ug/L	
MW-03	MW-3	5/10/1990	Nickel	30	U	ug/L	
MW-03	MW-3	9/29/1997	Arsenic	5	U	ug/L	
MW-04	MW-4	5/11/1990	Cadmium	0.3	U	ug/L	
MW-04	MW-4	5/11/1990	Chromium	20	U	ug/L	
MW-04	MW-4	5/11/1990	Silver	20	U	ug/L	
MW-04	MW-4	5/11/1990	Antimony	24		ug/L	
MW-04	MW-4	5/11/1990	Arsenic	5	U	ug/L	
MW-04	MW-4	5/11/1990	Beryllium	10	U	ug/L	
MW-04	MW-4	5/11/1990	Copper	20	U	ug/L	
MW-04	MW-4	5/11/1990	Lead	5	U	ug/L	
MW-04	MW-4	5/11/1990	Mercury	0.5	U	ug/L	
MW-04	MW-4	5/11/1990	Selenium	5	U	ug/L	
MW-04	MW-4	5/11/1990	Thallium	5	U	ug/L	
MW-04	MW-4	5/11/1990	Zinc	20	U	ug/L	
MW-04	MW-4	5/11/1990	Nickel	30	U	ug/L	
MW-05	MW-5	12/2/1989	Cadmium	5	U	ug/L	
MW-05	MW-5	12/2/1989	Chromium	10	U	ug/L	
MW-05	MW-5	12/2/1989	Silver	10	U	ug/L	
MW-05	MW-5	12/2/1989	Antimony	30	U	ug/L	
MW-05	MW-5	12/2/1989	Arsenic	2	U	ug/L	
MW-05	MW-5	12/2/1989	Beryllium	5	U	ug/L	
MW-05	MW-5	12/2/1989	Copper	20	U	ug/L	
MW-05	MW-5	12/2/1989	Lead	3	U	ug/L	
MW-05	MW-5	12/2/1989	Mercury	0.5	U	ug/L	
MW-05	MW-5	12/2/1989	Selenium	2	U	ug/L	
MW-05	MW-5	12/2/1989	Thallium	2	U	ug/L	
MW-05	MW-5	12/2/1989	Zinc	10	U	ug/L	
MW-05	MW-5	12/2/1989	Nickel	10	U	ug/L	
MW-05	MW-5	5/10/1990	Cadmium	0.7	J	ug/L	
MW-05	MW-5	5/10/1990	Chromium	20	U	ug/L	
MW-05	MW-5	5/10/1990	Silver	20	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
MW-05	MW-5	5/10/1990	Antimony	19	J	ug/L	
MW-05	MW-5	5/10/1990	Arsenic	5	U	ug/L	
MW-05	MW-5	5/10/1990	Beryllium	10	U	ug/L	
MW-05	MW-5	5/10/1990	Copper	20	U	ug/L	
MW-05	MW-5	5/10/1990	Lead	5	U	ug/L	
MW-05	MW-5	5/10/1990	Mercury	0.5	U	ug/L	
MW-05	MW-5	5/10/1990	Selenium	5	U	ug/L	
MW-05	MW-5	5/10/1990	Thallium	5	U	ug/L	
MW-05	MW-5	5/10/1990	Zinc	20	U	ug/L	
MW-05	MW-5	5/10/1990	Nickel	30	U	ug/L	
MW-08	MW-8	9/30/1997	Arsenic	5	U	ug/L	
MW-08	MW-8	9/22/1999	Arsenic	5	U	ug/L	
MW-08	MW-8	12/30/1999	Arsenic	5	U	ug/L	
MW-08	MW-8	3/28/2000	Arsenic	5	U	ug/L	
MW-08	MW-8	6/28/2000	Arsenic	3.3	J	ug/L	
MW-09	MW-9	9/30/1997	Arsenic	5	U	ug/L	
MW-09	MW-9	9/22/1999	Arsenic	5	U	ug/L	
MW-09	MW-9	12/29/1999	Arsenic	5	U	ug/L	
MW-09	MW-9	3/28/2000	Iron	20	U	ug/L	
MW-09	MW-9	3/28/2000	Manganese	5	U	ug/L	
MW-09	MW-9	3/28/2000	Arsenic	5	U	ug/L	
MW-09	MW-9	6/28/2000	Arsenic	3.6	J	ug/L	
MW-10	MW-10	9/22/1999	Arsenic	6.7		ug/L	
MW-10	MW-10	12/30/1999	Arsenic	11		ug/L	
MW-10	MW-10	3/30/2000	Arsenic	9.7		ug/L	
MW-10	MW-10	6/26/2000	Arsenic	11.1		ug/L	
MW-10	MW-10	12/18/2002	Arsenic	5.6		ug/L	
MW-12	MW-12	9/30/1997	Arsenic	44		ug/L	
MW-12A	MW-12A	9/21/1999	Arsenic	5.3		ug/L	
MW-12A	MW-12A	12/30/1999	Arsenic	5	U	ug/L	
MW-12A	MW-12A	3/31/2000	Iron	20	U	ug/L	
MW-12A	MW-12A	3/31/2000	Manganese	5	U	ug/L	
MW-12A	MW-12A	3/31/2000	Arsenic	5	U	ug/L	
MW-12A	MW-12A	6/28/2000	Arsenic	4	J	ug/L	
MW-12A	MW-12A	9/2/2003	Arsenic	1.8	J	ug/L	
MW-12A	MW-24A	9/21/1999	Arsenic	5.6		ug/L	Dup of MW-12A
MW-12A	MW-24A	12/30/1999	Arsenic	5	U	ug/L	Dup of MW-12A
MW-13	MW-13	9/22/1999	Arsenic	5	U	ug/L	
MW-13	MW-13	12/30/1999	Arsenic	5	U	ug/L	
MW-13	MW-13	3/28/2000	Iron	20	U	ug/L	
MW-13	MW-13	3/28/2000	Manganese	5	U	ug/L	
MW-13	MW-13	3/28/2000	Arsenic	5	U	ug/L	
MW-13	MW-13	6/28/2000	Arsenic	3.8	J	ug/L	
MW-14	MW-14	9/21/1999	Arsenic	5	U	ug/L	
MW-14	MW-14	12/30/1999	Arsenic	5	U	ug/L	
MW-14	MW-14	3/29/2000	Iron	20	U	ug/L	
MW-14	MW-14	3/29/2000	Manganese	5	U	ug/L	
MW-14	MW-14	3/29/2000	Arsenic	5	U	ug/L	
MW-14	MW-14	6/28/2000	Arsenic	4.1	J	ug/L	
MW-14	MW-14	9/2/2003	Arsenic	3.1	J	ug/L	
MW-15	MW-15	9/21/1999	Arsenic	5	U	ug/L	
MW-15	MW-15	12/30/1999	Arsenic	5	U	ug/L	
MW-15	MW-15	3/29/2000	Iron	20	U	ug/L	
MW-15	MW-15	3/29/2000	Manganese	5	U	ug/L	
MW-15	MW-15	3/29/2000	Arsenic	5	U	ug/L	
MW-15	MW-15	6/28/2000	Arsenic	3	J	ug/L	
MW-15	MW-15	9/2/2003	Arsenic	2.2	J	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
MW-15	MW-22	9/21/1999	Arsenic	5	U	ug/L	Dup of MW-15
MW-15	MW-22	12/30/1999	Arsenic	5	U	ug/L	Dup of MW-15
MW-15	MW-22	3/29/2000	Iron	20	U	ug/L	Dup of MW-15
MW-15	MW-22	3/29/2000	Manganese	5	U	ug/L	Dup of MW-15
MW-15	MW-22	3/29/2000	Arsenic	5	U	ug/L	Dup of MW-15
MW-15	MW-22	6/28/2000	Arsenic	3.4	J	ug/L	Dup of MW-15
MW-15	MW-27	9/2/2003	Arsenic	3	J	ug/L	
MW-16	MW-16	9/22/1999	Arsenic	5	U	ug/L	
MW-16	MW-16	12/30/1999	Arsenic	5	U	ug/L	
MW-16	MW-16	3/29/2000	Iron	20	U	ug/L	
MW-16	MW-16	3/29/2000	Manganese	5	U	ug/L	
MW-16	MW-16	3/29/2000	Arsenic	5	U	ug/L	
MW-16	MW-16	6/28/2000	Arsenic	3.8	J	ug/L	
MW-16	MW-16	9/2/2003	Arsenic	3	J	ug/L	
MW-17S	MW-17S	12/18/2002	Arsenic	4.3	J	ug/L	
MW-17S	MW-17S	9/2/2003	Arsenic	3.6	J	ug/L	
MW-18D	MW-18D	12/18/2002	Arsenic	3.3	J	ug/L	
MW-18D	MW-18D	9/2/2003	Arsenic	2.4	J	ug/L	
MW-21S	MW-21S	9/2/2003	Arsenic	3.2	J	ug/L	
MW-22D	MW-22D	9/2/2003	Arsenic	2.8	J	ug/L	
MW-23S	MW-23S	9/2/2003	Arsenic	2.3	J	ug/L	
MW-24D	MW-24D	9/2/2003	Arsenic	3.5	J	ug/L	
MW-25S	MW-25S	9/2/2003	Arsenic	2.4	J	ug/L	
MW-26D	MW-26D	9/2/2003	Arsenic	3	J	ug/L	
N Supply	North Supply	12/1/1995	Barium	35		ug/L	
N Supply	North Supply	12/1/1995	Cadmium	4	U	ug/L	
N Supply	North Supply	12/1/1995	Chromium	20	U	ug/L	
N Supply	North Supply	12/1/1995	Iron	44		ug/L	
N Supply	North Supply	12/1/1995	Manganese	20	U	ug/L	
N Supply	North Supply	12/1/1995	Silver	10	U	ug/L	
N Supply	North Supply	12/1/1995	Antimony	3	U	ug/L	
N Supply	North Supply	12/1/1995	Arsenic	5	U	ug/L	
N Supply	North Supply	12/1/1995	Beryllium	4	U	ug/L	
N Supply	North Supply	12/1/1995	Copper	10	U	ug/L	
N Supply	North Supply	12/1/1995	Lead	2	U	ug/L	
N Supply	North Supply	12/1/1995	Mercury	0.2	U	ug/L	
N Supply	North Supply	12/1/1995	Selenium	5	U	ug/L	
N Supply	North Supply	12/1/1995	Thallium	2	U	ug/L	
N Supply	North Supply	12/1/1995	Zinc	124		ug/L	
N Supply	North Supply	12/1/1995	Nickel	30	U	ug/L	
N Supply	North Supply Well	6/27/2002	Arsenic	4.6	J	ug/L	
OH-EW-01	OH-EW-1	10/4/1995	Arsenic	5	U	ug/L	
OH-EW-01	OH-EW-1	9/16/1998	Arsenic	5	U	ug/L	
OH-EW-01	OH-EW-1	3/30/2000	Arsenic	5	U	ug/L	
OH-EW-01	OH-EW-1	6/29/2000	Arsenic	2.8	J	ug/L	
OH-EW-01	OH-EW-1	10/5/2000	Arsenic	5	U	ug/L	
OH-EW-01	OH-EW-1	4/19/2001	Arsenic	3.7	J	ug/L	
OH-EW-01	OH-EW-1	6/19/2001	Arsenic	2.9	J	ug/L	
OH-EW-01	OH-EW-1	9/13/2001	Arsenic	2.9	J	ug/L	
OH-EW-01	OH-EW-1	12/6/2001	Arsenic	2.7	J	ug/L	
OH-EW-01	OH-EW-1	3/21/2002	Arsenic	2.8	J	ug/L	
OH-EW-01	OH-EW-1	6/27/2002	Arsenic	3.8	J	ug/L	
OH-EW-01	OH-EW-1	9/27/2002	Arsenic	3.3	J	ug/L	
OH-EW-01	OH-EW-1	12/19/2002	Arsenic	6.2	J	ug/L	
OH-EW-01	OH-EW-1	5/16/2003	Arsenic	3	J	ug/L	
OH-EW-01	OH-EW-1	9/5/2003	Arsenic	2.1	J	ug/L	
OH-EW-01	OH-EW-1	7/1/2004	Arsenic	2.5	J	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
OH-EW-01	OH-EW-1	10/29/2004	Arsenic	5	J	ug/L	
OH-EW-01	OH-EW-1	7/29/2005	Arsenic	3.4		ug/L	
OH-EW-01	OH-EW-1	10/29/2005	Arsenic	3.16		ug/L	
OH-EW-01	OH-EW-1	4/22/2006	Arsenic	2.95		ug/L	
OH-EW-01	OH-EW-1	10/25/2006	Arsenic	3.32		ug/L	
OH-EW-01	OH-EW-1	4/16/2007	Arsenic	3.37		ug/L	
OH-EW-01	OH-EW-1	10/22/2007	Arsenic	2.97		ug/L	
OH-EW-01	OH-EW-1	4/24/2008	Arsenic	3.32		ug/L	
OH-EW-01	OH-EW-1	10/22/2008	Arsenic	3		ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Cadmium	5	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Chromium	10	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Silver	5	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Antimony	50	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Arsenic	5	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Beryllium	5	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Copper	10	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Lead	3	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Mercury	0.2	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Selenium	5	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Thallium	5	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Zinc	10	U	ug/L	
OH-EW-01	OH-EW-1-1000	12/15/1993	Nickel	10	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Cadmium	5	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Chromium	10	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Silver	10	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Antimony	30	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Arsenic	83		ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Beryllium	5	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Copper	20	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Lead	3	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Mercury	0.5	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Selenium	2		ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Thallium	2	U	ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Zinc	40		ug/L	
OH-MW-01	OH-MW-1	12/1/1989	Nickel	10	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Cadmium	0.3	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Chromium	20	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Silver	20	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Antimony	17		ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Arsenic	150		ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Beryllium	10	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Copper	20		ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Lead	5	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Mercury	0.5	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Selenium	5	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Thallium	5	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Zinc	20	U	ug/L	
OH-MW-01	OH-MW-1	5/8/1990	Nickel	30	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Cadmium	5	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Chromium	10	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Silver	10	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Antimony	30	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Arsenic	69		ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Beryllium	5	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Copper	20	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Lead	3	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Mercury	0.5	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
OH-MW-02	OH-MW-2	12/1/1989	Selenium	5		ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Thallium	2	U	ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Zinc	20		ug/L	
OH-MW-02	OH-MW-2	12/1/1989	Nickel	10	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Cadmium	0.3	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Chromium	20	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Silver	20	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Antimony	21		ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Arsenic	85		ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Beryllium	10	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Copper	20	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Lead	5	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Mercury	0.5	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Selenium	5	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Thallium	5	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Zinc	20	U	ug/L	
OH-MW-02	OH-MW-2	5/8/1990	Nickel	30	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Cadmium	5	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Chromium	10	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Silver	10		ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Antimony	30	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Arsenic	31		ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Beryllium	5	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Copper	20	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Lead	3	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Mercury	0.5	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Selenium	5		ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Thallium	2	U	ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Zinc	30		ug/L	
OH-MW-03	OH-MW-3	12/1/1989	Nickel	10	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Cadmium	0.3	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Chromium	20	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Thallium	5	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Zinc	20	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Nickel	30	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Cadmium	5	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Chromium	10	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Silver	10	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Antimony	30	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Arsenic	95		ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Beryllium	5	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Copper	20	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Lead	3	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Mercury	0.5	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Selenium	2	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Thallium	2	U	ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Zinc	20		ug/L	
OH-MW-05	OH-MW-5	12/1/1989	Nickel	10	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Cadmium	0.3	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Chromium	20	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Silver	20	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Antimony	16		ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Arsenic	5	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Beryllium	10	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Copper	20	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Lead	5	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Mercury	0.5	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
OH-MW-05	OH-MW-5	5/8/1990	Selenium	5	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Thallium	5	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Zinc	20	U	ug/L	
OH-MW-05	OH-MW-5	5/8/1990	Nickel	30	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Cadmium	5	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Chromium	10	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Silver	10	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Antimony	30	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Arsenic	110		ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Beryllium	5	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Copper	20	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Lead	3	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Mercury	0.5	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Selenium	5		ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Thallium	2	U	ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Zinc	20		ug/L	
OH-MW-06	OH-MW-6	12/1/1989	Nickel	10	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Cadmium	0.3	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Chromium	20	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Silver	20	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Antimony	5	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Arsenic	5	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Beryllium	10	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Copper	20	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Lead	5	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Mercury	0.5	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Selenium	5	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Thallium	5	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Zinc	20	U	ug/L	
OH-MW-06	OH-MW-6	5/8/1990	Nickel	30	U	ug/L	
OH-MW-10	OH-MW-10-AS2	12/11/1990	Arsenic	110		ug/L	
TL-MW-02	TL-MW-2	10/27/1993	Chromium	10	U	ug/L	
TL-MW-03	TL-MW-3	12/3/1991	Chromium	10	U	ug/L	
TL-MW-04	TL-MW-4	12/3/1991	Chromium	10	U	ug/L	
TL-MW-04	TL-MW-4	10/27/1993	Chromium	10	U	ug/L	
TL-MW-04	TL-MW-4	4/28/1994	Chromium	10	U	ug/L	
TL-MW-04	TL-MW-4	3/30/2000	Iron	3750		ug/L	
TL-MW-04	TL-MW-4	3/30/2000	Manganese	558		ug/L	
TL-MW-04	TL-MW-4	3/30/2000	Arsenic	21.1		ug/L	
W Supply	W Water Sup.	5/11/1990	Cadmium	0.3	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Chromium	20	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Silver	20	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Silver	20	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Antimony	18		ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Arsenic	31		ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Beryllium	10	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Copper	20	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Lead	5	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Mercury	0.5	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Selenium	5	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Thallium	5	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Zinc	20	U	ug/L	
OH-MW-03	OH-MW-3	5/8/1990	Nickel	30	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Cadmium	5	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Chromium	10	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Silver	10	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Antimony	30	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
OH-MW-04	OH-MW-4	12/1/1989	Arsenic	42		ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Beryllium	5	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Copper	20	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Lead	3	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Mercury	0.5	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Selenium	2	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Thallium	2	U	ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Zinc	20		ug/L	
OH-MW-04	OH-MW-4	12/1/1989	Nickel	10	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Cadmium	0.3	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Chromium	20	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Silver	20	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Antimony	13		ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Arsenic	55		ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Beryllium	10	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Copper	20	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Lead	5	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Mercury	0.5	U	ug/L	
OH-MW-04	OH-MW-4	5/8/1990	Selenium	5	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Antimony	22	J	ug/L	
W Supply	W Water Sup.	5/11/1990	Arsenic	5	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Beryllium	10	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Copper	20	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Lead	5	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Mercury	0.5	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Selenium	5	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Thallium	5	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Zinc	10	U	ug/L	
W Supply	W Water Sup.	5/11/1990	Nickel	30	U	ug/L	
WW-EW-01	WW-EW-1	10/5/1995	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	9/30/1997	Arsenic	5.3		ug/L	
WW-EW-01	WW-EW-1	12/16/1997	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	2/18/1998	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	5/4/1998	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	9/16/1998	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	12/15/1998	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	9/22/1999	Arsenic	5.2		ug/L	
WW-EW-01	WW-EW-1	3/30/2000	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	6/29/2000	Arsenic	4.3	J	ug/L	
WW-EW-01	WW-EW-1	10/5/2000	Arsenic	5	U	ug/L	
WW-EW-01	WW-EW-1	4/19/2001	Arsenic	5		ug/L	
WW-EW-01	WW-EW-1	6/19/2001	Arsenic	3.3	J	ug/L	
WW-EW-01	WW-EW-1	9/13/2001	Arsenic	3.9	J	ug/L	
WW-EW-01	WW-EW-1	12/6/2001	Arsenic	1.6	J	ug/L	
WW-EW-01	WW-EW-1	3/21/2002	Arsenic	4.4	J	ug/L	
WW-EW-01	WW-EW-1	6/27/2002	Arsenic	4.7	J	ug/L	
WW-EW-01	WW-EW-1	9/27/2002	Arsenic	3.9	J	ug/L	
WW-EW-01	WW-EW-1	12/19/2002	Arsenic	6.8	J	ug/L	
WW-EW-01	WW-EW-1	5/16/2003	Arsenic	3.4	J	ug/L	
WW-EW-01	WW-EW-1	9/5/2003	Arsenic	3.7	J	ug/L	
WW-EW-01	WW-EW-1	7/1/2004	Arsenic	4.2	J	ug/L	
WW-EW-01	WW-EW-1	10/29/2004	Arsenic	20	U	ug/L	
WW-EW-01	WW-EW-1	7/29/2005	Arsenic	4.4		ug/L	
WW-EW-01	WW-EW-1	10/28/2005	Arsenic	4		ug/L	
WW-EW-01	WW-EW-1	4/20/2006	Arsenic	4.02		ug/L	
WW-EW-01	WW-EW-1	10/25/2006	Arsenic	4.2		ug/L	
WW-EW-01	WW-EW-1	10/22/2007	Arsenic	3.89		ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
WW-EW-01	WW-EW-1	4/24/2008	Arsenic	4.44		ug/L	
WW-EW-01	WW-EW-1	10/22/2008	Arsenic	3.9		ug/L	
WW-EW-01	WW-EW-1 DUP	12/15/1998	Arsenic	5	U	ug/L	Dup of WW-EW-1
WW-EW-01	WW-EW-100	10/22/2008	Arsenic	4.1		ug/L	Dup of WW-EW-1
WW-EW-02	WW-EW-2	2/18/1998	Arsenic	5.3		ug/L	
WW-EW-02	WW-EW-2	5/4/1998	Arsenic	5	U	ug/L	
WW-EW-02	WW-EW-2	9/16/1998	Arsenic	5.1		ug/L	
WW-EW-02	WW-EW-2	12/15/1998	Arsenic	5	U	ug/L	
WW-EW-02	WW-EW-2	12/29/1999	Arsenic	5	U	ug/L	
WW-EW-02	WW-EW-2	3/30/2000	Arsenic	5	U	ug/L	
WW-EW-02	WW-EW-2	6/29/2000	Arsenic	4.4	J	ug/L	
WW-EW-02	WW-EW-2	10/5/2000	Arsenic	5	U	ug/L	
WW-EW-02	WW-EW-2	4/19/2001	Arsenic	4.9	J	ug/L	
WW-EW-02	WW-EW-2	6/19/2001	Arsenic	3.4	J	ug/L	
WW-EW-02	WW-EW-2	9/13/2001	Arsenic	4.2	J	ug/L	
WW-EW-02	WW-EW-2	12/6/2001	Arsenic	3.9	J	ug/L	
WW-EW-02	WW-EW-2	3/21/2002	Arsenic	4.2	J	ug/L	
WW-EW-02	WW-EW-2	6/27/2002	Arsenic	5	J	ug/L	
WW-EW-02	WW-EW-2	9/27/2002	Arsenic	4	J	ug/L	
WW-EW-02	WW-EW-2	12/19/2002	Arsenic	6.5	J	ug/L	
WW-EW-02	WW-EW-2	5/16/2003	Arsenic	3	J	ug/L	
WW-EW-02	WW-EW-2	9/5/2003	Arsenic	4.9	J	ug/L	
WW-EW-02	WW-EW-2	7/1/2004	Arsenic	3.9	J	ug/L	
WW-EW-02	WW-EW-2	10/29/2004	Arsenic	20	U	ug/L	
WW-EW-02	WW-EW-2	7/29/2005	Arsenic	4.8		ug/L	
WW-EW-02	WW-EW-2	10/28/2005	Arsenic	3.9		ug/L	
WW-EW-02	WW-EW-2	4/23/2006	Arsenic	3.69		ug/L	
WW-EW-02	WW-EW-2	10/25/2006	Arsenic	4.44		ug/L	
WW-EW-02	WW-EW-2	10/22/2007	Arsenic	4.07		ug/L	
WW-EW-02	WW-EW-2	4/24/2008	Arsenic	4.18		ug/L	
WW-EW-02	WW-EW-2	10/22/2008	Arsenic	4.2		ug/L	
WW-EW-02	WW-EW-WA	10/28/2005	Arsenic	4.1		ug/L	Dup of WW-EW-2
WW-EW-03	WW-EW-3	4/25/2008	Arsenic	4.9		ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Chromium	10	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Silver	10	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Antimony	30	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Arsenic	2	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Copper	20	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Lead	3	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Mercury	0.5	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Selenium	2	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Thallium	2	U	ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Zinc	10		ug/L	
WW-MW-01	WW-MW-1	11/30/1989	Nickel	10	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Chromium	20	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Silver	20	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Antimony	19		ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Arsenic	6		ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Copper	20	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Lead	5	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Selenium	5	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Thallium	5	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
WW-MW-01	WW-MW-1	5/9/1990	Zinc	20	U	ug/L	
WW-MW-01	WW-MW-1	5/9/1990	Nickel	30	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Chromium	10	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Silver	10	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Antimony	30	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Arsenic	2	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Copper	20	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Lead	3	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Mercury	0.5	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Selenium	2	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Thallium	2	U	ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Zinc	10		ug/L	
WW-MW-02	WW-MW-2	11/30/1989	Nickel	10	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Chromium	20	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Silver	20	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Antimony	23		ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Arsenic	6		ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Copper	20	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Lead	5	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Selenium	5	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Thallium	5	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Zinc	20	U	ug/L	
WW-MW-02	WW-MW-2	5/9/1990	Nickel	30	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Chromium	10	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Silver	10	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Antimony	30	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Arsenic	48		ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Copper	20	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Lead	3	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Mercury	0.5	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Selenium	2	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Thallium	2	U	ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Zinc	10		ug/L	
WW-MW-03	WW-MW-3	11/30/1989	Nickel	10	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Chromium	20	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Silver	20	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Antimony	16		ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Arsenic	20		ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Copper	20	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Lead	5	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Selenium	5	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Thallium	5	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Zinc	20	U	ug/L	
WW-MW-03	WW-MW-3	5/9/1990	Nickel	30	U	ug/L	
WW-MW-03	WW-MW-3	9/29/1997	Arsenic	28		ug/L	
WW-MW-03	WW-MW-3	3/29/2000	Iron	165		ug/L	
WW-MW-03	WW-MW-3	3/29/2000	Manganese	118		ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
WW-MW-03	WW-MW-3	3/29/2000	Arsenic	5.2		ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Chromium	10	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Silver	30		ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Antimony	30	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Arsenic	33		ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Copper	20	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Lead	3	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Mercury	0.5	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Selenium	2	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Thallium	2	U	ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Zinc	10		ug/L	
WW-MW-04	WW-MW-4	11/30/1989	Nickel	10	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Chromium	20	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Silver	20	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Antimony	8		ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Arsenic	56		ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Copper	20	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Lead	5	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Selenium	5	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Thallium	5	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Zinc	20	U	ug/L	
WW-MW-04	WW-MW-4	5/9/1990	Nickel	30	U	ug/L	
WW-MW-04	WW-MW-4B	5/9/1990	Cadmium	0.3	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Chromium	20	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Silver	20	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Antimony	10		ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Arsenic	48		ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Beryllium	10	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Copper	20	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Lead	5	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Mercury	0.5	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Selenium	5	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Thallium	5	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Zinc	20	U	ug/L	Dup of WW-MW-04
WW-MW-04	WW-MW-4B	5/9/1990	Nickel	30	U	ug/L	Dup of WW-MW-04
WW-MW-05	WW-MW-5	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Chromium	10	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Silver	10	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Antimony	30	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Arsenic	25		ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Copper	20	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Lead	3	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Mercury	0.5	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Selenium	2	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Thallium	2	U	ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Zinc	10		ug/L	
WW-MW-05	WW-MW-5	11/30/1989	Nickel	10	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Chromium	20	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Silver	20	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Antimony	10		ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
WW-MW-05	WW-MW-5	5/9/1990	Arsenic	28		ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Copper	20	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Lead	5	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Selenium	5	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Thallium	5	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Zinc	20	U	ug/L	
WW-MW-05	WW-MW-5	5/9/1990	Nickel	30	U	ug/L	
WW-MW-05	WW-MW-5B	5/9/1990	Cadmium	0.3	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Chromium	20	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Silver	20	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Antimony	13		ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Arsenic	23		ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Beryllium	10	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Copper	20	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Lead	5	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Mercury	0.5	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Selenium	5	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Thallium	5	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Zinc	20	U	ug/L	Dup of WW-MW-05
WW-MW-05	WW-MW-5B	5/9/1990	Nickel	30	U	ug/L	Dup of WW-MW-05
WW-MW-06	WW-MW-6	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Chromium	10	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Silver	10	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Antimony	30	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Arsenic	20		ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Copper	20	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Lead	3	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Mercury	0.5	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Selenium	3		ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Thallium	2	U	ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Zinc	20		ug/L	
WW-MW-06	WW-MW-6	11/30/1989	Nickel	10	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Chromium	20	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Silver	20	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Antimony	9		ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Arsenic	18		ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Copper	20	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Lead	5	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Selenium	5	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Thallium	5	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Zinc	20	U	ug/L	
WW-MW-06	WW-MW-6	5/9/1990	Nickel	30	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Cadmium	5	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Chromium	10	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Silver	10	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Antimony	30	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Arsenic	15		ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Beryllium	5	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Copper	20	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Lead	3	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Mercury	0.5	U	ug/L	

Table 3-3 - Summary Results for Total Metals in Groundwater

Station	Sample ID	Date	Analyte Name	Value	Qual	Units	Comment
WW-MW-07	WW-MW-7	11/30/1989	Selenium	5		ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Thallium	2	U	ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Zinc	20		ug/L	
WW-MW-07	WW-MW-7	11/30/1989	Nickel	10	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Cadmium	0.3	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Chromium	20	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Silver	20	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Antimony	18		ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Arsenic	5	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Beryllium	10	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Copper	20	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Lead	5	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Mercury	0.5	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Selenium	5	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Thallium	5	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Zinc	20	U	ug/L	
WW-MW-07	WW-MW-7	5/9/1990	Nickel	30	U	ug/L	
WW-MW-07	WW-MW-7	3/29/2000	Iron	37.5		ug/L	
WW-MW-07	WW-MW-7	3/29/2000	Manganese	107		ug/L	
WW-MW-07	WW-MW-7	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-08	WW-MW-8	3/29/2000	Iron	20.7		ug/L	
WW-MW-08	WW-MW-8	3/29/2000	Manganese	19.1		ug/L	
WW-MW-08	WW-MW-8	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-09	WW-MW-9	3/29/2000	Iron	615		ug/L	
WW-MW-09	WW-MW-9	3/29/2000	Manganese	131		ug/L	
WW-MW-09	WW-MW-9	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-10	WW-MW-10	3/29/2000	Iron	252		ug/L	
WW-MW-10	WW-MW-10	3/29/2000	Manganese	113		ug/L	
WW-MW-10	WW-MW-10	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-11	WW-MW-11	3/29/2000	Iron	20	U	ug/L	
WW-MW-11	WW-MW-11	3/29/2000	Manganese	5	U	ug/L	
WW-MW-11	WW-MW-11	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-12	WW-MW-12	3/29/2000	Iron	20	U	ug/L	
WW-MW-12	WW-MW-12	3/29/2000	Manganese	5	U	ug/L	
WW-MW-12	WW-MW-12	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-15	WW-MW-15	9/30/1997	Arsenic	5	U	ug/L	
WW-MW-15	WW-MW-15	3/29/2000	Iron	20	U	ug/L	
WW-MW-15	WW-MW-15	3/29/2000	Manganese	5	U	ug/L	
WW-MW-15	WW-MW-15	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-18	WW-MW-18	9/30/1997	Arsenic	380		ug/L	
WW-MW-18	WW-MW-18	9/21/1999	Arsenic	6.7		ug/L	
WW-MW-18	WW-MW-18	3/29/2000	Iron	20	U	ug/L	
WW-MW-18	WW-MW-18	3/29/2000	Manganese	5	U	ug/L	
WW-MW-18	WW-MW-18	3/29/2000	Arsenic	5	U	ug/L	
WW-MW-18	WW-MW-18	9/2/2003	Arsenic	15.8		ug/L	
WW-MW-18	WW-MW-BD	9/30/1997	Arsenic	400		ug/L	Dup of WW-MW-18
WW-MW-19	WW-MW-19	3/29/2000	Iron	2480		ug/L	
WW-MW-19	WW-MW-19	3/29/2000	Manganese	651		ug/L	
WW-MW-19	WW-MW-19	3/29/2000	Arsenic	13		ug/L	

Table 3-4 - Summary of PCB Congener Detections and Reporting Limits

Analyte	Homolog Group	Congener Number	Unit	No. of Samples		No. of Detects		Congener Reporting Limits
				Fall 2008	Spring 2009	Fall 2008	Spring 2009	
CL1-PCB-1	CL1	1	pg/L	17	20	17	20	0.59
CL1-PCB-2	CL1	2	pg/L	17	20	3	4	0.674
CL1-PCB-3	CL1	3	pg/L	17	20	17	18	0.88
CL2-PCB-4	CL2	4	pg/L	17	20	17	20	8.42
CL2-PCB-5	CL2	5	pg/L	17	20	3	4	5.85
CL2-PCB-6	CL2	6	pg/L	17	20	14	19	5.21
CL2-PCB-7	CL2	7	pg/L	17	20	15	13	5.16
CL2-PCB-8	CL2	8	pg/L	17	20	16	19	4.97
CL2-PCB-9	CL2	9	pg/L	17	20	12	17	5.09
CL2-PCB-10	CL2	10	pg/L	17	20	16	20	4.98
CL2-PCB-11	CL2	11	pg/L	17	20	15	16	5.46
CL2-PCB-12/13	CL2	12/13	pg/L	17	20	14	17	5.43
CL2-PCB-14	CL2	14	pg/L	17	20	0	0	5.21
CL2-PCB-15	CL2	15	pg/L	17	20	15	19	6.94
CL3-PCB-16	CL3	16	pg/L	17	20	17	20	0.501
CL3-PCB-17	CL3	17	pg/L	17	20	17	20	0.501
CL3-PCB-18/30	CL3	18/30	pg/L	17	20	17	20	0.501
CL3-PCB-19	CL3	19	pg/L	17	20	17	20	0.501
CL3-PCB-20/28	CL3	20/28	pg/L	17	20	17	20	8.63
CL3-PCB-21/33	CL3	21/33	pg/L	17	20	17	20	8.13
CL3-PCB-22	CL3	22	pg/L	17	20	17	20	9.41
CL3-PCB-23	CL3	23	pg/L	17	20	0	2	8.54
CL3-PCB-24	CL3	24	pg/L	17	20	17	20	0.501
CL3-PCB-25	CL3	25	pg/L	17	20	17	20	8.12
CL3-PCB-26/29	CL3	26/29	pg/L	17	20	17	20	8.5
CL3-PCB-27	CL3	27	pg/L	17	20	17	20	0.501
CL3-PCB-31	CL3	31	pg/L	17	20	17	20	8.25
CL3-PCB-32	CL3	32	pg/L	17	20	17	20	8.26
CL3-PCB-34	CL3	34	pg/L	17	20	15	19	8.68
CL3-PCB-35	CL3	35	pg/L	17	20	10	11	9.63
CL3-PCB-36	CL3	36	pg/L	17	20	0	0	9.24
CL3-PCB-37	CL3	37	pg/L	17	20	17	20	9.43
CL3-PCB-38	CL3	38	pg/L	17	20	11	8	8.99
CL3-PCB-39	CL3	39	pg/L	17	20	14	16	9
CL4-PCB-40/41/71	CL4	40/41/71	pg/L	17	20	17	20	0.544
CL4-PCB-42	CL4	42	pg/L	17	20	17	20	0.501
CL4-PCB-43	CL4	43	pg/L	17	20	17	20	0.642
CL4-PCB-44/47/65	CL4	44/47/65	pg/L	17	20	17	20	0.506

Table 3-4 - Summary of PCB Congener Detections and Reporting Limits

Analyte	Homolog Group	Congener Number	Unit	No. of Samples		No. of Detects		Congener Reporting Limits
				Fall 2008	Spring 2009	Fall 2008	Spring 2009	
CL4-PCB-45/51	CL4	45/51	pg/L	17	20	17	20	0.586
CL4-PCB-46	CL4	46	pg/L	17	20	17	20	0.646
CL4-PCB-48	CL4	48	pg/L	17	20	17	20	0.534
CL4-PCB-49/69	CL4	49/69	pg/L	17	20	17	20	0.501
CL4-PCB-50/53	CL4	50/53	pg/L	17	20	17	20	0.571
CL4-PCB-52	CL4	52	pg/L	17	20	17	20	0.556
CL4-PCB-54	CL4	54	pg/L	17	20	17	20	0.599
CL4-PCB-55	CL4	55	pg/L	17	20	5	12	6.69
CL4-PCB-56	CL4	56	pg/L	17	20	17	20	3.57
CL4-PCB-57	CL4	57	pg/L	17	20	13	17	3.76
CL4-PCB-58	CL4	58	pg/L	17	20	12	13	3.81
CL4-PCB-59/62/75	CL4	59/62/75	pg/L	17	20	17	20	0.501
CL4-PCB-60	CL4	60	pg/L	17	20	17	20	3.6
CL4-PCB-61/70/74/76	CL4	61/70/74/76	pg/L	17	20	17	20	3.36
CL4-PCB-63	CL4	63	pg/L	17	20	17	20	3.37
CL4-PCB-64	CL4	64	pg/L	17	20	17	20	0.501
CL4-PCB-66	CL4	65	pg/L	17	20	17	20	3.35
CL4-PCB-67	CL4	66	pg/L	17	20	15	20	3.1
CL4-PCB-68	CL4	67	pg/L	17	20	10	14	3.91
CL4-PCB-72	CL4	68	pg/L	17	20	13	18	3.72
CL4-PCB-73	CL4	69	pg/L	17	20	0	0	0.501
CL4-PCB-77	CL4	70	pg/L	17	20	14	16	3.29
CL4-PCB-78	CL4	71	pg/L	17	20	0	0	3.51
CL4-PCB-79	CL4	72	pg/L	17	20	15	16	3.11
CL4-PCB-80	CL4	73	pg/L	17	20	1	0	3.21
CL4-PCB-81	CL4	74	pg/L	17	20	6	8	3.54
CL5-PCB-82	CL5	75	pg/L	17	20	17	20	0.977
CL5-PCB-83/99	CL5	83/89	pg/L	17	20	17	20	0.913
CL5-PCB-84	CL5	84	pg/L	17	20	17	20	1.06
CL5-PCB-85/116/117	CL5	85/116/117	pg/L	17	20	17	20	0.746
CB-86/87/97/108/119/125		86/87/97/108/119/125	pg/L	17	20	17	20	0.784
CL5-PCB-88/91	CL5	88/91	pg/L	17	20	17	20	0.936
CL5-PCB-89	CL5	89	pg/L	17	20	14	20	0.987
CL5-PCB-90/101/113	CL5	90/101/113	pg/L	17	20	17	20	0.809
CL5-PCB-92	CL5	92	pg/L	17	20	17	20	0.927
CL5-PCB-93/95/98/100/102	CL5	93/95/98/100/102	pg/L	17	20	17	20	0.949

Table 3-4 - Summary of PCB Congener Detections and Reporting Limits

Analyte	Homolog Group	Congener Number	Unit	No. of Samples		No. of Detects		Congener Reporting Limits
				Fall 2008	Spring 2009	Fall 2008	Spring 2009	
CL5-PCB-94	CL5	94	pg/L	17	20	17	20	1.05
CL5-PCB-96	CL5	96	pg/L	17	20	17	20	0.501
CL5-PCB-103	CL5	103	pg/L	17	20	14	19	0.874
CL5-PCB-104	CL5	104	pg/L	17	20	6	8	0.501
CL5-PCB-105	CL5	105	pg/L	17	20	17	20	1.09
CL5-PCB-106	CL5	106	pg/L	17	20	2	2	1.18
CL5-PCB-107/124	CL5	107/124	pg/L	17	20	14	17	1.4
CL5-PCB-109	CL5	109	pg/L	17	20	14	19	1.29
CL5-PCB-110/115	CL5	110/115	pg/L	17	20	17	20	0.661
CL5-PCB-111	CL5	111	pg/L	17	20	0	1	0.676
CL5-PCB-112	CL5	112	pg/L	17	20	0	0	0.652
CL5-PCB-114	CL5	114	pg/L	17	20	15	17	1.18
CL5-PCB-118	CL5	118	pg/L	17	20	17	20	1.15
CL5-PCB-120	CL5	120	pg/L	17	20	3	4	0.634
CL5-PCB-121	CL5	121	pg/L	17	20	0	0	0.708
CL5-PCB-122	CL5	122	pg/L	17	20	14	17	1.35
CL5-PCB-123	CL5	123	pg/L	17	20	14	17	1.21
CL5-PCB-126	CL5	126	pg/L	17	20	4	3	1.2
CL5-PCB-127	CL5	127	pg/L	17	20	0	1	1.27
CL6-PCB-128/166	CL6	128/166	pg/L	17	20	17	17	0.501
CL6-PCB-129/138/160/163	CL6	129/138/160/163	pg/L	17	20	17	20	0.501
CL6-PCB-130	CL6	130	pg/L	17	20	14	17	0.501
CL6-PCB-131	CL6	131	pg/L	17	20	10	14	0.501
CL6-PCB-132	CL6	132	pg/L	17	20	17	20	0.501
CL6-PCB-133	CL6	133	pg/L	17	20	7	12	0.501
CL6-PCB-134/143	CL6	134/143	pg/L	17	20	14	17	0.501
CL6-PCB-135/151/154	CL6	135/151/154	pg/L	17	20	17	20	0.501
CL6-PCB-136	CL6	136	pg/L	17	20	17	20	0.501
CL6-PCB-137	CL6	137	pg/L	17	20	13	17	0.501
CL6-PCB-139/140	CL6	139/140	pg/L	17	20	12	15	0.501
CL6-PCB-141	CL6	141	pg/L	17	20	15	17	0.501
CL6-PCB-142	CL6	142	pg/L	17	20	0	1	0.501
CL6-PCB-144	CL6	144	pg/L	17	20	13	17	0.501
CL6-PCB-145	CL6	145	pg/L	17	20	1	3	0.501
CL6-PCB-146	CL6	146	pg/L	17	20	17	18	0.501
CL6-PCB-147/149	CL6	147/149	pg/L	17	20	17	20	0.501
CL6-PCB-148	CL6	148	pg/L	17	20	2	3	0.501

Table 3-4 - Summary of PCB Congener Detections and Reporting Limits

Analyte	Homolog Group	Congener Number	Unit	No. of Samples		No. of Detects		Congener Reporting Limits
				Fall 2008	Spring 2009	Fall 2008	Spring 2009	
CL6-PCB-150	CL6	150	pg/L	17	20	2	3	0.501
CL6-PCB-152	CL6	152	pg/L	17	20	2	3	0.501
CL6-PCB-153/168	CL6	153/168	pg/L	17	20	17	20	0.501
CL6-PCB-155	CL6	155	pg/L	17	20	0	0	0.501
CL6-PCB-156/157	CL6	156/157	pg/L	17	20	16	17	0.501
CL6-PCB-158	CL6	158	pg/L	17	20	13	16	0.501
CL6-PCB-159	CL6	159	pg/L	17	20	1	5	0.501
CL6-PCB-161	CL6	161	pg/L	17	20	0	0	0.501
CL6-PCB-162	CL6	162	pg/L	17	20	2	5	0.501
CL6-PCB-164	CL6	164	pg/L	17	20	13	16	0.501
CL6-PCB-165	CL6	165	pg/L	17	20	0	0	0.501
CL6-PCB-167	CL6	167	pg/L	17	20	11	12	0.501
CL6-PCB-169	CL6	169	pg/L	17	20	1	0	0.501
CL7-PCB-170	CL7	170	pg/L	17	20	17	14	0.501
CL7-PCB-171/173	CL7	171/173	pg/L	17	20	7	9	0.501
CL7-PCB-172	CL7	172	pg/L	17	20	5	7	0.501
CL7-PCB-174	CL7	174	pg/L	17	20	16	17	0.501
CL7-PCB-175	CL7	175	pg/L	17	20	3	5	0.501
CL7-PCB-176	CL7	176	pg/L	17	20	4	6	0.501
CL7-PCB-177	CL7	177	pg/L	17	20	12	12	0.501
CL7-PCB-178	CL7	178	pg/L	17	20	8	11	0.501
CL7-PCB-179	CL7	179	pg/L	17	20	12	14	0.501
CL7-PCB-180/193	CL7	180/193	pg/L	17	20	17	19	0.501
CL7-PCB-181	CL7	181	pg/L	17	20	1	3	0.501
CL7-PCB-182	CL7	182	pg/L	17	20	2	1	0.501
CL7-PCB-183/185	CL7	183/185	pg/L	17	20	15	11	0.501
CL7-PCB-184	CL7	184	pg/L	17	20	0	0	0.501
CL7-PCB-186	CL7	186	pg/L	17	20	0	0	0.501
CL7-PCB-187	CL7	187	pg/L	17	20	17	18	0.501
CL7-PCB-188	CL7	188	pg/L	17	20	0	1	0.501
CL7-PCB-189	CL7	189	pg/L	17	20	3	5	0.501
CL7-PCB-190	CL7	190	pg/L	17	20	4	7	0.501
CL7-PCB-191	CL7	191	pg/L	17	20	2	5	0.501
CL7-PCB-192	CL7	192	pg/L	17	20	0	0	0.501
CL8-PCB-194	CL8	194	pg/L	17	20	11	9	0.501
CL8-PCB-195	CL8	195	pg/L	17	20	5	6	0.501
CL8-PCB-196	CL8	196	pg/L	17	20	5	8	0.501
CL8-PCB-197/200	CL8	197/200	pg/L	17	20	2	4	0.501

Table 3-4 - Summary of PCB Congener Detections and Reporting Limits

Analyte	Homolog Group	Congener Number	Unit	No. of Samples		No. of Detects		Congener Reporting Limits
				Fall 2008	Spring 2009	Fall 2008	Spring 2009	
CL8-PCB-198/199	CL8	198/199	pg/L	17	20	13	11	0.501
CL8-PCB-201	CL8	201	pg/L	17	20	2	5	0.501
CL8-PCB-202	CL8	202	pg/L	17	20	4	6	0.501
CL8-PCB-203	CL8	203	pg/L	17	20	8	8	0.501
CL8-PCB-204	CL8	204	pg/L	17	20	0	0	0.501
CL8-PCB-205	CL8	205	pg/L	17	20	3	5	0.501
CL9-PCB-206	CL9	206	pg/L	17	20	3	6	0.501
CL9-PCB-207	CL9	207	pg/L	17	20	1	2	0.501
CL9-PCB-208	CL9	208	pg/L	17	20	2	5	0.501
CL10-PCB-209	CL10	209	pg/L	17	20	16	19	0.501

Well Location Plan

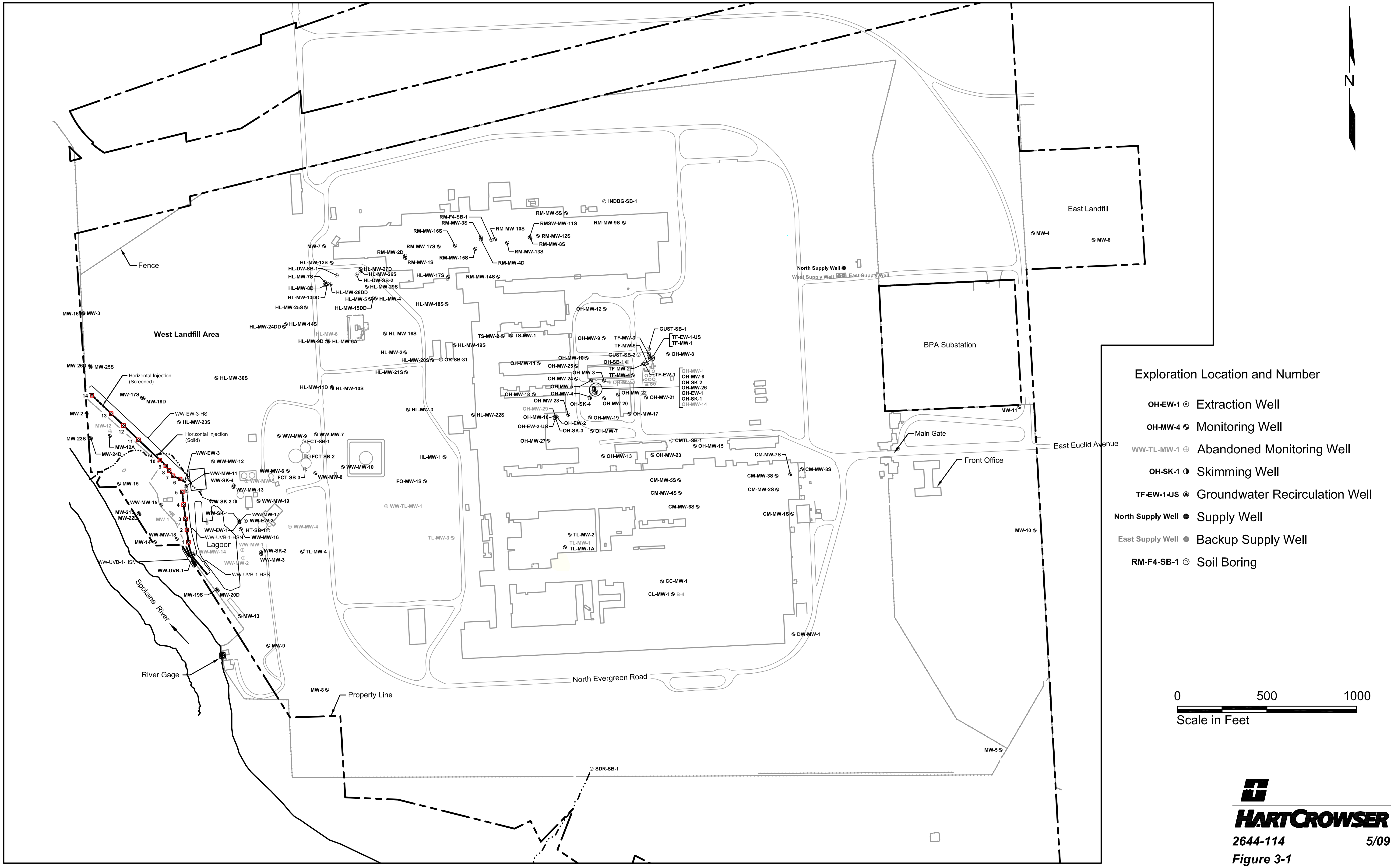

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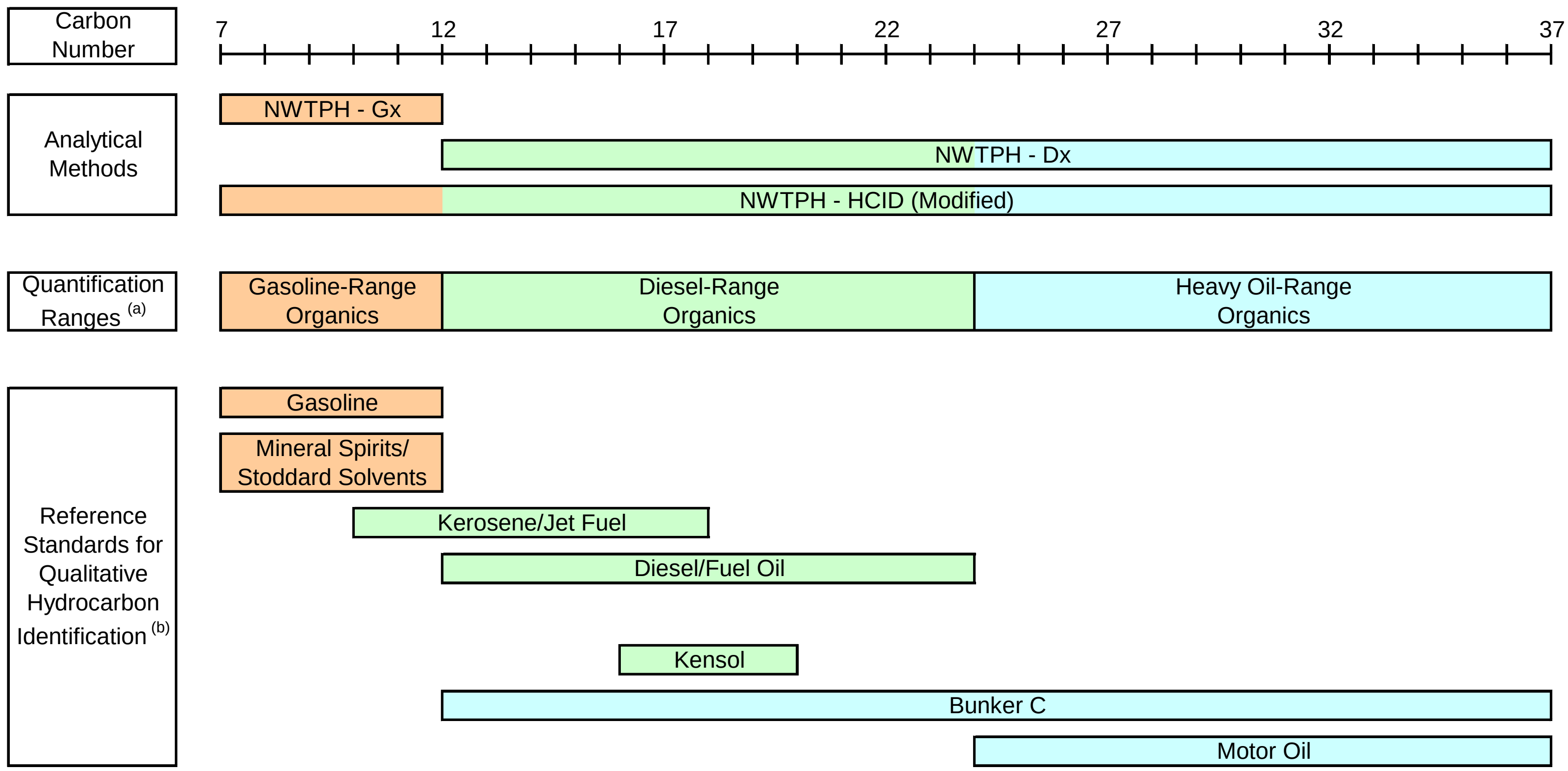
Figure 3-1

Hydrocarbon Ranges, Corresponding Component, and Analytical Methods



🟧 Gasoline-Range Organics
🟩 Diesel-Range Organics
🟦 Heavy Oil-Range Organics

(a) Petroleum components are grouped into Gasoline-, Diesel-, and Heavy Oil-Range Organics for comparision to screening levels.

(b) Typical composition range for each petroleum product is presented.

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Figure 3-2

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Petroleum Hydrocarbon Screening Level Flow Chart

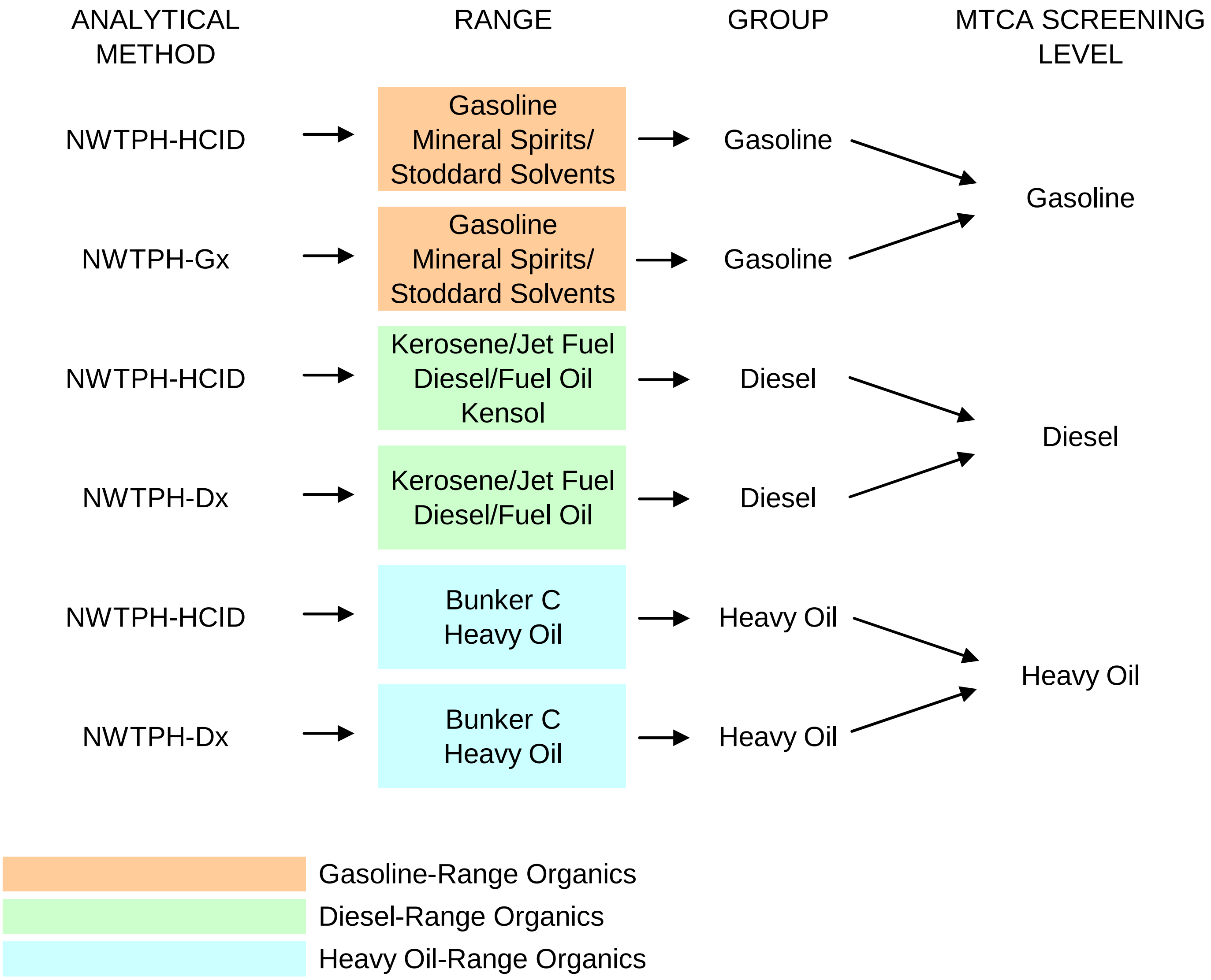

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Figure 3-3

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Site and Exploration Map

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Plate 1

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FIGURES

4.0 HYDROGEOLOGY AND SURFACE WATER HYDROLOGY

This section describes the regional and local geology and hydrogeology in the vicinity of the Facility in addition to the conventional chemical characteristics of surface water and groundwater. The geology and hydrogeology are defined using regional data sources and site-specific explorations. The physical site descriptions presented in this section are developed largely from on-site exploration logs and water level monitoring data. For reference, these data sources are presented in Appendices A and B, respectively and in Appendix A of the 2003 Groundwater RI/FS report (DVD enclosed) for wells installed prior to 2003.

4.1 REGIONAL GEOLOGY AND HYDROGEOLOGY

4.1.1 Geology

The regional geology in the Spokane Valley area consists of six primary geological units. A geologic map is provided on Figure 4-1. A geologic cross section showing the relationship of the regional geologic units is shown on Figure 4-2. The six primary geological units from youngest to oldest are described by Johnson et al. (1998) and provided below.

- **Undifferentiated Alluvium and Loess Deposits, Holocene to Pleistocene (Qa and Ql).** The alluvium unit (Qa) consists of stratified to unstratified and well sorted to poorly sorted boulders, cobbles, gravel, sand, silt, and clay in floodplains, terraces, and valley bottoms. The loess unit (Ql) consists chiefly of massive eolian silt and fine sand ranging in color from light tan to yellow-brown to dark red to orange-brown. Older loess layers typically have deeper coloration. The loess has a maximum thickness of 75 feet in Spokane County; it averages 20 feet thick south of the Spokane River and thins to the north where there is more topographic relief.

- **Glacial Flood Deposits, Pleistocene (Qglf and Qfg).** The glaciolacustrine deposits consist of silt, clay, and fine sand with interbedded coarse clastic deposits of catastrophic floods. The flood deposits are poorly to moderately well sorted, massive to thick bedded, stratified deposits of boulders, cobbles, pebbles, and sand resulting from multiple episodes of catastrophic outbursts from glacially dammed Lake Missoula. Subrounded to angular clasts of diverse lithologies locally are as large as 10 feet in diameter. Glacial Lake Missoula formed by the damming of the present-day Clark Fork River near Sandpoint, Idaho, by advancing glaciers during the ice ages. There were as many as 100 Lake Missoula flood events between 15,000 and 12,000 years ago as the ice dam repeatedly formed and failed. The Spokane Valley was the main channel way that carried flood waters from Lake Missoula through the Spokane area. Deposits in the Spokane Valley are several hundred feet thick and are dominated by boulder- and cobble-gravel. The unit is a productive aquifer due to the high porosity and permeability.

- **Columbia River Basalt Group.** The Columbia River Basalts represent a vast outpouring of basaltic lava flows from vents in eastern Oregon and southeastern Washington and Idaho from about 17 to 6 million years ago. Two of the units exposed in Spokane County, the Wanapum and Grande Ronde, were erupted from vents in Idaho and reached the Pacific Ocean. The Columbia River Basalt cover an area of 163,000 square kilometers and are estimated to have been nearly 42,000 cubic miles of lava. Drainages dammed by the flows formed local lakes along the eastern margin of the basalt field. Sediments deposited in those lakes formed the Latah Formation in Spokane County.

  - **Basalts, Miocene, Priest River Member [Mv(wpr)].** The Priest Rapids Member of the Wanapum Basalt consists of fine- to coarse-grained basalt flows where olivine and plagioclase phenocrysts commonly are visible in hand specimens. The Priest Rapids unit has reverse magnetic polarity and was erupted 15.3 to 14.5 million years ago (middle Miocene). The unit overlies the Grand Ronde Basalt unit and, when present, the lakebed sediments of the Latah Formation. The Priest Rapids Member is also invasive into the Latah Formation. In the Spokane area, the Priest Rapids Member forms prominent rim rock and steep cliffs, commonly with well developed columnar jointing.

  - **Lacustrine and Fluvial Deposits, Miocene, Latah Formation [Mc(l)].** The Latah Formation unit consists of lacustrine and fluvial deposits of gray to tan to yellow-orange siltstone, claystone, and minor sandstone that underlie and are interbedded with the Grande Ronde Basalt and Priest Rapids Member of the Wanapum Basalt in the Spokane area. The unit locally contains fossil leaves and carbonized logs (middle Miocene) and is more than 1,100 feet thick at its deepest known point on the Peone Prairie.

- **Undifferentiated Gneiss and Granite, Cretaceous [Kog(n), Kiat(s), and TKiaa].** The gneiss unit [Kog(n) - Newman Lake Gneiss] consists of medium to dark gray, medium- to coarse-grained, mylonitic, hornblende-biotite granodiorite gneiss. The unit is characterized by megacrysts of orthoclase as large as 3/4 of an inch long and contains plagioclase, potassium feldspar, quartz, biotite, and hornblende. The unit contains conspicuous foliation that dips gently southwest and a mineral lineation that plunges southwest. The granite units [Kiat(s) and TKiaa] consist of leucocratic, foliated to massive, medium- to fine-grained biotite-muscovite granite to monzogranite. The units are variably deformed, grading from homogeneous granite in the western parts of the units, to deformed granite and mylonite, to mylonitic rocks of the Newman Lake Gneiss that may be deformed equivalents of the Mt. Spokane granite.

- **Gneiss and Heterogeneous Metamorphic Rocks, Precambrian [pCbg(h) and pChm(p)].** The gneiss unit [pCbg(h) - Hauser Lake Gneiss] contains medium-grained, well banded, foliated and lineated mylonitic biotite-orthoclase-plagioclase-quartz gneiss and schist. Quartzite is locally present. Muscovite-biotite schist layers are less than 1 meter thick and quartz-feldspar layers are up to 3 meters thick. Foliation and lineation generally are gently dipping to horizontal. The heterogeneous metamorphic rocks unit [pChm(p)] is composed of unassigned highgrade metamorphic rocks that range from common metasedimentary quartz-feldspar-mica gneisses, schists, and quartzites to locally occurring sillimanite- or andalusite-bearing graphitic quartz-mica schist, amphibolite, migmatite, and orthogeniss.

4.1.2 Hydrogeology

The regional aquifer system is called the Spokane Valley-Rathdrum Prairie (SVRP) aquifer and was designated a Sole Source Aquifer by the U.S. Environmental Protection Agency in 1978 (Kahle et al. 2005). A Sole Source Aquifer is defined as one that supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer (EPA 2009). The SVRP aquifer provides drinking water for approximately 500,000 residents and covers approximately 370 square miles including Rathdrum Prairie and Coeur d'Alene areas in Idaho, and Spokane Valley and northern Spokane areas in Washington (Kahle and Bartolino 2007).

The SVRP aquifer is comprised of the glacial flood deposits (Qfg) originating from the glacial Lake Missoula. These high-energy glacial flood waters deposited coarser grained material than is typically found in basin aquifers, which results in a highly productive aquifer with well yields as high as 40,000 gpm (Kahle et al. 2005). Recent alluvium (Qal) locally covers the glaciofluvial unit, but the alluvium is also coarse-grained sand and gravel making it difficult to distinguish it from the glacial outwash deposits. Figure 4-2 illustrates the Facility is located above the SVRP (Qfg).

Aquifer Boundaries

The SVRP aquifer is considered to be an unconfined aquifer with no confining unit or boundaries above the aquifer. It is bounded below by bedrock comprised of igneous and metamorphic rocks. The surface of the bedrock material forms a deeply eroded trough that exhibits considerable relief. Most of the bedrock is buried beneath hundreds of feet of the aquifer's unconsolidated sediments. However, the bedrock is more than a thousand feet higher along the edges of the trough to form some of the predominant peaks in the area. The lower boundary of the aquifer is largely unknown except in areas where borings or wells have penetrated through the aquifer to bedrock. These areas are usually along the margins or in shallower parts of the aquifer.

An outcrop of the Newman Lake Gneiss forms a low hill called the Pines Road Knoll immediately southwest of the Facility and extends southward beneath the valley floor (Figures 4-2 and 4-3). The Pines Road Knoll creates a barrier to groundwater flow in the SVRP aquifer, which causes deep groundwater to flow around the knoll and shallow groundwater to flow upward into the Spokane River.

Saturated Thickness

The aquifer's saturated thickness is about 500 feet near the Washington-Idaho border, but more than 600 feet within Rathdrum Prairie and more than 700 feet in northeast Spokane (Kahle et al. 2005). The saturated thickness is between 100 and 200 feet in valley margin areas north and northeast of Pines Road Knoll (CH2M HILL 1998).

Groundwater Flow

Regional groundwater flow tends to reflect the topography of the area. Groundwater flows generally west from lakes in Idaho (Lake Pend Oreille, Hayden Lake, and Lake Coeur d'Alene) toward Spokane, then northwest to Little Spokane River (Kahle et al. 2005). Figure 4-3 illustrates regional groundwater elevation contours based on September 2004 water level measurements (Campbell 2005). Estimated groundwater velocities exceed 60 feet per day (ft/d) near the Washington-Idaho border to approximately 47 ft/d in the northern Spokane area (Drost and Seitz 1978). Seasonal water level fluctuations are generally less than 15 feet in most areas of the aquifer (Drost and Seitz 1978; Kahle et al. 2005).

The SVRP aquifer discharges mainly to the Spokane and Little Spokane Rivers and to pumping wells (Drost and Seitz 1978). Recharge to the aquifer occurs by infiltration of precipitation, irrigation water, septic tank effluent, subsurface inflow from adjoining highland tributaries, leakage from adjacent and overlying surface water sources, and the Spokane River (Drost and Seitz 1978, Kahle and Bartolino 2007). Total estimated average annual recharge into the SVRP aquifer is 1,471 cubic feet per second (cfs; Kahle and Bartolino 2007).

Aquifer Properties

Several previous studies estimated aquifer characteristics based on aquifer tests and groundwater model simulations. Although hydraulic properties of the aquifer are variable, most results indicate that hydraulic conductivity (a measure of the ability of the aquifer material to transmit water) and transmissivity (the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient) values are on the upper end of values measured in the natural environment (Kahle et al. 2005).

Drost and Seitz (1978) reported transmissivity values that ranged from less than 130,000 feet squared per day (ft^2/d) in the western part of the aquifer to greater than 13 million ft^2/d near the Washington-Idaho border.

Bolke and Vaccaro (1981) estimated horizontal hydraulic conductivity values of 2,600 to 6,000 ft/d for most of the aquifer on the Washington side and about 860 ft/d in the less permeable area of northern Spokane. CH2M HILL (1998) reported hydraulic conductivity values ranging from about 100 to 6,200 ft/d, with most values greater than 1,000 ft/d.

Vertical anisotropy is the ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity (Kahle et al. 2005). Bolke and Vaccaro (1981) stated that the available data suggested no vertical stratification of the aquifer lithology suggesting that the aquifer has little if any vertical anisotropy. However, current studies estimated vertical anisotropy in the SVRP aquifer for groundwater modeling efforts. Golder Associates, Inc. (2004) used an initial vertical anisotropy of 3:1 and CH2M HILL (1998) assumed a vertical anisotropy of 10:1, which produced conservative, or large, estimates of well capture zones.

Caldwell and Bowers (2003) estimated a horizontal hydraulic gradient of 0.001 foot/foot (ft/ft) in the central part of the valley using approximately 70 wells. The horizontal hydraulic gradient near the losing reaches of the Spokane River has a larger estimated value of 0.08 ft/ft that is potentially due to the localized recharge from the river and the hydraulic properties of the aquifer material near the river.

Well yield is the maximum pumping rate that can be supplied by a well without lowering the water level below the pump intake. Reported values for well yields screened in the SVRP aquifer range up to 8,000 gpm with a median of 100 gpm (Kahle and Bartolino 2007).

Specific capacity is calculated by dividing the drawdown in the well by the well yield. Specific capacity for wells screened in the SVRP aquifer ranged up to 5,500 gpm/ft with a median of 200 gpm/ft (Kahle and Bartolino 2007).

Supply Wells in the Surrounding Area

Wells within a quarter mile of the Facility were identified using Ecology's well log database (Ecology 2009) to characterize the groundwater use in the area. Water supply well logs are presented in Appendix A following Table A-2. Water well construction details are summarized in Table A-2. The location of the wells is shown in Figure 4-13.

Fourteen water supply wells are located in the area, not including the Facility's water supply wells. At the time of drilling, these wells were owned by Trentwood Irrigation #3, Irvin Water District #6, Consolidated Irrigation District # 19, Spokane Industrial Park, Hillyard Processing Company, and Cominco Products Inc.

Excluding Kaiser's wells, seven resource protection, or monitoring, wells are located in the area. One well was owned by Washington Water Power and three wells were owned by General Electric Power Systems, which were decommissioned, or abandoned, in 2005. Three wells have "Unknown" for the owner at the time of drilling, but did include reference to the consulting firm, CDM, on the well logs.

4.2 FACILITY GEOLOGY AND HYDROGEOLOGY

4.2.1 Geology

A geophysical survey was completed at the site in 1994 (Section 3.6). The location of the survey's three 1,508-foot-long seismic refraction lines are shown on Figure 4-4. Survey results indicate that the bedrock surface occurs at depths of 200 to 350 feet below ground surface beneath the Facility. Interpreted top of bedrock elevation contours based on the survey results and observed bedrock outcrops in the area are also presented on Figure 4-4. The detailed seismic survey report is included in Appendix O of the 2003 Groundwater RI/FS (enclosed on DVD).

Boring and well installation logs, well construction details, and photographs of the soil recovered from one well are presented in Appendix A. The photographs illustrate well HL-MW-28DD's soil core from drilling with a sonic rig. Well locations are shown on Figure 4-5, along with local geologic cross section locations.

Geologic Cross Sections B-B′ and C-C′ (Figures 4-6 and 4-7, respectively) present interpreted geologic conditions underlying the Facility, based on the geophysical survey and geologic descriptions of soils encountered during drilling at the Facility. Deep observation well WW-MW-16 in the Wastewater Treatment area (Figure 4-7) encountered bedrock at a depth of 192 feet, which is consistent with the geophysical survey results (Figure 4-4). Two wells, WW-UVB-1 and North Supply Well, appear to approach bedrock, but do not encounter bedrock, which is also consistent with the geophysical survey. Well WW-UVB-1, just southwest of WW-MW-16, encountered cobble-size basalt (possibly weathered bedrock) at a depth of 143 feet below ground surface. The North Supply Well encountered red-brown silt and sand with angular gravels, possibly characteristic of weathered bedrock, at a depth of 205 feet below ground surface (Figure 4-7). Also shown on Figure 4-7, the bedrock surface is deeply incised along a northwest-southeast trending channel that appears to wrap around the Pines Road Knoll southwest of the Facility. The bedrock surface rises above the water table north of the Facility forming the northern limit of the aquifer as shown on Figure 4-3. The steeply rising basement outcrop (Pines Road Knoll) near the southwest corner of the Facility marks the aquifer limits in that direction.

As shown on Figures 4-6 and 4-7, the unconsolidated glaciofluvial deposits underlying the Facility generally consist of poorly sorted sand and gravel with occasional sand lenses. The deposits appear to grade finer with depth beneath the Facility. The following briefly describes the coarse- to fine-grained facies that were encountered.

- Gravel with scattered open work zones was encountered in the Hot Line, Remelt, and Truck Shop areas in the upper 90 feet and between 110 to 150 feet below ground surface (e.g., HL-MW-27D and HL-MW-28DD). The open work zones are poorly sorted gravels with little or no sand or other fines between individual pieces of gravel. Photographs A-13 and A-22 are examples of gravels with open work zones in the soil sequence from HL-MW-28DD.

- A 22-foot interval of slightly silty, medium to fine Sand was encountered in the Oil House area between depths of 140 and 162 feet below ground surface (1847 to 1869 feet elevation) in boring OH-EW-2. This horizon was underlain by medium to coarse sand to the total depth explored (195 feet) in that boring.

- A silt and sand lens was encountered at the bottom of the North Supply Well at a depth of 205 feet below ground surface and contained angular gravels that could be indicative of weathered bedrock.

4.2.2 Hydrogeology

The Facility is underlain by the SVRP aquifer. The geophysical survey described in Sections 3.7 and 4.2.1 estimates bedrock to be at 200 to 350 feet below the Facility and defines the local aquifer boundary. Based on this, the local aquifer is approximately 200 to 350 feet thick with a varying saturated thickness depending on groundwater elevations.

Groundwater Flow

The water table gradient beneath the Facility is generally to the west and southwest, with groundwater elevations fluctuating seasonally and with changes in river stage. Groundwater elevation contour maps representing typical spring wet season and fall dry season conditions are shown on Figures 4-8 and 4-9, respectively. With reference to these figures, groundwater elevations are approximately 3 to 5 feet higher in the spring and steeper water table gradients occur in the fall when the water table is typically at its lowest elevation for the year. The monitoring well hydrographs presented on Figure 4-10 further illustrate seasonal fluctuations in groundwater elevations. However, as water levels and gradients change, little alteration of the flow direction is observed. A compilation of water level monitoring data is included in Appendix B.

Groundwater-Surface Water Interaction

The Spokane River consists of a series of gaining and losing reaches due to the variable gradient of the river compared to the uniform gradient of the SVRP aquifer (Miller et al. 2002). The Spokane River changes from a losing to a gaining stream just upstream from the Facility, possibly due to the Pines Road Knoll. Groundwater that encounters the impermeable bedrock may either flow around the knoll or upward into the Spokane River. Figure 4-11 illustrates that the Facility's river gage elevation is typically lower than the perimeter well elevations indicating groundwater is flowing into the Spokane River.

Water Levels

Water levels at the Facility are strongly influenced by winter/spring precipitation recharge and Spokane River stage. Groundwater levels at the Facility generally respond within a matter of hours to changes in river stage. Particularly in the spring when river flow is most variable, groundwater elevations can change on a day to day basis.

The water table parallels the topography's sloping surface. The depth to groundwater decreases from approximately 60 to 70 feet on the east and north sides of the property to 45 to 55 feet on the south and west.

Aquifer Properties

An understanding of aquifer properties near the Facility is based on groundwater pumping tests (Hart Crowser 1992, 1994, 1996a, 1996b, and 1997), a combined interpretation of site-wide groundwater flow model calibration, and review of literature. Development and calibration of the site-wide groundwater flow model is discussed in greater detail in Appendix C of the 2003 Groundwater RI/FS (enclosed on DVD). Table 4-4 summarizes pumping tests that have been conducted at the Facility.

Horizontal Gradient. Horizontal hydraulic gradients calculated from groundwater elevation measurements and distances between selected wells at the Facility are presented in Table 4-1. The calculated horizontal gradients range from 0.0025 to 0.0069 ft/ft with an average of 0.0038 ft/ft. These values are slightly higher than Caldwell and Bowers (2003) regional hydraulic gradient estimate of 0.001 ft/ft.

Vertical Gradient. Vertical hydraulic gradients calculated from groundwater elevation measurements in nested well pairs at the site are presented in Table 4-2. Differences in measured groundwater elevations in well pairs range from 0 to 0.20 foot, with an average difference of 0.07 foot. Vertical gradients range from 0 to 0.0041 ft/ft with an average of 0.0013 ft/ft. Away from the river, the vertical gradients vary between slightly upward and slightly downward. Near the river (e.g., at well pairs MW-21S and MW-22D, and MW-23S and MW-24D), vertical gradients are generally upward, indicating groundwater discharge to the river. Localized downward gradients were measured at well pair MW-25S and MW-26D, which may reflect the mounding due to infiltration of water from the north horizontal recirculation well screen in the Wastewater Treatment area when well WW-EW-3 was pumping. The vertical gradients are consistent with calculated gradients from 2002, which are presented in Table 4-3.

Saturated Thickness. The saturated thickness of the aquifer ranges from zero at the edge of the bedrock outcrop area southwest of the Facility to a maximum of approximately 280 feet on the southeast corner of the property. The average saturated thickness beneath the property is approximately 150 feet. Based on information compiled by CH2M Hill (1998), the saturated thickness of the aquifer may increase to as much as 600 feet south of the Facility toward the center of the Spokane River valley.

Horizontal Hydraulic Conductivity and Transmissivity. Based on an interpretation of pumping tests conducted in four extraction wells at the Facility, the transmissivity of the aquifer beneath the Facility ranges from 1.3 to 2 million gpd/ft (174,000 to 267,000 ft^2/d) (Table 4-4). Calibration of the site-wide groundwater model indicated a range between 1.7 and 1.9 million gpd/ft (227,000 to 254,000 ft^2/d) near the Oil House and Wastewater Treatment area extraction wells with lower values southwest and north of the Facility (mainly because of reduced saturated thickness). These values are consistent with the regional transmissivity data provided by Drost and Seitz (1978).

Hydraulic conductivity of the aquifer beneath the Facility ranged from 2,000 to 7,000 ft/d (0.7 to 2.5 cm/sec) based on the interpretation of the pumping tests (Table 4-4). Horizontal hydraulic conductivity decreases with depth, consistent with the observation of decreasing gravel content noted in the drilling records and can be seen in the Oil House area in logs for wells OH-EW-1 and OH-EW-2 (see 2003 Groundwater RI/FS).

In the calibration of the groundwater flow model, best fit hydraulic conductivities were estimated for simulated pumping conditions. Near the water table, best fit hydraulic conductivity values ranged from 2,000 to 3,000 ft/d (0.7 to 1.1 cm/sec). Within the finer-grained sand horizon identified in boring OH-EW-2 at a depth of 140 to 162 feet (Figure 4-7), a hydraulic conductivity value of 200 ft/d (0.1 cm/sec) provided the best fit. Within the coarse sand underlying the finer grained sand horizon, best fit hydraulic conductivity values ranged from 500 to 1,000 ft/d (0.2 to 0.4 cm/sec).

Vertical Hydraulic Conductivity. There are no field measurements of vertical hydraulic conductivities for the SVRP aquifer. Based on calibration of the groundwater flow model, vertical hydraulic conductivity values ranged from one-tenth to one-fifth of horizontal hydraulic conductivity values were indicated, which is consistent with vertical hydraulic conductivity values used by CH2M HILL (1998) and Golder (2004) in their groundwater flow models. The vertical hydraulic conductivity is much lower than the horizontal hydraulic conductivity due to the stratification of the aquifer system.

Specific Yield/Specific Capacity. Specific yield (the volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in the water table) values estimated from pumping tests ranged from 0.02 to 0.3. For the groundwater flow model, a value of 0.15 provided the best fit in most of the study area. To account for residual oil trapped in the hydrocarbon smear zone, lower specific yield values, down to 0.03 were used inside areas with free phase petroleum hydrocarbon accumulations. Specific capacity values estimated from pumping tests ranged from 250 to 1,900 gpm/ft, which is within the range of the regional data provided above.

Porosity. Porosity (the volume of voids divided by the total unit volume) was estimated through grain size analysis from soils sampled during drilling. Table 4-5 presents the results of the grain size analyses conducted on selected soil samples. Porosity was calculated using weight-volume relationships and has values that range from 29 to 35 percent. Effective porosity is the available porosity for fluid flow and is typically a smaller value than porosity. The USGS provided a summary of groundwater flow modeling information available as of June 2005 for the SVRP aquifer and used an effective porosity of 20 percent throughout the model domain (Kahle et al. 2005). Since open work gravels are present in the subsurface of the Facility, the effective porosity would be higher than the USGS value. Using the lower end of the calculated porosity range, the estimated effective porosity is 30 percent.

Average Linear Velocity. Average linear velocity was calculated from the bromide tracer test conducted at the Wastewater Treatment area in April 2001 (Hart Crowser 2003). The average linear velocity estimated was 570 ft/d from the bromide test, which is approximately 10 times greater than the regional groundwater flow velocities of the SVRP aquifer.

Using 2,500 ft/d for hydraulic conductivity, 0.004 ft/ft for horizontal hydraulic gradient, and 0.30 for effective porosity, the calculated average linear velocity is 33 ft/d, which is seven times less than the velocity calculated from the bromide tracer test. The lower value is possibly due to a reflection of the average hydraulic conductivity calculated from the pumping tests conducted at the Wastewater Treatment area, whereas the average linear velocity calculated from the tracer test reflects the high permeability zones in the formation.

4.2.3 Field Water Quality Parameters

The field water quality parameters are measured at sampling locations during purging of wells and include pH, temperature, conductivity, turbidity, oxygen reduction potential (ORP), and dissolved oxygen. Dissolved oxygen has been measured in groundwater wells since 1998. Field parameters have been collected when sampling wells but these data were not entered into the groundwater database until 2006.

Appendix F presents statistics and distributions of the field water quality parameters data available in the groundwater database and measured at the Facility and report the 5th and 95th percentile ranges for each parameter. The pH of the groundwater ranged from 7 to 8 with an average of 7.6. Temperature of the groundwater at the Facility ranged from 10 to 13 Celsius (C) with an average of 11 C. Groundwater temperature near the Remelt area tends to be warmer, probably due to the casting pits. Conductivity of the groundwater ranged from 0.2 to 0.4 microsiemens per centimeter (μS/cm) with an average of 0.3 μS/cm. Turbidity of the groundwater samples ranged from 0 to 300 Nephelometric Turbidity Units (NTU) with an average of 50 NTU. ORP of the groundwater ranged from –60 to 440 millivolts (mV) with an average of 110 mV. Dissolved oxygen in the groundwater showed a bimodal distribution and ranged from 0.8 to 10 mg/L with an average of 7 mg/L.

4.3 REGIONAL GROUNDWATER QUALITY

Regional groundwater quality conditions provide a framework for comparison with the site-specific chemical data obtained during this investigation.

4.3.1 Spokane Valley-Rathdrum Prairie Aquifer

Four sources of information are used as primary references, including interpretive overviews prepared by Spokane County and the USGS, and a published and a draft water quality report prepared by Spokane County (2004 and 2007, respectively). Data available from these sources generally cover the area extending from the Idaho border on the east to the confluence of the Spokane and Little Spokane Rivers toward the north and west.

Regional monitoring data indicate that groundwater quality within the SVRP aquifer is relatively good and typically meets federal drinking water standards. A summary of data compiled by the USGS in 1978 and by Spokane County from 1994 to 2007 is presented in Table 4-6. Conventional parameters exceeded drinking water maximum contaminant levels (MCLs) in less than 1 percent of the samples reported in 1978 and between 1994 and 2003. Conventional parameter concentrations appear to be declining since the 1978 data were compiled, except for sulfate. In 2007, sulfate increased in concentration and exceeded the secondary MCLs (SMCLs) in 78 samples. The sulfate SMCL is based on aesthetics (taste and odor) and is not a human health-based standard.

With the exception of iron and manganese, which more commonly exceeded SMCLs, metals results exceeded the MCLs in fewer than 1 percent of the samples analyzed. Manganese and iron concentrations from the 1978 USGS study exceeded SMCLs in 2 and 8 percent of the samples tested, respectively. Comparison of 1994 data to the more recent iron and manganese data from the Spokane County database appears to show an increase in the percent of samples containing exceedances of the SMCLs for these metals. However, this apparent increase is more likely related to different wells being sampled between the two time periods.

4.4 SURFACE WATER HYDROLOGY

4.4.1 Surface Drainage

The Facility has its own wastewater treatment system on site for the Facility's sanitary sewer and industrial wastewater systems. Stormwater runoff and process water flow into storm drains and then to the industrial wastewater treatment system. Precipitation that falls on pervious surfaces, which is not evaporated or transpired by plants, percolates into the SVRP aquifer. There are drywell catch basins located throughout the facility, including nine drywells located to the southwest of the Remelt building. Stormwater runoff from paved areas drains into a drywell catch basin and percolates into the aquifer.

The topography near the west and south discharge ravine areas indicate there were once streams that flowed into the Spokane River, but are no longer flowing. Currently there are no streams that flow through the Facility.

4.4.2 Spokane River

Description

The Spokane River above the City of Spokane drains more than 4,000 square miles of land in northeastern Washington and the Idaho panhandle. The river has a long history of water quality concerns, including sludge accumulations, pathogen hazards, low dissolved oxygen, noxious algae blooms, and metal toxicity (Patmont et al. 1987). Most of these concerns have been attributed to municipal wastewater discharges in Spokane and to mining-related sources near Kellogg, Idaho. The discussions that follow reference available data that describe the persistence of metals and PCBs in the Spokane River relative to potential discharges from the Facility.

Flow

Flow along the Facility reach (RM 86 to 87) of the Spokane River is controlled by Post Falls dam upriver of the facility. Figure 4-12 illustrates the daily average flow rates at Cochran Street in Spokane (RM 72.9) and the Barker Road in Greenacres (RM 90.5). Table 4-7 presents the Spokane River flow statistics. The river fluctuates 3 to 10 feet from lower elevations in the late summer and fall to higher elevations in the early spring. Discharge rates range from 16 cfs in late summer and fall at Greenacres to 43,200 cfs in spring at Post Falls.

Ambient Water Quality

Water Quality Parameters

Field water quality parameters have been measured at the Facility's river gage since 2006 and include temperature, pH, conductivity, turbidity, ORP, and dissolved oxygen.

Temperature of the Spokane River at the Facility's river gage ranges from 2 to 18 C with an average of 9.6 C. The pH of the river ranges from 7 to 8 with an average of 7.5. Conductivity of the river ranges from 40 to 200 µS/cm with an average of 80 µS/cm. ORP of the river ranges from −180 to 170 mV with an average of 50 mV. Dissolved oxygen in the river ranges from 8 to 14 mg/L with an average of 11 mg/L.

Metals

Metals contamination within the upper Spokane River, resulting from mining sources in Idaho, is well documented (Patmont et al. 1987, Pelletier 1994, Hopkins and Johnson 1997, EPA 2000, and Clark 2003). Although conditions in the river have improved over the past 20 or more years, metals concentrations still remain above surface water quality screening criteria. Table 4-8 presents a summary of Spokane River water quality at the Stateline bridge and indicates that dissolved arsenic does not exceed these screening criteria. Although dissolved arsenic data are non-detect, the reporting limit (RL) is above the screening criteria. Total recoverable arsenic, cadmium, lead, and zinc regularly exceed water quality criteria at this location. Metals concentrations in the Spokane River generally decrease proceeding downstream from the outlet of Lake Coeur d'Alene, consistent with the presence of significant upstream sources in Idaho. EPA (2000) has been evaluating potential alternatives for control of mining-related metals releases to Lake Coeur d'Alene. However, dischargers within the Spokane River have already implemented controls for metals based on a total maximum daily loading (TMDL) analysis developed by Pelletier and Merrill (1998) and approved by EPA.

PCBs

Within the Spokane River near the Facility reach, PCB concentrations have been monitored since 1993 in river sediments, selected fish species, stormwater outfalls, and surface water. PCB monitoring in the river has been performed through collaborative efforts of Ecology (Ecology 2006a, 2006b, and 2007b), Kaiser (Hart Crowser 1995a), Anchor Environmental (2004), and the U.S. Geological Survey (USGS 2003).

Within the Spokane River, the best record of historical declines in PCB concentrations is observed in the sediment record preserved in the relatively low-velocity sediment deposition area located immediately upstream of Upriver Dam (RM 80). Dated sediment core sections reported in Hart Crowser (1995a) reveal that since the 1960s, PCB concentrations have declined steadily in this area at a half-life of approximately 7 years.

PCBs tend to bioaccumulate in the fatty tissue (lipids) of fish. Table 4-9 summarizes Ecology's investigation (2006b) of PCB concentrations in fish tissue in the Spokane River at Stateline (RM 96.1), Plante Ferry Park (RM 84.8), and Mission Park (RM 76.5). PCB concentrations in largescale suckers collected at Stateline in 2005 are approximately half those measured in 1999. PCB concentrations in largescale suckers and rainbow trout collected at Plante Ferry decreased by one order of magnitude from 1993 to 2005. Largescale suckers and rainbow trout collected at Mission Park showed increasing PCB concentrations, whereas the whitefish sampled showed decreasing PCB concentrations from 1994 to 2005. Ecology's conclusion suggested there was no strong evidence of improving conditions at the Mission Park reach of the Spokane River.

Ecology conducted a Total Maximum Daily Load (TMDL) assessment for PCBs in the Spokane River from 2003 to 2004 and 2005 (Ecology 2006a and Ecology 2007b). Sampling conducted as part of the TMDL indicated that PCB loads from stormwater runoff in urbanized areas of Spokane delivered significant PCB loads to the river. Total PCB concentrations in the stormwater samples varied from 0.062 to 280 nanograms per liter (ng/L), with an average value of 22.5 ng/L. The largest stormwater PCB loads to the Spokane River originate from basins near RM 69, 75.8, and 76.2.

Ecology (2001) sampled surface water in 2000 at Barker Road (RM 90.4), just upstream from the Facility, which had non-detect PCB concentrations at 0.9 ng/L detection limit and at Argonne Road (RM 82.6), downstream of the Facility, with a PCB concentration of 1.1 ng/L. Ecology (2006a) sampled surface water in 2003 and 2004 and indicate that average PCB concentrations showed a fairly consistent trend of increasing concentrations moving downstream starting from the Idaho border [0.11 ng/L at RM 96.1] to lower Long Lake (0.40 ng/L at RM 38.4), with a corresponding eight-fold increase in loads [477 – 3,664 milligrams per day (mg/d)]. The 2003 and 2004 investigation was able to report at lower detection limits using low-level water sampling devices (e.g., semi-permeable membrane devices).

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Table 4-1 - Horizontal Hydraulic Gradients in Selected Well Pairs for 2008

Well ID	Distance between Wells	January-08		April-08		July-08		October-08	
		WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient
Perimeter and Wastewater Areas									
MW-23S	370	1922.38	0.0064	1927.98	0.0025	1922.54	0.0069	1921.74	0.0069
MW-17S	.	1924.73		1928.92		1925.11		1924.28	
MW-19S	850	1924.23	0.0043	1929.20	0.0034	1924.75	0.0049	1923.93	0.0045
WW-MW-8		1927.90		1932.13		1928.88		1927.79	
Hot Line and Remelt Areas									
HL-MW-30S	490	1927.22	0.0046	1931.33	0.0040	1928.28	0.0051	1927.06	0.0049
HL-MW-14S		1929.46		1933.30		1930.76		1929.45	
HL-MW-10S	800	1928.98	0.0037	1933.21	0.0032	1930.23	0.0042	1928.87	0.0039
HL-MW-18S		1931.94		1935.77		1933.56		1931.98	
HL-MW-29S	540	1931.05	0.0030	1934.85	0.0029	1932.59	0.0034	1931.05	0.0032
RM-MW-16S		1932.68		1936.39		1934.42		1932.77	
HL-MW-17S	1020	1932.24	0.0030	1936.00	0.0028	1933.95	0.0034	1932.33	0.0031
RM-MW-9S		1935.32		1938.88		1937.37		1935.51	
Oil House and Cold Mill Areas									
OH-MW-18	350	1932.38	0.0032	1936.29	0.0029	NR	NR	1932.41	0.0033
OH-MW-10		1933.51		1937.32		NR		1933.58	
OH-MW-27	700	1932.09	0.0036	1935.19	0.0046	1933.51	0.0042	1932.11	0.0038
TF-MW-2		1934.61		1938.38		1936.48		1934.74	
CM-MW-4S	620	1934.62	0.0030	1938.61	0.0028	1936.32	0.0034	1934.74	0.0031
CM-MW-7S		1936.47		1940.34		1938.42		1936.69	
Across Site									
MW-19S	4980	1924.23	0.0031	1929.2	0.0028	1924.75	0.0035	1923.93	0.0033
MW-4		1939.67		1943.02		1942.23		1940.15	

Notes:

Well pairs are listed in order of increasing distance from the Spokane River.

Gradients (ft/ft) calculated as difference in groundwater elevations divided by distance between well pairs.

NR - Not reported due to suspect water level measurement.

Elevations are in NAVD88 datum in feet.

Distances are in feet.

Table 4-2 - Vertical Hydraulic Gradients in Selected Well Pairs for 2008

Well ID	Screen Mid-point Elevation	January-08		April-08		July-08		October-08	
		WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient
Perimeter Area									
MW-21S	1927.8	1922.79	0.0009	1928.16	-0.0013	1923.17	0.0009	1922.35	0.0022
MW-22D	1905.1	1922.81		1928.13		1923.19		1922.40	
MW-23S	1929.2	1922.38	0.0017	1927.98	0.0017	1922.54	0.0026	1921.74	0.0021
MW-24D	1905.9	1922.42		1928.02		1922.60		1921.79	
MW-19S	1929.3	1924.23	0.0014	1929.20	0.0018	1924.75	0.0009	1923.93	0.0014
MW-20D	1907.6	1924.26		1929.24		1924.77		1923.96	
MW-25S	1930.3	1924.37	-0.0017	1928.66	0.0000	1924.72	0.0000	1923.93	-0.0013
MW-26D	1906.7	1924.33		1928.66		1924.72		1923.90	
MW-17S	1931.2	1924.73	0.0004	1928.92	0.0008	1925.11	-0.0004	1924.28	0.0004
MW-18D	1906.1	1924.74		1928.94		1925.10		1924.29	
Hot Line Area									
HL-MW-14S	1928.3	1929.46	0.0015	1933.30	0.0024	1930.76	0.0028	1929.45	0.0022
HL-MW-24DD	1856.8	1929.57		1933.47		1930.96		1929.61	
HL-MW-6A	1927.4	1929.80	0.0029	1933.72	0.0029	1931.13	0.0041	1929.79	0.0027
HL-MW-9D	1893.5	1929.90		1933.82		1931.27		1929.88	
HL-MW-07S	1933.6	1930.50	-0.0005	1934.21	0.0009	1931.94	-0.0014	1930.46	-0.0019
HL-MW-08D	1912.3	1930.49		1934.23		1931.91		1930.42	
HL-MW-5	1913.3	1931.04	0.0030	1934.85	0.0020	1932.57	0.0030	1931.03	0.0026
HL-MW-15DD	1862.8	1931.19		1934.95		1932.72		1931.16	
HL-MW-26S	1931.5	1931.10	0.0010	1934.84	0.0014	1932.63	0.0021	1931.12	0.0014
HL-MW-27D	1882.8	1931.15		1934.91		1932.73		1931.19	
Remelt Area									
RM-MW-3S	1928.4	1933.06	0.0015	1936.73	0.0002	1934.82	0.0021	1933.10	0.0024
RM-MW-4D	1862.7	1933.16		1936.74		1934.96		1933.26	

Notes:

Well pairs are listed in order of increasing distance from the Spokane River.

Gradients (ft/ft) calculated as difference in groundwater elevations divided by difference in screen mid-point elevations.

Negative value indicates downward gradient, positive value indicates upward gradient.

Elevations are in NAVD88 datum in feet.

Table 4-3 - Vertical Hydraulic Gradients in Selected Well Pairs for 2002

	Screen Mid-point	March-02		June-02		July-02		August-02		September-02		December-02	
Well ID	Elevation	WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient	WaterElev	Gradient
HL-MW-07S	1933.6	1933.56	-0.0005	1935.76	0.0009	1929.96	0.0000	1928.61	-0.0009	1929.54	-0.0014	1929.95	-0.0014
HL-MW-08D	1912.3	1933.55		1935.78		1929.96		1928.59		1929.51		1929.92	
HL-MW-10S	1933.4	1932.43	0.0000	1934.34	-0.0014	1928.33	0.0000	1927.07	0.0005	1928.07	0.0005	1928.60	0.0005
HL-MW-11D	1911.5	1932.43		1934.31		1928.33		1927.08		1928.08		1928.61	
MW-17S	1931.2	1928.04	0.0012	1928.93	0.0020	1924.00	-0.0004	1923.06	-0.0008	1923.93	0.0000	1924.47	0.0004
MW-18D	1906.1	1928.07		1928.98		1923.99		1923.04		1923.93		1924.48	
MW-19S	1929.3	1928.06	0.0005	1929.00	0.0018	1923.27	0.0023	1922.29	0.0005	1923.44	0.0023	1923.83	0.0014
MW-20D	1907.6	1928.07		1929.04		1923.32		1922.30		1923.49		1923.86	
MW-21S	1927.8	1927.11	0.0018	NR	NR	1921.71	0.0004	1920.57	0.0018	1921.82	0.0022	1922.39	0.0004
MW-22D	1905.1	1927.15		NR		1921.72		1920.61		1921.87		1922.40	
MW-23S	1929.2	1926.99	0.0009	1927.45	0.0017	1921.14	0.0030	1919.88	0.0034	1921.25	0.0026	1921.85	0.0030
MW-24D	1905.9	1927.01		1927.49		1921.21		1919.96		1921.31		1921.92	
MW-25S	1930.3	1927.80	-0.0013	1928.77	-0.0008	1923.76	-0.0017	1922.86	-0.0025	1923.64	-0.0008	1923.90	-0.0017
MW-26D	1906.7	1927.77		1928.75		1923.72		1922.80		1923.62		1923.86	

Notes:

Well pairs are listed in order of increasing distance from the Spokane River.

Gradients (ft/ft) calculated as difference in groundwater elevations divided by difference in screen mid-point elevations.

Negative value indicates downward gradient, positive value indicates upward gradient.

NR - Not reported due to suspect water level measurement.

Elevations are in NAVD88 datum in feet.

Referenced from the 2003 Groundwater RI/FS.

Table 4-4 - Summary of Pumping Tests Conducted at Kaiser Trentwood

Pumped Well	Elevation of Screened Interval in Feet (i)	Duration of Constant Rate Test in Hours	Pumping Rate in gpm	Observation Wells	Estimated Transmissivity		Saturated Thickness in ft (j)	Hydraulic Conductivity in ft/day (k)	Specific Capacity in gpm/ft	Specific Yield/ Storativity
					in ft^2/day	in gpd/ft				
TF-EW-1 (a) (h)	1913.4 to 1948.4	24	1060	OH-MW-14, TF-MW-1, TF-MW-3, TF-MW-4,	174,000	1.3 million	26	6,692	700	0.3
OH-EW-1 (b)	1879.6 to 1910.1	25	1065	OH-MW-26, OH-MW-22, OH-MW-18	267,000	2 million	55	4,855	625	0.02 to 0.03
OH-EW-2 (e)	1823.1 to 1843.1 and 1869.1 to 1901.1	24	1200	OH-MW-14, OH-MW-19, OH-MW-29, OH-SK-3	225,000 (g)	1.7 million(g)	111	2,027	860	0.03 to 0.15
OH-EW-2 (e)	1823.1 to 1843.1 and 1869.1 to 1901.1	24	1270	OH-MW-14, OH-MW-19, OH-MW-29, OH-SK-3	---	---	---	---	250	---
WW-EW-1 (c)	1795.5 to 1860.5	24	4900	WW-SK-1, WW-MW-3, WW-MW-6, WW-MW-10, WW-MW-11, WW-MW-13, WW-MW-15, WW-MW-16, WW-MW-17, HL-MW-4, OH-MW-8, MW-8, MW-9	264,000 (g)	1.9 million(g)	136	1,941	1020	0.03 to 0.15
WW-EW-2 (f)	1807.2 to 1864.2	6	2500	WW-EW-1, WW-MW-17	---	---	---	---	1900	---
WW-EW-3, Lower Screen Only	1790 to 1824	24	1280	MW-15, WW-MW-11, WW-MW-12, WW-MW-15	---	---	---	---	260	---
WW-EW-3, Upper Screen Exposed	1790 to 1824 and 1831 to 1881	24	1280	MW-15, WW-MW-11, WW-MW-12, WW-MW-15	---	---	---	---	1280	---
WW-UVB-1, Lower Screen Only	1833.8 to 1868.8	24	810	MW-14, WW-MW-16, WW-MW-17, WW-MW-18, WW-SK-1	---	---	---	---	1500	---
North Supply Well (d)	1807 to 1822	4	550	None	---	---	---	---	275	---

Notes:
--- Not calculated.
(a) Hart Crowser 1992.
(b) Hart Crowser 1994.
(c) Kaiser 1995.
(d) Hart Crowser 1996a.
(e) Hart Crowser 1996b.
(f) Hart Crowser 1997.
(g) Based on groundwater model calibration.
(h) TF-EW-1 was deepened in 4/00.
(i) Elevations are in NAVD88 datum.
(j) Represents the well's saturated thickness (depth of water table to the depth of the well's bottom of screened interval).
(k) Hydraulic conductivity calculations based on well's saturated thickness.

Table 4-5 - Summary of Grain Size Analyses

Name	Report Date	Sample Depth	Gravel	Sand	Silt/Clay	D85	D60	D50	D30	D15	D10	Cc	Cu	Moisture	Porosity
			in Percent			in Millimeters								in Percent	
HL-MW-24DD-S12	3/7/2006	150	23.6	73.4	3	6.28	2.86	2.07	0.92	0.36	0.27	1.11	10.81		
HL-MW-28DD	9/26/2006	150	2.1	80.4	17.5	0.77	0.46	0.38	0.25						
MW-13/S-1	1/24/1998	52	64.6	33.4	2	9.23	6.44	5.70	4.07	2.63	2.28	1.13	2.80		
MW-14/S-1	1/24/1998	27	42.6	50.5	6.9	8.03	4.99	4.06	2.13	0.80	0.29	3.09	17.00		
MW-14/S-2	1/24/1998	37	47.7	49.3	3	9.51	5.64	4.51	2.45	1.09	0.64	1.65	8.70		
MW-15/S-1	1/28/1998	34	36.2	58.8	5	6.90	4.42	3.55	1.91	0.85	0.47	1.76	9.50		
MW-15/S-2	1/28/1998	49	67.1	32.5	0.4	10.07	6.85	6.03	4.55	3.25	2.73	1.11	2.50		
MW-16/S-1	1/28/1998	77	51.3	43.2	5.5	9.50	5.99	4.89	2.65	1.07	0.62	1.89	9.60		
OH-EW-2/S-1	11/3/1995	100	73.8	25.8	0.4	25.23	13.71	9.93	5.46	2.74	1.89	1.15	7.20	2	29
OH-EW-2/S-10	11/3/1995	185	6.4	92.6	1	3.56	2.12	1.79	1.28	0.94	0.81	0.95	2.60	3	30
OH-EW-2/S-2	11/3/1995	110	74	25.5	0.5	18.84	10.59	8.78	5.40	2.90	2.01	1.37	5.30	2	29
OH-EW-2/S-3	11/3/1995	120	69.8	29.6	0.6	22.08	9.31	7.48	4.72	2.59	1.82	1.32	5.10	2	29
OH-EW-2/S-4	11/3/1995	130	69.7	30	0.3	31.62	17.38	11.18	4.66	2.23	1.67	0.75	10.40	2	29
OH-EW-2/S-5	11/3/1995	135	74.2	25.6	0.2	18.11	12.19	9.57	5.45	3.06	2.30	1.06	5.30	2	29
OH-EW-2/S-6	11/3/1995	165	13.6	85.8	0.6	4.47	2.28	1.82	1.14	0.58	0.35	1.63	6.60	5	31
OH-EW-2/S-7	11/3/1995	170	7.5	92.1	0.4	3.55	2.00	1.69	1.22	0.90	0.77	0.97	2.60	5	31
OH-EW-2/S-8	11/3/1995	175	4.2	95.3	0.5	2.83	1.73	1.51	1.14	0.88	0.77	0.98	2.30	4	30
OH-EW-2/S-9	11/3/1995	180	4.6	94.9	0.5	3.26	1.96	1.67	1.22	0.92	0.80	0.95	2.50	4	30
OH-MW-13/S-1	1/30/1991	70	70.6	21.9	7.5	15.63	9.28	7.54	4.81	2.01	0.73	3.43	12.70	6	32
Oil House Grab Sample	10/10/1990		86.7	11.1	2.2	43.10	24.43	20.00	11.72	5.55	3.16	1.78	7.70	3	30
RM-MW-16S/S-9	9/26/2006	90	76.2	18.8	5	26.10	17.00	13.20	7.14	2.58	1.57	1.91	10.84		
WW-EW-2/S-10	12/3/1996	140	69.6	30.2	0.2	45.87	29.96	17.44	4.64	2.22	1.63	0.44	18.40	3	30
WW-EW-2/S-11	12/3/1996	150	34.9	64.1	1	8.61	4.17	3.22	1.88	1.15	0.92	0.92	4.50	6	32
WW-EW-2/S-12	12/3/1996	155	33.4	65.6	1	9.01	3.75	2.63	1.38	0.81	0.62	0.82	6.10	11	35
WW-EW-2/S-14	12/3/1996	165	31.2	68.6	0.2	8.81	3.75	2.92	1.81	1.21	1.02	0.86	3.70	10	34
WW-EW-2/S-16	12/3/1996	170	14.8	84.2	1	4.73	2.90	2.45	1.70	1.16	0.98	1.02	3.00	6	32
WW-EW-2/S-5	12/3/1996	120	74.7	24.8	0.5	19.05	12.37	10.62	6.47	1.78	1.15	2.94	10.80		
WW-EW-2/S-8	12/3/1996	135	68.7	30.9	0.4	21.88	13.65	10.35	4.42	1.76	1.27	1.12	10.70		
WW-MW-8/S-1	1/30/1991	65	65.2	24.5	10.3	19.95	13.03	10.23	3.39	0.59				11	35

Table 4-5 - Summary of Grain Size Analyses

Name	Description	USCS
HL-MW-24DD-S12	Gravelly SAND	SW
HL-MW-28DD	Silty, fine to medium SAND	SM
MW-13/S-1	Very sandy GRAVEL	GP
MW-14/S-1	Slightly silty, very gravelly SAND	SP-SM
MW-14/S-2	Very gravelly SAND	SW
MW-15/S-1	Slightly silty, very gravelly SAND	SW-SM
MW-15/S-2	Very sandy GRAVEL	GP
MW-16/S-1	Slightly silty, very sandy GRAVEL	GW-GM
OH-EW-2/S-1	Sandy GRAVEL	GW
OH-EW-2/S-10	Gravelly, coarse to medium SAND	SP
OH-EW-2/S-2	Sandy GRAVEL	GW
OH-EW-2/S-3	Sandy GRAVEL	GW
OH-EW-2/S-4	Very sandy GRAVEL	GP
OH-EW-2/S-5	Sandy GRAVEL	GW
OH-EW-2/S-6	Gravelly SAND	SW
OH-EW-2/S-7	Slightly gravelly, coarse to medium SAND	SP
OH-EW-2/S-8	Coarse to medium SAND	SP
OH-EW-2/S-9	Coarse to medium SAND	SP
OH-MW-13/S-1	Slightly silty, sandy GRAVEL	GP-GM
Oil House Grab Sample	Slightly sandy GRAVEL	GW
RM-MW-16S/S-9	Slightly silty, sandy GRAVEL	GW-GM
WW-EW-2/S-10	Very sandy GRAVEL	GP
WW-EW-2/S-11	Very gravelly SAND	SP
WW-EW-2/S-12	Very gravelly SAND	SP
WW-EW-2/S-14	Very gravelly SAND	SP
WW-EW-2/S-16	Gravelly SAND	SP
WW-EW-2/S-5	Sandy GRAVEL	GP
WW-EW-2/S-8	Very sandy GRAVEL	GP
WW-MW-8/S-1	Slightly silty, sandy GRAVEL	GP-GM

Notes:
Porosity was calculated using weight-volume relationships. Saturated weight and specific gravity of solids were estimated as 120 pounds per cubic foot and 2.65, respectively.

Table 4-6 - Regional Groundwater Quality Data Summary

			Drinking Water Criteria		Groundwater Quality Data Before 1978 (e)			1994 - 2000 (f)			2003 (g)			2007 (h)		
Constituent	MCL in mg/L	Secondary MCL in mg/L	MCL(a) in mg/L	SMCL(b) in mg/L	Number of Samples	Number Exceeding MCLs	Maximum Value in mg/L	Number of Samples	Number Exceeding MCL/SMCL	Maximum Value in mg/L	Number of Samples	Number Exceeding MCL/SMCL	Maximum Value in mg/L	Number of Samples	Number Exceeding MCL/SMCL	Maximum Value in mg/L
Conventionals																
Sulfate	--	250	--	250	596	0	210	1395	0	44.8	172	1	263	205	78	38.3
Chloride	--	250	--	250	1115	4	>1000	1395	0	42	171	0	17.4	206	0	23.3
Fluoride	2	--	4	2	706	2	3.2	1105	0	0.225	172	0	0.12	206	0	0.329
Nitrate	10	--	10	--	940	11	28	207	0	8.53	169	0	4.74	204	0	6.5
TDS	--	500	--	500	1087	3	539	1393	1	660	171	0	329	206	1	896
pH (std. Units	--	6.5 - 8.5		6.5 to 8.5	918	3	6.2 to 9.4	483	1	8.54	169	0	7.97	177	1	8.6
Metals (c)																
Antimony			0.006	--	--	--	--	177	0	<0.005	5	0	<0.003	--	--	--
Arsenic	0.05	--	0.01	--	185	1	0.064	352	0	0.0098	172	0	0.008	196	1	5
Cadmium	0.01	--	0.005	--	336	0	0.006	853	0	0.00148	172	0	<0.002	206	5	0.007
Chromium	0.05	--	0.1	--	186	0	0.03	706	0	0.01	172	0	0.005	206	0	0.006
Copper	--	1	1.3 (d)	1.0	210	1	5.2	985	0	0.0648	172	0	0.125	206	0	0.03
Iron	--	0.3	--	0.3	758	58	78	1056	135	12	172	18	1.33	206	15	7.38
Lead	0.05	--	0.015(d)	--	235	1	0.42	1063	3	0.0285	172	1	0.029	206	3	0.039
Manganese	--	0.05	--	0.05	700	12	1.6	973	10	0.19	172	2	0.175	206	5	0.447
Mercury	0.002	--	0.002	--	196	0	0.0002	708	0	<0.0005	172	0	<0.001	206	0	0.0005
Zinc	--	5	--	5	395	1	7.5	1056	0	0.6	172	0	0.14	204	0	0.2

Notes:

-- No data available.

TDS - Total Dissolved Solids

(a) MCL - Maximum Contaminant Level based on National Primary Drinking Water Regulation 40 CFR Part 141.

(b) Secondary MCL based on aesthetic effects (taste and odor) from the National Secondary Drinking Water Regulation 40 CFR Part 143.

(c) Metal results from 1978 study are total and dissolved. Metal results from 1994 study are total only.

(d) At-the-Tap Action Level. Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps.

(e) USGS (1978).

(f) Spokane County Water Quality Management Program (2000).

(g) Spokane County Utilities - Water Resources (2004).

(h) Spokane County Water Resources Department of Utilities (2007).

Table 4-7 - Spokane River Flow Statistics

Data from 1989 through 2008	River Gage at Kaiser	Spokane (RM 72.9)	Greenacres* (RM 90.5)	Post Falls (RM 100.7)
Elevation in Feet				
Maximum Elevation	1940.72	--	--	--
Minimum Elevation	1930.19	--	--	--
Average Elevation	1933.27	--	--	--
Date of Maximum Elevation	4/17/2006	--	--	--
Date of Minimum Elevation	8/29/1994	--	--	--
Daily Mean Flow Rates in Cubic Feet per Second				
Maximum Flow Rate	--	42,200	40,800	43,200
Minimum Flow Rate	--	473	16	210
Average Flow Rate	--	6,243	5,154	6,177
Date of Maximum Flow Rate	--	5/19/1997	5/23/2008	5/19/1997
Date of Minimum Flow Rate	--	8/21/1994	8/12/2007	8/18/1992

Notes:

Elevation is in NAVD88 datum.

RM = River Mile

-- = No Data

*Greenacres data ranges from 1999 through 2008

Spokane, Greenacres, and Post Falls gaging station data are from USGS website: http://waterdata.usgs.gov/nwis.

Table 4-8 - Summary of Surface Water Quality Data from the Spokane River at Stateline Bridge

Sample	Hardness	Dissolved Metals in ug/L						Total Recoverable Metals in ug/L					
Date	in mg/L	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc
5/3/94			**0.298** P	1.42	0.209	1	**96.9**	30 U					
7/6/94			0.15 P	0.496 P	0.18 P	1 U	**58**	30 U					
9/6/94			0.04 U	0.4 P	0.12 P	1 U	22.3	30 U					
11/7/94			0.13 P	0.495 P	0.143 P	1 U	**59.7**	30 U					
1/9/95			0.18 P	0.44 P	0.064 P	0.41 P	**79.7**	30 U					
3/6/95			**0.406**	0.706	**0.818**	0.575	**104**	30 U					
10/2/95	21		0.11	0.41	0.172	1 U	**51.2**	1 U	0.16	0.605	**1.38**	1 U	**48.4** N
12/4/95	22		**0.289**	0.345	0.212	1 U	**92.1**	1 U	**0.47**	0.44	**3.74**	1 U	**102** J
2/5/96	21		**0.377**	0.841	**1.15**	0.512	**94.5**	1 U	**0.46**	0.89	**5.38**	1 U	**89.6**
4/9/96	17		**0.37**	0.931	**3.87**	0.509	**86.1**	1 U	**0.4**	1.1	**14.8**	0.58	**82.3**
6/3/96			**0.282**	0.547	**1.64**		**66.5**		**0.34**	0.9	**5.6**		**67.1** J
8/5/96			**0.281**	0.45	0.206		**46.1**		**0.45**	1.1	**1.4**		**45.7**
10/8/96			0.219	0.5	0.227		**50.2** J		0.18	0.8 J	**1.2**		**46.9** J
12/3/96			0.249	0.45	0.34		**81.6**		**0.3**	0.6	**1.5**		**78.6**
2/4/97			**0.342**	0.593	**0.914**		**105**		**0.34**	0.7	**3.1**		**110** J
4/8/97	23.2		**0.44**	0.86	**1.41**		**119**						
5/6/97	20.3		**0.318**	0.632	**2.69**		**74.5**		**0.45**		**12.3**		**87.4**
5/12/97	19.3		**0.275**	0.576	**1.93**		**61**		**0.37**		**9.2**		**75.8**
6/3/97	16.3		**0.337**	0.64	**1.65**		**78.9**		**0.41**		**12.2**		**79.5**
10/6/97	21		0.11	0.46	0.2	0.31	**46.2**	**0.44**	0.1	0.6	**0.9**		**42** J
11/3/97	21		0.17	0.505	0.228	0.37	**61**	**0.37**	0.19	0.6	**1**		**50.8**
12/8/97	22		**0.285**	0.548	0.18	0.46	**82**	**0.49**	**0.35**	0.7	**1.1**		**82.4** J
2/2/98	23		**0.334**	0.718	0.12	0.48	**102**	**0.44**	**0.3**	0.8	**0.8**		**83.4**
3/2/98	23		**0.322**	0.63	0.15	0.608	**97.1**	**0.4**	**0.31**	0.6	**0.8**	1.08	**81.7**
4/14/98	23		**0.355**	0.592	**0.64**	0.48	**96**	**0.42**	**0.36**	0.7	**2.2**		**96.9** J
5/4/98	23		0.02 U	0.05 U	0.02 U	0.14	7.07	**0.38**	**0.4**	0.9	**3.9**		**102** J
6/8/98	21		**0.269**	0.47	0.36	0.38	**67.1**	**0.32**	**0.28**	2.2	**1.6**		**58.3**
8/3/98	23		0.13	0.46	0.1	0.39	**42.3**	**0.43**	0.16	0.6	**0.9**		**40.1**
10/5/98	25		0.069	0.35	0.17	0.21	**32.7**	**0.44**	0.13	**11.4**	**1.2**		**49.6**
12/7/98	25		0.233	0.511	0.08	0.41	**79.1**	**0.49**	**0.25**	0.6	**0.7**		**71.3**
2/8/99	26		**0.26**	0.556	0.308	0.55	**89.4**	**0.46**	**0.29**	0.7	**1.2**		**97** J
3/8/99	48		**0.285**	0.614	0.501	0.557	**87.7**	**0.44**	**0.33**	0.8	**1.8**		**80.3**
4/5/99	24		**0.353**	0.641	**1.19**	0.5	**99.3**	**0.44**	**0.39**	0.7	**3**		**92.2**

Table 4-8 - Summary of Surface Water Quality Data from the Spokane River at Stateline Bridge

Sample	Hardness	Dissolved Metals in ug/L						Total Recoverable Metals in ug/L					
Date	in mg/L	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc
5/3/99	21		**0.319**	0.598	**1.12**	0.44	**76.7**	**0.41**	**0.36**	0.9 J	**3.3**		**75.5**
6/7/99	18		0.245	0.52	**0.97**	0.23	**52.4**	**0.42**	**0.29**	1.1	**7.4**		**61.2** J
7/10/01								**0.43**					
8/7/01								**0.58**					
9/11/01								**0.67**					
10/15/01	23.6	0.02 U	0.08	0.504	0.223	0.27	31.5	**0.55**	0.13	0.63	**1.16**	0.27	**37.6**
11/5/01								**0.49**					
12/3/01	23.4	0.02 U	0.15	0.45	0.068	0.1 U	**55.1**	**0.5**	0.18	0.84 J	**0.98**	0.2 U	**61.2**
1/14/02								**0.47**					
2/12/02	24.6	0.02 U	0.16	0.591	0.254	0.39	**61.3**	**0.5**	0.19	0.86 J	**1.33**	0.21	**68.7**
3/12/02								**0.56**					
4/9/02	24.7	0.02 U	0.228	0.591	**0.549**	0.39	**71.8**	**0.51**	**0.27**	0.92	**2.78**	0.45	**69**
5/13/02								**0.55**					
6/4/02	17.8	0.02 U	0.23	0.517	**1.77**	0.3	**49.1**	**0.45**	**0.32**	0.76	**10.1**	0.61	**54.5**
8/13/02	18.4	0.02 U	0.12	0.45	0.19	0.17	**34.6**	**0.47**	0.13	0.79	**1.2**	0.19	**38**
10/14/02	19.1	0.1 U	0.1 U	0.31	0.229	0.22	29.8	**0.49**	0.14	0.45	**1.33**	0.39	**33**
12/15/02	20.4	0.1 U	**0.255**	0.52	0.17	0.26	**63.4**	**0.39**	**0.25**	0.73	**1.11**	0.3	**63.7**
2/2/03	20.7	0.02 U	0.229	0.59	0.12	0.35	**67.2**	**0.58**	**0.41**	0.88	**4.75**	0.46	**77.6**
4/6/03	21.9	0.02 U	**0.28**	0.64	**0.691**	0.41	**75.5**	**0.44**	**0.3**	0.87 J	**2.52**	0.49	**72.5**
6/1/03	21.8	0.02 U	**0.276**	0.54	**0.609**	0.3	**49**	**0.31**	**0.27**	0.7	**2.48**	0.41	**55.3**
8/3/03	22.3	0.02 U	0.098	0.53	0.13	0.37	**34.6**	**0.5**	0.13	0.69	**0.89**	0.46	**35**
10/7/03	22	0.02 U	0.068	0.5	0.12	0.15 J	**34**	**0.41**	0.13	0.59	**1.31**	0.37	**36**
12/9/03	21.3	0.02 U	0.19	0.55	0.086	0.38	**60.9**	**0.47**	**0.25**	0.7	**0.87**	0.48	**60.4**
2/10/04	23	0.02 U	0.19	0.53	0.096	0.37	**63.7**	**0.48**	0.22	0.63	**0.72**	0.39	**58.1**
4/13/04	21.4	0.02 U	**0.263**	0.54	**0.633**	0.27	**67.8**	**0.52**	**0.38**	0.83	**4.04**	0.48	**79.5**
6/15/04	19.4	0.02 U	0.2	0.48	0.13	0.27	**51**	**0.33**	**0.25**	0.48	**1.1**	0.27	**52.1**
8/3/04	23.4	0.02 U	0.11	0.82	0.16	0.39	**33**	**0.5**	0.15	0.57	**1.25**	0.37	**36**
10/5/04	22.4	0.02 U	0.084	0.5	0.209	0.24	**37.5**	**0.7**	0.15	0.48	**1.2**	0.25	**38**
12/13/04	22.5	0.02 U	0.19	0.42	0.081	0.31	**66.3**	**0.63**	0.43	0.92	**4.77**	0.45	**84.3**
2/8/05	22.7	0.02 U	0.222	0.45	0.19	0.32	**68.2**	**0.43**	**0.26**	1.99	**1.36**	0.41	**74.9**
4/5/05	21.5	0.02 U	0.212	0.56	0.18	0.34	**67.4**	**0.51** J	**0.28**	2.37	**2.06**	0.5	**73.8**
6/7/05	20.2	0.02 U	0.16	0.41	0.15	0.28	**47.9**	**0.37**	0.23	0.7 J	**1.48**	0.32	**48.5**
8/2/05	23.3	0.02 U	0.081	0.57	0.11	0.4	**32.6**	**0.35**	0.13	0.95	**1.19**	0.5 U	**37**
10/4/05	23.3	0.02 U	0.077	0.48	0.15	0.32	**37.4**	**0.49**	0.13	0.57	**1.18**	0.36	**36**
12/6/05	23.6	0.02 U	0.16	0.49	0.13	0.31	**58.4**	**0.4**	0.18	0.59	**1.06**	0.42	**59.2**
2/7/06	23.7	0.02 U	0.21	1.01	0.222	0.45	**85.9**	**0.48**	0.22	0.84	**1.29**	0.43	**61.1**

Table 4-8 - Summary of Surface Water Quality Data from the Spokane River at Stateline Bridge

Sample	Hardness	Dissolved Metals in ug/L						Total Recoverable Metals in ug/L					
Date	in mg/L	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc
4/11/06	23	0.02 U	0.24	0.63	**0.85**	0.43	**72.7**	**0.45**	**0.29**	0.87	**2.72**	0.42	**70.3**
6/6/06	19.3	0.02 U	0.17	0.42	0.26	0.27	**44**	**0.48**	0.23	0.54	**2.03**	0.24	**48**
8/8/06	21.7	0.02 U	0.098	0.61	0.16	0.44	**35**	**0.46**	0.13	0.6	**0.98**	0.43 J	**33**
10/3/06	21.8	0.02 U	0.093	0.55	0.14	0.33	**36**	**0.49**	0.13	0.61	**0.92**	0.3	**36.7**
12/5/06	21.4	0.02 U	0.17	0.56	0.13	0.44	**56.9**	**0.45**	0.18	0.56	**0.68**	0.49	**51.7**
2/13/07	77	0.02 U	0.18	0.57	0.419	0.38	**57.7**	**0.46**	0.22	0.66	**1.67**	0.43	**61.4**
4/3/07	23.1	0.02 U	0.21	0.59	**0.98**	0.39	**66.4**	**0.48**	**0.26**	0.71	**4.24**	0.43	**64**
6/6/07	19.3	0.02 U	0.18	1.14	**1.33**	0.5	**66.9**	**0.36**	0.2	0.6	**1.6**	0.33	**43**
8/8/07	21.9	0.02 U	0.072	0.53	0.14	0.22	28.7	**0.54**	0.11	0.68	**0.8**	0.43	27
Chronic (a)		0.018	0.25	3.5	0.54	49	32	0.018	0.25	3.5	0.54	49	32

Notes:

U = Not detected at detection limit indicated

J = Estimated value

P = Estimated value below quantitation limit

N = Low spike recovery

Data collected from center of Stateline Bridge.

(a) Ecology surface water quality screening criteria for fresh water (Chapter 173-201A WAC, Clean Water Act §304, and 40 CFR 131).

Bolded value exceeds Ecology's surface water screening criteria.

Reporting limits for arsenic exceeds screening criteria.

Reference: http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?sta=57A150.

Table 4-9 - Summary of PCB Concentrations in Spokane River Fish

Reach	River Mile	Year	Species	Tissue	Composite Sample	Analysis	PCB in ug/kg	Average PCB in ug/kg
Stateline	96.1	1999	LSS	Whole	Y	Aroclor	120	102
Stateline	96.1	1999	LSS	Fillet	N	Aroclor	342	
Stateline	96.1	1999	LSS	Fillet	N	Aroclor	62	
Stateline	96.1	1999	LSS	Fillet	N	Aroclor	61	
Stateline	96.1	1999	LSS	Fillet	N	Aroclor	6	
Stateline	96.1	1999	LSS	Fillet	N	Aroclor	21	
Stateline	96.1	2004	LSS	Whole	Y	Congener	59	101
Stateline	96.1	2004	LSS	Whole	Y	Congener	142	
Stateline	96.1	2005	LSS	Whole	Y	Aroclor	77	56
Stateline	96.1	2005	LSS	Whole	Y	Aroclor	74.4	
Stateline	96.1	2005	LSS	Whole	Y	Aroclor	15.5	
Stateline	96.1	1999	RBT	Fillet	N	Aroclor	85	101
Stateline	96.1	1999	RBT	Fillet	N	Aroclor	133	
Stateline	96.1	1999	RBT	Fillet	N	Aroclor	105	
Stateline	96.1	1999	RBT	Fillet	N	Aroclor	133	
Stateline	96.1	1999	RBT	Fillet	N	Aroclor	74	
Stateline	96.1	1999	RBT	Whole	Y	Aroclor	77	
Plante Ferry	84.8	2005	LSS	Whole	Y	Aroclor	180	122
Plante Ferry	84.8	2005	LSS	Whole	Y	Aroclor	90.9	
Plante Ferry	84.8	2005	LSS	Whole	Y	Aroclor	94.4	
Plante Ferry	84.8	1993	LSS	Whole	N	Aroclor	2005	2005
Plante Ferry	84.8	1994	LSS	Whole		Aroclor	531	531
Plante Ferry	84.8	1996	LSS	Whole	Y	Aroclor	530	530
Plante Ferry	84.8	1999	LSS	Whole	Y	Aroclor	283	171
Plante Ferry	84.8	1999	LSS	Fillet	N	Aroclor	207	
Plante Ferry	84.8	1999	LSS	Fillet	N	Aroclor	215	
Plante Ferry	84.8	1999	LSS	Fillet	N	Aroclor	67	
Plante Ferry	84.8	1999	LSS	Fillet	N	Aroclor	60	
Plante Ferry	84.8	1999	LSS	Fillet	N	Aroclor	191	
Plante Ferry	84.8	2003	LSS	Whole	Y	Congener	140	97
Plante Ferry	84.8	2003	LSS	Whole	Y	Congener	54	
Plante Ferry	84.8	1993	RBT	Fillet		Aroclor	1084	918
Plante Ferry	84.8	1993	RBT	Fillet		Aroclor	950	
Plante Ferry	84.8	1993	RBT	Fillet	Y	Aroclor	720	
Plante Ferry	84.8	1994	RBT	Fillet		Aroclor	383	452
Plante Ferry	84.8	1994	RBT	Fillet		Aroclor	387	
Plante Ferry	84.8	1994	RBT	Fillet		Aroclor	740	
Plante Ferry	84.8	1994	RBT	Fillet		Aroclor	471	
Plante Ferry	84.8	1994	RBT	Fillet		Aroclor	280	
Plante Ferry	84.8	1996	RBT	Fillet	Y	Aroclor	1870	799
Plante Ferry	84.8	1996	RBT	Fillet	Y	Aroclor	313	
Plante Ferry	84.8	1996	RBT	Fillet	Y	Aroclor	215	
Plante Ferry	84.8	1999	RBT	Fillet	N	Aroclor	1353	922
Plante Ferry	84.8	1999	RBT	Fillet	N	Aroclor	1248	
Plante Ferry	84.8	1999	RBT	Fillet	N	Aroclor	70	
Plante Ferry	84.8	1999	RBT	Fillet	N	Aroclor	1610	
Plante Ferry	84.8	1999	RBT	Fillet	N	Aroclor	100	
Plante Ferry	84.8	1999	RBT	Fillet	N	Aroclor	1320	
Plante Ferry	84.8	1999	RBT	Whole	Y	Aroclor	755	

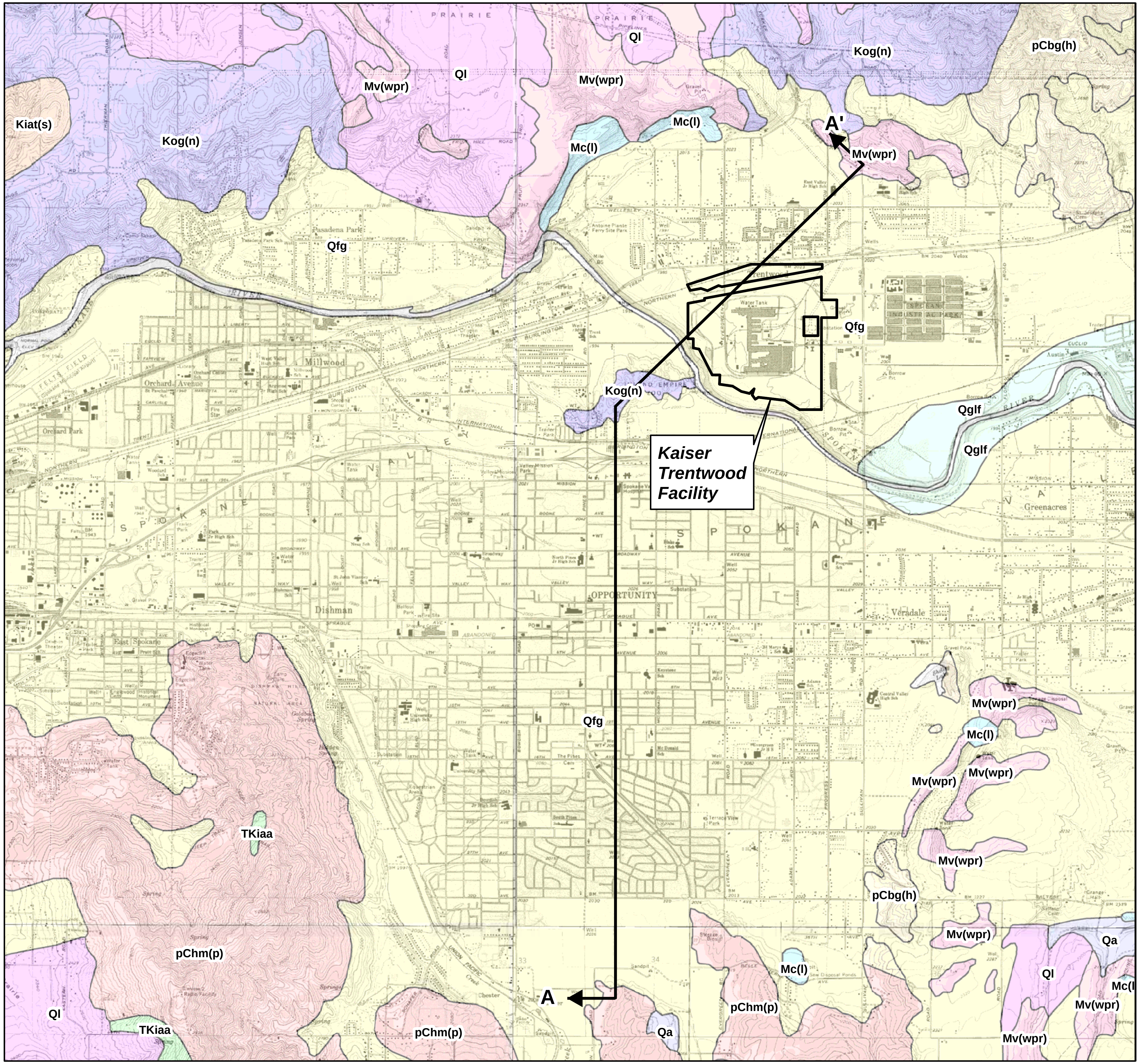
Table 4-9 - Summary of PCB Concentrations in Spokane River Fish

Reach	River Mile	Year	Species	Tissue	Composite Sample	Analysis	PCB in ug/kg	Average PCB in ug/kg
Plante Ferry	84.8	2003	RBT	Fillet	Y	Congener	28	35
Plante Ferry	84.8	2003	RBT	Fillet	Y	Congener	41	
Plante Ferry	84.8	2005	RBT	Fillet	Y	Aroclor	68	55
Plante Ferry	84.8	2005	RBT	Fillet	Y	Aroclor	48.6	
Plante Ferry	84.8	2005	RBT	Fillet	Y	Aroclor	48	
Mission Park	76.5	1994	LSS	Whole		Aroclor	201	201
Mission Park	76.5	1996	LSS	Whole	Y	Aroclor	116	116
Mission Park	76.5	1999	LSS	Whole	Y	Aroclor	449	262
Mission Park	76.5	1999	LSS	Whole	Y	Aroclor	440	
Mission Park	76.5	1999	LSS	Fillet	N	Aroclor	144	
Mission Park	76.5	1999	LSS	Fillet	N	Aroclor	429	
Mission Park	76.5	1999	LSS	Fillet	N	Aroclor	92	
Mission Park	76.5	1999	LSS	Fillet	N	Aroclor	193	
Mission Park	76.5	1999	LSS	Fillet	N	Aroclor	88	
Mission Park	76.5	2005	LSS	Whole	Y	Aroclor	1369	1823
Mission Park	76.5	2005	LSS	Whole	Y	Aroclor	3000	
Mission Park	76.5	2005	LSS	Whole	Y	Aroclor	1100	
Mission Park	76.5	1994	MWF	Fillet		Aroclor	530	568
Mission Park	76.5	1994	MWF	Fillet		Aroclor	449	
Mission Park	76.5	1994	MWF	Fillet		Aroclor	725	
Mission Park	76.5	1996	MWF	Fillet	Y	Aroclor	398	381
Mission Park	76.5	1996	MWF	Fillet	Y	Aroclor	364	
Mission Park	76.5	1999	MWF	Fillet	N	Aroclor	478	348
Mission Park	76.5	1999	MWF	Fillet	N	Aroclor	338	
Mission Park	76.5	1999	MWF	Fillet	N	Aroclor	335	
Mission Park	76.5	1999	MWF	Fillet	N	Aroclor	380	
Mission Park	76.5	1999	MWF	Fillet	N	Aroclor	162	
Mission Park	76.5	1999	MWF	Whole	Y	Aroclor	397	
Mission Park	76.5	2005	MWF	Fillet	Y	Aroclor	280	234
Mission Park	76.5	2005	MWF	Fillet	Y	Aroclor	220	
Mission Park	76.5	2005	MWF	Fillet	Y	Aroclor	203	
Mission Park	76.5	1994	RBT	Fillet		Aroclor	164	145
Mission Park	76.5	1994	RBT	Fillet		Aroclor	111	
Mission Park	76.5	1994	RBT	Fillet		Aroclor	161	
Mission Park	76.5	1996	RBT	Fillet	Y	Aroclor	73	76
Mission Park	76.5	1996	RBT	Fillet	Y	Aroclor	78	
Mission Park	76.5	1999	RBT	Fillet	N	Aroclor	136	248
Mission Park	76.5	1999	RBT	Fillet	N	Aroclor	325	
Mission Park	76.5	1999	RBT	Fillet	N	Aroclor	398	
Mission Park	76.5	1999	RBT	Fillet	N	Aroclor	143	
Mission Park	76.5	1999	RBT	Fillet	N	Aroclor	126	
Mission Park	76.5	1999	RBT	Whole	Y	Aroclor	362	
Mission Park	76.5	2005	RBT	Fillet	Y	Aroclor	220	153
Mission Park	76.5	2005	RBT	Fillet	Y	Aroclor	121	
Mission Park	76.5	2005	RBT	Fillet	Y	Aroclor	118	

Notes

LSS = largescale sucker
MWF = mountain whitefish
RBT = rainbow trout
Reference: Ecology 2006b. Publication No. 06-03-025.

Regional Geologic Map



Description of Map Units

🟪 Qa: Alluvium Deposits, Holocene
🟪 Ql: Loess Deposits, Holocene to Pleistocene
🟩 Qglf: Glacial Flood Deposits, Pleistocene
🟨 Qfg: Glacial Flood Deposits, Pleistocene
🟪 Mv(wpr): Basalt, Miocene, Priest River Member
🟦 Mc(l): Lacustrine and Fluvial Deposits, Miocene, Latah Formation
🟩 TKiaa: Granite, Tertiary to Cretaceous
🟧 Kiat(s): Granite, Createaceous
🟪 Kog(n): Gneiss, Cretaceous
🟫 pCbg(h): Gneiss, Precambrian
🟥 pChm(p): Heterogeneous Metamorphic Rocks, Precambrian

A A' Cross Section Location and Designation
(See Figure 4-2)

Notes: 1.) Base map prepared from the USGS 7.5 minute quadrangle of Spokane NE and Greenacres, Washington, dated 1986, Freeman and Spokane SE, Washington, dated 1995.

2.) Geologic map prepared from Washington State Department of Natural Resources Open File Report 2005-3.

N

0 2,000 4,000 8,000 Feet

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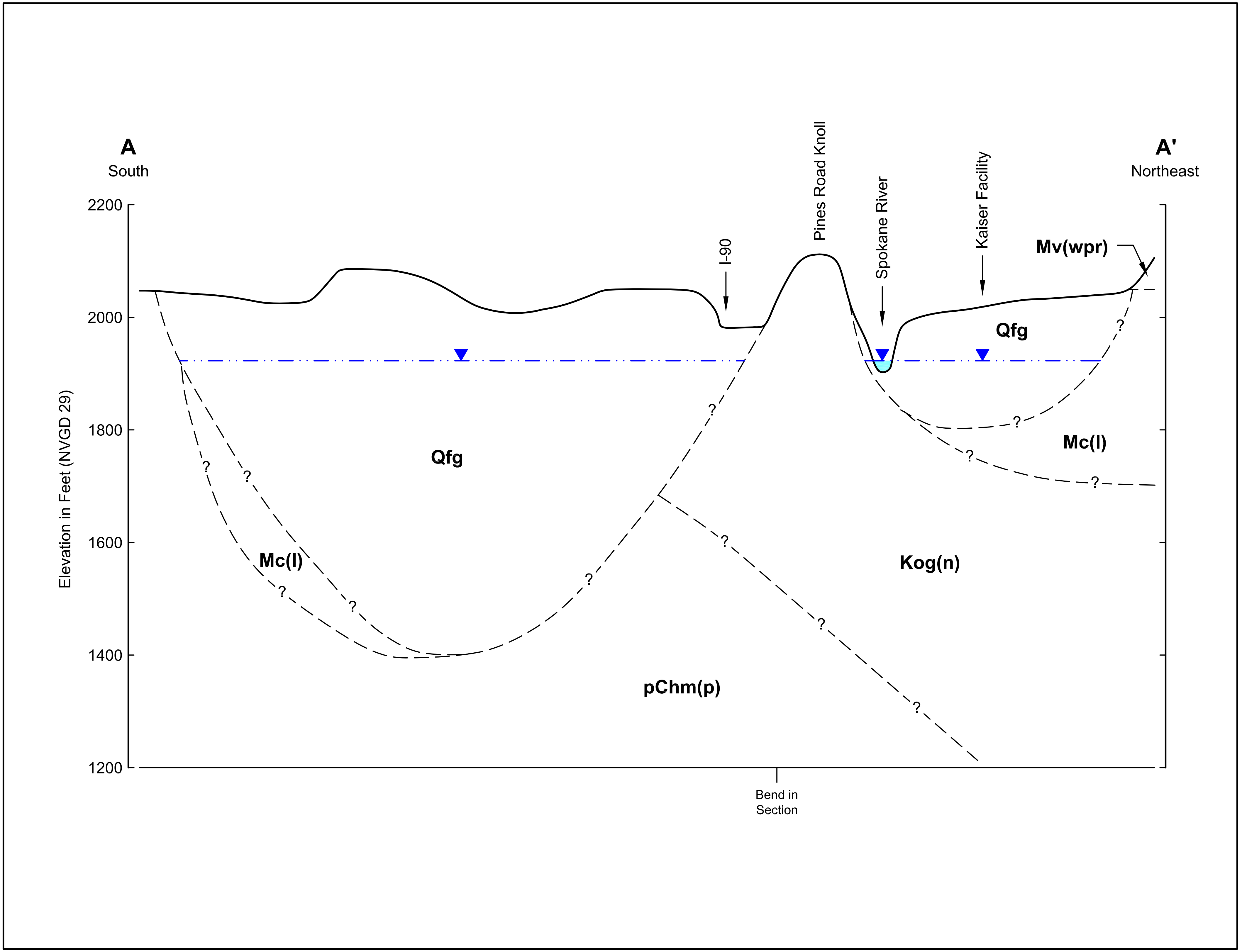
Figure 4-1

Regional Geologic Cross Section A-A'



EAL 05/12/09 2644114-026.DWG

Qfg	Glacial Flood Deposits (Spokane Valley-Rathdum Prairie Aquifer)
Mv(wpr)	Basalt
Mc(l)	Lacustrine and Fluvial Deposits
Kog(n)	Gneiss
pChm(p)	Heterogeneous Metamorphic Rocks
—·▼·—	Water Table (September 2004)

Notes:
Cross section based on USGS Scientific Investigations Report 2005-5227.

Horizontal Scale in Feet
0 4000 8000
0 200 400
Vertical Scale in Feet
Vertical Exaggeration x 20

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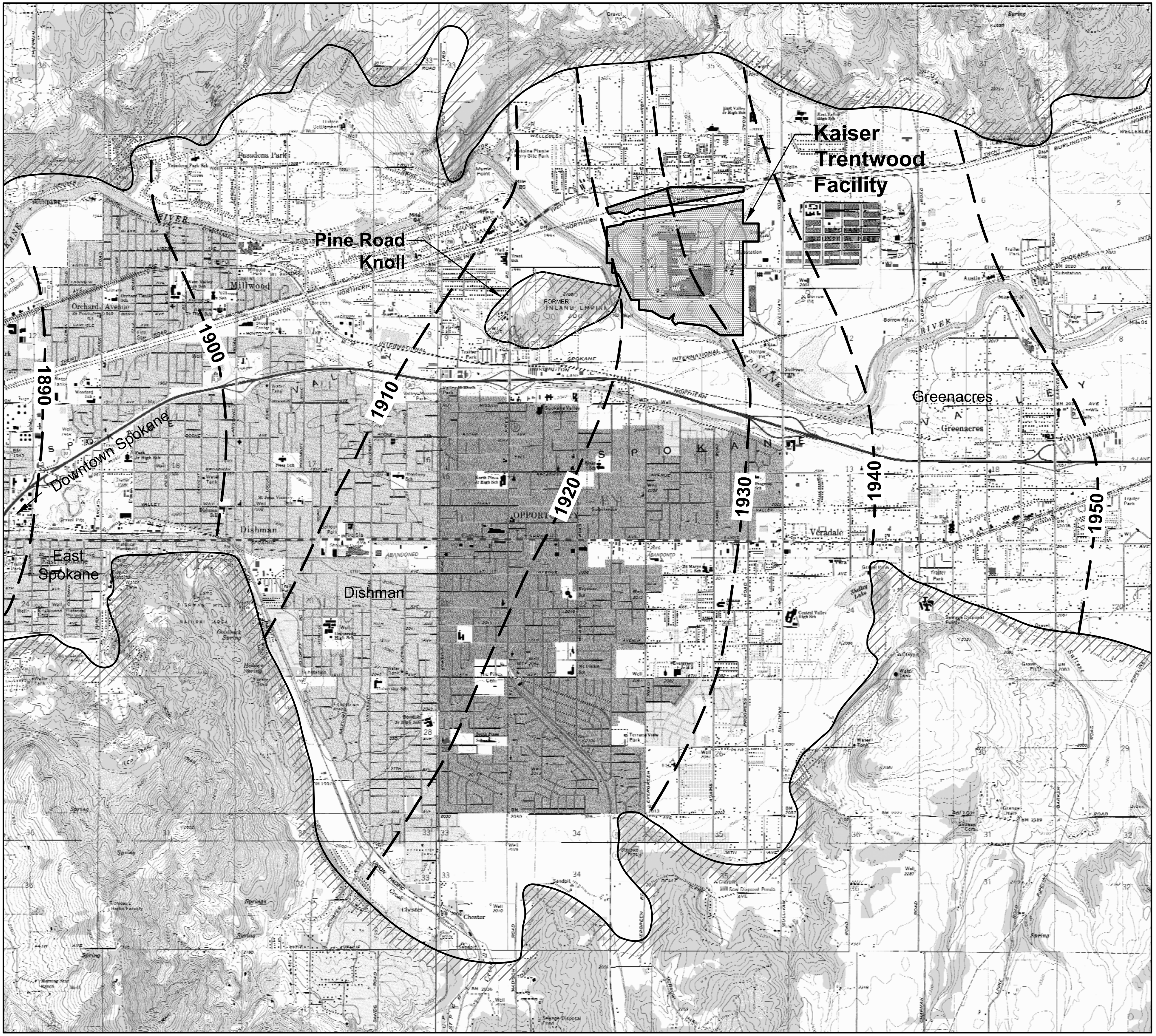
2644-114 ***5/09***

Figure 4-2

Regional Hydrogeologic Map showing September 2004 Groundwater Elevation Contours



— —1900— — Groundwater Elevation Contour in Feet

▨ Boundary of Spokane Valley-Rathdum Prairie Aquifer

← Generalized Groundwater Flow Direction

Notes:

1. Base map prepared from USGS 7.5 minute quadrangle maps of Spokane NE and Greenacres, Washington, dated 1986 and Freeman and Spokane SE, Washington, dated 1995.

2. Groundwater elevations recontoured from USGS Scientific Investigations Map 2905 (2005).

3. Contours in 10-foot intervals with NAVD88 datum.

N

0 4000 8000

Scale in Feet

EAL 02/06/09 2644114-027.dwg

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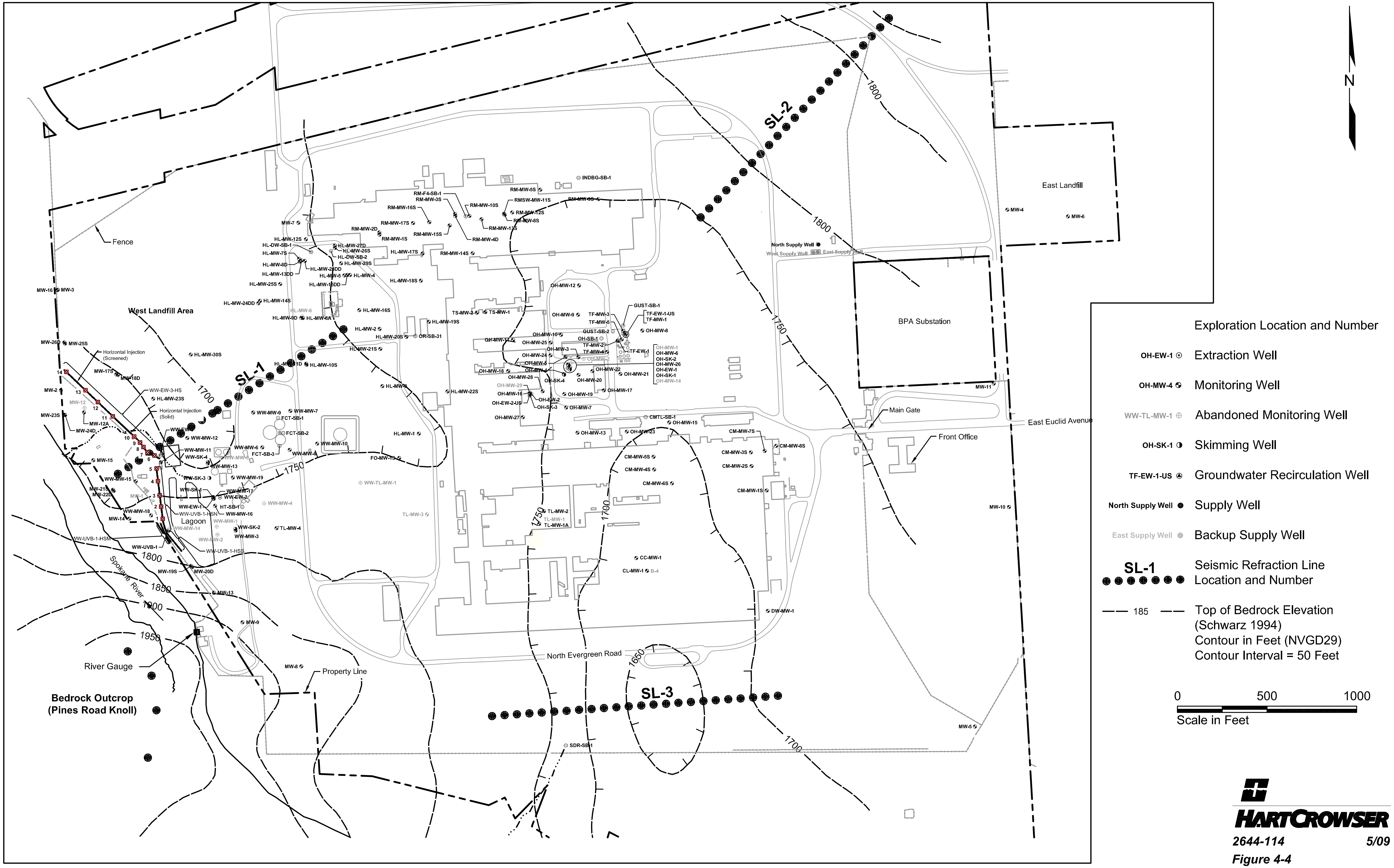
Figure 4-3

Top of Bedrock Elevation Contour Map



Exploration Location and Number

OH-EW-1 ⊙	Extraction Well
OH-MW-4 ◐	Monitoring Well
WW-TL-MW-1 ⊕	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ⊛	Groundwater Recirculation Well
North Supply Well ●	Supply Well
East Supply Well ●	Backup Supply Well
SL-1 ● ● ● ● ● ● ●	Seismic Refraction Line Location and Number
— 185 —	Top of Bedrock Elevation (Schwarz 1994) Contour in Feet (NVGD29) Contour Interval = 50 Feet

0 500 1000
Scale in Feet

EAL 05/10/09 2644114-031.DWG

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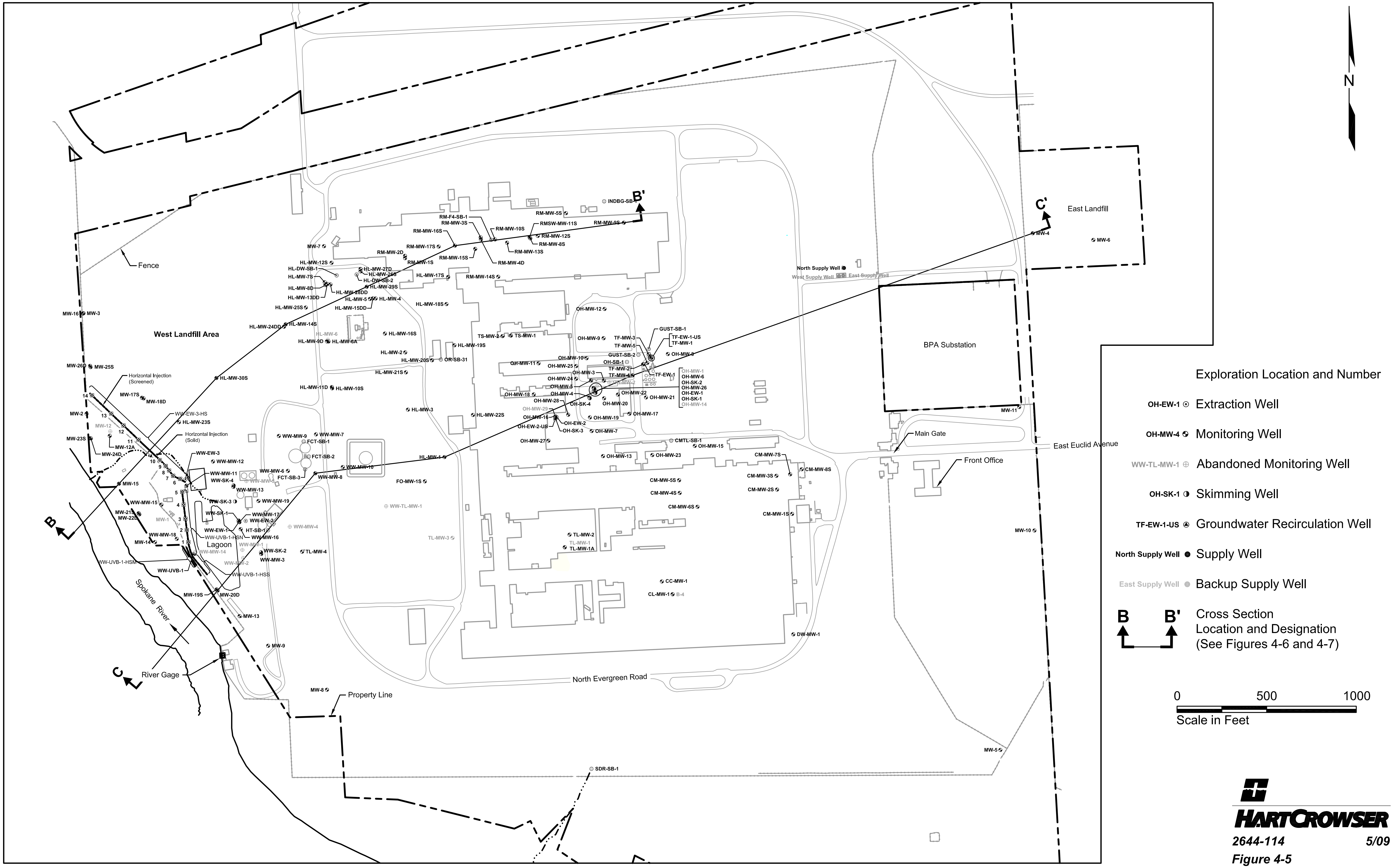
Figure 4-4

Cross Section Location Plan



Exploration Location and Number

OH-EW-1	⊙	Extraction Well
OH-MW-4	◈	Monitoring Well
WW-TL-MW-1	⊕	Abandoned Monitoring Well
OH-SK-1	◑	Skimming Well
TF-EW-1-US	◉	Groundwater Recirculation Well
North Supply Well	●	Supply Well
East Supply Well	●	Backup Supply Well
B B'		Cross Section Location and Designation (See Figures 4-6 and 4-7)

0 500 1000
Scale in Feet

EAL 05/11/09 2644114-084.DWG

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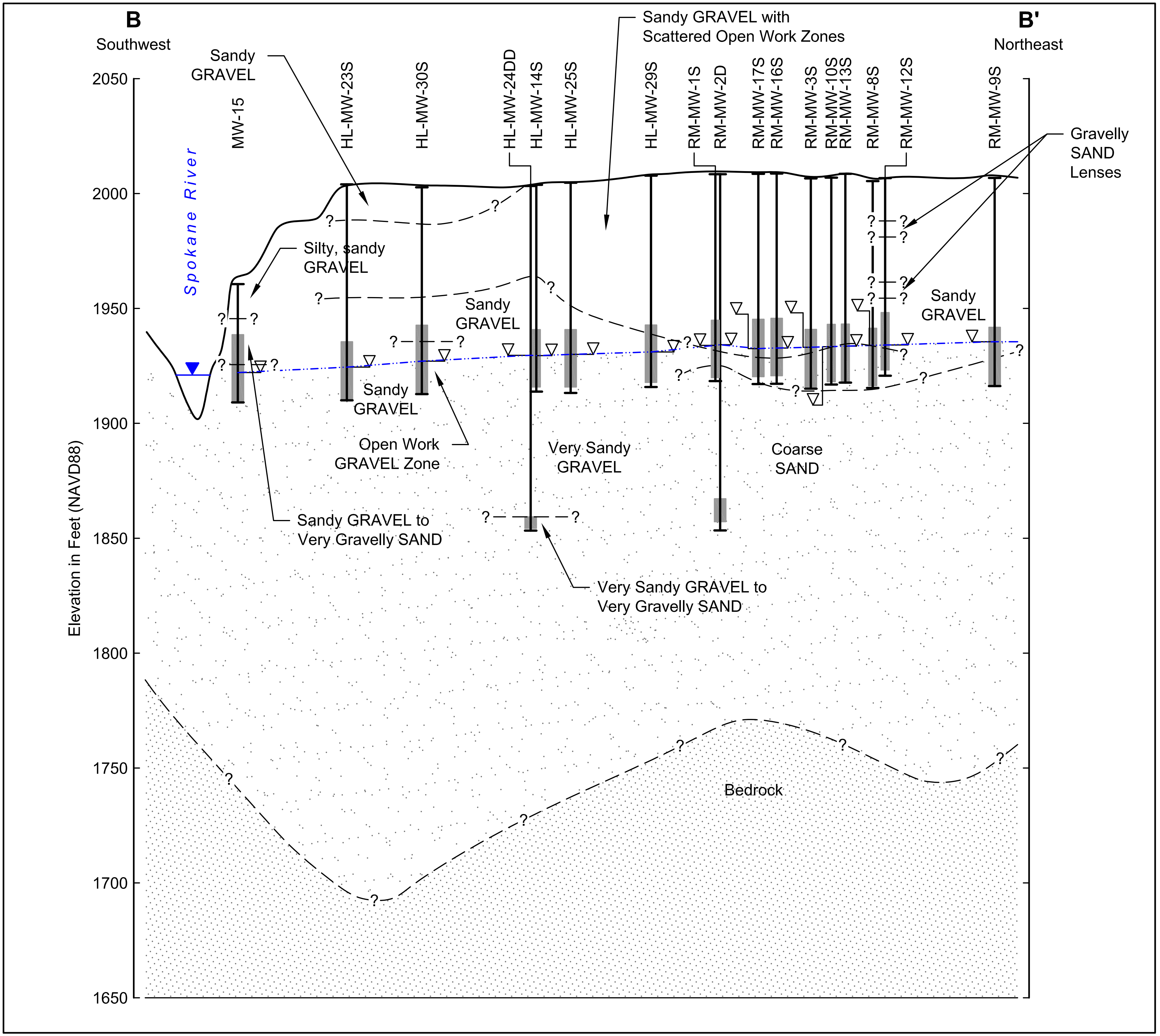
2644-114 5/09

Figure 4-5

Local Geologic Cross Section B-B'



Note:
Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

EAL 05/10/09 2644114-032.DWG

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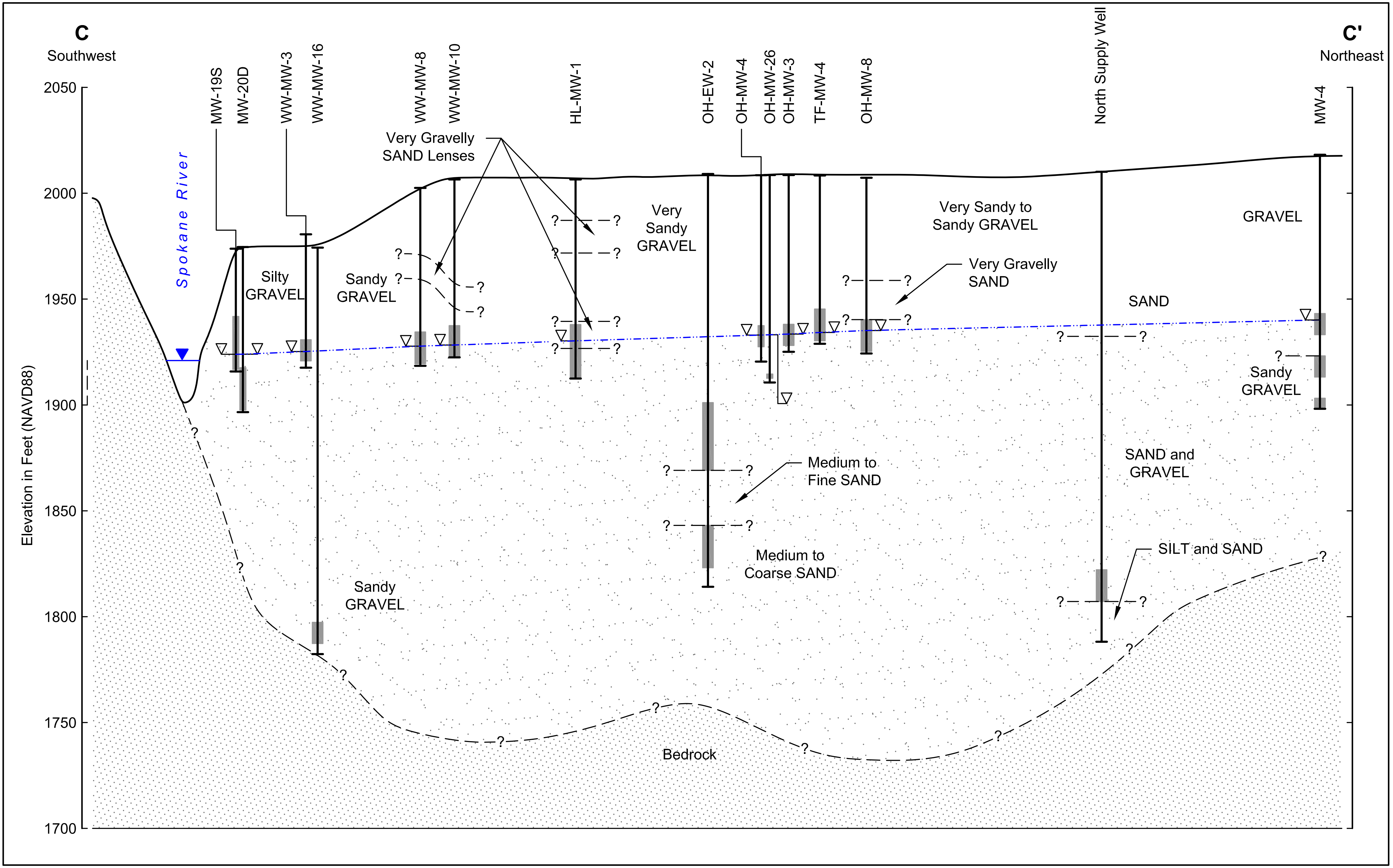
2644-114 ***5/09***

Figure 4-6

Local Geologic Cross Section C-C'



EAL 05/10/09 2644114-033.DWG

MW-19S Well Number

Well Location

▽ Water Level, October 2008

▮ Screened Interval

☐ Unsaturated Sand and Gravel

░ Saturated Sand and Gravel (Spokane Valley-Rathdrum Prairie Aquifer)

▒ Bedrock (Metamorphic Complex)

Note:
Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

Horizontal Scale in Feet
0 500 1000
0 50 100
Vertical Scale in Feet
Vertical Exaggeration x 10

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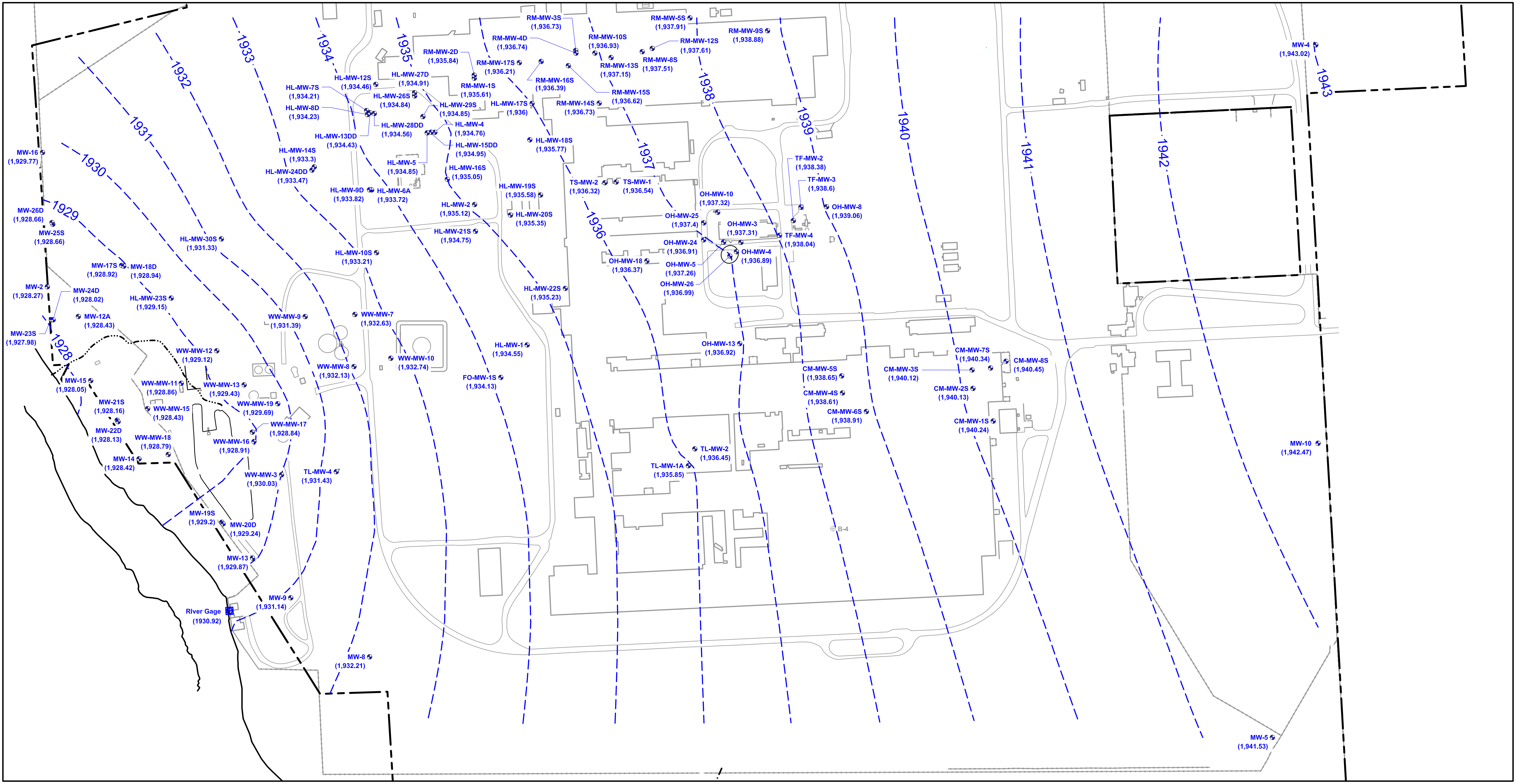
2644-114 ***5/09***

Figure 4-7

Groundwater Elevation Contour Map

April 2008



EAL 05/10/09 2644114-030.DWG

Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

Monitoring Well Location and Number
Spot Groundwater Elevation in Feet

Groundwater Elevation Contour in Feet

0 400 800
Scale in Feet
Vertical Datum in NAVD88

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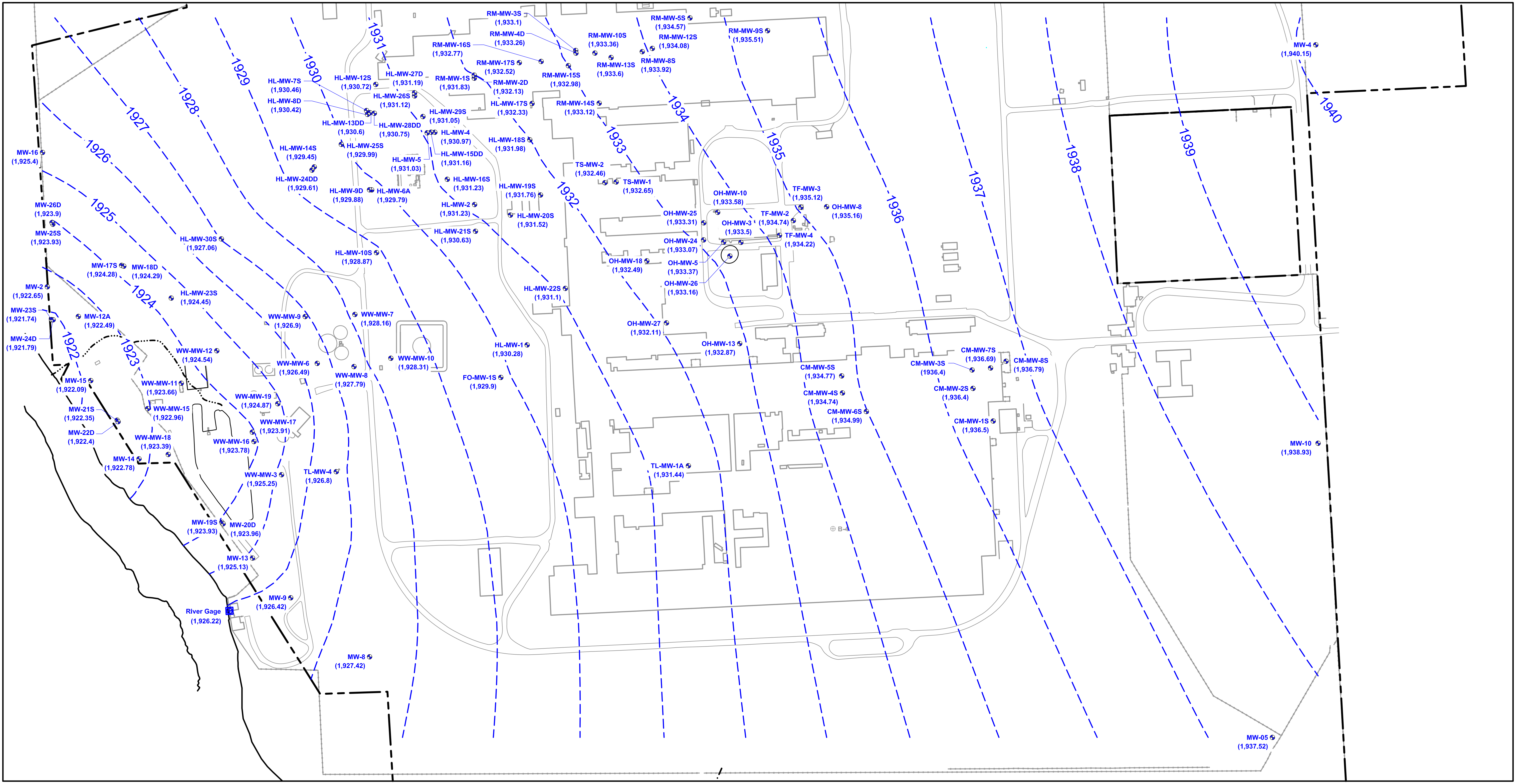
2644-114 ***5/09***
Figure 4-8

Groundwater Elevation Contour Map

October 2008



EAL 05/11/09 2644114-029.DWG

Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

HL-MW-02 ⊕	Monitoring Well Location and Number
(1,931.23)	Spot Groundwater Elevation in Feet
1923 – – – – –	Groundwater Elevation Contour in Feet

0 400 800

Scale in Feet

Vertical Datum in NAVD88

N

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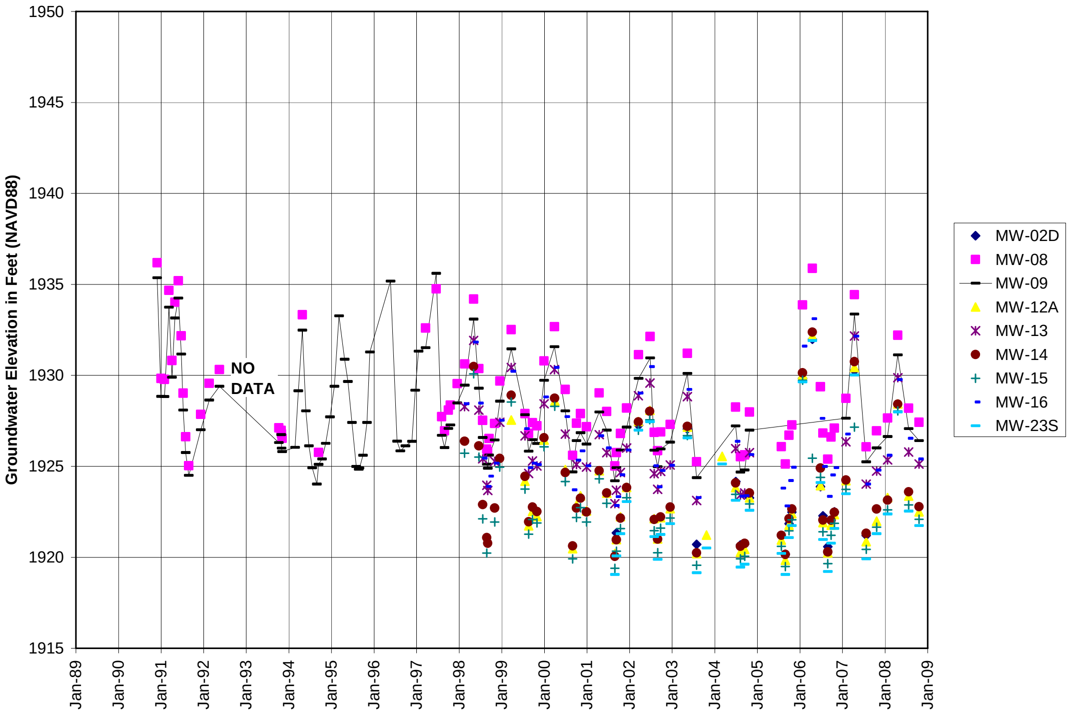
2644-114 ***5/09***

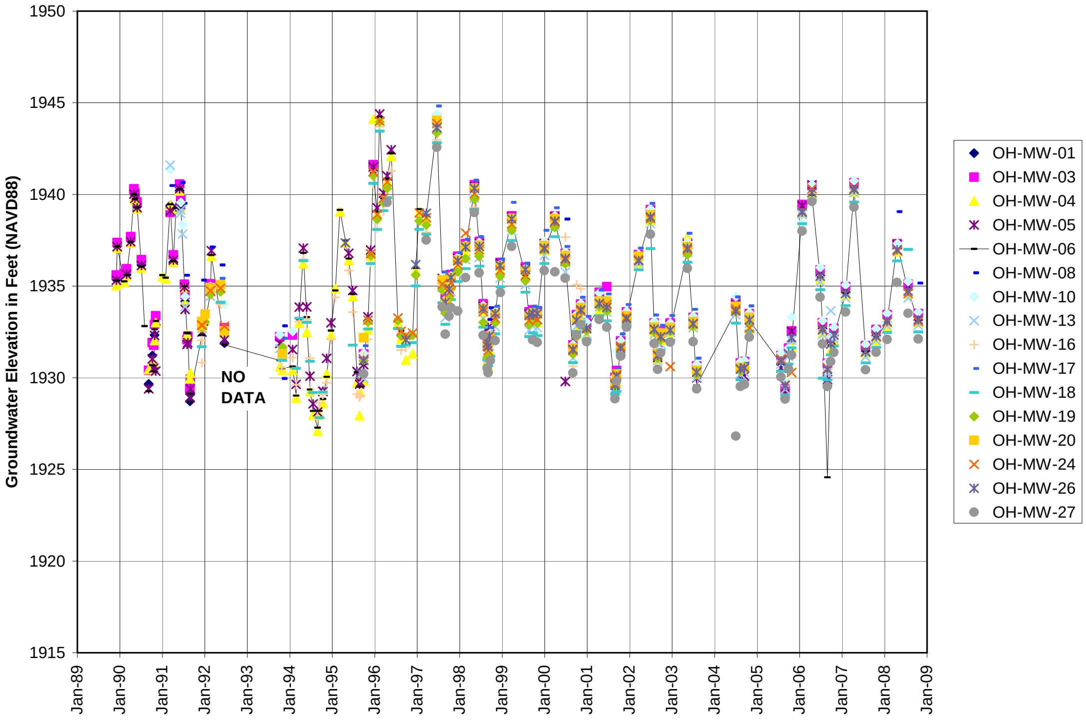
Figure 4-9

Groundwater Elevation Hydrographs
1989 to 2008

Perimeter Wells



Oil House Area Wells



Note: Representative data sets are
traced to aid in data interpretations.

AJG 5/8/09 2644114\GW RI\Section 4\Figure 4-10.doc

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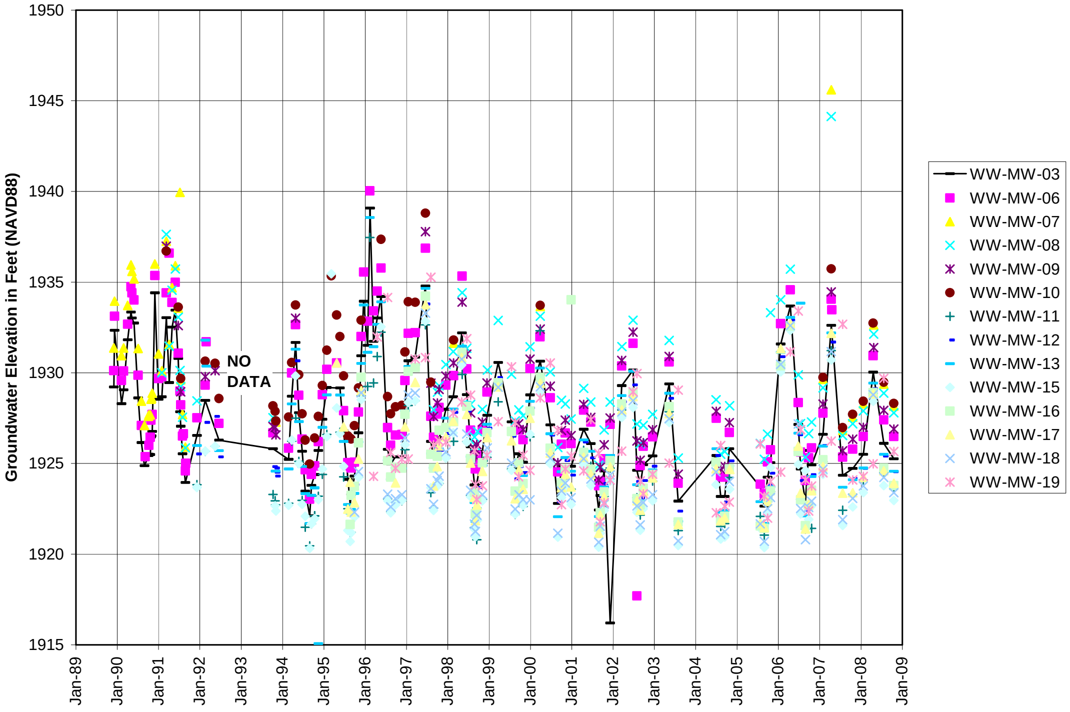
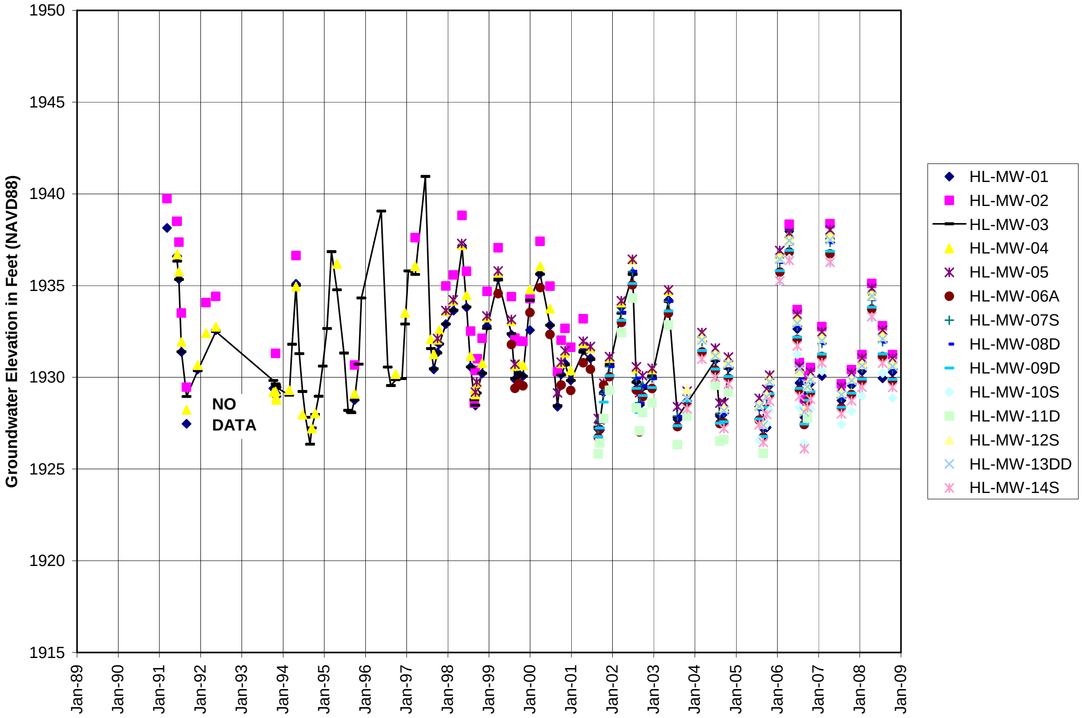
2644-114 ***5/09***
Figure 4-10 ***1/2***

Groundwater Elevation Hydrographs
1989 to 2008

Wastewater Area Wells



Hot Line Area Wells



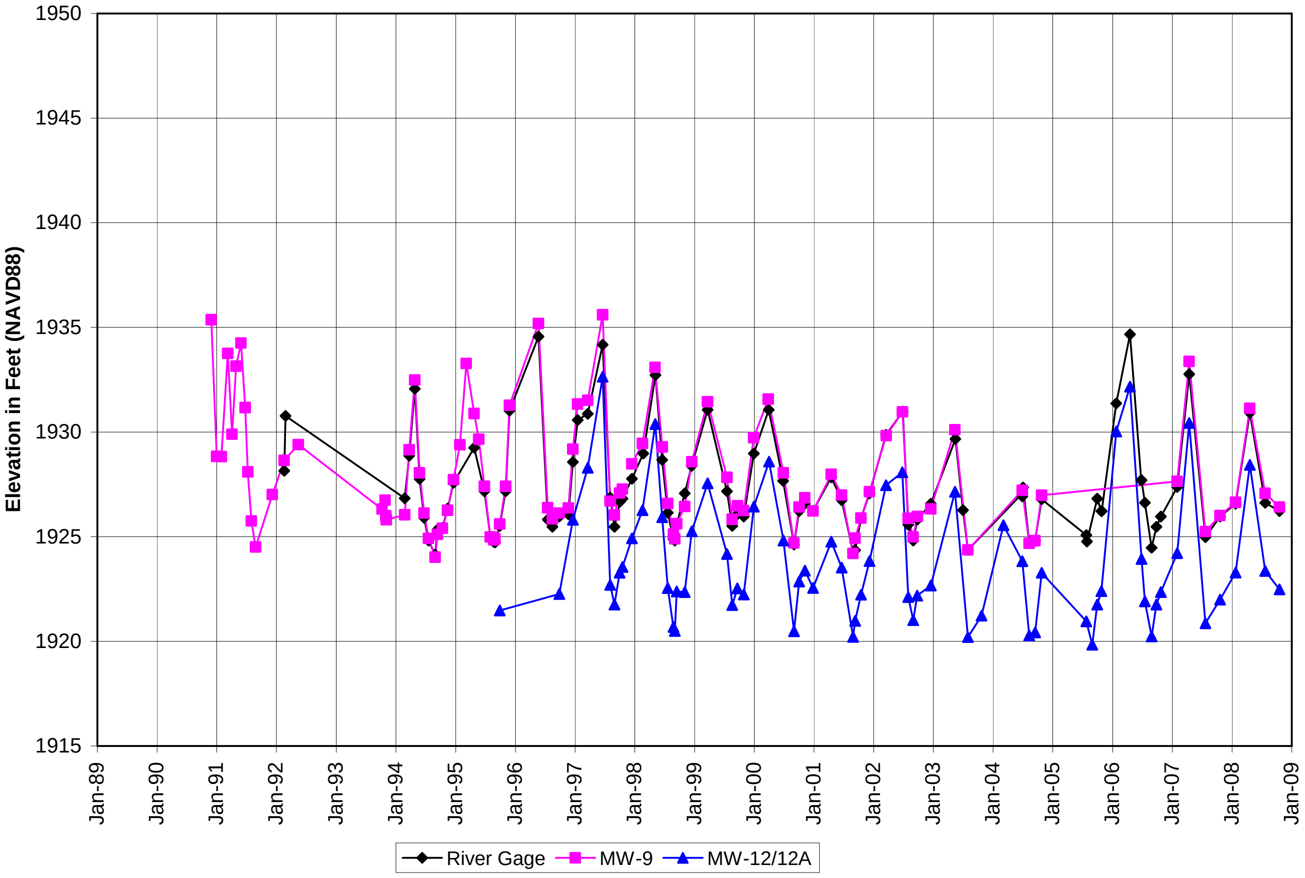
Note: Representative data sets are traced to aid in data interpretations.

AJG 5/8/09 2644114\GW RI\Section 4\Figure 4-10.doc

HARTCROWSER

2644-114 ***5/09***
Figure 4-10 ***2/2***

Groundwater Elevation Hydrographs
1990 to 2008



AJG 5/8/09 2644114\GW RI\Section 4\Figure 4-11.doc

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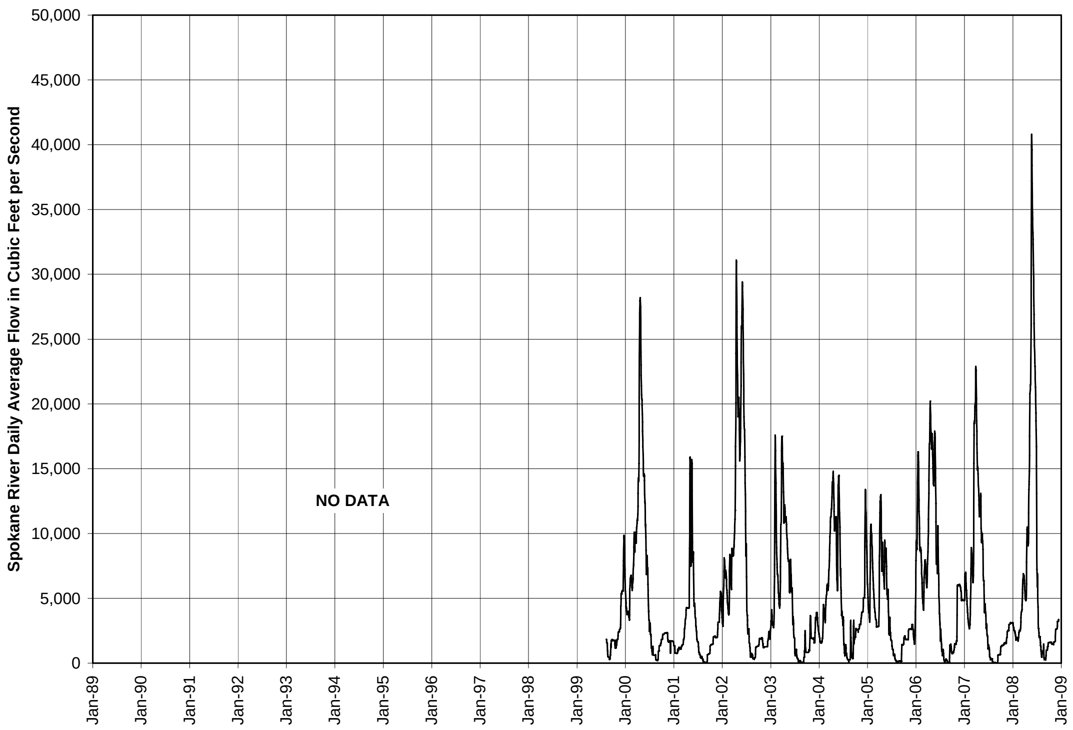
2644-114 5/09

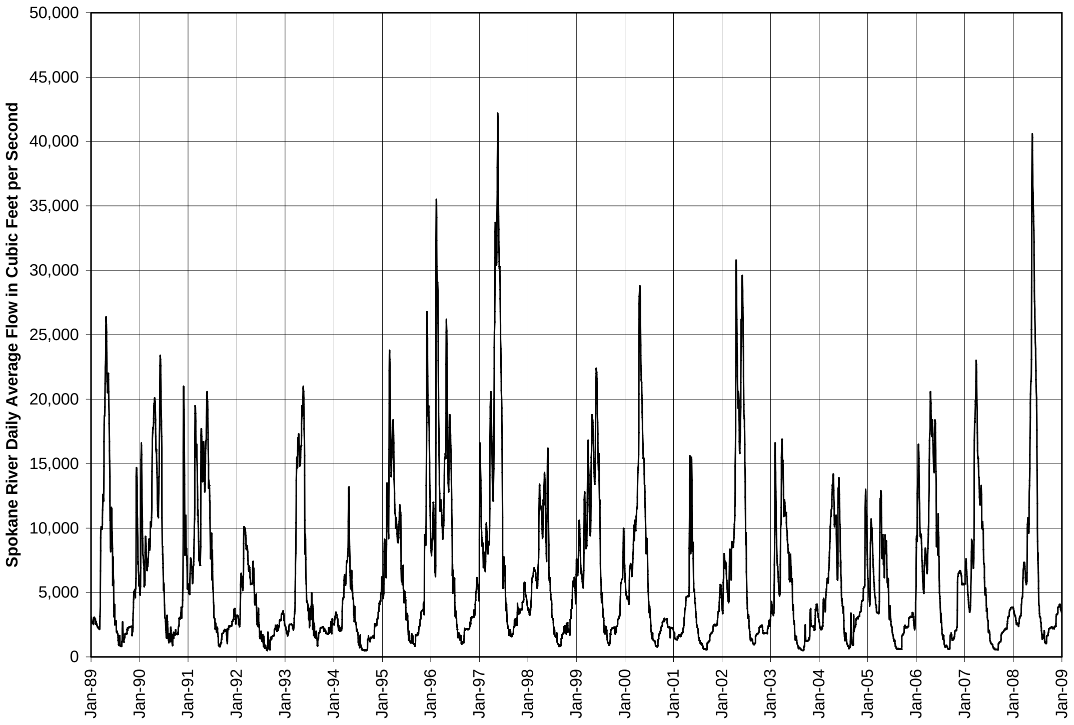
Figure 4-11

Daily Average Spokane River Flow Rates 1989 to 2008

Greenacres Gage (RM 90.5)



Spokane Gage (RM 72.9)



Note: Data from USGS National
Water Information System (2009)

AJG 5/8/09 2644114\GW RI\Section 4\Figure 4-12.doc

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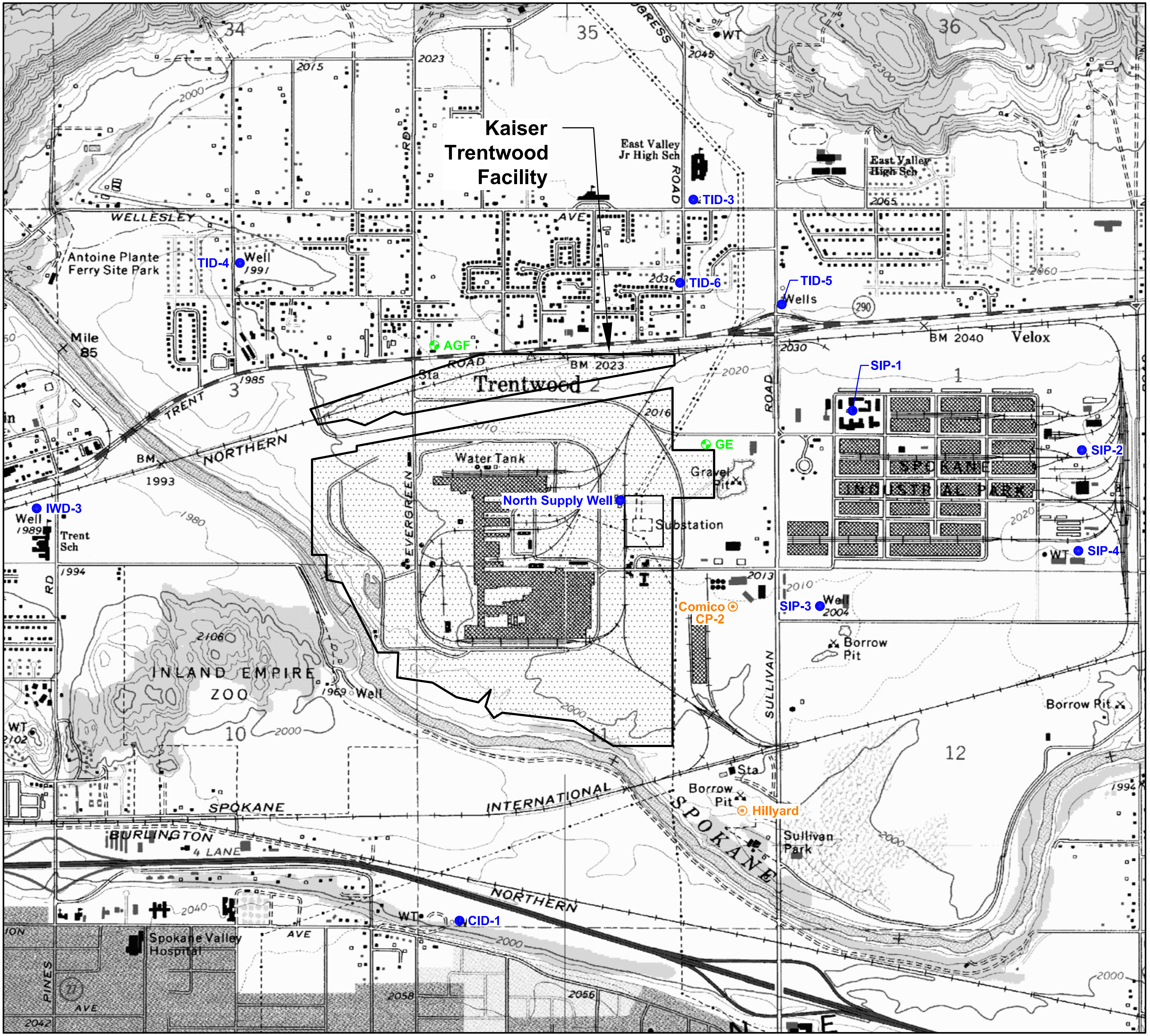
2644-114 ***5/09***

Figure 4-12

Section Water Supply and Resource Protection Well Locations



Well ID	Well Owner Name
Water Supply Wells	
TID-3	Trentwood Irrigation District #3
TID-4	Trentwood Irrigation District #3
TID-5	Trentwood Irrigation District #3
TID-6	Trentwood Irrigation District #3
SIP-1	Spokane Industrial Park
SIP-2	Spokane Industrial Park
SIP-3	Spokane Industrial Park
SIP-4	Spokane Industrial Park
CID-1	Consolidated Irrigation District #19
IWD-3	Irvin Water District #6
Hill	Hillyard Processing Company
Comico	Comico Products Inc.
Comico	Comico Products Inc.
CP-2	Comico Products Inc.
Resource Protection Wells	
GE	GE - 3919 N Sullivan
GE	GE - 3919 N Sullivan
GE	GE - 3919 N Sullivan
AGF	13919 E Trent
AGF	13919 E Trent
AGF	13919 E Trent

SIP-3 ●	Water Supply Well (Location Approximate)
Hillyard ⊙	Water Supply Well (Nearest Quarter Section)
GE ⊕	Resource Protection Well (Location Approximate)

N

0 1500 3000

Scale in Feet

Note:
Base map prepared from USGS 7.5 minute quadrangle maps of Spokane NE and Greenacres, Washington, dated 1986 and Freeman and Spokane SE, Washington, dated 1973.

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Figure 4-13

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5.0 GROUNDWATER CONTAMINATION

This section discusses the results of groundwater sampling and analysis at the Facility completed between December 1989 and December 2008. Table 5-1 summarizes the historical groundwater quality data at the Facility. The groundwater monitoring well locations for the groundwater sampling program are presented on Figure 3-1. A summary of groundwater chemical data quality review and the groundwater chemical database are presented in Appendix F. Appendix B includes groundwater elevation and free phase petroleum monitoring data. Note that Appendix F only contains data generated after January 2003. Consult Appendix K in the 2003 Groundwater RI/FS for a summary of earlier data (enclosed on DVD).

5.1 IDENTIFICATION OF CONSTITUENTS OF POTENTIAL CONCERN

The compilation of Facility groundwater quality data was reviewed to identify constituents of potential concern (COPCs). COPCs for groundwater were identified using a three-step procedure summarized below:

- The Facility groundwater quality database was reviewed to identify the chemicals analyzed and detected in groundwater samples. Table 5-1 presents a statistical summary of groundwater analytes and data results from the Facility groundwater quality database.

- Screening levels were developed for any chemicals detected at least once in groundwater. Screening levels for individual chemicals were defined as the most conservative of the eight published cleanup levels and standards taken from Ecology's CLARC database (Table 5-2). This includes both groundwater and surface water cleanup levels to address the groundwater to surface water pathway. The screening levels were intended to identify COPCs and should not to be considered cleanup levels or standards. The groundwater screening process is described in Section 5.1.1.

- The results of the comparison of the groundwater quality data relative to the groundwater screening levels are presented in Table 5-3. The groundwater screening results are discussed in Section 5.1.2.

5.1.1 Groundwater Screening Process

Validated groundwater sample analytical results were screened relative to the established screening levels to identify COPCs in groundwater at the Facility.

The screening level evaluation was designed to be conservative based on a broad range of environmental protection and cleanup standards. Any chemical detected at least once in groundwater was subjected to the groundwater screening process. Exceedance of these screening levels does not necessarily indicate that remedial actions are required or that there is a risk but this approach allows the RI to focus on those constituents that may pose a potential risk to human health and the environment. Screening levels established in this manner are conservative and are intended for screening purposes only to identify COPCs, not as cleanup levels or standards.

Potential receptors for groundwater constituents identified at the Facility include:

- Humans or flora consuming groundwater from a future potential well installed within the area of groundwater contamination; and
- If constituents of concern were to reach the river, humans, flora, or fauna exposed to surface water downgradient of the Facility.

Risk-based cleanup levels defined for the potential receptors of groundwater were used to screen the sampling data include:

- Federal Safe Drinking Water Act MCL (40 CFR Part 141);
- State Drinking Water MCLs (WAC 246-290-310);
- Federal Safe Drinking Water Act Secondary MCL based on aesthetic affects (40 CFR Part 143);
- Model Toxics Control Act (MTCA) Method A and Method B cleanup levels for groundwater (WAC 173-340-720);
- Water Quality Standards for Surface Waters of the State of Washington for Fresh Water (Chapter 173-201A WAC);
- Clean Water Act 304 for Freshwater Human Health and Chronic Aquatic Life;
- National Toxics Rule (40 CFR Part 131) for Freshwater Human Health and Chronic Aquatic Life; and
- MTCA Method B cleanup levels for surface water (WAC 173-340-730).

The eight published cleanup levels used to establish the Facility groundwater screening levels are presented in Table 5-2. The most stringent of these cleanup levels for each constituent were established as the screening levels for the Facility.

5.1.2 Groundwater Screening Results

Table 5-3 presents a summary of the results of groundwater comparing concentrations against the screening levels for COPCs at the Facility. Table 5-3 presents detected analytes with their respective groundwater screening levels. Relatively few of the detected constituents exceed the screening levels. The analytes with one or more detections, which exceed the screening levels include:

- Petroleum hydrocarbons (gasoline, diesel, and heavy oil);
- Polychlorinated biphenyls (PCBs);
- Metals (antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, and zinc);
- Polycyclic aromatic hydrocarbons (PAHs), specifically carcinogenic PAHs;
- Volatile organic compounds (VOCs) (1, 2-dichloroethane (1,2-DCA)**,** benzene, tetrachlorethene (PCE), and trichlorethene (TCE)); and
- Nitrate.

5.2 GROUNDWATER CONSTITUENTS OF POTENTIAL CONCERN

The following section identifies the COPCs for groundwater at the Facility. The constituents identified from the screening process are assessed to determine whether they are a COPC. The distribution of identified and retained COPCs is discussed in Section 5.3.

5.2.1 Free Phase Petroleum

Free phase petroleum is petroleum liquid present in the subsurface. Free phase petroleum is equivalent to light non-aqueous phase liquids (LNAPL), which means petroleum liquid that is less dense than and does not mix with water.

Free phase petroleum thicknesses in monitoring wells have been detected and monitored since December 1989. The presence of free phase petroleum is believed to be derived from accidental spills and releases from petroleum storage or distribution areas.

Free phase petroleum is a COPC because it is regulated under MTCA and is present in groundwater at the Facility.

5.2.2 Petroleum Hydrocarbons

Since about 2005, many of the groundwater samples were analyzed for TPH using both NWTPH-HCID and NWTPH-Dx and/or NWTPH-Gx methods. The purpose of these seemingly duplicate analyses was to provide data to demonstrate that the quantification of the various petroleum fractions using the NWTPH-HCID method is consistent with NWTPH-Dx and NWTPH-Gx quantifications. Because the NWTPH-HCID method is the predominant analytical method for groundwater at the Kaiser Facility, we have used these results and not the NWTPH-Dx or NWTPH-Gx results in our evaluation of petroleum COPCs. This avoids the problem of double counting the total number of analyses and the number of detections that would occur if both methods were used.

Gasoline. The groundwater screening level for gasoline is 0.8 mg/L. Gasoline concentrations exceeding the groundwater screening level were detected in 16 of 1,660 groundwater samples analyzed by NWTPH-HCID. Gasoline has not been detected at the Facility since 1998.

Gasoline is not considered to be a COPC at the Facility due to the infrequent detections, low magnitude of detected concentrations, limited areal extent, and association of known areas of petroleum hydrocarbon contamination.

Diesel. The groundwater screening level for diesel is 0.5 mg/L. Diesel concentrations that exceed the groundwater screening level were detected in 119 of 1,653 groundwater samples analyzed by NWTPH-HCID.

Historically diesel has been generally distributed across the Facility at concentrations above the screening level of 0.5 mg/L, as shown on Figure 5-1. Maximum historical diesel concentrations that exceed the screening level are associated with Oil House, Wastewater Treatment, ORB, and Cold Mill areas.

Diesel screening level exceedances in groundwater are generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface. Diesel is considered to be a COPC at the Facility due to its frequency of detection and association with free phase petroleum pools. Figure 5-2 shows the areas with diesel detections during the 2008 monitoring events. The inferred extent of diesel shown in Figure 5-2 is based a combination of presence of measurable and trace free phase petroleum as well as dissolved diesel concentrations.

Heavy Oil. The groundwater screening level for heavy oil is 0.5 mg/L. Heavy oil sample concentrations that exceed the screening level were detected in 50 of 1,647 groundwater samples analyzed by NWTPH-HCID.

Historically heavy oil has been generally distributed across the Facility at concentrations above the groundwater screening level of 0.5 mg/L, as shown on Figure 5-3. Historical heavy oil concentrations that exceed the screening level are associated with the Oil House, Wastewater Treatment, Hot Line, ORB, and Cold Mill areas.

Currently heavy oil screening level exceedances are generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface. Heavy oil is considered to be a COPC at the Facility due to the presence of small discontinuous plumes as shown on Figure 5-4.

5.2.3 PCBs

Groundwater samples were analyzed for individual Aroclors. The sum of the individual Aroclors is referred to as Total PCBs. For purposes of this report, Total PCBs is interchangeable with the simpler term PCBs. The individual PCB Aroclors detected in groundwater samples have been Aroclors 1242, 1248, 1254, and 1260. The primary Aroclors present in groundwater samples at the Facility were Aroclor 1242 and 1248. The chart below summarizes the detected frequency of PCBs in groundwater at the Facility.

Analyte	Detection Frequency
Pesticides/PCBs	
Aroclor 1016	0/1664
Aroclor 1242	344/1658
Aroclor 1248	72/1658
Aroclor 1254	13/1667
Aroclor 1260	7/1667
Total PCBs	435/1667

Note that there are two distinct occurrences of PCBs at the Facility. The Remelt groundwater PCB plume in the northern portion of the mill is not associated with petroleum hydrocarbons and appears, at least in part, to be dissolved in groundwater. Other detections of PCB in well samples from the Oil House, Wastewater, and Cold Mill areas are associated with documented petroleum occurrences. The significance of this distinction is that the PCB detections associated with petroleum are not dissolved in groundwater and, as discussed later in this report, are not migrating.

PCB concentrations were detected in 435 of 1,667 well samples (i.e., both dissolved and associated with petroleum) analyzed from the Facility between 1990 to 2008. The groundwater screening level for PCBs is 0.000064 ug/L (0.064 ng/L) based on the surface water criteria for protection of human health. Because the screening level for PCB is so low, every detected PCB concentration exceeds the screening level.

The historical extent of PCBs detected in samples from wells at the Facility are presented on Figure 5-5 with expanded views of the West and East area of the Facility on Figures 5-6 and 5-7. These figures differentiate between the Remelt groundwater PCB plume to the north and those smaller PCB detection areas that are associated with petroleum. The most recently measured PCB concentrations in wells at the Facility are presented on Figure 5-8. This figure represents the most recent analytical results for PCBs for each well that had PCBs detected between 1991 and 2008. PCBs in groundwater and associated with oil in groundwater are considered to be a COPC at the Facility.

5.2.4 Metals

This section discusses the process of identifying metals as COPCs at the Facility. Groundwater samples were collected and analyzed for both total and dissolved metals in accordance with the groundwater SAP/QAPP approved by Ecology . Total metals represent unfiltered samples prior to laboratory analysis and dissolved metals are samples filtered in the field prior to submitting them for laboratory analysis. Nearly all the metals samples were field filtered to provide data representative of the mobile metals fractions. For the purposes of comparing to the groundwater screening levels, no differentiation is made between total and dissolved metals. Table 3-3 presents a summary of total (unfiltered) metals results for groundwater samples.

The screening process (Table 5-3) identifies nine metals that had one or more exceedances of the applicable groundwater screening level. These metals and the number of exceedances include.

- Antimony (67 samples);
- Arsenic (708 samples);
- Cadmium (1 sample);
- Chromium (4 samples);
- Copper (1 sample);

- Iron (37 samples);
- Lead (5 samples);
- Manganese (71 samples); and
- Zinc (2 samples).

The rational for determining which of these nine metals are retained as COPCs is discussed in the following sections.

Metals Excluded as COPCs

Some of the metals standards or criteria for protection of aquatic life in surface water are hardness dependent. For the purpose of our screening level evaluation in table 5-2, we used a conservative hardness of 25 mg/L to calculate an aquatic life protection value for hardness dependent metals.

Antimony. The groundwater screening level for antimony is 6 ug/L. Antimony concentrations were detected in 366 of 409 groundwater samples analyzed for antimony. Antimony concentrations exceeding the screening level were detected in 67 samples. The maximum recorded concentration of antimony was 24 ug/L in a groundwater sample collected from well MW-4 on May 11, 1990. This well is located upgradient (east) of the Kaiser mill within the former east landfill fences line (Figure 3-1). This well is one of the original wells installed at the site. The maximum antimony detection is from an unfiltered (total) sample.

Exceedances of the antimony groundwater screening level are considered to be an artifact of the analytical method and/or background for the area. Groundwater samples were analyzed for antimony using EPA Method 7041 by atomic absorption from 1989 to 1995. The antimony detection limit using EPA Method 7041 is 5 ug/L, with reported antimony concentrations ranging from 5 to 24 ug/L. Concentrations in 67 samples were greater than the 6 ug/L screening level. Analysis of groundwater samples for antimony was not conducted between 1995 and 2005.

Since 2005, some groundwater samples were analyzed for antimony using EPA Method 200.8 by inductively coupled plasma and mass spectrometry. The reporting limit for antimony using EPA Method 200.8 is approximately 0.15 ug/L with detected concentrations ranging from 0.028 J to 0.55 ug/L. Of the 296 groundwater samples analyzed for antimony since 2005, antimony was non-detect in three samples and 293 samples had antimony detected at concentrations well below the screening level. Since adopting EPA Method

200.8 in 2005, no exceedances of the groundwater screening level have occurred for antimony.

Historical concentrations are attributed, at least in part, to analytical issues associated with EPA Method 7041. As discussed in Section 3.4 (page 3-17) of the 2003 Groundwater RI/FS, statistical evaluation of the antimony data showed no statistical difference between antimony detections from upgradient wells compared to downgradient wells. Thus, antimony present in groundwater is attributed, in part, to area background conditions and is not considered a groundwater COPC.

Cadmium. The groundwater screening level for cadmium is 0.25 ug/L based on the federal clean water act criteria (Table 5-2). Cadmium was detected in 38 of 206 groundwater samples analyzed for cadmium. Cadmium concentrations only exceeded the groundwater screening level in one sample. The only sample above the screening level was detected at an estimated concentration of 0.7 J ug/L in a groundwater sample collected from well MW-5 on May 10, 1990. This well is located at the upgradient property line in the southeast corner of the property, well beyond any possible influences from Kaiser operations (Figure 3-1).

Groundwater samples were analyzed for cadmium using EPA Method 6010B from November 1989 to March 2005. The cadmium detection limit using EPA Method 6010B ranged from 0.3 to 5 ug/L, with the only detection at 0.7 J ug/L in well MW-5. Groundwater sampling and analysis for cadmium was not conducted between 1995 and 2004. Since July 2005, cadmium was analyzed using EPA Method 200.8 or SW-6020 by inductively coupled plasma and mass spectrometry. The reporting limit for the EPA method is approximately 0.02 ug/L with detected concentrations since July 2005 ranging from 0.006 T to 0.112 J ug/L.

The detections of cadmium have been minor and existing cadmium are attributed to area background conditions. Therefore, cadmium is not considered a COPC at the Facility. In addition, the single exceedance of the screening level is upgradient of Mill operations and would be representative of groundwater quality entering the Facility.

Chromium. The groundwater screening level for chromium is 50 ug/L based on the MTCA Method A groundwater cleanup level (Table 5-2). Chromium was detected in 165 of 282 groundwater samples. Chromium concentrations that exceeded the groundwater screening level of 50 ug/L were detected in four samples. The maximum recorded concentration of chromium was 608 ug/L in the groundwater sample collected from well TL-MW-1A on September 3, 2003.

Groundwater samples were analyzed for chromium using EPA Method 6010B from November 1989 to March 2005. The chromium detection limit using EPA Method 6010B ranged from 5 to 10 ug/L with concentrations ranging from 2.8 to 608 ug/L. Since March 2005, chromium has been analyzed for using EPA Method 200.8 or SW-6020 by inductively coupled plasma and mass spectrometry. The reporting limit for EPA Method 200.8 or SW-6020 is approximately 0.5 ug/L with detected concentrations since March 2005 ranging from 0.16 J to 23.1 ug/L.

The four chromium exceedances are associated with two wells, TL-MW-1 and its replacement well TL-MW-1A, located in the Finishing area. Chromium concentrations detected in TL-MW-1 on April 1994 and March 1995 were 100 and 63 ug/L, respectfully. The detected chromium concentrations in the replacement well TL-MW-1A from samples collected between 1995 and 2003 ranged from 2.8 to 39 ug/L. On September 3, 2003, the maximum detected chromium concentration for the Facility was 608 ug/L. Since September 2003, chromium detected in TL-MW-1 had been below the screening level at concentrations of 0.53 to 23.1 ug/L.

Because only 4 of 282 samples exceeded the screening level and because groundwater concentrations have been below the screening level since September 2003, chromium is not considered a COPC.

Copper. The groundwater screening level for copper is 3.5 ug/L based on the state water quality standards for protection of aquatic life (Table 5-2). Copper was detected in only one of 42 groundwater samples collected and analyzed for copper at the Facility from 1989 to 1995. The only sample with a concentration (20 ug/L) above the groundwater screening level, was collected in OH-MW-15 in May 8, 1990. Groundwater samples were analyzed for copper using EPA Method 7211 from December 1989 to December 1995. The copper detection limit using EPA Method 7211 was 20 ug/L and was based on an unfiltered (total) sample.

The detections of copper have been minor and infrequent, therefore, copper in groundwater is attributed to area background conditions and is not considered a COPC for the Facility.

Lead. The groundwater screening level for lead is 0.54 ug/L based on the state water quality standards for protection of aquatic life (Table 5-2). Lead concentrations were detected in 107 of 206 samples collected at the Facility from 1989 to 2008. Total and dissolved lead concentrations that exceed the groundwater screening level were detected in five samples. The maximum recorded lead concentration was 12.7 ug/L in a filtered groundwater sample collected from well CM-MW-6S on October 28, 2004.

Lead was analyzed using EPA Method 7421 from November 1989 to March 2005. The lead detection limit using EPA Method 7421 ranged from 2 to 5 ug/L with concentration ranging from 1.1 J to 12.7 ug/L. Groundwater sampling and analysis for lead was not conducted between 1995 and 2004. Since March 2005, lead was analyzed using EPA Method 200.8 or SW-6020 by inductively coupled plasma and mass spectrometry. The reporting limit for EPA Method 200.8 or SW-6020 was generally 0.02 ug/L with concentrations ranging from 0.004 to 0.296 ug/L.

Lead was detected at concentrations above the screening level in four wells (CM-MW-2S, CM-MW-3S, CM-MW-6S, and CM-MW-7S) from the Cold Mill area in 2004 and 2005. The exceeding lead concentrations ranged from 1.1J to 12.7, with the maximum concentration detected in CM-MW-6S.

Since adopting EPA Method 200.8 or SW-6020 in March 2005, no exceedances of screening levels have occurred on the Facility for total or dissolved lead including wells CM-MW-2S, CM-MW-3S, CM-MW-6S, and CM-MW-7S.

Historical concentrations are attributed to analytical issues. Minor and infrequent lead exceedances of the screening level are attributed to area background conditions. Five minor exceedances of the aquatic life screening level out of 206 analyses (2 percent) does not indicate that lead is a COPC for the Facility.

Zinc. The groundwater screening level for zinc is 32 ug/L based on state water quality standards for protection of aquatic life (Table 5-2). Zinc concentrations were detected in 15 of 42 groundwater samples analyzed from the Facility from 1989 to 1995. Zinc concentrations exceeded groundwater screening level in only two samples. The maximum recorded zinc concentration was 124 ug/L in a groundwater sample from the North Supply Well on December 1, 1995. This detection did not exceed any of the human health-based standards listed in Table 5-2.

Groundwater samples were analyzed for zinc using EPA Method 7951 from November 1989 to December 1995. The zinc detection limit using EPA Method 7951 ranged from 0.01 to 0.02 ug/L with concentrations ranging from 0.01 to 0.124 ug/L. Groundwater sampling and analysis for zinc was not conducted between 1995 and 2008. There were only two minor exceedances of the conservative screening level out of 42 analyses.

Zinc exceedances of the screening level are infrequent and minor and the detections for zinc are attributed to area background conditions. Thus, zinc is not considered a COPC.

Metals Retained as COPCs

Arsenic. The groundwater screening level for arsenic is 0.018 ug/L based on protection of human health per Clean Water Act criteria (Table 5-2). Arsenic was detected in 708 of 909 samples collected at the Facility from 1989 to 2008. Arsenic concentrations exceeding the groundwater screening level were detected in all 708 detected samples. The maximum recorded concentration was 380 ug/L in a groundwater sample collected from well WW-MW-18 on September 30, 1997.

Arsenic is attributed in part to area background conditions and the historical petroleum pools in the Wastewater Treatment and Oil House areas that cause reducing conditions and mobilize naturally occurring arsenic in groundwater. A summary of publically available regional groundwater quality data (Table 4-6) show a range in arsenic concentrations of 0.008 to 5 mg/L (8 to 5,000 ug/L). A summary of publically available surface water quality data from Spokane River at Stateline Bridge (Table 4-8) shows a range in arsenic concentrations of 0.31 to 0.7 ug/L.

It is important to note that the screening levels for arsenic are based on the Clean Water Act Section 304 Water Quality Criteria for Freshwater Human Health and Chronic Aquatic Life. These screening levels are conservatively low and are comparable to background conditions, every detected arsenic concentration exceeds the arsenic screening concentration of 0.018 ug/L. Arsenic is considered to be a COPC based on this screening level evaluation.

Iron. The groundwater screening level for iron is 300 ug/L based on the secondary MCL (taste and odor) in the Safe Drinking Water Act. Iron concentrations were detected in 210 of 367 groundwater samples collected between 1991 and 2008 at the Facility. Iron concentrations exceeded the groundwater screening level in 37 samples. The maximum recorded concentration of 22,400 ug/L was detected in a groundwater sample collected from well TF-MW-2 on April 24, 2008.

Iron was analyzed using EPA Method 200.7 and SW-6010B from June 1991 to October 2008. The iron detection limit ranged from approximately 10 to 50 ug/L with detected concentrations ranging from 3.1J to 22,400 ug/L. Groundwater sampling and analysis for iron was not conducted between 1992 and 1994, 1996 and 1997, 1999, and 2001 and 2004.

It is important to note that the screening levels for iron are based on potential adverse secondary (aesthetic) effects in accordance with MTCA procedures for establishing groundwater cleanup levels. These screening levels are based on potential taste and odor thresholds in drinking water and do not represent concentrations that may pose a risk to human health. Iron is considered to be a COPC because of secondary effects based on this screening level evaluation.

Manganese. The groundwater screening level for manganese is 50 ug/L based on the secondary MCL (taste and odor) in the Safe Drinking Water Act. Manganese concentrations were detected in 295 of 368 groundwater samples. Manganese concentrations that exceed the groundwater screening level were detected in 71 samples. The maximum recorded concentration was 2,840 ug/L in a groundwater sample collected from well WW-MW-18 on October 25, 2006.

Manganese was analyzed using EPA Method 6010B from June 1991 to March 2000. The manganese detection limit using EPA Method 6010B ranged from 1 to 10 ug/L with concentrations ranging from 1 to 28 ug/L. Groundwater sampling and analysis for manganese was not conducted between 1995 and 1998, and 2000 and 2005. Since July 2005, manganese was analyzed using EPA Method 200.8 or SW-6020 by inductively coupled plasma and mass spectrometry. The reporting limit for EPA Method 200.8 or SW-6020 was generally 0.05 and 5 ug/L with concentrations ranging from 0.011 to 2,840 ug/L.

It is important to note that the screening levels for manganese are based on potential adverse secondary (aesthetic) effects in accordance with MTCA procedures for establishing groundwater cleanup levels. These screening levels are based on potential taste and odor thresholds in drinking water and do not represent concentrations that may pose a risk to human health. Manganese is considered to be a COPC based on this screening level evaluation.

5.2.5 Volatiles Organic Compounds (VOCs)

Benzene, tetrachloroethene (PCE), trichloroethene (TCE) and 1, 2-dichloroethane (1,2-DCA) were the only VOC detected in groundwater samples above the screening levels (Table 5-3).

Benzene. The groundwater screening level for benzene is 0.8 ug/L based on the MTCA Method B groundwater cleanup level (Table 5-2). Benzene concentrations were detected in only seven of 825 samples analyzed at the Facility and five of these detections exceeded the screening level (0.6 percent). Detected concentrations ranged from 0.24 T to 3 ug/L. The maximum concentration was 3 ug/L in the groundwater sample collected from well WW-MW-12 on December 4, 1991.

Benzene has been used as an additive in gasoline and is occasionally used in industrial solvent formulations. The seven samples that exceeded the screening level were from wells sampled from 1989 to 1995. Since 1995, benzene has not been detected in the groundwater samples analyzed.

Benzene is not included as a COPC at the Facility because of infrequent historical detections and because the magnitude of the exceedances are low.

Tetrachloroethene (PCE). The groundwater screening level for PCE is 0.081 ug/L based on the MTCA Method B groundwater cleanup level (Table 5-2). PCE concentrations have been detected in only one of 728 samples at the Facility (0.1 percent). The detected concentration was 2 ug/L. The maximum concentration was detected in the groundwater sample collected from well MW-2D on December 2, 1989.

PCE is used as an industrial degreasing solvent or in cleaning solvent formulations. PCE was detected above screening levels in monitoring well MW-2D in 1996 . Since 1996, no detections or exceedances of PCE have occurred at the Facility. PCE is not included as a COPC at the Facility because of infrequent and low historical detections at the Facility.

Trichloroethene (TCE). The groundwater screening level for trichloroethene (TCE) is 0.49 ug/L based on the MTCA Method B groundwater cleanup level (Table 5-2). TCE concentrations were detected in three of 728 samples at the Facility (0.4 percent). Detected concentrations ranged from 0.07 T to 4 ug/L. The maximum TCE concentration was detected in the groundwater sample collected from well OH-MW-5 on December 1, 1989.

TCE was detected above screening levels in the North Supply Well and monitoring well OH-MW-5 in 1995 and 1989, respectfully. Since 1995, no detections or exceedances of TCE have occurred at the Facility.

TCE is used as an industrial degreasing solvent or in cleaning solvent formulations. It can also occur in the environment as a biological breakdown product of PCE, especially under anaerobic conditions.

Since the detected concentrations are infrequent and low at the Facility and have not occurred since 1995, TCE is not included as a COPC for the Facility.

1,2-Dichloroethane (1,2-DCA). The groundwater screening level for 1,2-dichloroethane (1,2-DCA) is 0.38 ug/L based on the federal Clean Water Act criteria (Table 5-2). 1,2-DCA concentrations were detected in five of 728 samples (0.7 percent) collected and analyzed at the Facility. Detected concentrations ranged from 0.41 J to 5.4 ug/L. The 1,2-DCA detections in groundwater samples were from wells sampled in September 2002. The maximum concentration was 5.4 ug/L in the groundwater sample collected from well MW-21S on September 24, 2002.

In summary, the source of the 1,2-DCA in groundwater during the September 2002 sampling event is not known. The samples were collected on the same day and in near proximity to each other downgradient of the Wastewater Treatment area. These detections are thought to be either an artifact of the sampling or laboratory analysis.

1,2-DCA is not included as a COPC at the Facility because of low and infrequent historical detections.

5.2.6 Semivolatile Organic Compounds (SVOC)

The only SVOCs that have been detected in groundwater at concentrations that exceed screening levels are the carcinogenic PAHs (cPAHs).

Polycyclic Aromatic Hydrocarbons (PAHs). The only PAHs of significance in groundwater samples are classified as cPAHs.

The cPAHs include the following:

- Benzo(a)anthracene;
- Benzo(a)pyrene;
- Benzo(b)fluoranthene;
- Benzo(k)fluoranthene;
- Chrysene;
- Dibenz(a,h)anthracene; and
- Indeno(1,2,3-cd)pyrene.

The cPAHs exceeded the groundwater screening level in 56 of 317 samples collected and analyzed from the Facility. Total Equivalence Concentration (TEQ) concentrations ranged from 0.0081 to 173.9 ug/L. The maximum TEQ concentration was detected in a sample collected from well HL-MW-20S on July 27, 2005.

The groundwater screening levels for cPAHs were established using the TEQ process using toxicity equivalency factors (TEFs) established by Ecology (WAC 173-304-900, Table 708-3). TEQs were calculated for each groundwater sample with a detected concentration of cPAHs. For this calculation non-detect cPAHs were assigned a value of zero. For mixtures of cPAHs, the reference chemical is benzo(a)pyrene (BaP), which has a groundwater screening level of 0.0028 ug/L. The TEQ concentration was compared to BaP groundwater screening level for screening purposes. cPAHs are considered to be a COPC based on this screening level evaluation.

5.2.7 Conventional Parameters

Nitrate. The groundwater screening level for nitrate is 10 mg/L. Groundwater samples were analyzed for nitrate in the following forms; nitrate + nitrite and nitrate as nitrogen; the two separate forms will be referred to as nitrate.

Nitrate concentrations were detected in 123 of 129 samples (nitrate + nitrite) and in 104 of 113 samples (nitrate as nitrogen) collected and analyzed from the Facility from 1990 to 2008. Nitrate concentrations that exceed the groundwater screening level were detected in three samples (1 percent of samples analyzed). The maximum recorded nitrate concentration was 157 mg/L in the groundwater sample collected from well OH-EW-1 on January 24, 2008.

Nitrate concentrations that exceed the screening level were detected in just three groundwater samples from deep in the aquifer—West Water Supply Well and monitoring wells WW-EW-1 and OH-EW-1. The groundwater samples WW-EW-1 and OH-EW-1 collected on January 24, 2008, are significantly higher than historical nitrate data collected at the Facility. The significantly higher nitrate values are attributed to analytical issues or sampling protocols. Nitrate is not considered to be a COPC at the Facility.

5.2.8 Constituents of Potential Concern at the Facility

Based on the groundwater analysis described above, the following constituents are not considered to be COPCs at the Facility;

- Petroleum hydrocarbons (gasoline);
- Metals (antimony, cadmium, chromium, copper, lead, and zinc);
- Volatile organic compounds (VOCs) (1, 2-dichloroethane (1,2-DCA), benzene, tetrachlorethene (PCE), and trichlorethene (TCE)); and
- Nitrate.

The retained constituents identified from the screening process as COPCs are discussed in Section 5.3. The following constituents are considered to be COPCs at the facility;

- Free phase petroleum;

- Petroleum hydrocarbons (diesel and heavy oil);
- Polychlorinated biphenyls (PCBs) in groundwater and associated with petroleum in groundwater;
- Metals (arsenic, iron, and manganese); and
- Carcinogenic polycyclic aromatic hydrocarbons (cPAHs);

5.3 DISTRIBUTION OF CONSTITUENTS OF POTENTIAL CONCERN

The following section discusses the nature and extent of contamination at the Facility focused on the retained COPCs, identified in Section 5.2.

5.3.1 Free Phase Petroleum

The presence of free phase petroleum was determined using an oil/water interface probe. Measurable free phase petroleum is defined as accumulations greater than 0.01 inch, which is the minimal measureable free phase petroleum using an oil/water interface probe.

Apparent Free Phase Petroleum

The thickness of free phase petroleum measured in a well casing does not equate to a thickness of free phase petroleum on the water table. The apparent free phase petroleum thickness is measured from each well bore casing. However, these apparent thickness data provide a conservative measure of free phase petroleum accumulation because capillary forces resulting in the well bore are greater than actual free phase petroleum layers on the adjacent water table surface. The degree of free phase petroleum thickness exaggeration in a well is roughly correlated to the grain size of the surrounding aquifer material, with smaller grain sizes resulting in greater exaggeration. Typically, actual free phase petroleum thickness on the water table is between one-half to one-tenth of the apparent thickness measured in wells (EPA 1996). For sands and gravels, actual free phase petroleum thickness on the water table is typically between one-half to one-quarter of the apparent thickness measured in wells. Generally, free phase petroleum thicknesses are expected to be less pronounced at the Facility due to presence of sands and gravels with weak capillary effects. No adjustments have been made to data in this report to account for the effects of capillary forces. Thus, these reported free phase petroleum thicknesses are conservative.

Free Phase Petroleum Recovered to Date

Kaiser has operated a free phase petroleum recovery system as part of the IRM at the Facility beginning in 1994. In 2000, Kaiser expanded the IRM system to enhance biodegradation. The recorded free phase petroleum volumes recovered since 1994 at the Facility are presented in Table 5-4.

The first free phase petroleum wells were installed in 1993, when skimming wells OH-SK-1 and WW-SK-1 were completed and equipped with skimmer pump systems in the Oil House and Wastewater Treatment areas. Skimming well OH-SK-1 was later augmented with OH-SK-2 in 1995. In 2000, Kaiser expanded the IRM system with the installation of four additional skimming wells (WW-SK-2, WW-SK-3, WW-SK-4, and OH-SK-4). Currently, the skimming wells are put into operation only when free phase petroleum is present.

Over 4,000 gallons of free phase petroleum have been recovered at the Facility. In 1994, approximately 2,150 gallons of free phase petroleum were recovered in the Oil House area (OH-SK-1). However, due to problems with the well screen, OH-SK-1 was augmented with OH-SK-2 in 1995 and another 100 gallons were recovered from the new skimming well. The lower free phase petroleum recovery in 1995 was the result of lower free phase petroleum accumulation thicknesses and the fact that much of the recoverable free phase petroleum had been removed the prior year. As indicated by total annual precipitation and Facility water levels, 1995 was a much wetter year than 1994. As a result, groundwater elevations were higher in the Oil House area wells in 1995 and recoverable free phase petroleum accumulation thicknesses were lower compared to those in 1994.

Between 1995 and 1999, free phase petroleum accumulations in the skimming wells were minimal, primarily because of inefficient skimming systems in the wells and higher groundwater elevations even during typical summer low flow periods. In 2000, Kaiser began experimenting with absorbent belt skimmers to remove free phase petroleum from the wells. These were more effective at removing small accumulations than the skimming pumps, and Kaiser has replaced skimming pumps with belt skimmers. In 2000, 300 gallons were removed from skimming wells; in 2001 (a low water elevation year), approximately 1,100 total gallons were removed; and in 2002 (a high water elevation year), only 5 gallons were removed.

Free Phase Petroleum Occurrence and Extent

This section describes the occurrence and extent of free phase petroleum at the Facility. Historically free phase petroleum has been detected in 39 wells at the

Facility with a thickness ranging from 0.01 to 3.11 feet (Table 5-5). The historical distribution of free phase petroleum is presented on Figure 5-9. Historical distributions of free phase petroleum are illustrated for the Wastewater Treatment and Oil House areas on Figures 5-10 and 5-11, respectively.

The extent of free phase petroleum detected in 2008 is shown on Figure 5-12. As of 2008, the free phase petroleum is limited to small discontinuous pools in the Wastewater and Oil House areas (Figures 5-13 and 5-14). In 2008, measurable free phase petroleum was detected in 10 wells ranging from 0.01 to 0.1 foot thick (Table 5-5).

Free phase petroleum has been identified historically in following five areas.

- Cold Mill (CM-MW-1S) area;
- Oil Reclamation Building (HL-MW-20S/HL-MW-21S);
- Oil House area;
- Wastewater Treatment area; and
- West Landfill area (MW-17S/MW-25S).

The occurrence and distribution of free phase petroleum is discussed below. See Section 5.3.3 for a discussion of PCBs in the Oil House and Wastewater Treatment smear zones.

Remelt Area. In the Remelt area, free phase petroleum was measured in July 2005 in one well (RM-MW-13S) at a thickness of 0.01 foot. RM-MW-13 has been monitored for free phase petroleum generally on a quarterly basis between July 2005 through October 2008. Free phase petroleum has not been detected in this well at any other time since the well was installed in 2005. No dissolved petroleum hydrocarbon constituents have been detected in groundwater samples collected and analyzed from RM-MW-13S including the groundwater sample collected on July 2005.

In addition, trace free phase petroleum was measured in January 2007 in RM-MW-17S. RM-MW-17S has been monitored for free phase petroleum and dissolved petroleum hydrocarbon constituents have been detected in groundwater samples collected and analyzed from RM-MW-17S including groundwater samples collected in January 2007.

The presence of free phase petroleum in RM-MW-13 and RM-MW-17S is inconsistent with the absence of petroleum hydrocarbons in historical groundwater dissolved petroleum data. The infrequent detection and the possibility of spurious data indicated that free phase petroleum is not present in the vicinity of the Remelt area. Thus, we have not identified these wells on Figures 5-9 through 5-12.

Cold Mill Area. Free phase petroleum was detected in January 2006 at a thickness of 0.01 foot in one well (CM-MW-1S) in the Cold Mill area. Well CM-MW-1S was monitored for free phase petroleum on a quarterly basis from July 2005 through October 2008. Since July 2005, no free phase petroleum has been detected in CM-MW-1S.

CM-MW-1S has been sampled and analyzed for petroleum hydrocarbons 12 times since October 2004. Kensol-range petroleum hydrocarbons were detected once at a concentration of 0.36 mg/L in a sample collected in October 2008.

The infrequent detection and the possibility of spurious data indicate that free phase petroleum is not likely to be present the vicinity of the Cold Mill area.

Oil Reclamation Building Area. Free phase petroleum was detected in two wells (HL-MW-20S and HL-MW-21S) in the vicinity of the Oil Reclamation Building (ORB) area.

HL-MW-20S and HL-MW-21S have been monitored for free phase petroleum 19 times between 2005 and 2008. Free phase petroleum was detected in HL-MW-20S seven times at thickness ranging from 0.11 to 0.61 foot between 2005 and 2007. Free phase petroleum was only detected once in HL-MW-21S at a thickness of 0.01 foot in June 2006. Free phase petroleum was not detected in either HL-MW-20S or HL-MW-21S in 2008. See Figure 5-15b for a hydrograph showing petroleum thickness and water table elevation over time and Figure 5-16b for a comparison of product thickness versus groundwater elevation.

Heavy oil-range petroleum hydrocarbons have been consistently detected in HL-MW-20S at concentrations ranging from 2.7 to 520 ug/L and once (24 ug/L) in HL-MW-21S.

The infrequent historical detections and the absence of free phase petroleum in 2008, suggests that free phase petroleum is currently not present in the ORB area. These wells will continue to be monitored for free phase petroleum in accordance with the Groundwater Sampling and Analysis Plan (Hart Crowser

2007). Additional discussion of this potential source area is presented in the Soil RI (Hart Crowser 2012).

Oil House Area. In the Oil House area, free phase petroleum has been detected historically in 23 wells (Table 5-5) with thicknesses ranging from 0.01 foot at well OH-MW-18 to 3.11 feet at well OH-SK-1. Figure 5-11 illustrates the inferred historical extent of free phase petroleum in the Oil House area. Areas of free phase petroleum accumulation are surrounded by a zone (Figure 5-11) in which petroleum sheen has been observed in groundwater collected from wells screened across the water table. In 2008, free phase petroleum was detected in 8 wells (Table 5-5) within an area consisting of two small discontinuous accumulations centered on the extraction wells OH-EW-1 and TF-EW-1 (Figure 5-14).

The majority of the monitoring wells in the Oil House area were screened across the water table. There are two deep monitoring wells (OH-MW-14 and OH-MW-26) that are completed at depths ranging from 98 to 130 feet below ground surface. The purpose of the deep wells is to evaluate vertical gradients and to monitor for potential downward migration of petroleum hydrocarbons near the groundwater extraction wells. No free phase petroleum has been detected in groundwater samples from these deep wells.

Based on petroleum hydrocarbon analysis, constituents detected in the Oil House area are primarily Kensol-range petroleum hydrocarbons although diesel/fuel oil-, heavy oil- kerosene/jet fuel-, gasoline-, and stoddard solvent/mineral spirits-range petroleum hydrocarbons have been reported.

The Oil House area has historically served as the central point where petroleum oils arrive at the Facility for storage and eventual distribution to the different work areas within the Facility. Numerous USTs and associated systems were located around the Oil House for storing diesel and gasoline and process oils such as hydraulic oil, Kensol lubricant, mineral oil, Stoddard solvents, and kerosene. In addition, the Oil House has also served in the past as a central management area for storage and management of used oils within the plant. Petroleum tanks at the Oil House and a Kensol spill in the Tank Farm area in 1991 appear to be the primary sources of free phase petroleum in the Oil House area. Available soil data indicate that a large area around the Oil House has a prominent petroleum smear zone at the water table. Additional discussion of these potential source areas is presented in the Soil RI (Hart Crowser 2012).

The free phase petroleum pools in the Oil House area have been steadily shrinking in size and volume due to a combination of the free phase petroleum recovery system and natural attenuation. There is no evidence that the free phase petroleum pools in the Oil House area are migrating. In fact, available data clearly show that they are shrinking.

Additional discussion of PCBs in the smear zone and free phase petroleum is presented in Section 5.3.3 below.

Wastewater Treatment Area. Free phase petroleum in the Wastewater Treatment area has been detected in 13 wells (Table 5-5) with thicknesses ranging from 0.01 foot at wells WW-MW-08 and WW-MW-15 to 1.63 feet at well WW-MW-13. Figure 5-10 illustrates the inferred historical extent of free phase petroleum in the Wastewater Treatment area. The Wastewater Treatment area free phase petroleum pool is centered east and upgradient of extraction wells WW-EW-1, WW-EW-2, and WW-EW-3. As of 2008, the free phase petroleum has been detected in five wells (Table 5-5) with an area consisting of two small discontinuous accumulations east and upgradient of the skimming well WW-SK-4 and centered on the skimming well WW-SK-2 (Figure 5-13).

The majority of the monitoring wells in the Wastewater Treatment area were constructed to be screened across the water table. There are two deep monitoring wells (WW-MW-16 and WW-MW-17) that are completed at depths ranging from 104 to 192 feet below the ground surface to monitor for potential downward migration of petroleum hydrocarbons near the groundwater extraction wells. The purpose of the deep wells is to evaluate vertical gradients and define the vertical distribution of constituents of potential concern.

Based on petroleum hydrocarbon constituents detected in the groundwater from Wastewater Treatment area wells, a range of petroleum hydrocarbons are present, including diesel/fuel oil-, Kensol-, heavy oil-, and kerosene/jet fuel-range petroleum hydrocarbons. The primarily petroleum hydrocarbons are in the heavy oil-range. The source of free phase petroleum in the Wastewater Treatment area appears to be the former Hoffman tank and to a lesser extent the Field-Constructed Tanks and the Rail Car Unloading area. Additional discussion of these potential source areas is provided in the Soil RI (Hart Crowser 2012).

The Wastewater Treatment area free phase petroleum pool currently appears to consist of two small discontinuous accumulations east and upgradient of the skimming well WW-SK-4 and centered on skimming well WW-SK-2. The free phase petroleum pools have been steadily shrinking in size and volume due to a combination of the free phase petroleum recovery system and natural attenuation. There is no evidence that the free phase petroleum pools in the Wastewater Treatment area are migrating.

Additional discussion of PCBs in the smear zone and free phase petroleum in the Wastewater Treatment area is presented in Section 5.3.3 below.

West Landfill Area. Trace free phase petroleum was detected in January 2007 in both MW-17S and MW-25S in the West Landfill area. MW-17S and MW-25S were both monitored for free phase petroleum on a quarterly basis from August 2001 through October 2008. Since January 2007, no free phase petroleum has been detected in MW-17S and MW-25S. No dissolved petroleum hydrocarbon constituents have been detected in groundwater samples collected and analyzed from MW-17S and MW-25S including the groundwater sample collected on January 2007.

The infrequent detection and the possibility of spurious data indicate that free phase petroleum is not present the vicinity of the West Landfill area. Thus, we have not identified the wells MW-17S and MW-25S on Figures 5-9 and 5-10.

Free Phase Petroleum Trends

Thickness. Over time, the thickness of the free phase petroleum is controlled by fluctuations in water table elevation, natural and enhanced biodegradation, and petroleum recovery efforts. These three factors result in seasonal variability superimposed on a long-term declining trend, which is illustrated using data from the four wells with the consistently highest measured free phase petroleum values in the Oil House (OH-MW-04 and OH-MW-06) and Wastewater Treatment (WW-MW-03 and WW-MW-06) areas (Figure 5-15a). Figures 5-15b and 5-16b illustrate the relationship between free phase petroleum thickness and water levels in HL-MW-20S located in the Oil Reclamation Building area.

Free phase petroleum is thickest during periods of low water levels (in the fall). When the water table rises in the spring, the free phase petroleum is smeared or trapped in the soil and the measurable free phase petroleum thickness drops. The volume of recoverable free phase petroleum is affected by the elevation of the water table in the recovery wells as well as the duration the water table remains at a low elevation. In general, measurable free phase petroleum is not detected in the Oil House area when the water table is greater than elevation 1,937 feet nor in the Wastewater Treatment area when the water table is greater than elevation 1,928 feet.

Areal Extent. The areal extent of the Oil House and Wastewater Treatment free phase petroleum pools was estimated from the historical and 2008 pool maps (Figures 5-10 and 5-13). The estimated areas of the pools are summarized in Table 5-6.

The maximum extent of the free phase petroleum in the Oil House area is estimated to have been about 232,000 square feet. By 2008, the extent of free phase petroleum decreased to about 15,000 square feet, an almost 94 percent reduction in the size of the free phase petroleum pool.

The maximum extent of the free phase petroleum in the Wastewater Treatment area was estimated to have been about 409,000 square feet. By 2008, the extent of free phase petroleum decreased to about 72,000 square feet an almost 82 percent reduction in the size of the free phase petroleum pool.

5.3.2 Dissolved Petroleum Hydrocarbons

This section describes the nature and extent of dissolved total petroleum hydrocarbons in groundwater at the Facility.

Nature and Extent

Various petroleum hydrocarbons ranges were quantified by Method TPH-HCID, NWTPH-Gx, and NWTPH-Dx for individual petroleum hydrocarbon components including gasoline-, stoddard/mineral spirit-, diesel-, kerosene/jet fuel-, Kensol-, Bunker C-, and heavy oil-range petroleum hydrocarbons. The summary of groundwater screening results and detection frequency analysis for TPH is provided in Table 5-3. Individual petroleum hydrocarbon components and screening levels are discussed below. These individual hydrocarbon ranges are useful in determining the nature of petroleum contamination.

Gasoline

For screening purpose, Gasoline includes the sum of gasoline- and Stoddard solvent/mineral spirit-range petroleum hydrocarbons when analyzed by TPH-HCID or NWTPH-Gx.

Gasoline-Range Petroleum Hydrocarbons. Gasoline-range petroleum hydrocarbons concentrations were detected in only 20 of 1,660 groundwater samples collected and analyzed by NWTPH-HCID and in one of 243 groundwater samples collected and analyzed by NWTPH-Gx at the Facility. The maximum recorded concentration of gasoline was 140 mg/L for a groundwater sample collected from OH-MW-2 on March 9, 1991.

The only known source of gasoline-range hydrocarbons from operations and activities at the Facility are at the Oil House and Tank Farm areas. Gasoline concentrations were detected from six Oil House monitoring wells (OH-MW-1, OH-MW-2, OH-MW-4, OH-MW-7, OH-MW-16, and OH-MW-25) in groundwater samples collected in March 1991. Since March 1991, gasoline concentrations have not been detected in groundwater samples from monitoring wells OH-MW-7, OH-MW-16, and OH-MW-25. Monitoring wells OH-MW-1 and OH-MW-4 are located within the small discontinuous free phase petroleum plume near the Oil House area (Figure 5-14). Monitoring well OH-MW-4 had measurable free phase petroleum in October 2008. Monitoring well OH-MW-2 has not been sampled since March 1991, and is located upgradient of the small discontinuous free phase petroleum plume near the Oil House area.

Stoddard/Mineral Spirit-Range Petroleum Hydrocarbons. Stoddard/Mineral spirits-range petroleum hydrocarbon concentrations were detected in 13 of 1,648 samples analyzed by TPH-HCID. The maximum recorded concentration of Stoddard/Mineral spirits was 380 J mg/L from a groundwater sample collected from well OH-MW-5 on June 26, 1991.

The Stoddard/Mineral spirits concentrations were detected in six wells (OH-MW-3, OH-MW-4, OH-MW-5, OH-MW-10, OH-MW-20, and OH-MW-24) in the Oil House area between 1991 and 1998. Since 1998, Stoddard/Mineral spirits have been non-detect in monitoring wells OH-MW-10 and OH-MW-24. Monitoring well OH-MW-4 is located next to skimming well OH-SK-4 within the small discontinuous free phase petroleum plume near the Oil House area (Figure 5-14) and had measurable free phase petroleum in October 2008. Monitoring wells OH-MW-3, OH-MW-5, OH-MW-10, OH-MW-20, and OH-MW-24 are located adjacent to the small discontinuous free phase petroleum plume near the Oil House area. Of these nearby wells, only monitoring well OH-MW-3 had free phase petroleum sheen present in October 2008.

Diesel

For screening purposes, Diesel includes the sum of diesel/fuel oil-, kerosene/jet fuel-, and Kensol-range petroleum hydrocarbons analyzed by TPH-HCID or NWTPH-Dx.

Diesel/Fuel Oil-Range Petroleum Hydrocarbons. Diesel/fuel oil-range petroleum hydrocarbon concentrations were detected in 70 of 1,653 samples analyzed by TPH-HCID and 12 of 256 samples analyzed by NWTPH-Dx (Table 5-1). The maximum recorded concentration of diesel/fuel oil-range petroleum hydrocarbons was 950 mg/L in a groundwater sample from OH-MW-2 collected on March 9, 1991.

The detected diesel/fuel oil-range petroleum hydrocarbon concentrations were generally distributed across the Facility and associated with the Oil House, Wastewater Treatment, Hot Line, and Cold Mill areas. Diesel/fuel oil-range petroleum hydrocarbon detections are generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface.

Kerosene/Jet Fuel-Range Petroleum Hydrocarbons. Kerosene/jet fuel-range petroleum hydrocarbons were detected in 16 of 1,581 groundwater samples analyzed by TPH-HCID and 2 of 253 groundwater samples analyzed by NWTPH-Dx (Table 5-1). The maximum recorded concentration of kerosene/jet-fuel-range petroleum hydrocarbons was 9 mg/L in a groundwater sample collected from well WW-MW-11 on October 26, 1993.

The only known sources of kerosene/jet fuel from operations and activities at the Facility were stored at the Oil House area. The detected kerosene/jet fuel-range petroleum hydrocarbon concentrations were detected in ten wells (OH-MW-7, OH-MW-16, TL-MW-3, TL-MW-4, WW-MW-9, WW-MW-10, WW-MW-11, HL-MW-2, HL-MW-20S, and HL-MW-30) in the Oil House, Wastewater Treatment, and Hot Line areas, from 1992 through 2005. After 2005, groundwater concentrations were not detected for kerosene/jet fuel-range petroleum hydrocarbons in monitoring wells OH-MW-7, OH-MW-16, TL-MW-3, TL-MW-4, WW-MW-9, WW-MW-10, WW-MW-11, HL-MW-2, HL-MW-20S, and HL-MW-30.

Kensol-Range Petroleum Hydrocarbons. Kensol-range petroleum hydrocarbon concentrations were detected in 83 of 1,648 groundwater samples analyzed by NWTPH-HCID (Table 5-1). The maximum recorded concentration of Kensol-range petroleum hydrocarbons was 1,800 J mg/L in a groundwater sample collected from well OH-MW-5 on June 26, 1991.

The detected Kensol-range petroleum hydrocarbon concentrations were generally distributed across the Facility and associated with the Oil House, Wastewater Treatment, Hot Line, and Cold Mill areas. Kensol-range petroleum hydrocarbons concentrations were generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface.

Heavy Oil

For screening purposes, Heavy Oil is the sum of Bunker C-, and heavy oil-range petroleum hydrocarbons when analyzed by TPH-HCID or NWTPH-Dx.

Bunker C-Range Petroleum Hydrocarbons. Bunker C-range petroleum hydrocarbons were not detected in any of 1,587 groundwater samples analyzed by TPH-HCID (Table 5-1).

Heavy Oil-Range Petroleum Hydrocarbons. Heavy oil-range petroleum hydrocarbon concentrations were detected in 53 of the 1,647 groundwater samples analyzed by TPH-HCID and 13 of the 255 groundwater samples analyzed by NWTPH-Dx (Table 5-1). The maximum recorded concentration of heavy oil-range petroleum hydrocarbons was 520 mg/L in a groundwater sample collected from well HL-MW-20S on July 27, 2005, located at the southwest corner of the ORB (Figure 5-4).

The detected heavy oil-range petroleum hydrocarbon concentrations were generally distributed across the Facility and associated with the Oil House, Wastewater Treatment, Hot Line, and Cold Mill areas. Heavy oil-range petroleum hydrocarbon detections are generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface.

Vertical Distribution of Petroleum Hydrocarbons. The vertical distribution of dissolved petroleum hydrocarbons is evaluated using groundwater quality data from wells completed below the water table surface primarily within the Oil House and Wastewater Treatment areas. The majority of the monitoring wells within the Oil House and Wastewater Treatment areas were constructed and screened across the water table. Four intermediate monitoring wells (OH-MW-14, OH-MW-26, WW-MW-16, and WW-MW-17) were completed within in the Oil House and Wastewater Treatment areas to evaluate vertical gradients and define the vertical distribution of COPCs.

Groundwater quality samples collected from the extraction well clusters, screened below the water table surface, indicate that petroleum hydrocarbons are not detected in groundwater samples collected below the water table with the exception of two isolated detections. Kensol was detected in well OH-MW-14 with a concentration of 0.2 mg/L on September 20, 1991, and heavy oil was detected in well WW-MW-17 with a concentration of 3 mg/L on September 16, 1998. No other petroleum hydrocarbons were detected for wells OH-MW-14 and WW-MW-17. Based on Facility data, petroleum hydrocarbons can be assumed to be concentrated at or near the water table. The vertical distribution of petroleum hydrocarbons appears to be very limited at the Facility. Minimal vertical dispersion is expected at the Facility because of the rapid groundwater flow rates. Groundwater is moving through the Facility so quickly along the horizontal plane that there is insufficient time for vertical dispersion to take place. Natural biodegradation is also an important factor limiting vertical migration. Petroleum hydrocarbons will biodegrade quickly below the smear zone where sufficient oxygen is present to facilitate this natural process.

5.3.3 PCBs in Groundwater

This section describes the nature and extent of PCBs in groundwater at the Facility.

Nature and Extent

In general, the most significant PCB plume is located in the Remelt/Hot Line area, with smaller and more localized PCB plumes associated with petroleum present in the Oil House, Wastewater Treatment, and Cold Mill areas. Individual PCB plumes are discussed in the following sections.

Remelt/Hot Line PCB Plume. PCB concentrations in groundwater in the Remelt/Hot Line area are constrained to an elongated northeast-southwest trending zone. The PCB plume extends from the apparent source areas in the Remelt area and follows the local groundwater flow direction west southwest towards the River (Figure 5-5).

PCB concentrations were detected in October 2008 at 24 well locations: thirteen Hot Line wells, two deep Hot Line wells, and nine Remelt wells. PCB concentrations have also been infrequently detected at downgradient Perimeter wells MW-12A and MW-23S (Figure 5-8).

PCB concentrations from April 2007 through October 2008 are shown on Figure 5-17. Figures 5-18 and 5-19 show the Remelt/Hot Line PCB plume and relationship to groundwater flow patterns in April 2008 and October 2008, respectively, following in the local groundwater flow direction.

The highest PCB concentrations within this groundwater PCB plume were measured in the Remelt area at wells RM-MW-13S and RM-MW-17S at concentrations of 1,000 and 2,200 ng/L, respectively. These wells are in vicinity of the source area PCBs. It is likely that the PCBs originated from release of hydraulic fluids containing PCBs. PCBs usage was discontinued in the 1970s.

Figure 5-20 presents Generalized Subsurface Cross Section D-D′ along the axis of the PCB plume and shows its vertical extent. PCB concentrations in groundwater are concentrated in shallow monitoring wells but are present at depth in two deep monitoring wells (HL-MW-13DD and HL-MW-28DD).

A discussion of the potential mobility and transport mechanisms of the Remelt/ Hot Line PCB plume are discussed in Section 6.

Oil House Area. PCB detections in wells from the Oil House area appear to be limited to areas with free phase petroleum and/or dissolved petroleum hydrocarbons. The maximum measured PCB concentrations for the Oil House area are presented on Figure 5-7. The most recently measured PCB concentrations in the Oil House area are presented on Figure 5-8.

Since the 1990s, monitoring wells with measurable free phase petroleum or trace free phase petroleum sheen (Figure 5-7) generally have not been sampled and analyzed for PCBs. The only PCB concentrations detected in October 2008 were in two monitoring wells OH-MW-24 and OH-MW-26 with a PCB concentration of 2,100 and 9.8 ng/L, respectively. Well OH-MW-24 had a detection of TPH (Kensol) at a concentration of 17 mg/L during the same sampling event. While TPH was not detected in well OH-MW-26 in October 2008, a trace of oil (sheen) was detected on top of the water table indicating petroleum was present.

Downgradient wells (e.g., OH-MW-18 and OH-MW-19) have been sampled and analyzed periodically and show that migration of PCBs associated with petroleum from the Oil House area has not occurred.

PCBs were detected in soil samples from the smear zones of six monitoring wells in the Oil House area. These wells include OH-MW-16 (0.76 mg/kg), OH-MW-19 (0.24 – 0.90 mg/kg), OH-MW-20 (0.65 – 1.2 mg/kg), OH-MW-24 (0.60 mg/kg), SA-6 (0.21 – 0.27 mg/kg) and SA-7 (0.12 – 0.20 mg/kg). Free phase petroleum was not analyzed for PCBs during the RI. However, as presented in Table K-13 in the 2003 Groundwater RI/FS (Hart Crowser 2003) PCBs indicative of PCBs dissolved in oil product have been detected in the following wells in the Oil House area:

- OH-MW-03 (11 to 13 mg/L);
- OH-MW-04 (120 to 140 mg/L);
- OH-MW-5 (11 mg/L);
- OH-MW-06 (56 mg/L);
- OH-MW-16 (0.05U to 54 mg/L);
- OH-MW-20 (0.058 to 54 mg/L);
- OH-MW-24 (0.78 to 1.2 mg/L);

- OH-SK-1 (72 mg/L); and

- TL-MW-4 (0.032 mg/L).

It should be noted that these samples were all collected in the early 1990s and may not be representative of current site conditions.

Wastewater Treatment Area. The PCB detected in groundwater in the Wastewater Treatment area are associated with free phase petroleum and/or dissolved petroleum hydrocarbons. The maximum detected PCB concentrations for the Wastewater Treatment area are presented on Figure 5-6. The most recently measured PCB concentrations for the Wastewater Treatment area are presented on Figure 5-8. Historically PCBs have been detected in 11 monitoring wells at concentrations ranging from 6.4 to 17,000,000 ng/L. In general since the 1990s, monitoring wells with measurable free phase petroleum or trace free phase petroleum sheen (Figure 5-13) have not been sampled and analyzed for PCBs.

The only PCB concentration detected in October 2008 was from well WW-MW-8 with a PCB concentration of 6.3 ng/L. This well also had a diesel-range petroleum hydrocarbon detection of 8 mg/L during the same sampling event. PCBs have not been detected in wells downgradient of the Wastewater Treatment area free phase petroleum pool. These results indicate that migration of PCBs associated with petroleum from the Wastewater Treatment area has not occurred.

PCBs were not detected in soil samples from the smear zones of the Wastewater Treatment area. They were also not detected in the free-phase petroleum oil samples. However, as presented in Table K-13 of the 2003 Groundwater RI/FS Report (Hart Crowser 2003), groundwater samples from the Wastewater area that were collected from wells with free phase product and that have had PCB detections include:

- WW-MW-03 (52,000U to 4,800,000 ng/L PCBs);

- WW-MW-06 (17,000,000 ng/L);

- WW-MW-11 (31,000 to 2,200,000 ng/L PCBs); and

- WW-MW-13 (7,800,000 ng/L).

These data are indicative of PCBs being present in free phase petroleum in the Wastewater area. However, most of these samples were collected in the early 1990s and may not be indicative of current conditions.

Cold Mill Area. Historically PCBs have been detected infrequently in four monitoring wells in the Cold Mill area at concentration ranging from 4.3J to 17J ng/L. Each of these four wells has had only a single estimated (i.e., "J" flagged) PCB detection since PCB monitoring began in the Cold Mill area in 2004. The maximum detected PCB concentrations for the Cold Mill area are presented on Figure 5-7. The most recently PCB analyses for the Cold Mill area were non-detect as shown on Figure 5-8.

PCB has not been detected in any of the Cold Mill area wells since 2006.

PCB Concentration and Groundwater Trends

We evaluated PCB concentration trends and their relationship to groundwater elevations in monitoring wells in the Remelt/Hot Line PCB plume using plots presented in Appendix E. Temporal trends in PCB concentrations were evaluated using observed data and a simple best fit linear regression line of the plotted data. A word of caution is warranted regarding the trend lines shown in the PCB verses time plots in Appendix E. Using best fit linear regression analysis, one can draw a curve through any data set. This statistical evaluation is a "best fit" evaluation, and is not necessarily a "good fit". In the upper left hand corner of each plot with a trend line there is an R squared (R^2) value. This value is an indication of how well the data set fits the regression line. For example, an R^2 value of 0.2 means that the regression line explains 20 percent of the data points accounting for variations in the data. The other 80 percent of the data are not explained by the line. The highest R^2 in Appendix E is for well HL-MW-4 (page E-2) with a value of 0.49. This means that less than half the data are explained by the line. Thus, even this data point with the highest correlation to the trend line does not strongly indicate a trend.

In general it is difficult to discern any trends in the Remelt/Hot Line PCB plume. This is likely due to one or more of the following factors that interfere with any clearly defined trends:

- Fluctuations in groundwater elevation (up to 15 feet has been observed);

- Seasonal fluctuations in groundwater sampling depth (pump intakes are adjusted to within a foot or two of the groundwater surface at the time of sampling);

- Multiple PCB source area partitioning PCBs into groundwater at varying rates depending on groundwater elevation, infiltration rates, etc.; and

- Preferential flow paths that change due to groundwater elevation changes during each sampling event.

The monitoring wells that generally show an increasing trend in PCB concentrations on the basis of the linear regression analysis include:

HL-MW-4
HL-MW-5
HL-MW-13DD
HL-MW-14S
HL-MW-28DD
HL-MW-29S
RM-MW-3S
RM-MW-8S
RM-MW-10S
RM-MW-13S

The monitoring wells that generally show no definitive trend in PCB concentrations include:

HL-MW-6A
HL-MW-7S
HL-MW-8D
HL-MW-9D
HL-MW-17S
HL-MW-18S
HL-MW-23S
HL-MW-25S
HL-MW-26S
HL-MW-30S
MW-12/12A
MW-17S
MW-23S
MW-24D
RM-MW-1S
RM-MW-9S
RM-MW-14S
RM-MW-15S
RM-MW-16S
RM-MW-17S

The majority of the monitoring wells within the dissolved PCB plume in the Remelt and Hot Line areas show no clear trend through time. Increasing PCB concentrations generally occur in selected monitoring wells within the source area and along the axis of the Remelt/Hot Line PCB plume.

In general, no consistent relationship between PCB concentrations and groundwater elevations was observed.

5.3.4 PCB Congeners in Groundwater

Groundwater samples were collected from selected wells along the Remelt/Hot Line PCB plume axis, starting in the Remelt area and extending downgradient toward the Spokane River, in October 2007 and April 2008. The samples were analyzed for individual PCB congeners using EPA Method 1668A. Specific groups of PCB congeners were summed in various homologues based on the number of chlorine atoms (i.e., the entire range from monochlorobiphenyls to decachlorobiphenyls) as presented on Figure 5-21 and in Table 5-7. Because PCBs are ubiquitous in the environment and are often present in laboratory blank samples, groundwater data were blank corrected and included homolog group data in relative percent and by total homolog concentrations. Figure 5-21 presents the shallow groundwater PCB homolog fractions for select monitoring wells down the centerline of the PCB plume. Specific groups of PCB homologs are tabulated in Table 5-7 and the individual homologs are tabulated in Appendix F.

In general, the PCB homolog group compositions were consistent with the PCB Aroclors mixtures present at the Facility. The primary PCB homologs detected in groundwater samples were dichlorobiphenyls, trichlorobiphenyls, tetrachlorobiphenyls, and pentachlorobiphenyls. The primary groups of PCB homologs present in groundwater samples are consist with composition of the PCB Aroclors (1242 and 1248) mixtures identified in soil and groundwater.

5.3.5 PCB Source Areas

Soil samples were collected and analyzed for PCBs and TPH-HCID from the presumed PCB source areas for the Remelt/Hot Line PCB plume. Cross Section P-P′ (Plate 2) presents PCB, castor oil, and petroleum hydrocarbon concentrations in soil from monitoring wells and soil borings completed in the Remelt/Hot Line area.

The distribution of PCB and petroleum hydrocarbon concentrations in soil was quite variable. Beneath the Remelt building, PCBs were detected in soil samples collected from the unsaturated zone. PCBs were detected in soil samples from borings completed in the immediate vicinity of the Induction Furnace and the DC-1 and DC-4 Furnaces. In addition, borings completed west of the Remelt building have PCB detections below the water table to a maximum depth of 155 feet. Analytical results suggest that PCBs are mobilizing downward through unsaturated soils from source areas (i.e., Furnace areas) to the water table. Once at the water table, PCBs appear to be migrating with groundwater. HL-MW-28DD is the one exception; PCB concentrations (below the screening level) are present within 15 feet of the ground surface down to approximately 20 feet above the water table.

Castor oil and heavy oil-, gasoline- and diesel-range petroleum hydrocarbons were detected in soil in the vicinity of the furnaces DC-1 and DC-4 and a small isolated area near the Dry Wells located west of the Remelt building (HL-DW-SB-1) and the West Landfill (HL-MW-24DD) (Plate 2). Gasoline-range petroleum hydrocarbon concentrations were only observed in soils within the top 20 feet near the DC-4 furnace (RM-F4-SB-1) and were non-detect everywhere else within the Remelt/Hot Line area. Similarly, diesel- and heavy oil-range petroleum hydrocarbons were detected in the immediate vicinity of the

DC-4 furnace; however, petroleum hydrocarbon concentrations were also detected below the water table. In addition, castor oil was detected in soil samples from the ground surface to below the water table in monitoring well HL-MW-24D, located downgradient of the Hot Line area and the dry wells but upgradient from the West Landfill (Plate 2). Analytical results indicate that the dry wells may be a potential source for petroleum hydrocarbons or castor oil to soil and groundwater in areas downgradient from the Remelt building. However, castor oil has not been detected in groundwater to date.

Hydraulic oil containing PCB may have been stored at the Oil House Drum Storage area. Shallow soil containing PCBs were removed in the early 1990s. PCBs have been detected in soil samples from the smear zone beneath the Oil House area.

The source of PCBs in the Wastewater Treatment area is not clearly known but appears to be related to handling of wastewater with oils containing PCBs in the area.

5.3.6 Metals

This section describes the nature and extent of metals retained as COPCs in groundwater at the Facility. Based on analysis described in Section 5.2 arsenic, iron, and manganese are the metals retained as COPCs.

Nature and Extent

Arsenic. Arsenic is uniformly distributed across the Facility at low concentrations as shown on Figure 5-22, with the exception of two isolated locations associated with Wastewater Treatment and Oil House areas as shown on Figures 5-23 and 5-24, respectively. Every detected arsenic concentration exceeds the arsenic screening level. Arsenic concentrations within individual wells do not have large variations or evident trends in concentration through time, indicating steady state conditions. However, arsenic is considered a COPC at the Facility.

Iron. Iron is generally uniformly distributed across the Facility at concentrations below the screening level as shown on Figure 5-25 with the exception of two isolated locations associated with Wastewater Treatment and Oil House areas and few isolated well locations (TL-MW-3, TL-MW-4, HL-MW-20S, OH-MW-23, and CM-MW-2S). Figures 5-26 and 5-27 spatially show that iron exceedances are generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface.

Manganese. Manganese is generally uniformly distributed across the Facility at concentrations below the screening level as shown on Figure 5-28 with the exception of three isolated locations associated with Wastewater Treatment, Oil House, and ORB areas and few isolated well locations (MW-23S, TL-MW-3, OH-MW-13, OH-MW-23, and CM-MW-6S). Figures 5-29 and 5-30 spatially show that manganese exceedances are generally collocated in areas where free phase petroleum and/or sheen persist on the water table surface.

Summary. Graphical presentation of metals data demonstrate that arsenic, iron, and manganese exceedances are collocated in areas where free phase petroleum and/or sheen persist on the water table surface. Figures 5-22, 5-25, and 5-28 show that the most recently measured concentrations of arsenic, iron, and manganese are generally elevated only in the Oil House and Wastewater Treatment areas.

5.3.7 Polycyclic Aromatic Hydrocarbons (PAHs)

The distribution of groundwater samples with elevated TEQ concentrations for cPAHs is presented on Figure 5-31. The source of cPAHs is collocated in areas with petroleum hydrocarbon detections and appears to be from petroleum used in operations and activities at the Facility. The TEQ exceedances are limited to groundwater samples collected from the Cold Mill, Hot Line, Oil House, and Wastewater Treatment areas.

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Table 5-1 - Summary of Groundwater Quality Data

Analyte	Detection Frequency	Detection Range				Date of Max	Average	Median	Date Last Sampled
		Minimum		Maximum					
Conventionals in mg/L									
Chloride	114/131	1.5		147		6/27/02	12.0	4.5	10/22/08
Dissolved Organic Carbon	25/25	0.24	J	1.2		10/25/06	0.41	0.38	10/26/06
Dissolved Oxygen	805/805	0.1		15.2		12/30/99	6.4	7.3	5/12/03
Fluoride	2/3	0.177		0.42		5/11/90	0.299	0.299	12/1/95
Hardness as CaCO3	81/81	130		230		3/14/96	164	160	10/22/08
Nitrate + Nitrite	123/129	0.02	J	8.6		1/24/90	1.64	1.50	4/23/06
Nitrate as Nitrogen	104/113	0.046	J	157		1/24/08	4.77	1.50	10/22/08
Nitrite as Nitrogen	1/89	0.05		0.05		10/26/06	0.05	0.05	10/22/08
Ortho-phosphate	1/4	0.007		0.007		10/3/91	0.007	0.007	11/14/91
Sulfate	60/60	1.1		18.6		1/24/08	10.2	11.0	10/22/08
Total Alkalinity as CaCO3	20/20	151		175		4/24/08	161	161	10/22/08
Total Dissolved Solids	21/24	12		402		7/24/08	201	202	10/22/08
Total Kjeldahl Nitrogen	1/4	0.28		0.28		10/3/91	0.28	0.28	11/14/91
Total Organic Carbon	29/29	0.24	J	55		10/3/91	5.82	0.38	5/9/07
Total Sulfide	6/54	0.041	J	0.25		10/26/06	0.124	0.075	10/26/06
Total Suspended Solids	908/1678	0		8400		9/3/03	124	10	10/24/08
Metals in ug/L									
Antimony	366/409	0.028	J	24		5/11/90	2.82	0.180	10/24/08
Arsenic	708/909	0.11		380		9/30/97	7.39	3.67	10/24/08
Barium	166/166	28.2		220	J	1/24/90	45.9	36.9	10/22/08
Beryllium	0/42								12/1/95
Cadmium	38/206	0.006	T	0.7	J	5/10/90	0.053	0.037	10/22/08
Chromium	165/282	0.16	J	608		9/3/03	9.83	0.91	10/22/08
Copper	1/42	20		20		5/8/90	20	20	12/1/95
Cyanide	0/6								12/1/95
Iron	210/367	3.1	J	22400		4/24/08	548.2	9.4	10/24/08
Lead	107/206	0.004	JT	12.7		10/28/04	0.201	0.024	10/22/08
Manganese	295/368	0.011	J	2840		10/25/06	109.68	0.542	10/24/08
Mercury	0/168								2/1/07
Nickel	0/42								12/1/95
Selenium	122/206	0.1	J	5		11/30/89, 12/1/89	0.7	0.4	10/22/08
Silver	28/206	0.003	J	30		11/30/89	1.44	0.009	10/22/08
Sodium	1/1	4710		4710		12/1/95	4710	4710	12/1/95
Thallium	0/42								12/1/95
Zinc	15/42	10		124		12/1/95	25	20	12/1/95
Pesticides/PCBs in ug/L									
4,4'-DDD	0/7								4/18/96
4,4'-DDE	0/7								4/18/96
4,4'-DDT	0/7								4/18/96
Aldrin	0/7								4/18/96
Alpha-BHC	0/7								4/18/96
Aroclor 1016	0/1664								10/24/08
Aroclor 1016/1242	2/2	0.04		0.078		3/18/97	0.059	0.059	3/18/97
Aroclor 1016/1242/1248	1/1	0.061		0.061		9/16/98	0.061	0.061	9/16/98
Aroclor 1221	0/1667								10/24/08
Aroclor 1232	0/1667								10/24/08
Aroclor 1242	344/1658	0.0019	T	2200		10/26/93	8.69	0.11	10/24/08
Aroclor 1242/1248	6/6	0.026		120000		6/28/94	34167	6500	10/4/95
Aroclor 1248	72/1658	0.0045	J	130000		9/19/91	4108	0.0805	10/24/08
Aroclor 1254	13/1667	0.0043	J	280		5/14/92	30.82	0.0320	10/24/08
Aroclor 1260	7/1667	0.0011	J	0.095	JP	10/27/06	0.047	0.060	10/24/08
Beta-BHC	0/7								4/18/96
Chlordane	0/7								4/18/96

Table 5-1 - Summary of Groundwater Quality Data

Analyte	Detection Frequency	Detection Range				Date of Max	Average	Median	Date Last Sampled
		Minimum		Maximum					
Dieldrin	0/7								4/18/96
Endosulfan I	0/7								4/18/96
Endosulfan II	0/7								4/18/96
Endosulfan Sulfate	0/7								4/18/96
Endrin	0/7								4/18/96
Endrin Ketone	0/7								4/18/96
Gamma-BHC	0/7								4/18/96
Heptachlor	0/7								4/18/96
Heptachlor Epoxide	0/7								4/18/96
Methoxychlor	0/7								4/18/96
Total PCBs	435/1667	0.0019	T	130000		9/19/91	1159	0.1	10/24/08
Toxaphene	0/7								4/18/96
Semivolatiles in ug/L									
1,2,4-Trichlorobenzene	0/60								4/19/06
1,2-Dichlorobenzene	0/60								4/19/06
1,3-Dichlorobenzene	0/60								4/19/06
1,4-Dichlorobenzene	0/60								4/19/06
2,2'-Oxybis(2-chloropropane)	0/8								12/15/93
2,4,5-Trichlorophenol	0/68								4/19/06
2,4,6-Trichlorophenol	0/68								4/19/06
2,4-Dichlorophenol	0/68								4/19/06
2,4-Dimethylphenol	2/68	0.34	J	11	J	7/27/05	5.67	5.67	4/19/06
2,4-Dinitrophenol	0/68								4/19/06
2,4-Dinitrotoluene	0/68								4/19/06
2,6-Dinitrotoluene	0/68								4/19/06
2-Chloronaphthalene	0/68								4/19/06
2-Chlorophenol	0/68								4/19/06
2-Methylnaphthalene	87/317	0.0023	T	2.8		10/20/08	0.0411	0.0042	10/24/08
2-Methylphenol	0/68								4/19/06
2-Nitroaniline	0/68								4/19/06
2-Nitrophenol	0/60								4/19/06
3,3'-Dichlorobenzidine	0/60								4/19/06
3-Nitroaniline	0/68								4/19/06
4,6-Dinitro-2-methyphenol	0/68								4/19/06
4-Bromophenyl-Phenylether	0/68								4/19/06
4-Chloro-3-methylphenol	2/68	0.029	J	0.03	J	7/26/05	0.0295	0.0295	4/19/06
4-Chloroaniline	0/60								4/19/06
4-Chlorophenyl-phenylether	0/59								4/19/06
4-Methylphenol	3/68	0.078	J	10		7/27/05	3.69	1	4/19/06
4-Nitroaniline	0/68								4/19/06
4-Nitrophenol	0/68								4/19/06
Acenaphthene	14/317	0.0031	J	0.69		10/23/08	0.1458	0.0130	10/24/08
Acenaphthylene	26/317	0.0024	J	1.2		10/22/07	0.0712	0.0046	10/24/08
Aniline	0/16								3/24/05
Anthracene	15/317	0.0022	J	8.3		10/22/07	0.9986	0.0120	10/24/08
Benzidine	0/8								4/18/96
Benzo(g,h,i)perylene	29/317	0.0032	T	34	J	7/27/05	1.23	0.0110	10/24/08
Benzoic Acid	1/68	2.2	J	2.2	J	1/25/06	2.2	2.2	4/19/06
Benzyl Alcohol	1/68	1.3	J	1.3	J	3/23/05	1.3	1.3	4/19/06
Bis(2-Chloroethoxy)Methane	0/68								4/19/06
Bis(2-Chloroethyl)Ether	0/68								4/19/06
Bis(2-Ethylhexyl)Phthalate	9/68	0.36	J	1.1	J	7/26/05, 4/19/06	0.71	0.56	4/19/06
Bis(2-chloroisopropyl) Ether	0/60								4/19/06
Butylbenzylphthalate	3/68	0.034	J	1		10/29/05	0.357	0.037	4/19/06

Table 5-1 - Summary of Groundwater Quality Data

Analyte	Detection Frequency	Detection Range				Date of Max	Average	Median	Date Last Sampled
		Minimum		Maximum					
Di-N-Butylphthalate	1/68	0.16	J	0.16	J	10/29/05	0.16	0.16	4/19/06
Di-n-octyl Phthalate	0/68								4/19/06
Dibenzofuran	27/317	0.0068	J	1.2		10/22/07	0.1420	0.0240	10/24/08
Diethylphthalate	9/68	0.027	J	0.089	J	10/29/05	0.044	0.037	4/19/06
Dimethyl Phthalate	2/68	0.018	J	0.049	J	6/16/05	0.034	0.034	4/19/06
Fluoranthene	38/317	0.0041	J	6.5		10/22/07	0.2325	0.0225	10/24/08
Fluorene	53/317	0.0039	T	2.9		10/22/07	0.2108	0.0120	10/24/08
Hexachlorobenzene	0/68								4/19/06
Hexachlorobutadiene	0/103								4/19/06
Hexachlorocyclopentadiene	0/68								4/19/06
Hexachloroethane	0/68								4/19/06
Isophorone	0/68								4/19/06
N-Nitroso-di-n-propylamine	0/68								4/19/06
N-Nitrosodimethylamine	0/16								3/24/05
N-Nitrosodiphenylamine	0/68								4/19/06
Naphthalene	88/345	0.0037	T	0.79		10/20/08	0.0713	0.036	10/24/08
Nitrobenzene	0/68								4/19/06
Pentachlorophenol	0/68								4/19/06
Phenanthrene	65/317	0.0033	J	66	J	6/28/91	1.57	0.0110	10/24/08
Phenol	1/68	1.1	J	1.1	J	7/27/05	1.1	1.1	4/19/06
Total Phenolics	0/5								5/11/90
Trimethylbenzene Isomers	0/15								12/30/99
o-Nitrophenol	0/8								12/15/93
cPAHs in ug/L									
Benzo(a)anthracene	23/317	0.0031	T	0.6		10/27/05	0.0485	0.0099	10/24/08
Benzo(a)pyrene	11/317	0.0043	J	0.094		4/21/06	0.0214	0.0170	10/24/08
Benzo(b)fluoranthene	29/317	0.0023	T	0.2		10/22/07	0.0275	0.0059	10/24/08
Benzo(k)fluoranthene	15/317	0.0025	T	0.12		4/21/06	0.0180	0.0079	10/24/08
Chrysene	32/317	0.0015	J	10		10/22/07	0.6188	0.0300	10/24/08
Dibenz(a,h)anthracene	14/317	0.0025	T	0.074		4/21/06	0.0110	0.0051	10/24/08
Indeno(1,2,3-cd)pyrene	26/317	0.0025	J	29	J	7/27/05	1.14	0.0088	10/24/08
Pyrene	58/317	0.0034	J	20	J	7/27/05	0.8374	0.0295	10/24/08
TEQ Equivalent	56/56	0.00001		2.9		7/27/05	0.0647	0.0015	10/24/08
Volatiles in ug/L									
1,1,1,2-Tetrachloroethane	0/386								10/24/08
1,1,1-Trichloroethane	0/728								10/24/08
1,1,2,2-Tetrachloroethane	0/727								10/24/08
1,1,2-Trichloroethane	0/728								10/24/08
1,1-Dichloroethane	0/728								10/24/08
1,1-Dichloroethene	0/728								10/24/08
1,1-Dichloropropene	0/386								10/24/08
1,2,3-Trichlorobenzene	1/386	0.11	T	0.11	T	4/24/08	0.11	0.11	10/24/08
1,2,3-Trichloropropane	0/386								10/24/08
1,2,3-Trimethylbenzene	0/1								12/1/95
1,2,4-Trichlorobenzene	0/385								10/24/08
1,2,4-Trimethylbenzene	7/370	0.04	T	5.1		10/20/08	1.12	0.37	10/24/08
1,2-Dibromo-3-Chloropropane	0/385								10/24/08
1,2-Dibromoethane(EDB)	0/385								10/24/08
1,2-Dichlorobenzene	1/500	0.06	T	0.06	T	10/23/08	0.06	0.06	10/24/08
1,2-Dichloroethane(EDC)	5/728	0.41	J	5.4		9/24/02	2.94	3.3	10/24/08
1,2-Dichloroethene	0/1								12/1/95
1,2-Dichloroethene (Total)	0/8								3/23/99
1,2-Dichloropropane	0/728								10/24/08
1,3,5-Trimethylbenzene	0/386								10/24/08
1,3-Dichlorobenzene	0/394								10/24/08

Table 5-1 - Summary of Groundwater Quality Data

Analyte	Detection Frequency	Detection Range				Date of Max	Average	Median	Date Last Sampled
		Minimum		Maximum					
1,3-Dichloropropane	0/386								10/24/08
1,4-Dichlorobenzene	0/394								10/24/08
2,2-Dichloropropane	0/386								10/24/08
2-Butanone (MEK)	1/727	25		25		4/18/06	25	25	10/24/08
2-Chlorotoluene	0/385								10/24/08
2-Hexanone	0/727								10/24/08
2-Propanol, 2-methyl-	0/4								1/25/08
4-Chlorotoluene	0/385								10/24/08
4-Isopropyltoluene	0/336								8/13/08
4-Methyl-2-Pentanone	0/727								10/24/08
Acetone	20/727	2.8	T	14, 14	T	5/5/98, 10/23/08	6.6	5.3	10/24/08
Benzene	7/825	0.24	T	3		12/4/91	1.4	1	10/24/08
Bromobenzene	0/386								10/24/08
Bromochloromethane	0/386								10/24/08
Bromodichloromethane	2/728	0.19	J	0.22	T	10/22/07	0.21	0.21	10/24/08
Bromoform	5/728	0.32	J	0.53		10/24/07	0.39	0.36	10/24/08
Bromomethane	5/728	0.24	J	0.43	J	6/24/02	0.33	0.33	10/24/08
Butane, 2-methoxy-2-methyl-	0/4								1/25/08
Butylbenzene Isomers	0/1								12/1/95
Carbon Disulfide	16/727	0.05	T	6.7		4/20/08	0.81	0.16	10/24/08
Carbon Tetrachloride	0/728								10/24/08
Chlorobenzene	1/728	4		4		10/3/95	4	4	10/24/08
Chloroethane	0/728								10/24/08
Chloroform	8/728	0.05	T	1.7		6/29/04	0.34	0.14	10/24/08
Chloromethane	13/728	0.06	T	0.22	J	1/26/06	0.12	0.10	10/24/08
Cis-1,2-Dichloroethene	0/539								10/24/08
Cis-1,3-Dichloropropene	0/728								10/24/08
Cumene(Isopropylbenzene)	10/386	0.09	T	1.3	T	10/23/08	0.34	0.22	10/24/08
Dibromochloromethane	5/728	0.13	T	0.2	T	10/24/07	0.16	0.14	10/24/08
Dibromomethane	1/386	0.15	T	0.15	T	4/24/08	0.15	0.15	10/24/08
Dichloroethylenes	0/180								12/16/98
Diisopropyl Ether (Dot)	0/4								1/25/08
Ethylbenzene	39/825	0.06	T	14		11/30/89, 5/9/90	4.07	3	10/24/08
Freon 11	0/382								10/24/08
Freon 12	0/382								10/24/08
Hexachlorobutadiene	0/385								10/24/08
Methyl t-butyl ether	0/4								1/25/08
Methylene Chloride	9/728	0.2	J	0.37	T	10/20/08	0.26	0.23	10/24/08
N-Butylbenzene	5/386	0.06	T	0.43	T	10/20/08	0.21	0.13	10/24/08
N-Propylbenzene	8/386	0.04	T	1.4	T	10/23/08	0.36	0.21	10/24/08
Naphthalene	3/385	0.23	T	0.44	J	7/21/06	0.32	0.30	10/24/08
Propane, 2-Ethoxy-2-Methyl-	0/4								1/25/08
Sec-Butylbenzene	15/385	0.04	T	2.1		10/23/08	0.45	0.25	10/24/08
Styrene	1/728	0.04	T	0.04	T	10/22/08	0.04	0.04	10/24/08
Tert-Butylbenzene	5/386	0.05	T	0.12	T	4/24/08, 10/23/08	0.09	0.10	10/24/08
Tetrachloroethene	1/728	2		2		12/16/96	2	2	10/24/08
Toluene	103/825	0.05	T	15		5/9/90	0.65	0.17	10/24/08
Total Xylenes	53/306	1		160		6/26/91	28	15	5/20/05
Trans-1,2-Dichloroethene	0/540								10/24/08
Trans-1,3-Dichloropropene	0/728								10/24/08
Trichloroethene (TCE)	3/728	0.07	T	4		12/1/89	1.52	0.5	10/24/08
Trimethylbenzene Isomers	0/23								12/30/99

Table 5-1 - Summary of Groundwater Quality Data

	Detection	Detection Range				Date of			Date Last
Analyte	Frequency	Minimum		Maximum		Max	Average	Median	Sampled
Vinyl Acetate	0/364								9/3/03
Vinyl Chloride	0/728								10/24/08
m,p-Xylenes	2/519	0.09	T	0.42	J	6/29/04	0.26	0.26	10/24/08
o-Chlorotoluene	0/1								12/1/95
o-Xylene	2/519	0.12	T	0.17	J	6/29/04	0.15	0.15	10/24/08
p-Chlorotoluene	0/1								12/1/95
p-Cymene	1/50	0.41	T	0.41	T	10/20/08	0.41	0.41	10/24/08
TPH (418.1) in mg/L									
Total Petroleum Hydrocarbons	43/75	0.28		900		3/9/91	77.42	19	10/13/04
TPH-HCID in mg/L									
Gasoline	7/1660	0.1	J	140		3/9/91	32.7	6	1/22/09
Stoddard/Mineral spirits	13/1648	0.35	J	380	J	6/26/91	46.90	8.8	1/22/09
Kensol	83/1648	0.2		1800	J	6/26/91	70.4	3.5	1/22/09
Kerosene/Jet fuel	16/1581	0.1	J	9		10/26/93	2.6	0.6	1/22/09
Diesel/Fuel oil	70/1653	0.04		950		3/9/91	42.91	2.5	1/22/09
Bunker C	0/1587								1/22/09
Heavy oil	53/1647	0.2		460		10/22/07	39.1	5.5	1/22/09
TPH-Dx in mg/L									
Kerosene/Jet fuel	2/253	0.1	J	8.7		7/27/05	8.4	8.4	1/22/09
Diesel/Fuel oil	12/256	0.04		200		10/22/07	44.3	14	1/22/09
Heavy oil	13/255	0.2		520		7/27/05	104.9	14	1/22/09
TPH-Gx in mg/L									
Mineral spirits/Stoddard	0/240								10/24/08
Gasoline	1/242	0.1	J	0.2		10/27/04	0.2	0.2	1/22/09

J = Estimated value.
P = The relative percent difference is greater than 40% between the GC primary and confirmation column results.
T = Value is between the MDL and MRL.
Blank indicates there are no detections for specific analyte.

Table 5-2 - Summary of Groundwater Screening Levels

		Groundwater ARARs		Groundwater MTCA								Surface Water MTCA		
		Federal and State	Drinking Water Standards	Method A	Method B		Aquatic Life - Fresh/Chronic			Human Health - Fresh Water		Method B		PQL
Analyte	Groundwater Screening Level in ug/L	Primary MCL in ug/L	Secondary MCL in ug/L	in µg/L	Carcinogen in µg/L	Non-carcinogen in µg/L	Ch. 173-201A WAC in µg/L (a)	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Carcinogen in µg/L	Non-Carcinogen in µg/L	
Conventionals in ug/L		--	--	--	--	--	--	--	--	--	--	--	--	
Chloride	230000	--	250000	--	--	--	**230000**	**230000**	--	--	--	--	--	
Fluoride	960	4000	2000	--	--	**960**	--	--	--	--	--	--	--	
Nitrate	10000	**10000**	--	--	--	--	--	--	--	**10000**	--	--	--	
Sulfate	250000	--	**250000**	--	--	--	--	--	--	--	--	--	--	
Total Dissolved Solids	500000	--	**500000**	--	--	--	--	--	--	--	--	--	--	
Metals (Total and Dissolved) in ug/L														
Antimony	6	**6**	--	--	--	6.4	--	--	--	5.6	14	--	1000	0.05
Arsenic	0.018	10	--	5	0.058	4.8	190	150	190	**0.018**	**0.018**	0.098	18	0.5
Beryllium	4	**4**	--	--	--	32	--	--	--	--	--	--	270	0.05
Cadmium	0.25	5	--	5	--	8	0.37	**0.25**	1	--	--	--	20	0.05
Chromium	50	100	--	**50**	--	--	--	--	--	--	--	--	--	0.2
Copper	3.50	1300	1000	--	--	590	**3.5**	9	11	--	--	--	2700	
Cyanide	5.20	200	--	--	--	--	**5.2**	**5.2**	5.2	140	700	--	52000	
Iron	300	--	**300**	--	--	--	--	1000	--	**300**	--	--	--	20
Lead	0.54	15		15	--	--	**0.54**	2.5	2.5	--	--	--	--	0.02
Manganese	50	--	**50**	--	--	2200	--	--	--	**50**	--	--	--	0.05
Mercury	0.012	2	--	2	--	4.8	**0.012**	0.77	0.012	--	0.14	--	--	
Nickel	49	100	--	--	--	320	**49**	52	160	610	610	--	1100	
Selenium	5	50	--	--	--	80	**5**	**5**	**5**	170	--	--	2700	1
Silver	80	--	100	--	--	**80**	--	--	--	--	--	--		0.02
Thallium	0.24	2		--	--	1.1	--	--	--	**0.24**	1.7	--	1.6	
Zinc	32	--	5000	--	--	4800	**32**	120	100	7400	--	--	17000	
Semivolatiles in ug/L														
1,2,4-Trichlorobenzene	35	70	--	--	--	80	--	--	--	**35**	--	--	230	
1,2-Dichlorobenzene	420	600	--	--	--	720	--	--	--	**420**	2700	--	4200	
1,3-Dichlorobenzene	320	--	--	--	--	--	--	--	--	**320**	400	--	--	
1,4-Dichlorobenzene	1.8	75	--	--	**1.8**	--	--	--	--	63	400	4.9	--	
2,4,5-Trichlorophenol	800	--	--	--	--	**800**	--	--	--	1800	--	--	--	
2,4,6-Trichlorophenol	1.4	--	--	--	4	--	--	--	--	**1.4**	2.1	3.9	--	
2,4-Dichlorophenol	24	--	--	--	--	**24**	--	--	--	77	93	--	190	
2,4-Dimethylphenol	160	--	--	--	--	**160**	--	--	--	380	--	--	550	
2,4-Dinitrophenol	32	--	--	--	--	**32**	--	--	--	69	70.000	--	3500	
2,4-Dinitrotoluene	0.11	--	--	--	--	32	--	--	--	**0.11**	**0.11**	--	1400	
2,6-Dinitrotoluene	16	--	--	--	--	**16**	--	--	--	--	--	--	--	
2-Chlorophenol	40	--	--	--	--	**40**	--	--	--	--	--	--	97	
2-Methylnaphthalene	32	--	--	--	--	**32**	--	--	--	--	--	--	--	
3,3'-Dichlorobenzidine	0.021	--	--	--	0.19	--	--	--	--	**0.021**	0.04	0.046	--	
Acenaphthene	640	--	--	--	--	960	--	--	--	670	--	--	**640**	0.02
Aniline	7.7	--	--	--	**7.7**	--	--	--	--	--	--	--	--	
Anthracene	4800	--	--	--	--	**4800**	--	--	--	8300	9600	--	26000	0.02
Benzidine	0.000086	--	--	--	0.00038	48	--	--	--	**0.000086**	0.00012	0.00032	89	
Benzoic Acid	64000	--	--	--	--	**64000**	--	--	--	--	--	--	--	
Benzyl Alcohol	2400	--	--	--	--	**2400**	--	--	--	--	--	--	--	
Bis (2-Chloroethyl) Ether	0.03	--	--	--	0.04	--	--	--	--	**0.03**	0.031	0.85	--	

Table 5-2 - Summary of Groundwater Screening Levels

		Groundwater ARARs		Groundwater MTCA								Surface Water MTCA		
		Federal and State	Drinking Water Standards	Method A	Method B		Aquatic Life - Fresh/Chronic			Human Health - Fresh Water		Method B		PQL
Analyte	Groundwater Screening Level in ug/L	Primary MCL in ug/L	Secondary MCL in ug/L	in µg/L	Carcinogen in µg/L	Non-carcinogen in µg/L	Ch. 173-201A WAC in µg/L [(a)]	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Carcinogen in µg/L	Non-Carcinogen in µg/L	
Bis (2-Ethylhexyl) Phthalate	1.2	6	--	--	6.3	320	--	--	--	**1.2**	1.8	3.6	400	
Bis(2-chloroisopropyl) Ether	320	--	--	--	--	**320**	--	--	--	1400	1400	--	42000	
Butylbenzylphthalate	1300	--	--	--	--	3200	--	--	--	1500	--	--	**1300**	
Di-n-octyl Phthalate	320	--	--	--	--	**320**	--	--	--	--	--	--	--	
Dibenzofuran	32	--	--	--	--	**32**	--	--	--	--	--	--	--	
Diethylphthalate	13000	--	--	--	--	**13000**	--	--	--	17000	23000	--	28000	
Dimethyl Phthalate	16000	--	--	--	--	**16000**	--	--	--	270000	310000	--	72000	
Fluoranthene	90	--	--	--	--	640	--	--	--	130	300	--	**90**	0.02
Fluorene	640	--	--	--	--	**640**	--	--	--	1100	1300	--	3500	0.02
Hexachlorobenzene	0.00028	1	--	--	0.055	13	--	--	--	**0.00028**	0.001	0.000	0.240	
Hexachlorobutadiene	0.44	--	--	--	0.56	1.6	--	--	--	**0.44**	**0.44**	30	190	
Hexachlorocyclopentadiene	40	50	--	--	--	48	--	--	--	**40**	240	--	3600	
Hexachloroethane	1.4	--	--	--	3.1	8	--	--	--	**1.4**	1.9	5.3	30	
Isophorone	8.4	--	--	--	46	1600	--	--	--	35	**8.4**	1600	120000	
N-Nitroso-di-n-propylamine	0.005	--	--	--	--	--	--	--	--	**0.005**	--	0.82	--	
N-Nitrosodiphenylamine	3.3	--	--	--	--	--	--	--	--	**3.3**	5	9.7	--	
Naphthalene	160	--	--	**160**	--	**160**	--	--	--	--	--	--	4900	0.02
Nitrobenzene	4	--	--	--	--	**4**	--	--	--	17	17	--	450	
Pentachlorophenol	0.27	1	--	--	0.73	480	13.000	15.000	13.000	**0.27**	0.28	4.9	7100	
Phenol	4800	--	--	--	--	**4800**	--	--	--	21000	21000	--	1100000	
Pyrene	480	--	--	--	--	**480**	--	--	--	830	960	--	2600	0.02
cPAHs in ug/L														
Benzo(a)pyrene	0.0028	0.2	--	0.100	0.012	--	--	--	--	0.0038	**0.0028**	0.030	--	0.02
Benzo(a)anthracene	See BaP (b)	--	--	--	(c)	--	--	--	--	0.0038	See BaP (c)	(c)	--	0.02
Benzo(b)fluoranthene	See BaP (b)	--	--	--	(c)	--	--	--	--	0.0038	See BaP (c)	(c)	--	0.02
Benzo(k)fluoranthene	See BaP (b)	--	--	--	(c)	--	--	--	--	0.0038	See BaP (c)	(c)	--	0.02
Chrysene	See BaP (b)	--	--	--	(c)	--	--	--	--	0.0038	See BaP (c)	(c)	--	0.02
Dibenz(a,h)anthracene	See BaP (b)	--	--	--	(c)	--	--	--	--	0.0038	See BaP (c)	(c)	--	0.02
Indeno(1,2,3-cd)pyrene	See BaP (b)	--	--	--	(c)	--	--	--	--	0.0038	See BaP (c)	(c)	--	0.02
Volatiles in ug/L														
1,1,1,2-Tetrachloroethane	1.7	--	--	--	**1.7**	240	--	--	--	--	--	--	--	
1,1,1-Trichloroethane	200	**200**	--	**200**	--	7200	--	--	--	--	--	--	420000	
1,1,2,2-Tetrachloroethane	0.17	--	--	--	0.22	--	--	--	--	**0.17**	**0.17**	6.5	--	
1,1,2-Trichloroethane	0.59	5	--	--	0.77	32	--	--	--	**0.59**	0.600	25	2300	
1,1-Dichloroethane	1600	--	--	--	--	**1600**	--	--	--	--	--	--	--	
1,2,3-Trichloropropane	0.006	--	--	--	**0.006**	48	--	--	--	--	--	--	--	
1,2,4-Trimethylbenzene	400	--	--	--	--	**400**	--	--	--	--	--	--	--	
1,2-Dibromo-3-Chloropropane	0.031	0.2	--	--	**0.031**	--	--	--	--	--	--	--	--	
1,2-Dichlorobenzene	420	600	--	--	--	720	--	--	--	**420**	2700	--	4200	
1,2-Dichloroethane(EDC)	0.38	5	--	5	0.48	160	--	--	--	**0.38**	**0.38**	59	43000	
1,2-Dichloropropane	0.5	5		--	0.64	--	--	--	--	**0.5**	--	23	--	
1,3,5-Trimethylbenzene	400	--	--	--	--	**400**	--	--	--	--	--	--	--	
1,3-Dichlorobenzene	320	--	--	--	--	--	--	--	--	**320**	400	--	--	
1,4-Dichlorobenzene	1.8	75		--	**1.8**	--	--	--	--	63	400	4.9	--	
2-Butanone (MEK)	4800	--	--	--	--	**4800**	--	--	--	--	--	--	--	

Table 5-2 - Summary of Groundwater Screening Levels

		Groundwater ARARs		Groundwater MTCA								Surface Water MTCA		
		Federal and State	Drinking Water Standards	Method A	Method B		Aquatic Life - Fresh/Chronic			Human Health - Fresh Water		Method B		PQL
Analyte	Groundwater Screening Level in ug/L	Primary MCL in ug/L	Secondary MCL in ug/L	in µg/L	Carcinogen in µg/L	Non-carcinogen in µg/L	Ch. 173-201A WAC in µg/L $^{(a)}$	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Carcinogen in µg/L	Non-Carcinogen in µg/L	
Acetone	800	--	--	--	--	**800**	--	--	--	--	--	--	--	
Benzene	0.8	5	--	5	**0.8**	32	--	--	--	2.2	1.2	23	2000	
Bromodichloromethane	0.27	80	--	--	0.71	160	--	--	--	0.55	**0.27**	28	14000	
Bromoform	4.3	80	--	--	5.5	160	--	--	--	**4.3**	**4.3**	220	14000	
Bromomethane	11	--	--	--	--	**11**	--	--	--	47	48	--	970	
Carbon Disulfide	800	--	--	--	--	**800**	--	--	--	--	--	--	--	
Carbon Tetrachloride	0.23	5	--	--	0.34	5.6	--	--	--	**0.23**	0.25	2.7	97	
Chlorobenzene	100	**100**	--	--	--	160	--	--	--	130	680	--	5000	
Chloroform	5.7	80	--	--	7.2	80	--	--	--	**5.7**	**5.7**	280	6900	
Chloromethane	3.4	--	--	--	**3.4**	--	--	--	--	--	--	130	--	
Cumene (Isopropylbenzene)	800	--	--	--	--	**800**	--	--	--	--	--	--	--	
Dibromochloromethane	0.4	80	--	--	0.52	160	--	--	--	**0.4**	0.41	21	14000	
Dichlorodifluoromethane (Freon 12)	1600	--	--	--	--	**1600**	--	--	--	--	--	--	--	
Ethylbenzene	530	700	--	700	--	800	--	--	--	**530**	3100	--	6900	
Hexachlorobutadiene	0.44	--	--	--	0.56	1.600	--	--	--	**0.44**	**0.44**	30	190	
m+p Xylenes	16000	--	--	--	--	**16000**	--	--	--	--	--	--	--	
Methylene Chloride	4.60	5	--	5	5.8	480	--	--	--	**4.6**	4.7	960	170000	
Naphthalene	160	--	--	**160**	--	**160**	--	--	--	--	--	--	4900	
o-Chlorotoluene	160	--	--	--	--	**160**	--	--	--	--	--	--	--	
o-Xylene	16000	--	--	--	--	**16000**	--	--	--	--	--	--	--	
Styrene	1.5	100	--	--	**1.5**	1600	--	--	--	--	--	--	--	
Tetrachloroethene	0.081	5	--	5	**0.081**	80	--	--	--	0.690	0.8	0.390	840	
Toluene	640	1000	--	1000	--	**640**	--	--	--	1300	6800	--	19000	
Total Xylenes	1000	10000	--	**1000**	--	16000	--	--	--	--	--	--	--	
Trichloroethene (TCE)	0.49	5	--	5	**0.49**	2.4	--	--	--	2.5	2.7	6.7	71	
Vinyl Chloride	0.025	2	--	0.2	0.029	24	--	--	--	**0.025**	2	3.7	6,600	
Pesticides/PCBs in ug/L														
4,4'-DDD	0.00031	--	--	--	0.36	--	0.001	--	--	**0.00031**	0.00083	0.0005	--	
4,4'-DDE	0.00022	--	--	--	0.26	--	0.001	--	--	**0.00022**	0.00059	0.00036	--	
4,4'-DDT	0.00022	--	--	0.3	0.26	8	0.001	0.001	0.001	**0.00022**	0.00059	0.00036	0.024	
Aldrin	0.000049	--	--	--	0.0026	0.24	0.0019	--	--	**0.000049**	0.00013	0.000082	0.017	
alpha-Hexachlorocyclohexane	0.0026	--	--	--	0.014	--	--	--	--	**0.0026**	0.0039	0.008	--	
beta-Hexachlorocyclohexane	0.0091	--	--	--	0.049	--	--	--	--	**0.0091**	0.014	0.028	--	
Chlordane	0.00057	2	--	--	0.25	8	0.0043	0.004	0.004	0.001	**0.00057**	0.0013	0.092	
Dieldrin	0.000052	--	--	--	0.0055	0.8	0.0019	0.056	0.002	**0.000052**	0.00014	0.000087	0.028	
Endosulfan I	0.056	--	--	--	--	96	**0.056**	--	**0.056**	--	--	--	58	
Endrin	0.0023	2	--	--	--	4.8	**0.0023**	0.036	0.0023	0.059	0.76	--	0.2	
Heptachlor	0.000079	0.4	--	--	0.019	8	0.0038	0.0038	0.004	**0.000079**	0.00021	0.00013	0.12	
Heptachlor Epoxide	0.000039	0.2	--	--	0.0048	0.1	--	0.004	0.004	**0.000039**	0.0001	0.000064	0.003	
Methoxychlor	0.03	40	--	--	--	80	--	**0.03**	--	100	--	--	8.4	
Aroclor-1016	See Total PCBs	--	--	--	--	1.1	--	--	0.014	--	--	--	0.0058	0.005
Aroclor-1254	See Total PCBs	--	--	--	--	0.32	--	--	0.014	--	--	--	0.0017	0.005
Aroclor-1260	See Total PCBs	--	--	--	--	--	--	--	0.014	--	--	--	--	0.005
Total PCBs	0.000064	0.5	--	0.1	0.044	--	0.014	0.014	0.14	**0.000064**	0.00017	0.00011	--	0.005

Table 5-2 - Summary of Groundwater Screening Levels

		Groundwater ARARs		Groundwater MTCA								Surface Water MTCA		
		Federal and State	Drinking Water Standards	Method A	Method B		Aquatic Life - Fresh/Chronic			Human Health - Fresh Water		Method B		PQL
Analyte	Groundwater Screening Level in ug/L	Primary MCL in ug/L	Secondary MCL in ug/L	in µg/L	Carcinogen in µg/L	Non-carcinogen in µg/L	Ch. 173-201A WAC in µg/L (a)	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Clean Water Act §304 in µg/L	National Toxics Rule, 40 CFR 131 in µg/L	Carcinogen in µg/L	Non-Carcinogen in µg/L	
TPH as HCID in ug/L														
Gasoline	800	--	--	**800/1000** (c)	--	--	--	--	--	--	--	--	--	
Diesel	500	--	--	**500**	--	--	--	--	--	--	--	--	--	
Heavy Oil	500	--	--	**500**	--	--	--	--	--	--	--	--	--	
TPH-Dx in ug/L														
Diesel	500	--	--	**500**	--	--	--	--	--	--	--	--	--	
Heavy Oil	500	--	--	**500**	--	--	--	--	--	--	--	--	--	
TPH-Gx in ug/L														
Gasoline	800	--	--	**800/1000** (c)	--	--	--	--	--	--	--	--	--	

Notes

MCL = Maximum Contaminant Level

PQL = Practical Quantification Limit

-- = No Data

*Based on State MCL. No Federal MCL for constituent.

Bold value represents the most conservative value and is used as the screening level.

(a) Calculations for hardness-dependent metals were based on hardness = 25

Individual formulas are as follows:

Cadmium:

≤ (0.909)(e(0.7852[ln(hardness)]-3.490)) at hardness = 100. Conversions factor (CF) of 0.909 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.101672 - [(ln hardness)(0.041838)].

Chromium III

≤ (0.860)e(0.8190[ln(hardness)]+ 1.561)

Copper

≤ (0.960)(e(0.8545[ln(hardness)] - 1.465))

Lead

≤ (0.791)(e(1.273[ln(hardness)] - 4.705)) at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

Nickel

≤ (0.997)(e(0.8460[ln(hardness)]+ 1.1645))

(b) Screening levels are based on mixures of cPAH values based on Toxicity Equivalency Quotient (TEQ) calculation from WAC 173-304-708 as calculated in Table 1-4. The reference compound for Total cPAHs is benzo(a)pyrene (BaP).

(c) Benzene present/no benzene present

Table 5-3 - Summary of Groundwater Screening Results

Analyte	Screening Level	Detection Frequency	Exceedance Frequency	Average	Median	Maximum		Date of Maximum
Conventionals in mg/L								
Chloride	230	114/131	0/114	12.0	4.5	147		6/27/02
Fluoride	0.96	2/3	0/2	0.299	0.299	0.42		5/11/90
Nitrate + Nitrite	10	123/129	0/123	1.64	1.50	8.6		1/24/90
Nitrate as Nitrogen	10	104/113	3/104	4.77	1.50	157		1/24/08
Sulfate	250	60/60	0/60	10.2	11.0	18.6		1/24/08
Total Dissolved Solids	500	21/24	0/21	201	202	402		7/24/08
Metals in ug/L								
Antimony	6	366/409	67/366	2.82	0.180	24		5/11/90
Arsenic	0.018	708/909	708/708	7.39	3.67	380		9/30/97
Beryllium	4	0/42	0/0					
Cadmium	0.25	38/206	1/38	0.053	0.037	0.7	J	5/10/90
Chromium	50	165/282	4/165	9.83	0.91	608		9/3/03
Copper	3.5	1/42	1/1	20	20	20		5/8/90
Cyanide	5.2	0/6	0/0					
Iron	300	210/367	37/210	548.2	9.4	22400		4/24/08
Lead	0.54	107/206	5/107	0.201	0.024	12.7		10/28/04
Manganese	50	295/368	71/295	109.7	0.542	2840		10/25/06
Mercury	0.012	0/168	0/0					
Nickel	49	0/42	0/0					
Selenium	5	122/206	0/122	0.7	0.4	5		11/30/89, 12/1/89
Silver	80	28/206	0/28	1.44	0.009	30		11/30/89
Thallium	0.24	0/42	0/0					
Zinc	32	15/42	2/15	25	20	124		12/1/95
Pesticides/PCBs in ug/L								
4,4'-DDD	0.00031	0/7	0/0					
4,4'-DDE	0.00022	0/7	0/0					
4,4'-DDT	0.00022	0/7	0/0					
Aldrin	0.000049	0/7	0/0					
Alpha-BHC	0.0026	0/7	0/0					
Aroclor 1016	0.0058	0/1664	0/0					
Aroclor 1254	0.0017	13/1667	13/13	30.82	0.0320	280		5/14/92
Aroclor 1260	0.014	7/1667	4/7	0.047	0.060	0.095	JP	10/27/06
Beta-BHC	0.0091	0/7	0/0					
Chlordane	0.00057	0/7	0/0					
Dieldrin	0.000052	0/7	0/0					
Endosulfan I	0.056	0/7	0/0					
Endrin	0.0023	0/7	0/0					
Heptachlor	0.000079	0/7	0/0					
Heptachlor Epoxide	0.000039	0/7	0/0					
Methoxychlor	0.03	0/7	0/0					
Total PCBs	0.000064	435/1667	435/435	1159	0.1	130000		9/19/91
Semivolatiles in ug/L								
1,2,4-Trichlorobenzene	35	0/60	0/0					
1,2-Dichlorobenzene	420	0/60	0/0					
1,3-Dichlorobenzene	320	0/60	0/0					
1,4-Dichlorobenzene	1.8	0/60	0/0					
2,4,5-Trichlorophenol	800	0/68	0/0					
2,4,6-Trichlorophenol	1.4	0/68	0/0					
2,4-Dichlorophenol	24	0/68	0/0					
2,4-Dimethylphenol	160	2/68	0/2	5.67	5.67	11	J	7/27/05
2,4-Dinitrophenol	32	0/68	0/0					
2,4-Dinitrotoluene	0.11	0/68	0/0					
2,6-Dinitrotoluene	16	0/68	0/0					

Table 5-3 - Summary of Groundwater Screening Results

Analyte	Screening Level	Detection Frequency	Exceedance Frequency	Average	Median	Maximum		Date of Maximum
2-Chlorophenol	40	0/68	0/0					
3,3'-Dichlorobenzidine	0.021	0/60	0/0					
Acenaphthene	640	14/317	0/14	0.1458	0.0130	0.69		10/23/08
Aniline	7.7	0/16	0/0					
Anthracene	4800	15/317	0/15	0.9986	0.0120	8.3		10/22/07
Benzidine	0.000086	0/8	0/0					
Benzoic Acid	64000	1/68	0/1	2.2	2.2	2.2	J	1/25/06
Benzyl Alcohol	2400	1/68	0/1	1.3	1.3	1.3	J	3/23/05
Bis(2-Chloroethyl)Ether	0.03	0/68	0/0					
Bis(2-Ethylhexyl)Phthalate	1.2	9/68	0/9	0.71	0.56	1.1	J	7/26/05, 4/19/06
Bis(2-chloroisopropyl) Ether	320	0/60	0/0					
Butylbenzylphthalate	1300	3/68	0/3	0.357	0.037	1		10/29/05
Di-n-octyl Phthalate	320	0/68	0/0					
Dibenzofuran	32	27/317	0/27	0.1420	0.0240	1.2		10/22/07
Dimethyl Phthalate	16000	2/68	0/2	0.034	0.034	0.049	J	6/16/05
Fluoranthene	90	38/317	0/38	0.2325	0.0225	6.5		10/22/07
Fluorene	640	53/317	0/53	0.2108	0.0120	2.9		10/22/07
Hexachlorobenzene	0.00028	0/68	0/0					
Hexachlorobutadiene	0.44	0/103	0/0					
Hexachlorocyclopentadiene	40	0/68	0/0					
Hexachloroethane	1.4	0/68	0/0					
Isophorone	8.4	0/68	0/0					
N-Nitroso-di-n-propylamine	0.005	0/68	0/0					
N-Nitrosodiphenylamine	3.3	0/68	0/0					
Naphthalene	160	88/345	0/88	0.0713	0.036	0.79		10/20/08
Nitrobenzene	4	0/68	0/0					
Pentachlorophenol	0.27	0/68	0/0					
Phenol	4800	1/68	0/1	1.1	1.1	1.1	J	7/27/05
cPAHs in ug/L								
Benzo(a)anthracene	See BaP	23/317	23/23	0.0485	0.0099	0.6		10/27/05
Benzo(a)pyrene	0.0028	11/317	11/11	0.0214	0.0170	0.094		4/21/06
Benzo(b)fluoranthene	See BaP	29/317	27/29	0.0275	0.0059	0.2		10/22/07
Benzo(k)fluoranthene	See BaP	15/317	11/15	0.0180	0.0079	0.12		4/21/06
Chrysene	See BaP	32/317	29/32	0.6188	0.0300	10		10/22/07
Dibenz(a,h)anthracene	See BaP	14/317	12/14	0.0110	0.0051	0.074		4/21/06
Indeno(1,2,3-cd)pyrene	See BaP	26/317	24/26	1.14	0.0088	29	J	7/27/05
Pyrene	See BaP	58/317	0/58	0.8374	0.0295	20	J	7/27/05
TEQ Equivalent	See BaP	56/317	24/56	0.0647	0.0015	2.9		7/27/05
Volatiles in ug/L								
1,1,1,2-Tetrachloroethane	1.7	0/386	0/0					
1,1,1-Trichloroethane	200	0/728	0/0					
1,1,2,2-Tetrachloroethane	0.17	0/727	0/0					
1,1,2-Trichloroethane	0.59	0/728	0/0					
1,1-Dichloroethane	1600	0/728	0/0					
1,2,3-Trichloropropane	0.0063	0/386	0/0					
1,2,4-Trichlorobenzene	35	0/385	0/0					
1,2,4-Trimethylbenzene	400	7/370	0/7	1.12	0.37	5.1		10/20/08
1,2-Dibromo-3-Chloropropane	0.031	0/385	0/0					
1,2-Dichlorobenzene	420	1/500	0/1	0.06	0.06	0.06	T	10/23/08
1,2-Dichloroethane(EDC)	0.38	5/728	5/5	2.94	3.3	5.4		9/24/02
1,2-Dichloropropane	0.5	0/728	0/0					
1,3,5-Trimethylbenzene	400	0/386	0/0					
1,3-Dichlorobenzene	320	0/394	0/0					
1,4-Dichlorobenzene	1.8	0/394	0/0					

Table 5-3 - Summary of Groundwater Screening Results

Analyte	Screening Level	Detection Frequency	Exceedance Frequency	Average	Median	Maximum		Date of Maximum
Acetone	800	20/727	0/20	6.6	5.3	14, 14	T	5/5/98, 10/23/08
Benzene	0.8	7/825	5/7	1.4	1	3		12/4/91
Bromodichloromethane	0.27	2/728	0/2	0.21	0.21	0.22	T	10/22/07
Bromoform	4.3	5/728	0/5	0.39	0.36	0.53		10/24/07
Bromomethane	11	5/728	0/5	0.33	0.33	0.43	J	6/24/02
Carbon Disulfide	800	16/727	0/16	0.81	0.16	6.7		4/20/08
Carbon Tetrachloride	0.23	0/728	0/0					
Chlorobenzene	100	1/728	0/1	4	4	4		10/3/95
Chloroform	5.7	8/728	0/8	0.34	0.14	1.7		6/29/04
Chloromethane	3.4	13/728	0/13	0.12	0.10	0.22	J	1/26/06
Dibromochloromethane	0.4	5/728	0/5	0.16	0.14	0.2	T	10/24/07
Ethylbenzene	530	39/825	0/39	4.07	3	14		11/30/89, 5/9/90
Freon 12	1600	0/382	0/0					
Hexachlorobutadiene	0.44	0/385	0/0					
m,p-Xylenes	16000	2/519	0/2	0.26	0.26	0.42	J	6/29/04
Methylene Chloride	4.6	9/728	0/9	0.26	0.23	0.37	T	10/20/08
Naphthalene	160	3/385	0/3	0.32	0.30	0.44	J	7/21/06
o-Chlorotoluene	160	0/1	0/0					
o-Xylene	16000	2/519	0/2	0.15	0.15	0.17	J	6/29/04
Styrene	1.5	1/728	0/1	0.04	0.04	0.04	T	10/22/08
Tetrachloroethene	0.081	1/728	1/1	2	2	2		12/16/96
Toluene	640	103/825	0/103	0.65	0.17	15		5/9/90
Total Xylenes	1000	53/306	0/53	28	15	160		6/26/91
Trichloroethene (TCE)	0.49	3/728	2/3	1.52	0.5	4		12/1/89
Vinyl Chloride	0.025	0/728	0/0					
TPH in mg/L								
Total Petroleum Hydrocarbons	0.8	43/75	42/43	77.42	19	900		3/9/91
TPH-HCID in mg/L								
Gasoline	0.8	20/1660	16/20	41.92	6.9	380	J	6/26/91
Diesel	0.5	153/1653	119/153	58.08	30.5	1800	J	6/26/91
Heavy oil	0.5	53/1647	50/53	39.08	5.1	460		10/22/07
TPH-Dx in mg/L								
Diesel	0.5	14/257	14/14	39.18	14	200		10/22/07
Heavy oil	0.5	13/256	13/13	105	14	520		7/27/05
TPH-Gx in mg/L								
Gasoline	0.8	1/243	0/1	0.2	0.2	0.2		10/27/04

Notes:

J = Estimated value.

P = The relative percent difference is greater than 40 percent between the GC primary and confirmation column results.

T = Value is between the MDL and MRL.

Blank indicates there are no detections for specific analyte.

Petroleum components are grouped into Gasoline-, Diesel-, and Heavy Oil-Range Organics for comparison to screening levels, refer to Figure 3-2 and 3-3.

Table 5-4 - Free Phase Petroleum Recovered to Date

Year	Cumulative FFP Recovered in gallons	Yearly Product Recovered in gallons	Recovered FPP in gallons								
			WW-MW-3	WW-MW-13	WW-SK-1	WW-SK-2	WW-SK-3	WW-SK-4	OH-SK-1	OH-SK-2	OH-SK-4
1994	2150	2150	NC	NC	--	NC	NC	NC	2150	NC	NC
1995	2250	100	NC	NC	--	NC	NC	NC	A	100	NC
1996	2250	0	NC	NC	--	NC	NC	NC	A	--	NC
1997	2250	0	NC	NC	--	NC	NC	NC	A	--	NC
1998	2250	0	NC	NC	--	NC	NC	NC	A	--	NC
1999	2250	0	NC	NC	--	NC	NC	NC	A	--	NC
2000	2550	300	25	175	100	NC	NC	NC	A	--	NC
2001	3650	1100	NO	NO	550	220	55	110	A	55	110
2002	3655	5	NO	NO	5	NO	--	--	A	--	--
2003	3655	0	NO	NO	--	NO	--	--	A	--	--
2004	3655	0	NO	NO	--	NO	--	--	A	--	--
2005	3655	0	NO	NO	--	NO	--	--	A	--	--
2006	3830	175	NO	NO	30	NO	10	--	A	15	120
2007	4145	315	NO	NO	30	NO	10	--	A	50	225
2008	4221	76	NO	NO	23	NO	23	--	A	30	0

Notes:
FPP = free phase petroleum
-- = no data
NC = not constructed
A = abandoned or destoryed
NO = not operational

Table 5-5 - Free Phase Petroleum Measurements

Station	Maximum Historical FPP Thickness		Most Recent FPP Thickness in 2008		Last Recorded FPP Thickness	
	Product Thickness in Feet	Sample Date	Product Thickness in Feet	Sample Date	Product Thickness in Feet	Sample Date
Cold Mill Area						
CM-MW-01S	0.01	1/26/2006	ND	10/18/2008	0.01	1/26/2006
Oil Reclamation Building						
HL-MW-20S	0.61	10/24/2005	ND	10/18/2008	0.11	10/21/2007
HL-MW-21S	0.01	6/27/2006	ND	10/18/2008	0.01	6/27/2006
Oil House Area						
OH-MW-01	1.99	8/27/1991	--	--	1.00	6/18/1992
OH-MW-02	1.39	9/6/1990	--	--	0.33	6/18/1992
OH-MW-03	1.35	8/30/1991	ND	10/18/2008	0.01	1/23/2006
OH-MW-04	2.53	6/23/1994	0.04	10/18/2008	0.04	10/18/2008
OH-MW-05	2.01	9/6/1990	ND	10/18/2008	0.01	1/23/2006
OH-MW-06	2.41	6/23/1994	0.06	10/18/2008	0.06	10/18/2008
OH-MW-10	0.56	10/30/1993	ND	10/18/2008	0.56	10/30/1993
OH-MW-16	1.20	8/2/1995	--	--	0.13	9/26/1996
OH-MW-18	0.01	6/27/2006	ND	10/18/2008	0.01	6/27/2006
OH-MW-20	0.82	10/30/1993	--	--	0.82	10/30/1993
OH-MW-23	0.05	10/8/1993	--	--	0.05	10/8/1993
OH-MW-24	0.17	6/18/1992	ND	10/18/2008	0.02	8/30/2005
OH-MW-28	0.17	9/28/1995	--	--	0.17	9/28/1995
OH-SK-01	3.11	6/23/1994	0.02	10/18/2008	0.02	10/18/2008
OH-SK-02	1.00	8/9/2004	0.01	7/22/2008	0.01	7/22/2008
OH-SK-03	0.20	9/3/1998	0.09	1/23/2008	0.09	1/23/2008
OH-SK-04	0.97	8/30/2005	0.01	1/23/2008	0.01	1/23/2008
TF-MW-01	0.21	9/28/1995	0.03	10/18/2008	0.03	10/18/2008
TF-MW-02	0.46	9/28/1995	0.01	1/23/2008	0.01	1/23/2008
TF-MW-03	0.02	9/28/1995	ND	10/18/2008	0.02	9/28/1995
TF-MW-04	0.98	9/28/1995	ND	10/18/2008	0.02	10/21/2007
TF-MW-05	0.63	9/28/1995	--	--	0.03	4/16/2001
TF-EW-01	0.32	9/28/1995	--	--	0.32	9/28/1995
Wastewater Treatment Area						
TL-MW-04	0.37	8/28/2001	ND	10/18/2008	0.03	8/28/2006
WW-MW-03	1.36	8/29/1994	0.10	1/23/2008	0.10	1/23/2008
WW-MW-04	0.69	9/6/1990	--	--	0.66	10/19/1990
WW-MW-06	1.12	8/29/1994	0.10	7/22/2008	0.10	7/22/2008
WW-MW-08	0.01	10/24/2005	ND	10/18/2008	0.01	10/24/2005
WW-MW-11	0.13	9/13/1994	ND	10/18/2008	0.01	8/30/2005

Table 5-5 - Free Phase Petroleum Measurements

Station	Maximum Historical FPP Thickness		Most Recent FPP Thickness in 2008		Last Recorded FPP Thickness	
	Product Thickness in Feet	**Sample Date**	**Product Thickness in Feet**	**Sample Date**	**Product Thickness in Feet**	**Sample Date**
WW-MW-13	1.63	8/30/1995	0.02	10/18/2008	0.02	10/18/2008
WW-MW-15	0.01	10/24/2005	ND	10/18/2008	0.01	10/24/2005
WW-MW-19	0.52	8/28/2001	ND	10/18/2008	0.32	8/30/2005
WW-SK-01	0.80	8/28/2006	ND	10/18/2008	0.8	8/28/2006
WW-SK-02	0.52	8/30/2005	0.09	1/23/2008	0.09	1/23/2008
WW-SK-03	0.82	10/24/2005	0.06	10/18/2008	0.06	10/18/2008
WW-SK-04	0.76	7/31/2003	ND	10/18/2008	0.02	7/23/2007
Statistics						
Total Number of Wells	39		13		39	
Min	0.01		0.01		0.01	
Max	3.11		0.10		1.00	
Cold Mill Area	1					
Min	0.01		0		0.01	
Max	0.01		0		0.01	
Oil Reclamation Building	2					
Min	0.01		0		0.01	
Max	0.61		0		0.11	
Oil House Area	23					
Min	0.01		0.01		0.01	
Max	3.11		0.09		1.00	
Wastewater Treatment Area	13					
Min	0.01		0.02		0.01	
Max	1.63		0.10		0.80	

Notes:

FPP = Free phase petroleum

ND = Not Detected.

-- = Well no longer exists, destroyed, or not measured in 2008.

Table 5-6 - Aereal Extent of Free Phase Petroleum Plumes

Location	Total Area in Square Feet		Area Change in Square Feet	Percent Reduction
	Historical	2008		
Wastewater Area	409,000	72,000	337,000	82%
Oil House Area	232,000	15,000	217,000	94%

Notes:

Plume dimensions based on Figure 5-10 and 5-13.

Table 5-7 - Analytical Results for Groundwater Samples - Total Homologs and Relative Percent Homolog Fractions

Sample ID Sample Date	HL-MW-5 Oct-07	HL-MW-5 Apr-08	HL-MW-7S Oct-07	HL-MW-7S Apr-08	HL-MW-8D Apr-08	HL-MW-13DD Oct-07	HL-MW-13DD Apr-08	HL-MW-14S Oct-07	HL-MW-14S Apr-08	HL-MW-17S Oct-07	HL-MW-17S Apr-08	HL-MW-23S Oct-07	HL-MW-23S Apr-08
Blank Corrected Results **Total Homologs in pg/L**													
Total Monochloro Biphenyl	0.00	2.19	0.13	2.34	0.87	4.30	4.29	3.94	3.10	0.04	5.22	0.00	0.55
Total Dichloro Biphenyl	1263.38	1716.75	799.75	1417.30	519.53	1079.98	1230.50	2047.52	2327.60	3272.42	1715.83	13.03	12.11
Total Trichloro Biphenyl	27644.61	33985.28	23434.26	31564.43	14152.12	27878.35	31412.47	56672.60	54611.23	48592.57	29345.45	507.23	1234.96
Total Tetrachloro Biphenyl	29804.26	33969.54	30330.42	29901.40	16696.30	38119.53	42449.32	61800.57	60923.06	41951.34	28527.49	1289.81	1949.37
Total Pentachloro Biphenyl	3178.02	3606.13	3526.45	3015.30	2125.89	5004.30	5354.22	5555.62	5467.37	3097.17	2523.21	178.84	241.66
Total Hexachloro Biphenyl	122.61	160.39	116.76	92.04	68.82	176.00	191.43	105.54	112.25	101.54	131.34	0.58	8.26
Total Heptachloro Biphenyl	0.85	15.44	3.15	3.41	2.74	5.12	12.92	1.05	3.34	0.39	19.19	0.00	0.50
Total Octachloro Biphenyl	0.00	0.78	0.19	0.00	0.00	0.00	0.00	0.70	0.00	0.00	3.69	0.00	0.00
Total Nonachloro Biphenyl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Decachloro Biphenyl	0.20	0.05	0.00	0.13	0.00	0.00	0.02	0.00	0.13	0.00	0.10	0.77	0.00
Total Homologs	**62013.94**	**73456.55**	**58211.11**	**65996.35**	**33566.27**	**72267.58**	**80655.17**	**126187.53**	**123448.09**	**97015.47**	**62271.53**	**1990.26**	**3447.41**
Relative Percent Homolog Fractions													
Total Monochloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.01%	0.00%	0.02%
Total Dichloro Biphenyl	2.04%	2.34%	1.37%	2.15%	1.55%	1.49%	1.53%	1.62%	1.89%	3.37%	2.76%	0.65%	0.35%
Total Trichloro Biphenyl	44.58%	46.27%	40.26%	47.83%	42.16%	38.58%	38.95%	44.91%	44.24%	50.09%	47.12%	25.49%	35.82%
Total Tetrachloro Biphenyl	48.06%	46.24%	52.10%	45.31%	49.74%	52.75%	52.63%	48.98%	49.35%	43.24%	45.81%	64.81%	56.55%
Total Pentachloro Biphenyl	5.12%	4.91%	6.06%	4.57%	6.33%	6.92%	6.64%	4.40%	4.43%	3.19%	4.05%	8.99%	7.01%
Total Hexachloro Biphenyl	0.20%	0.22%	0.20%	0.14%	0.21%	0.24%	0.24%	0.08%	0.09%	0.10%	0.21%	0.03%	0.24%
Total Heptachloro Biphenyl	0.00%	0.02%	0.01%	0.01%	0.01%	0.01%	0.02%	0.00%	0.00%	0.00%	0.03%	0.00%	0.01%
Total Octachloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
Total Nonachloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Decachloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%
Total Homologs	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5-7 - Analytical Results for Groundwater Samples - Total Homologs and Relative Percent Homolog Fractions

Sample ID	HL-MW-25S	HL-MW-25S	HL-MW-26S	HL-MW-26S	HL-MW-28DD	HL-MW-29S	HL-MW-29S	HL-MW-30S	HL-MW-30S	MW-12A	MW-12A	MW-17S	MW-17S
Sample Date	Oct-07	Apr-08	Oct-07	Apr-08	Apr-08	Oct-07	Apr-08	Oct-07	Apr-08	Oct-07	Apr-08	Oct-07	Apr-08
Blank Corrected Results													
Total Homologs in pg/L													
Total Monochloro Biphenyl	1.60	5.76	0.00	1.49	7.84	15.86	10.22	1.12	2.99	0.00	1.20	1.20	0.67
Total Dichloro Biphenyl	1731.45	2801.00	279.04	936.81	2102.28	6005.62	4871.94	1211.38	1884.46	16.17	221.55	11.07	58.32
Total Trichloro Biphenyl	44732.73	57943.73	4160.01	22261.90	49555.64	116809.27	102709.56	34459.17	56085.91	966.22	5785.88	405.58	2184.19
Total Tetrachloro Biphenyl	50158.25	64068.97	6303.70	24709.80	69416.92	145209.21	121068.65	34140.46	60860.07	1699.16	6178.13	731.81	3322.38
Total Pentachloro Biphenyl	4311.96	6443.03	1569.41	5680.17	8781.08	14620.46	12400.89	2636.01	4231.30	165.90	487.51	140.18	452.83
Total Hexachloro Biphenyl	74.78	135.48	103.20	710.85	301.13	343.34	293.11	25.24	61.38	0.96	8.43	3.70	13.69
Total Heptachloro Biphenyl	0.00	3.69	1.44	171.70	15.06	6.60	8.50	0.00	2.21	0.00	0.00	1.00	6.16
Total Octachloro Biphenyl	0.00	0.00	0.00	27.07	0.00	7.35	0.00	0.00	0.83	0.00	0.00	0.09	2.24
Total Nonachloro Biphenyl	0.00	0.00	0.00	1.66	0.00	3.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Decachloro Biphenyl	0.11	0.41	0.11	0.18	0.00	0.85	0.66	0.27	0.00	0.02	0.36	0.13	0.11
Total Homologs	**101010.88**	**131402.08**	**12416.91**	**54501.64**	**130179.94**	**283022.20**	**241363.52**	**72473.65**	**123129.15**	**2848.44**	**12683.06**	**1294.74**	**6040.60**
Relative Percent Homolog Fractions													
Total Monochloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.01%	0.09%	0.01%
Total Dichloro Biphenyl	1.71%	2.13%	2.25%	1.72%	1.61%	2.12%	2.02%	1.67%	1.53%	0.57%	1.75%	0.85%	0.97%
Total Trichloro Biphenyl	44.29%	44.10%	33.50%	40.85%	38.07%	41.27%	42.55%	47.55%	45.55%	33.92%	45.62%	31.32%	36.16%
Total Tetrachloro Biphenyl	49.66%	48.76%	50.77%	45.34%	53.32%	51.31%	50.16%	47.11%	49.43%	59.65%	48.71%	56.52%	55.00%
Total Pentachloro Biphenyl	4.27%	4.90%	12.64%	10.42%	6.75%	5.17%	5.14%	3.64%	3.44%	5.82%	3.84%	10.83%	7.50%
Total Hexachloro Biphenyl	0.07%	0.10%	0.83%	1.30%	0.23%	0.12%	0.12%	0.03%	0.05%	0.03%	0.07%	0.29%	0.23%
Total Heptachloro Biphenyl	0.00%	0.00%	0.01%	0.32%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.10%
Total Octachloro Biphenyl	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.04%
Total Nonachloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Decachloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Total Homologs	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5-7 - Analytical Results for Groundwater Samples - Total Homologs and Relative Percent Homolog Fractions

Sample ID Sample Date	RM-MW-1S Oct-07	RM-MW-1S Apr-08	RM-MW-8S Oct-07	RM-MW-8S Apr-08	RM-MW-13S Oct-07	RM-MW-13S Apr-08	RM-MW-15S Oct-07	RM-MW-15S Apr-08	RM-MW-16S Apr-08	RM-MW-17S Oct-07	RM-MW-17S Apr-08
Blank Corrected Results **Total Homologs in pg/L**											
Total Monochloro Biphenyl	0.05	2.13	0.00	3.34	9.08	19.47	0.00	9.98	14.54	222.06	2389.61
Total Dichloro Biphenyl	1455.21	2825.17	4816.38	3368.17	18878.51	13709.20	3418.91	3319.32	14759.20	78367.61	122256.51
Total Trichloro Biphenyl	31460.87	94061.73	69811.27	123007.03	215611.87	510914.13	39787.42	55379.63	188946.13	558351.97	977357.53
Total Tetrachloro Biphenyl	34073.64	76773.35	185313.17	577882.04	203636.17	579447.84	36753.78	68233.11	112221.83	691593.47	1147693.84
Total Pentachloro Biphenyl	3830.18	5349.21	73488.50	317477.25	15058.98	58830.79	4514.03	11528.57	7866.45	89654.97	121697.72
Total Hexachloro Biphenyl	132.24	221.02	10068.77	54096.77	624.02	3141.57	246.86	1223.65	331.78	3786.25	4229.63
Total Heptachloro Biphenyl	0.54	16.95	1957.72	14244.05	53.93	590.77	13.23	265.99	47.61	342.57	363.97
Total Octachloro Biphenyl	0.00	3.41	380.62	2687.80	4.07	89.45	0.78	42.38	8.39	45.55	51.04
Total Nonachloro Biphenyl	0.00	0.00	31.67	169.70	0.00	7.21	0.00	2.38	0.93	2.28	3.86
Decachloro Biphenyl	0.00	0.00	0.71	5.22	0.01	0.05	0.00	0.22	0.12	0.37	0.00
Total Homologs	**70952.73**	**179252.97**	**345868.81**	**1092941.37**	**453876.64**	**1166750.47**	**84735.00**	**140005.24**	**324196.97**	**1422367.10**	**2376043.71**
Relative Percent Homolog Fractions											
Total Monochloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.02%	0.10%
Total Dichloro Biphenyl	2.05%	1.58%	1.39%	0.31%	4.16%	1.17%	4.03%	2.37%	4.55%	5.51%	5.15%
Total Trichloro Biphenyl	44.34%	52.47%	20.18%	11.25%	47.50%	43.79%	46.96%	39.56%	58.28%	39.26%	41.13%
Total Tetrachloro Biphenyl	48.02%	42.83%	53.58%	52.87%	44.87%	49.66%	43.37%	48.74%	34.62%	48.62%	48.30%
Total Pentachloro Biphenyl	5.40%	2.98%	21.25%	29.05%	3.32%	5.04%	5.33%	8.23%	2.43%	6.30%	5.12%
Total Hexachloro Biphenyl	0.19%	0.12%	2.91%	4.95%	0.14%	0.27%	0.29%	0.87%	0.10%	0.27%	0.18%
Total Heptachloro Biphenyl	0.00%	0.01%	0.57%	1.30%	0.01%	0.05%	0.02%	0.19%	0.01%	0.02%	0.02%
Total Octachloro Biphenyl	0.00%	0.00%	0.11%	0.25%	0.00%	0.01%	0.00%	0.03%	0.00%	0.00%	0.00%
Total Nonachloro Biphenyl	0.00%	0.00%	0.01%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Decachloro Biphenyl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total Homologs	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Maximum Historical Diesel Concentrations in Groundwater

EAL 10/22/09 2644114-147.DWG

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Figure 5-1

Diesel Concentrations in Groundwater - 2008

Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ◐	Monitoring Well
TL-MW-3 ◐	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ◭	Upper Screen Well
North Supply Well ●	Supply Well
West Supply Well ●	Backup Supply Well
(3.0)	Diesel/Fuel Oil Concentration in mg/L
(ND)	Not Detected
— — —	Inferred Extent of Diesel in 2008 Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase

N

0 500 1000

Scale in Feet

EAL 10/22/09 2644114-148.DWG

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Figure 5-2

Maximum Historical Heavy Oil Concentrations in Groundwater

Heavy Oil Concentrations in Groundwater - 2008

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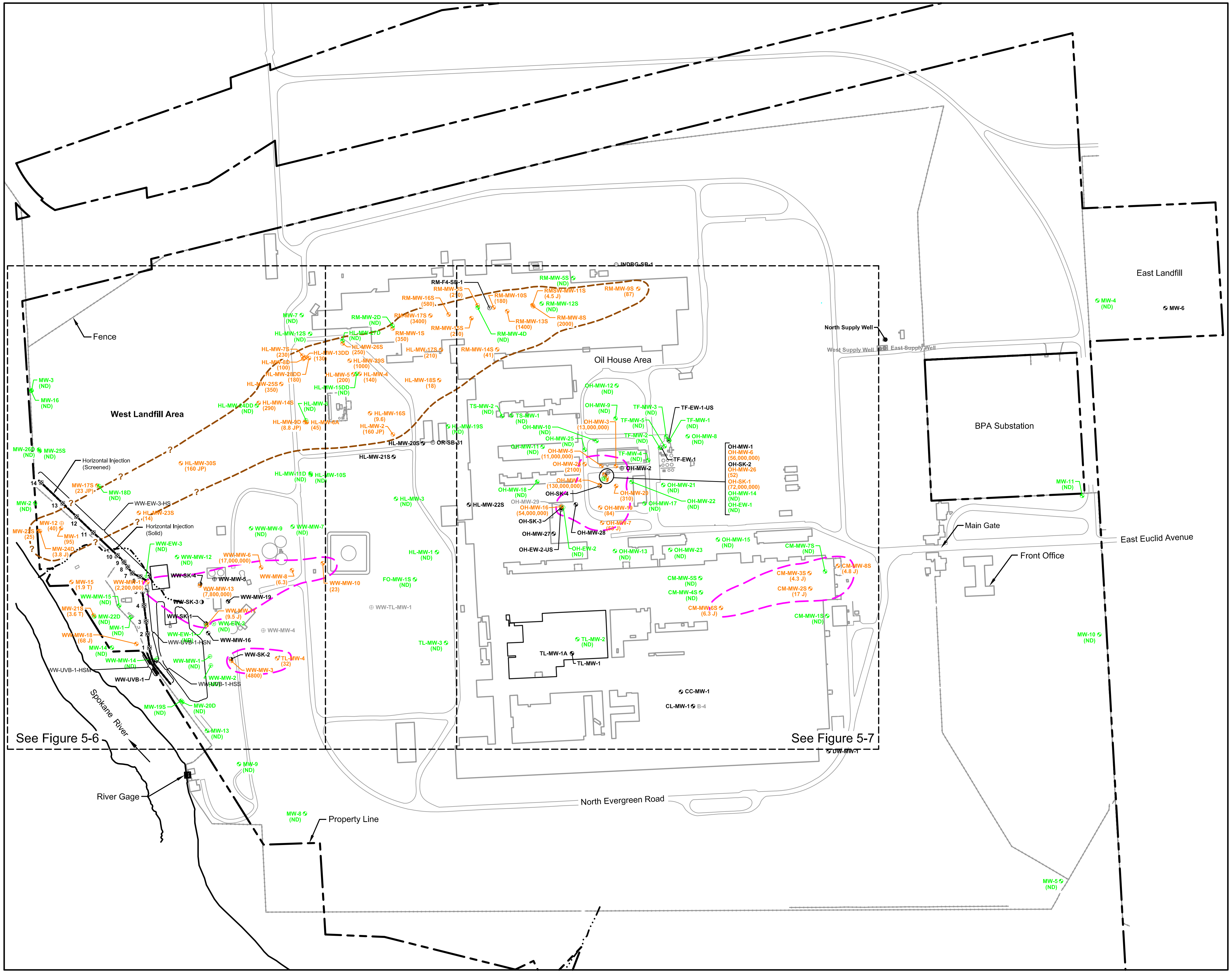
Figure 5-4

EAL 10/22/09 2644114-158.DWG

Maximum Historical Total PCB Concentrations in Groundwater and Associated with Petroleum in Groundwater

1990 to 2008



Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ◕	Monitoring Well
TL-MW-3 ◕	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ◬	Upper Screen Well
North Supply Well ●	Supply Well
West Supply Well ●	Backup Supply Well
(3.0)	Total PCB Concentration in ng/L
J	Estimated Value
P	GC Confirmation Criteria was Exceeded
T	Value is between the MDL and MRL
(ND)	Not Detected
- - - -	Inferred Extent of Historical PCB Concentrations Dissolved in Groundwater Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase
— — —	Inferred Extent of Historical PCB Concentrations Associated with Heavy Oil Petroleum Hydrocarbons Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase. PCB Concentrations are not Dissolved in Groundwater.
?	The question marks represent uncertainty. PCBs have been detected on an infrequent, intermittent basis in monitoring wells represented by the queried region. Investigations are in progress to provide additional chemical and hydrogologic information related to conditions within this queried region.

N

0 500 1000

Scale in Feet

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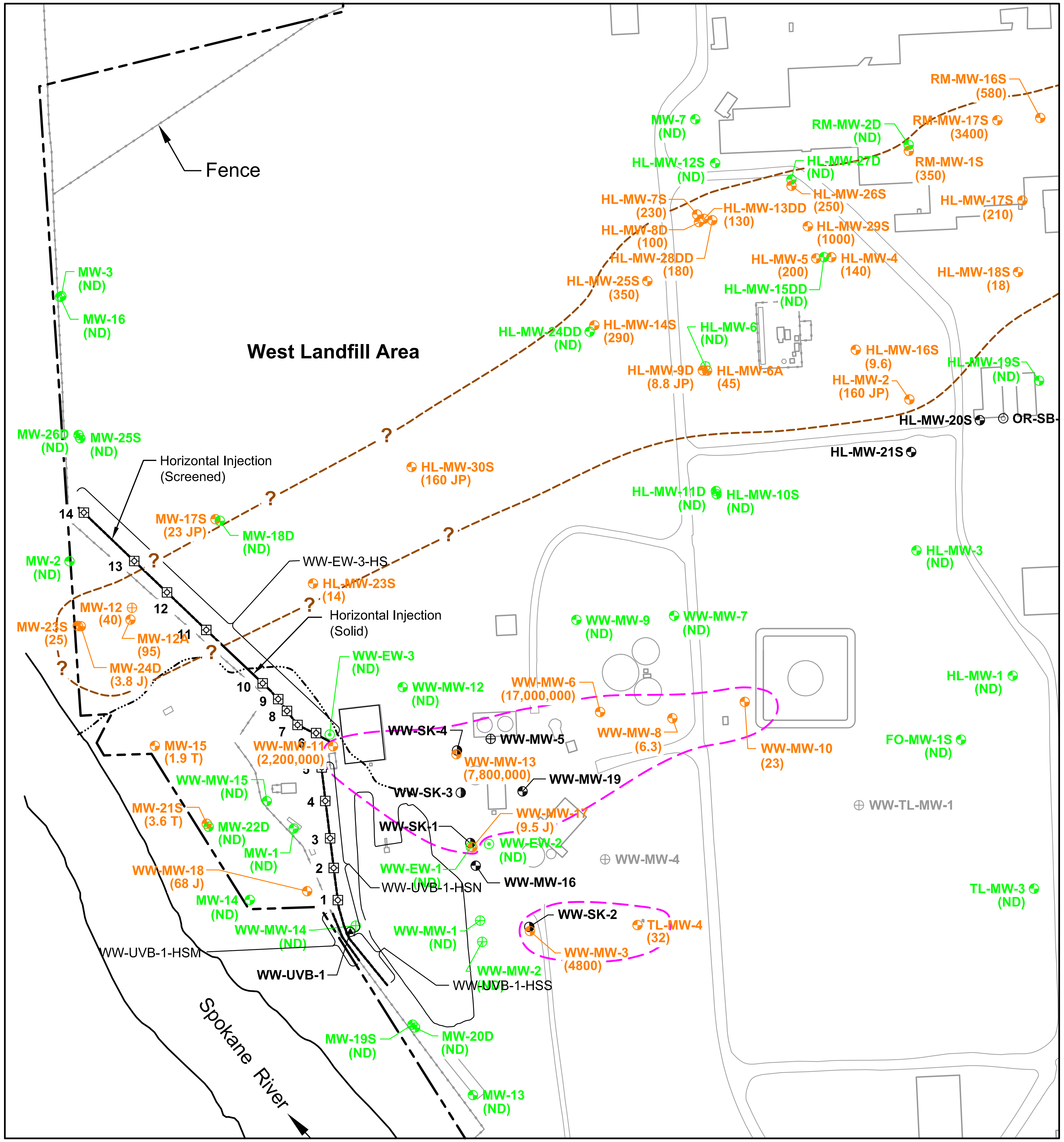
Figure 5-5

2644114-144.DWG

EAL 11/4/09

Maximum Historical Total PCB Concentrations in Groundwater and Associated with Petroleum in Groundwater
West Area



Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ◈	Monitoring Well
TL-MW-3 ◈	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ◈	Upper Screen Well
North Supply Well ●	Supply Well
West Supply Well ●	Backup Supply Well
(3.0)	Total PCB Concentration in ng/L
J	Estimated Value
P	GC Confirmation Criteria was Exceeded
T	Value is between the MDL and MRL
(ND)	Not Detected
- - - -	Inferred Extent of Historical PCB Concentrations Dissolved in Groundwater Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase
— — —	Inferred Extent of Historical PCB Concentrations Associated with Heavy Oil Petroleum Hydrocarbons Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase. PCB Concentrations are not Dissolved in Groundwater.
?	The question marks represent uncertainty. PCBs have been detected on an infrequent, intermittent basis in monitoring wells represented by the queried region. Investigations are in progress to provide additional chemical and hydrogeologic information related to conditions within this queried region.

N

0 500 1000
Scale in Feet

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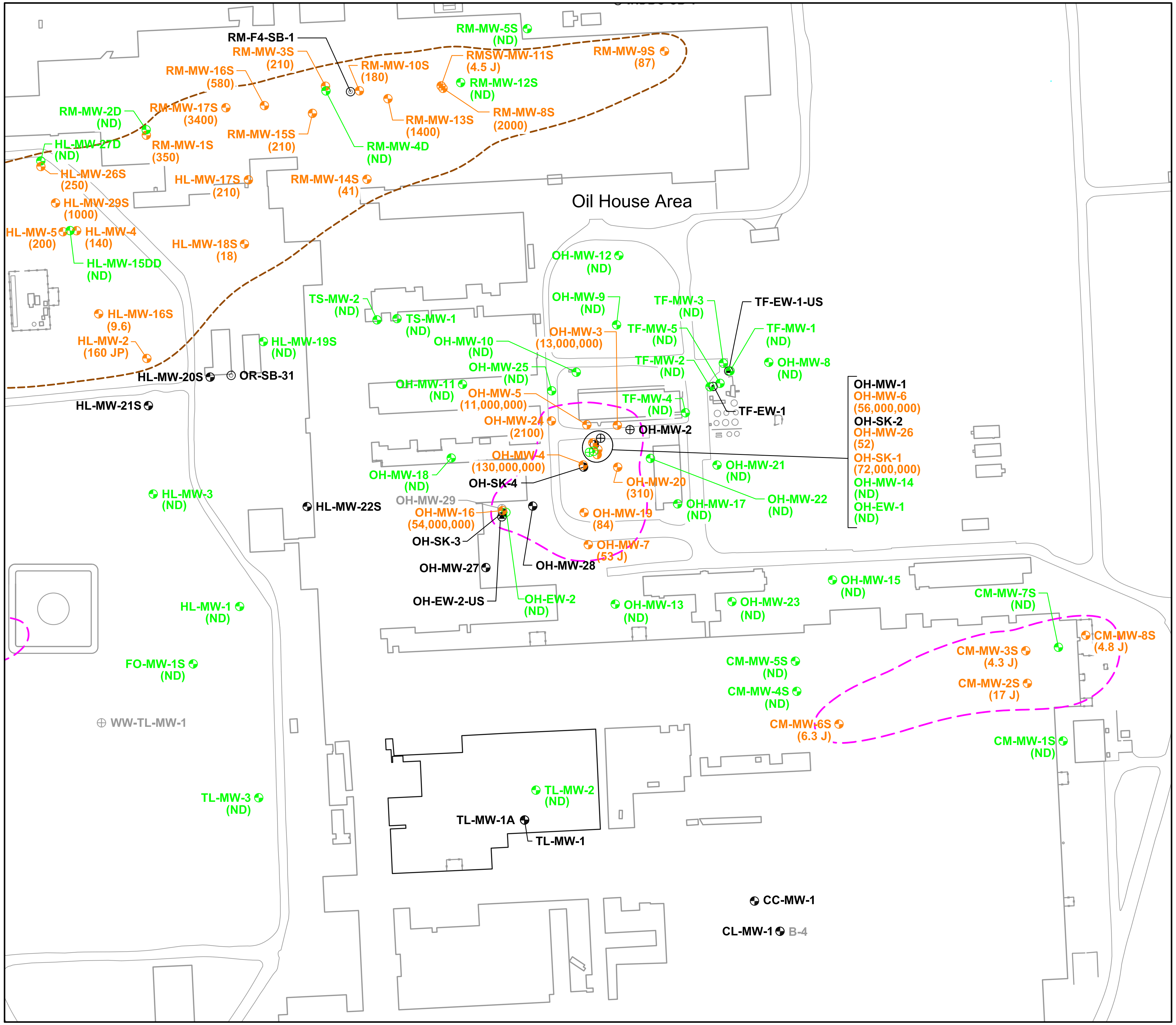
Figure 5-6

EAL 11/4/09 2644114-145.DWG

Maximum Historical Total PCB Concentrations in Groundwater and Associated with Petroleum in Groundwater
East Area



Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ◕	Monitoring Well
TL-MW-3 ◕	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ◕	Upper Screen Well
North Supply Well ●	Supply Well
West Supply Well ●	Backup Supply Well
(3.0)	Total PCB Concentration in ng/L
J	Estimated Value
P	GC Confirmation Criteria was Exceeded
T	Value is between the MDL and MRL
(ND)	Not Detected
------	Inferred Extent of Historical PCB Concentrations Dissolved in Groundwater Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase
— — —	Inferred Extent of Historical PCB Concentrations Associated with Heavy Oil Petroleum Hydrocarbons Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase. PCB Concentrations are not Dissolved in Groundwater.

0 250 500
Scale in Feet

N

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Figure 5-7

EAL 11/3/09 2644114-150.DWG

Total PCB Concentrations in Groundwater and Associated with Petroleum in Groundwater - Most Recently Measured

Exploration Location and Number

OH-EW-1 ◎ Extraction Well

OH-MW-03 Monitoring Well

TL-MW-3 Abandoned Monitoring Well

OH-SK-1 ◑ Skimming Well

TF-EW-1-US Upper Screen Well

North Supply Well ● Supply Well

West Supply Well ● Backup Supply Well

(3.0) Total PCB Concentration in ng/L

J Estimated Value

P GC Confirmation Criteria was Exceeded

T Value is between the MDL and MRL

(ND) Not Detected

Inferred Extent of Historical PCB Concentrations Dissolved in Groundwater Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase

Inferred Extent of Historical PCB Concentrations Associated with Heavy Oil Petroleum Hydrocarbons Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase. PCB Concentrations are not Dissolved in Groundwater.

? The question marks represent uncertainty. PCBs have been detected on an infrequent, intermittent basis in monitoring wells represented by the queried region. Investigations are in progress to provide additional chemical and hydrogologic information related to conditions within this queried region.

Note: PCB concentration contour in ng/L (ppt) (Based on shallow wells only).

0 500 1000

Scale in Feet

N

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Figure 5-8

EAL 11/4/09 2644114-151.DWG

Maximum Historical Free Phase Petroleum Thickness Contour Map

1989 to 2008

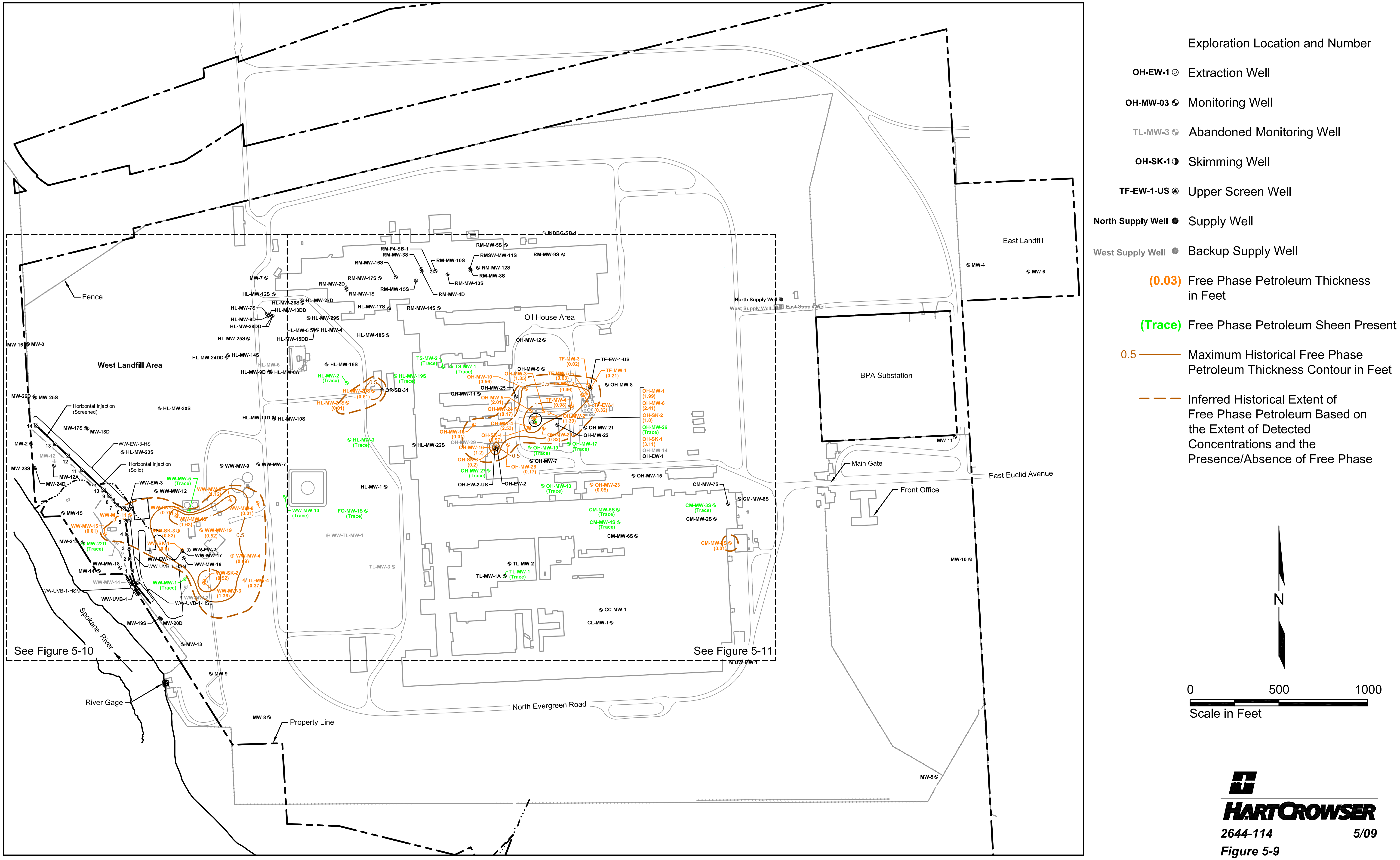

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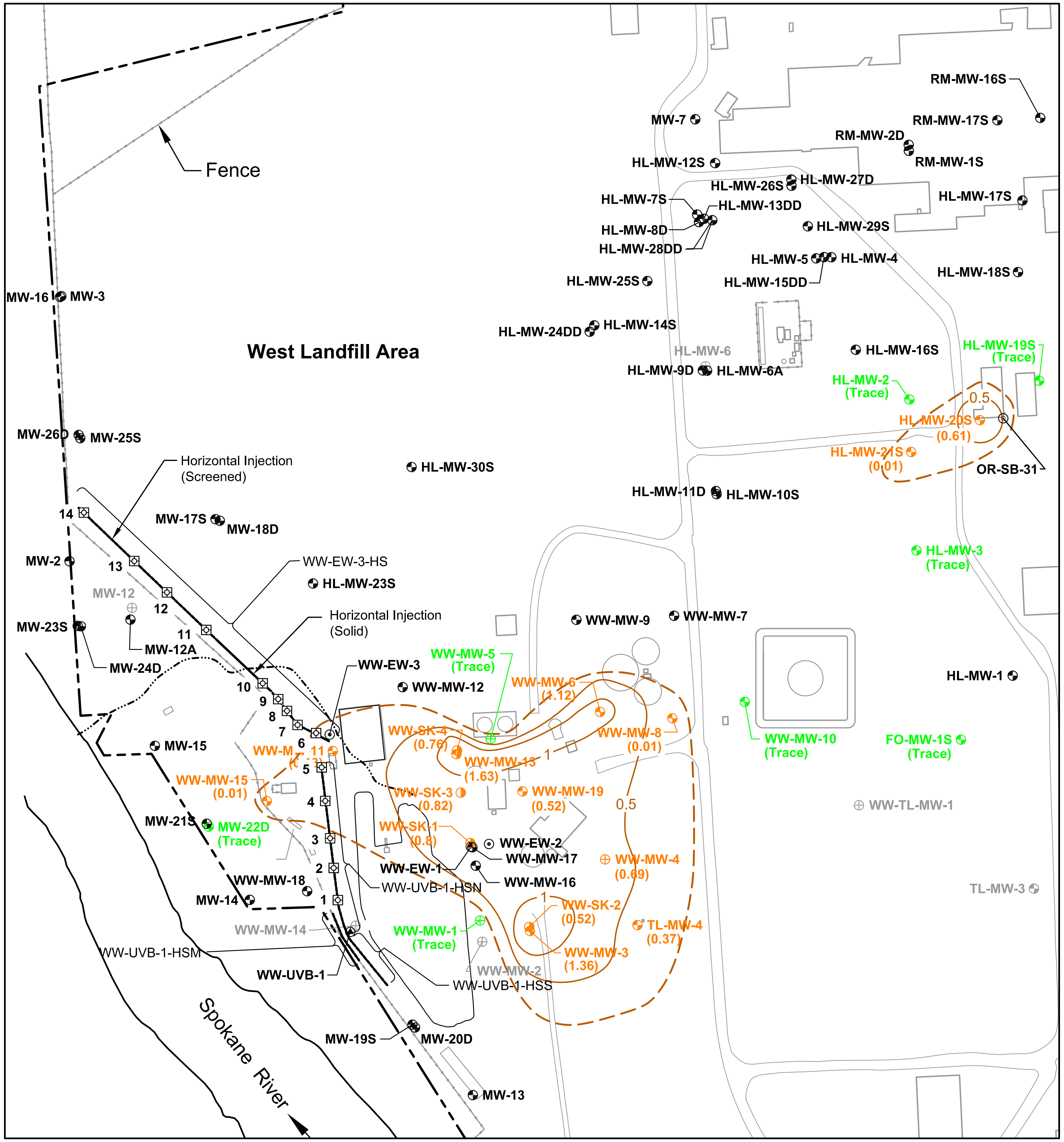
Figure 5-9

EAL 10/22/09 2644114-152.DWG

Maximum Historical Free Phase Petroleum Thickness Contour Map

West Area



Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ◐	Monitoring Well
TL-MW-3 ◐	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
(0.03)	Free Phase Petroleum Thickness in Feet
(Trace)	Free Phase Petroleum Sheen Present
0.5 ———	Maximum Historical Free Phase Petroleum Thickness Contour in Feet
— — —	Inferred Historical Extent of Free Phase Petroleum Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase

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Figure 5-10

EAL 10/22/09 2644114-153.DWG

Maximum Historical Free Phase Petroleum Thickness Contour Map

East Area

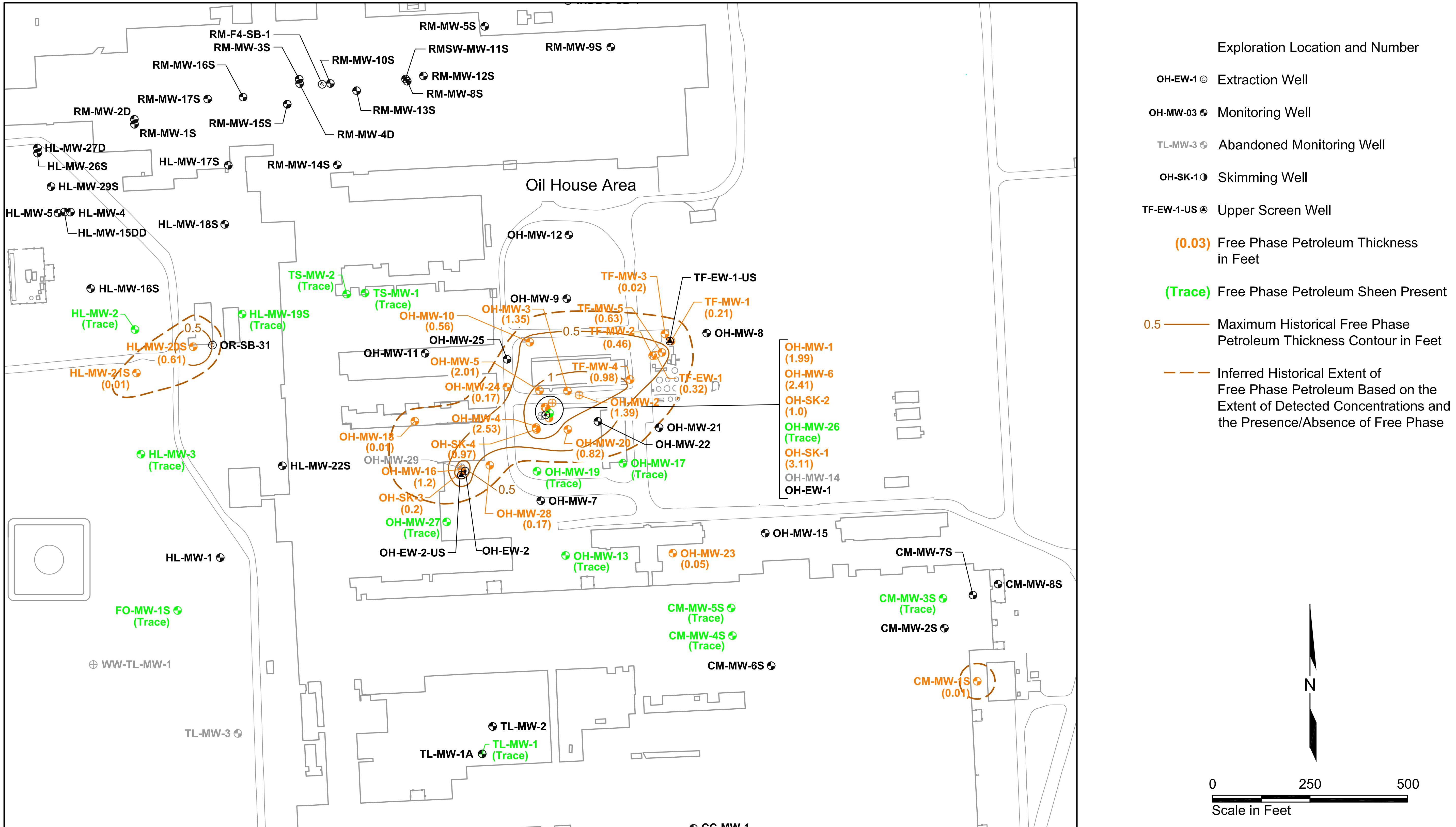

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Figure 5-11

Free Phase Petroleum Thickness Map

Measured 2008

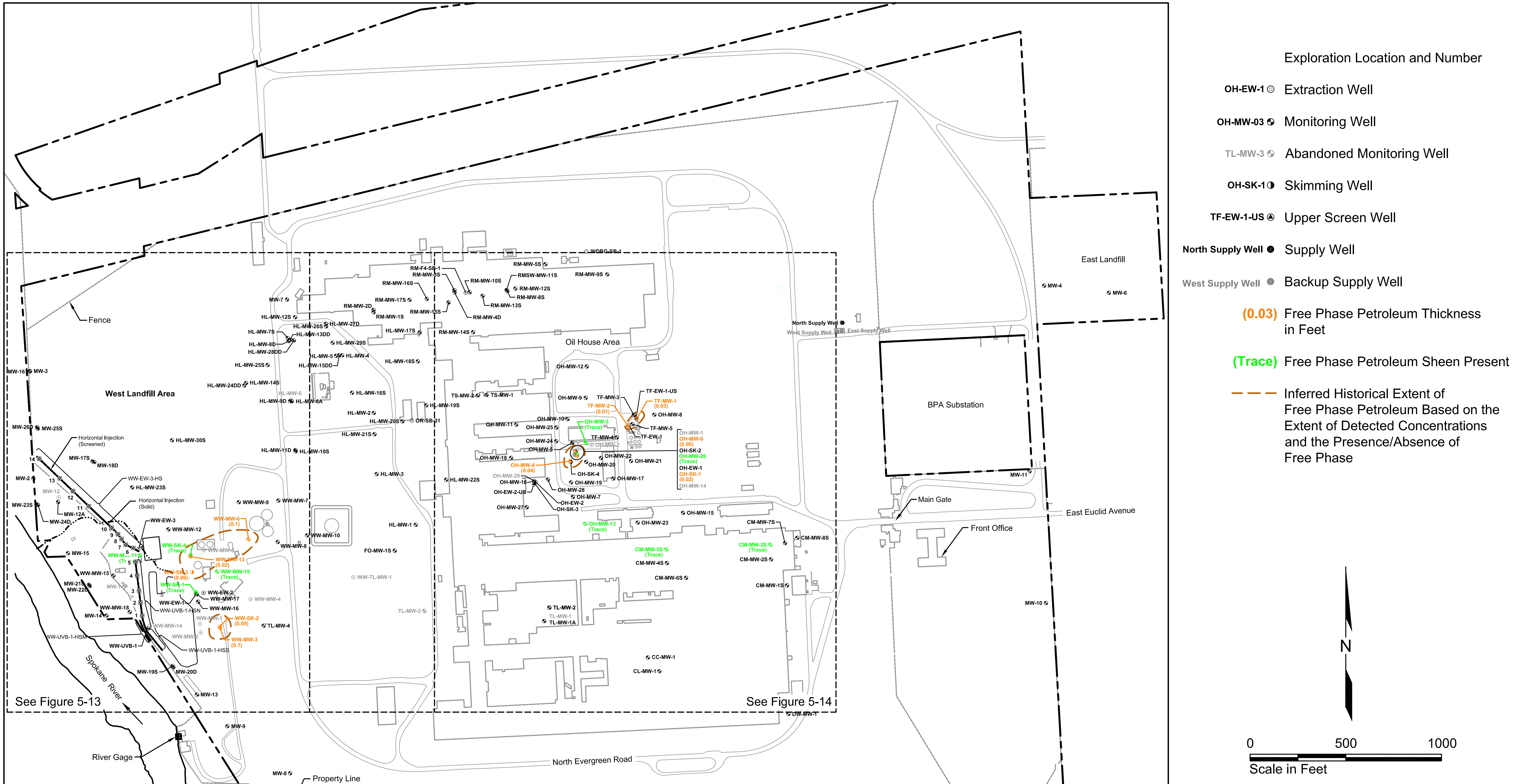

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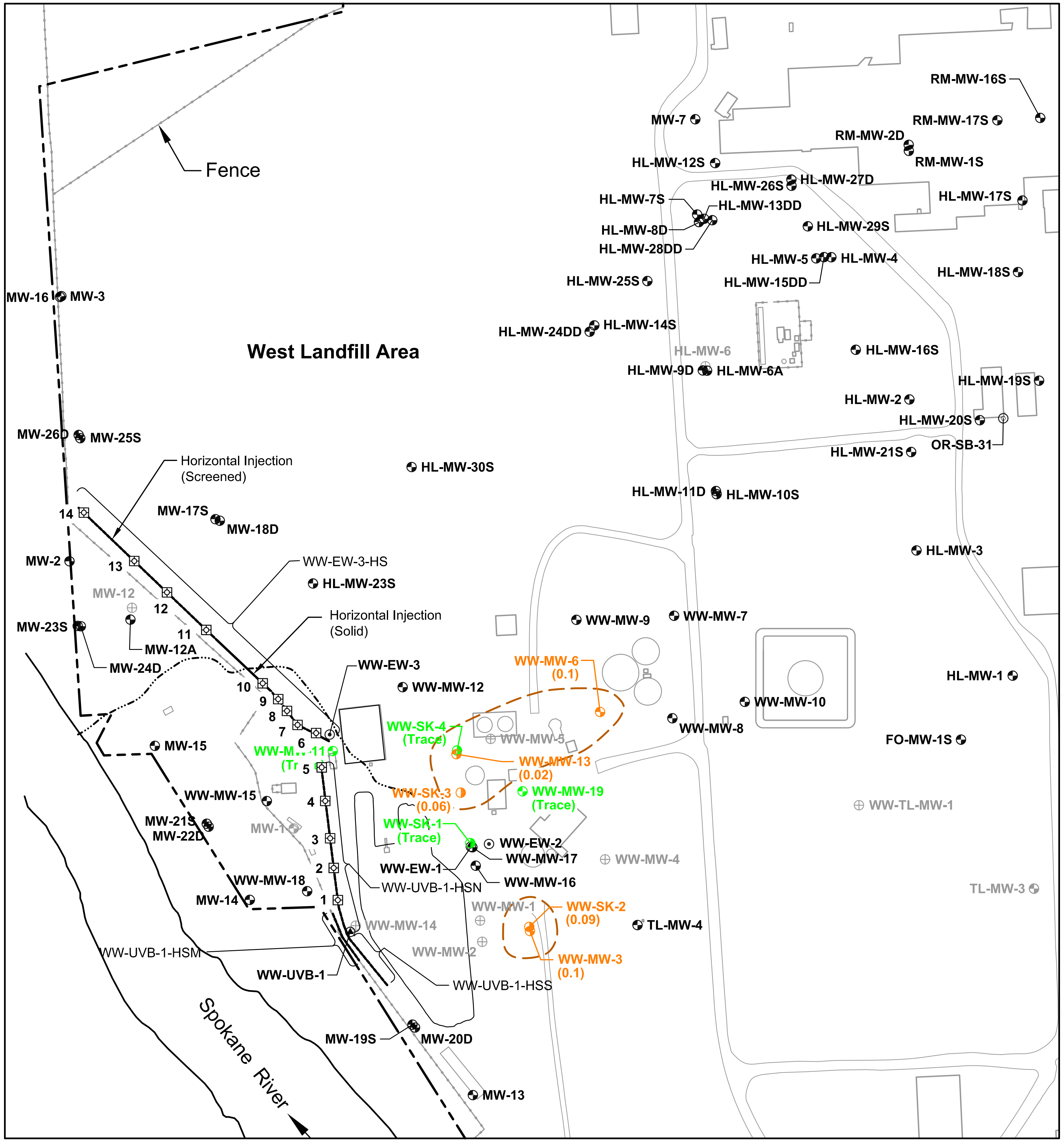
Figure 5-12

EAL 10/22/09 2644114-155.DWG

Free Phase Petroleum Thickness Map

Measured 2008 - West Area



Exploration Location and Number

OH-EW-1 ◎ Extraction Well

OH-MW-03 ⊕ Monitoring Well

TL-MW-3 ⊕ Abandoned Monitoring Well

OH-SK-1 ◑ Skimming Well

(0.03) Free Phase Petroleum Thickness in Feet

(Trace) Free Phase Petroleum Sheen Present

— — — Inferred Historical Extent of Free Phase Petroleum Based on the Extent of Detected Concentrations and the Presence/Absence of Free Phase

N

0 250 500

Scale in Feet

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Figure 5-13

EAL 10/22/09 2644114-156.DWG

Free Phase Petroleum Thickness Map

Measured 2008 - East Area

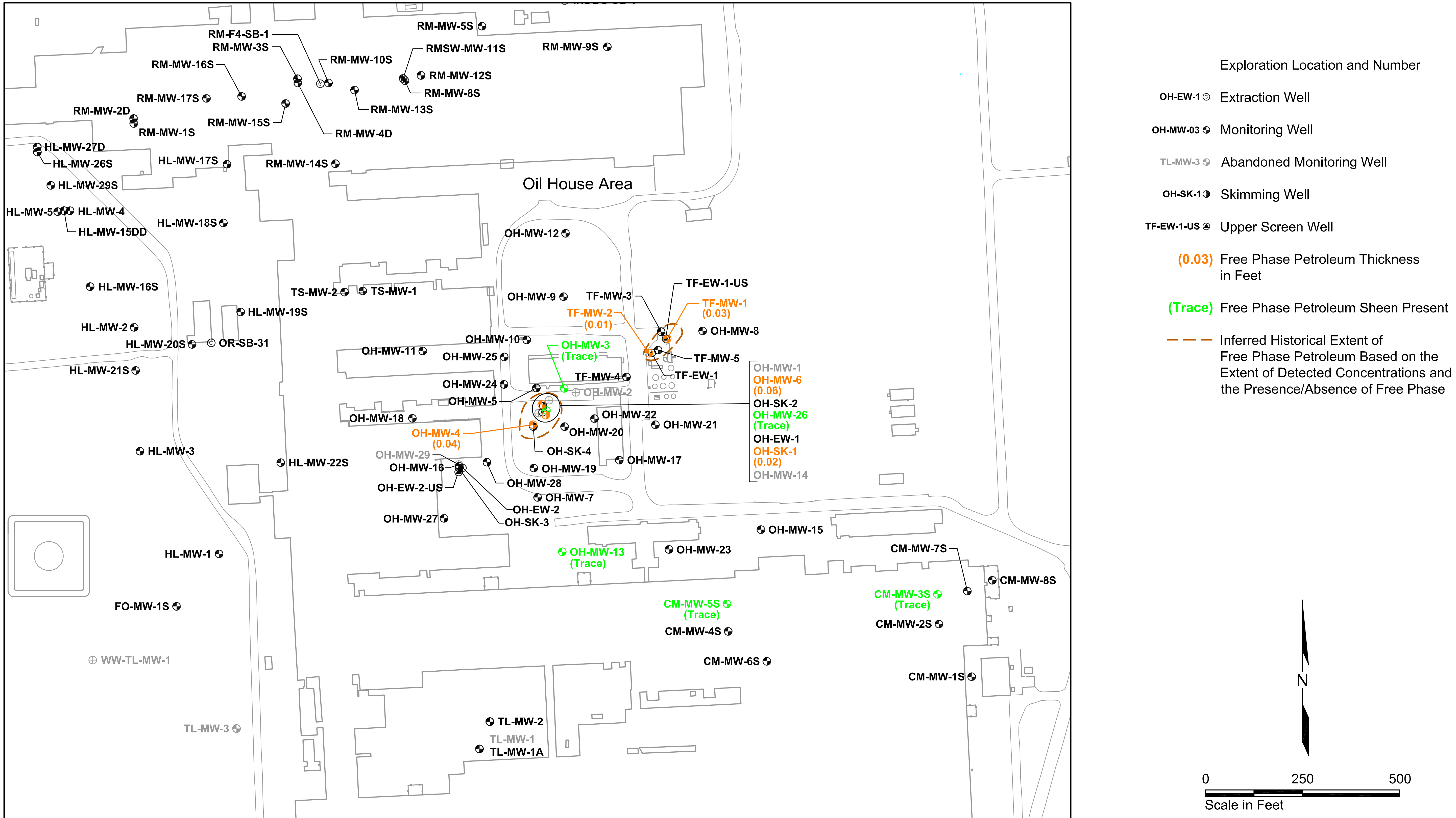

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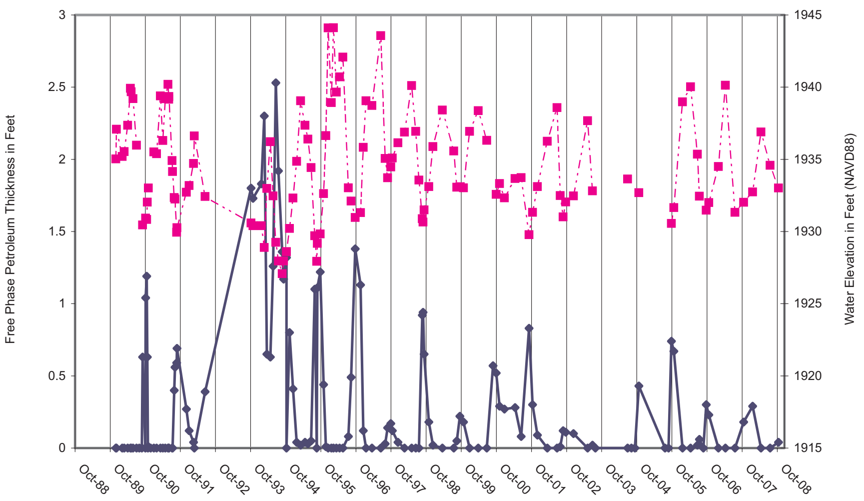
Figure 5-14

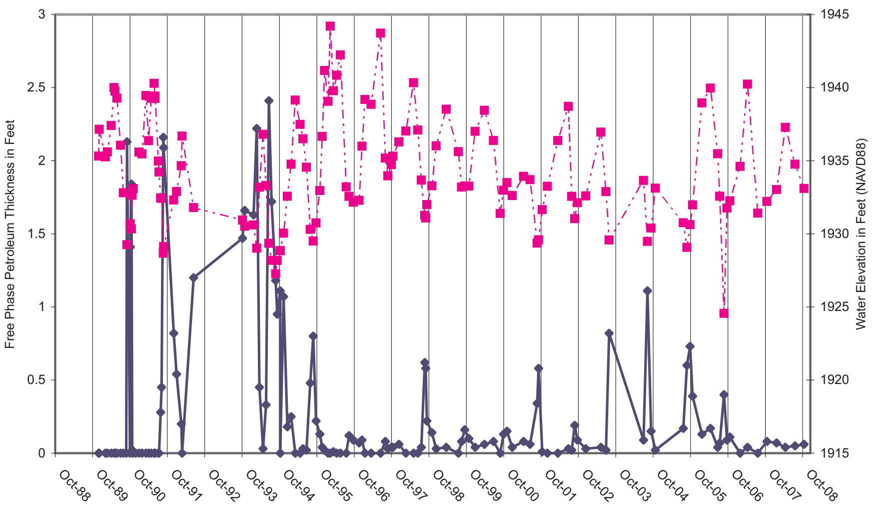
EAL 10/22/09 2644114-157.DWG

Free Phase Petroleum Thickness and Water Elevation over Time

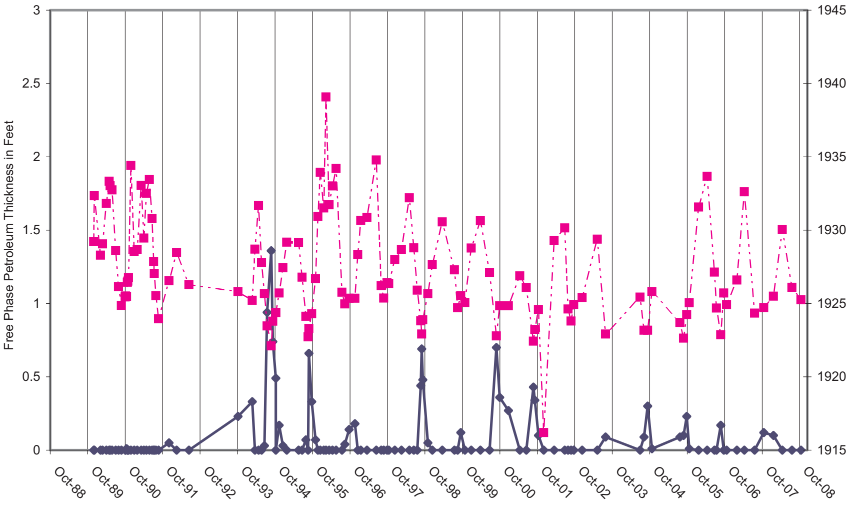
OH-MW-04



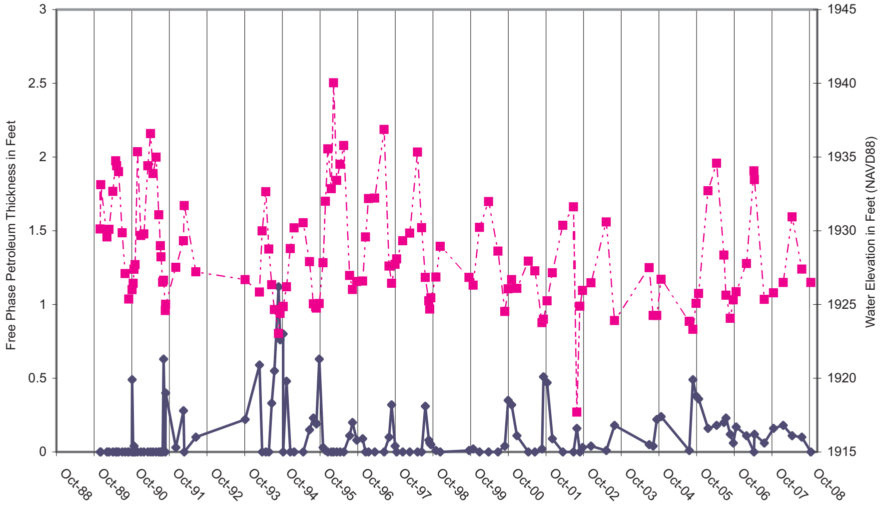
OH-MW-06



WW-MW-03



WW-MW-06



◆ Free Phase Petroleum Thickness vs. Time   ■ Water Elevation vs. Time

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Figure 5-15a
5/09

EAL 10/27/09 2644114-AR.cdr

Free Phase Petroleum Thickness and Water Elevation over Time

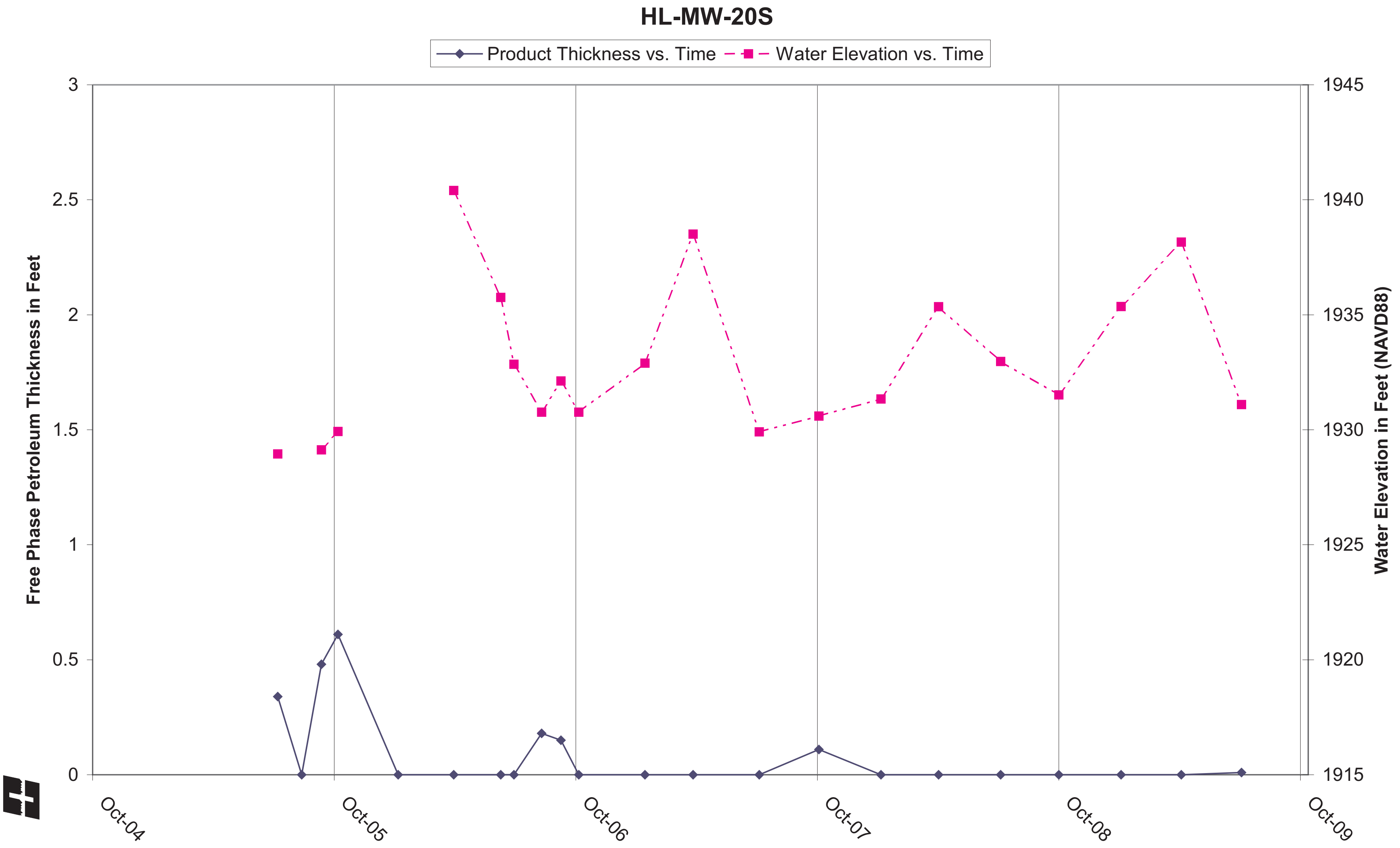

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Figure 5-15b

EAL 10/22/09 2644114-AT.cdr

Free Phase Petroleum Thickness Versus Water Elevation

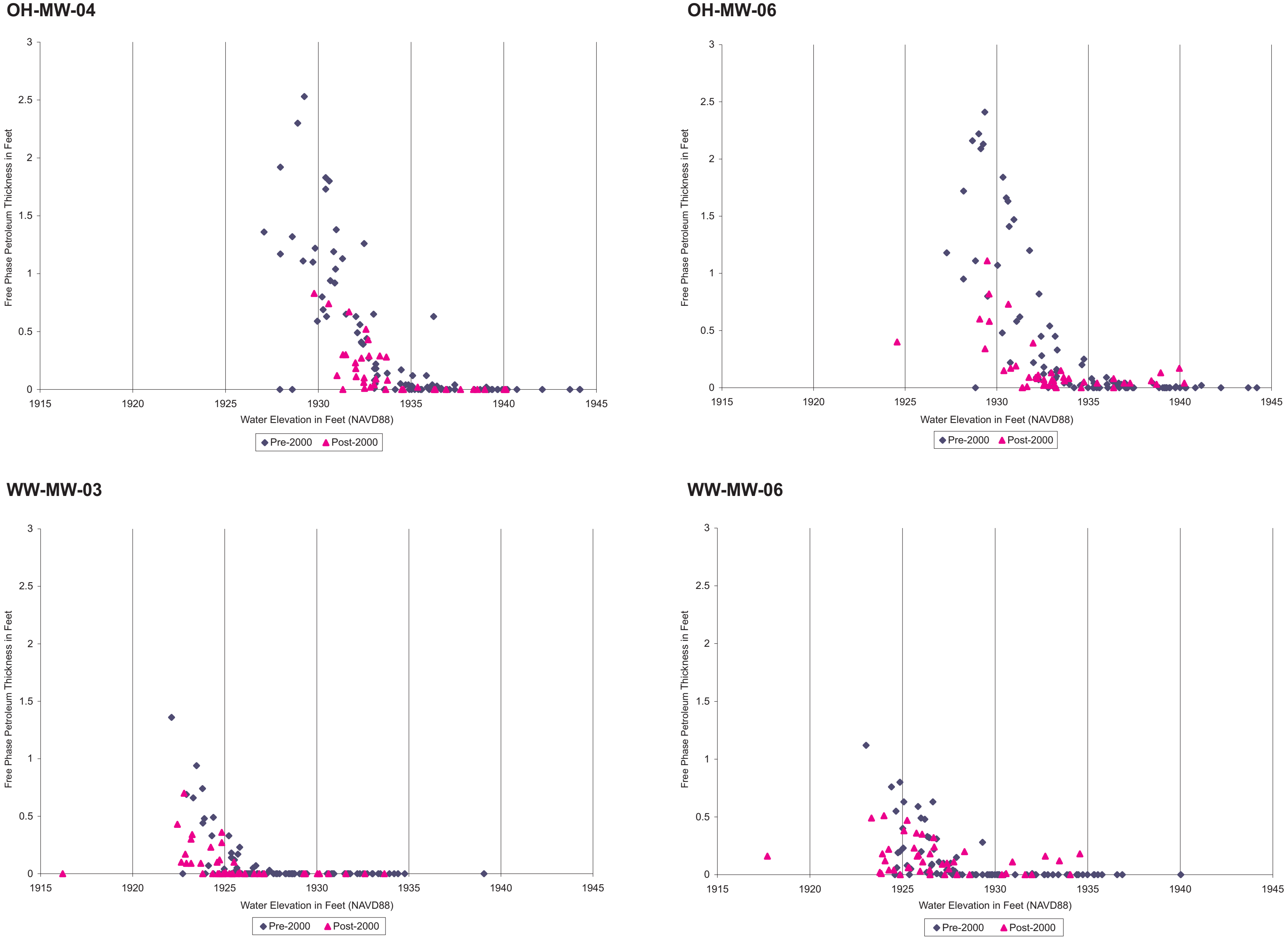

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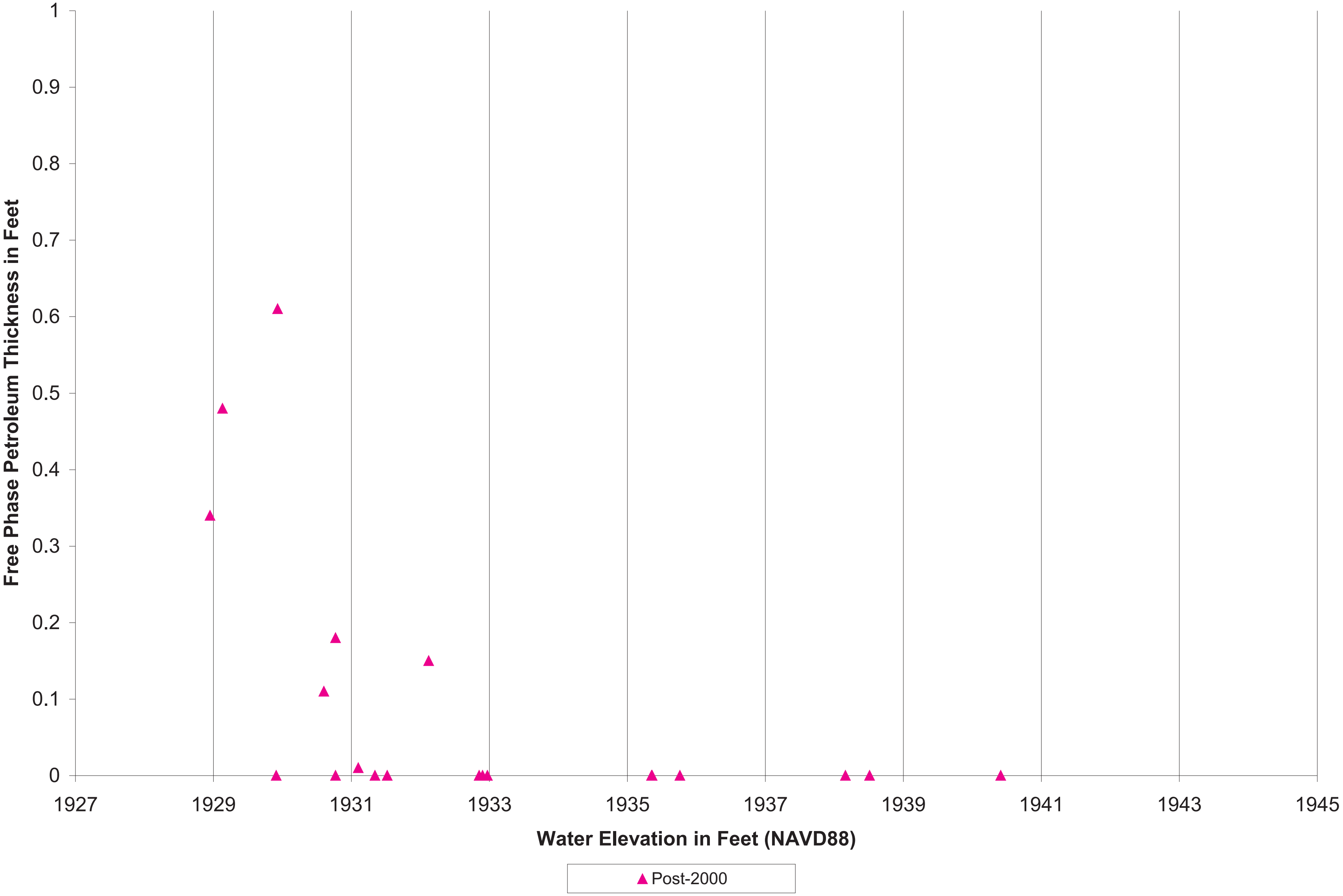
Figure 5-16a

5/09

EAL 10/27/09 2644114-AQ.cdr

Free Phase Petroleum Versus Water Elevation

HL-MW-20S



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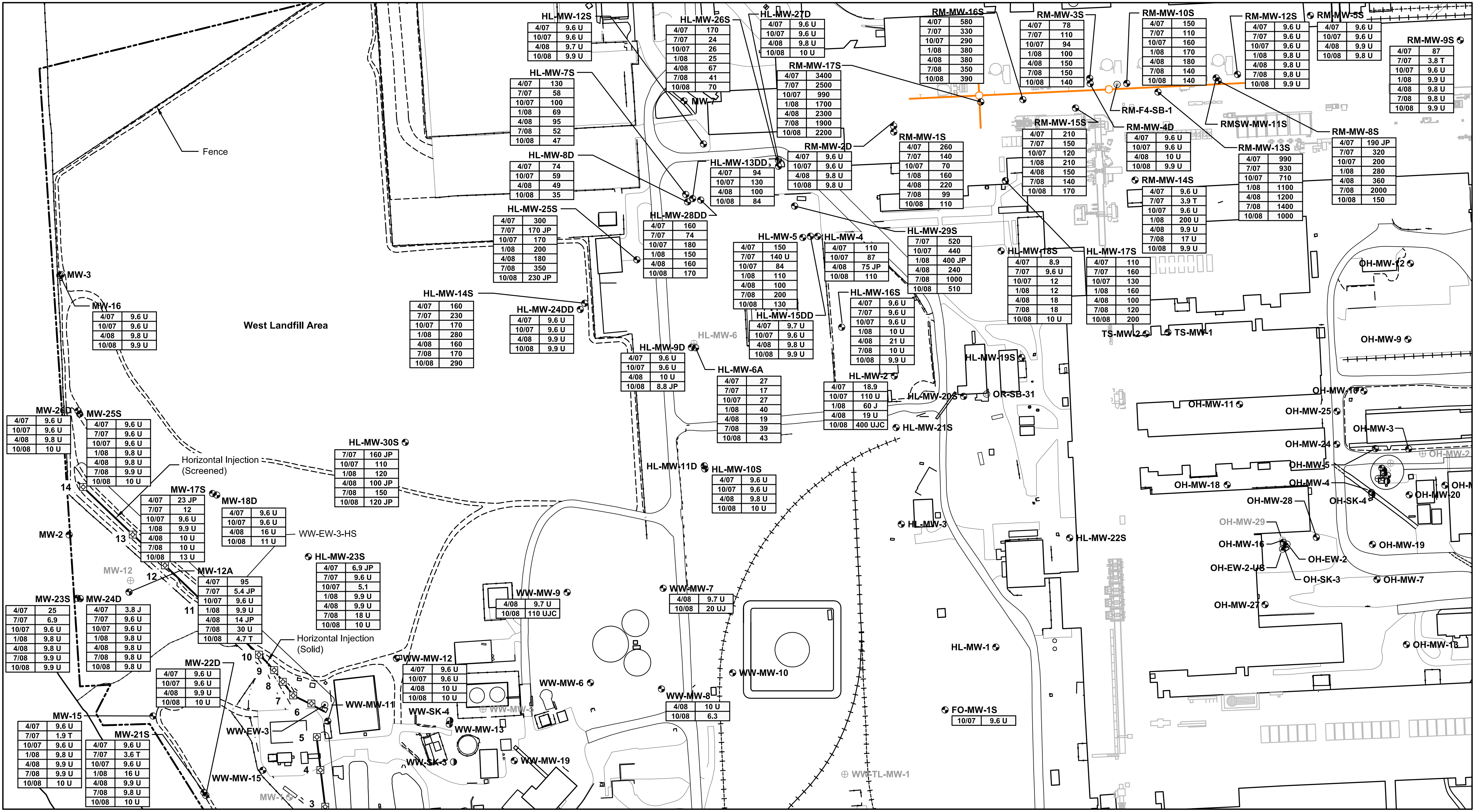
2644-114 10/09
Figure 5-16b

EAL 10/22/09 2644114-AS.cdr

Groundwater PCB Analytical Results Summary - April 2007 to October 2008



Source: Kaiser Aluminum Monitoring Well Location Map, dated 6/8/06.

HL-MW-20S ●	Monitoring Well Location and Number
U	Not Detected Above Reporting Limits
P	GC Confirmation Criteria was Exceeded
J	Estimated Value
C	Not Detect PCB Results are Reported at MDL
T	Value is Between the MDL and MRL

WW-MW-5 ⊕	Abandoned Monitoring Well Location and Number
WW-SK-3 ◑	Skimmer Well Location and Number
OR-SB-31 ◎	Soil Boring Location and Number
8 ⊡	Horizontal Injection Well Stickup Location and Number
- - - - - -	West Ravine

Date Sampled — PCB Concentration in ng/L

4/07	4.9 U

0 100 200

Scale in Feet

N

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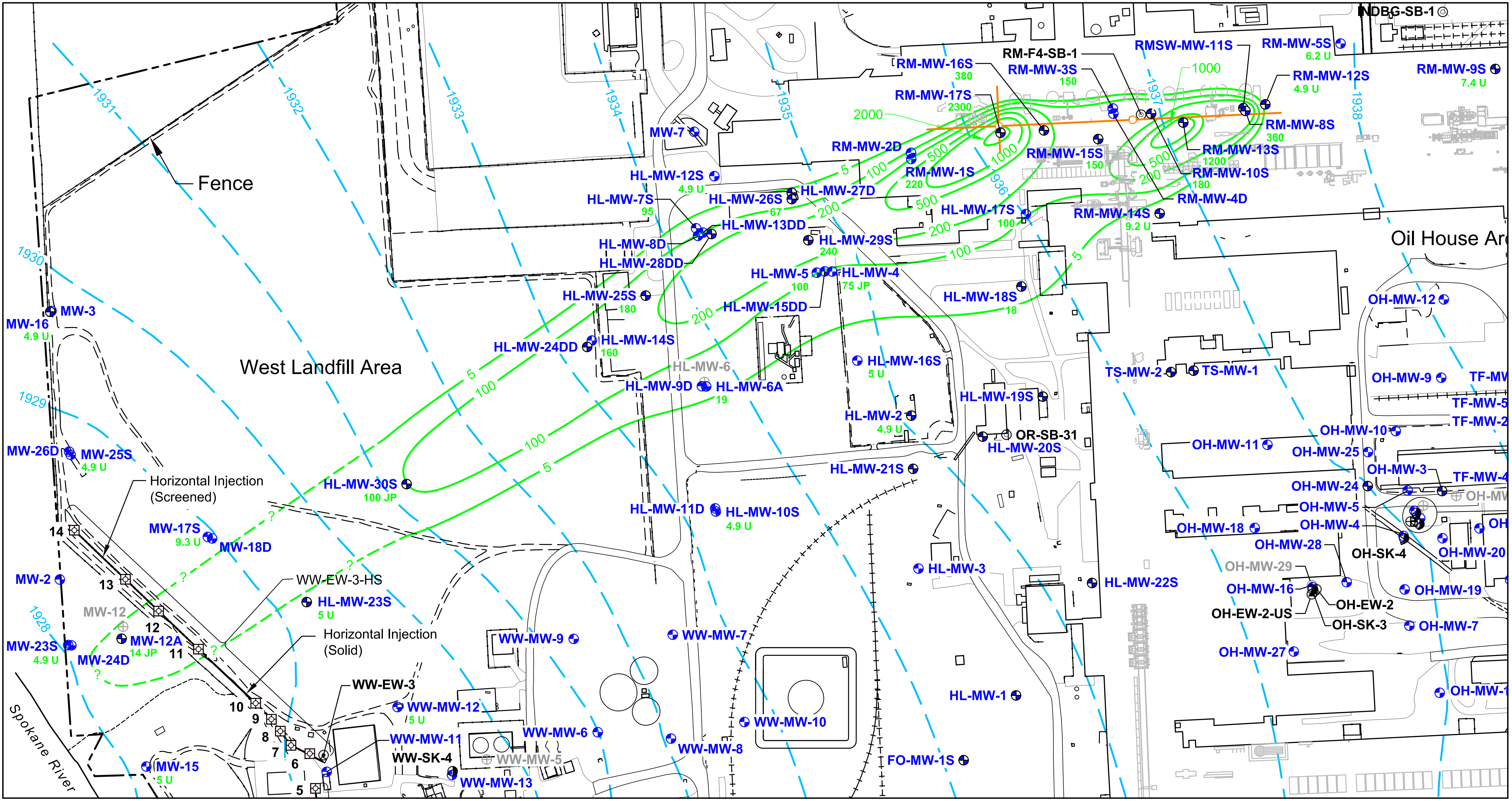
Figure 5-17

April 2008 Groundwater Elevation and PCB Concentration Contour Map



Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

HL-MW-26S ⊕	Monitoring Well Location and Number
40	PCB Concentration in PPT
U	Not Detected Above Reporting Limits
D	Results from a Diluted Sample
P	GC Confirmation Criteria was Exceeded
J	Estimated Value
WW-MW-5 ⊕	Abandoned Monitoring Well Location and Number
WW-SK-4 ◑	Skimmer Well Location and Number
OR-SB-31 ◎	Soil Boring Location and Number
11 ⊠	Horizontal Injection Well Stickup Location and Number
1923 — —	Groundwater Elevation Contour in Feet (NAVD88)
100 ——	PCB Concentration Contour in ng/L (ppt) (Based on Shallow Wells Only)

— — — The dashed PCB contour line represents uncertainty. PCBs have been detected on an infrequent, intermittent basis in monitoring wells represented by the dashed line region. Investigations are in progress to provide additional chemical and hydrogeologic information related to conditions within this dashed line region.

0 200 400
Scale in Feet
Vertical Datum in NAVD88

N

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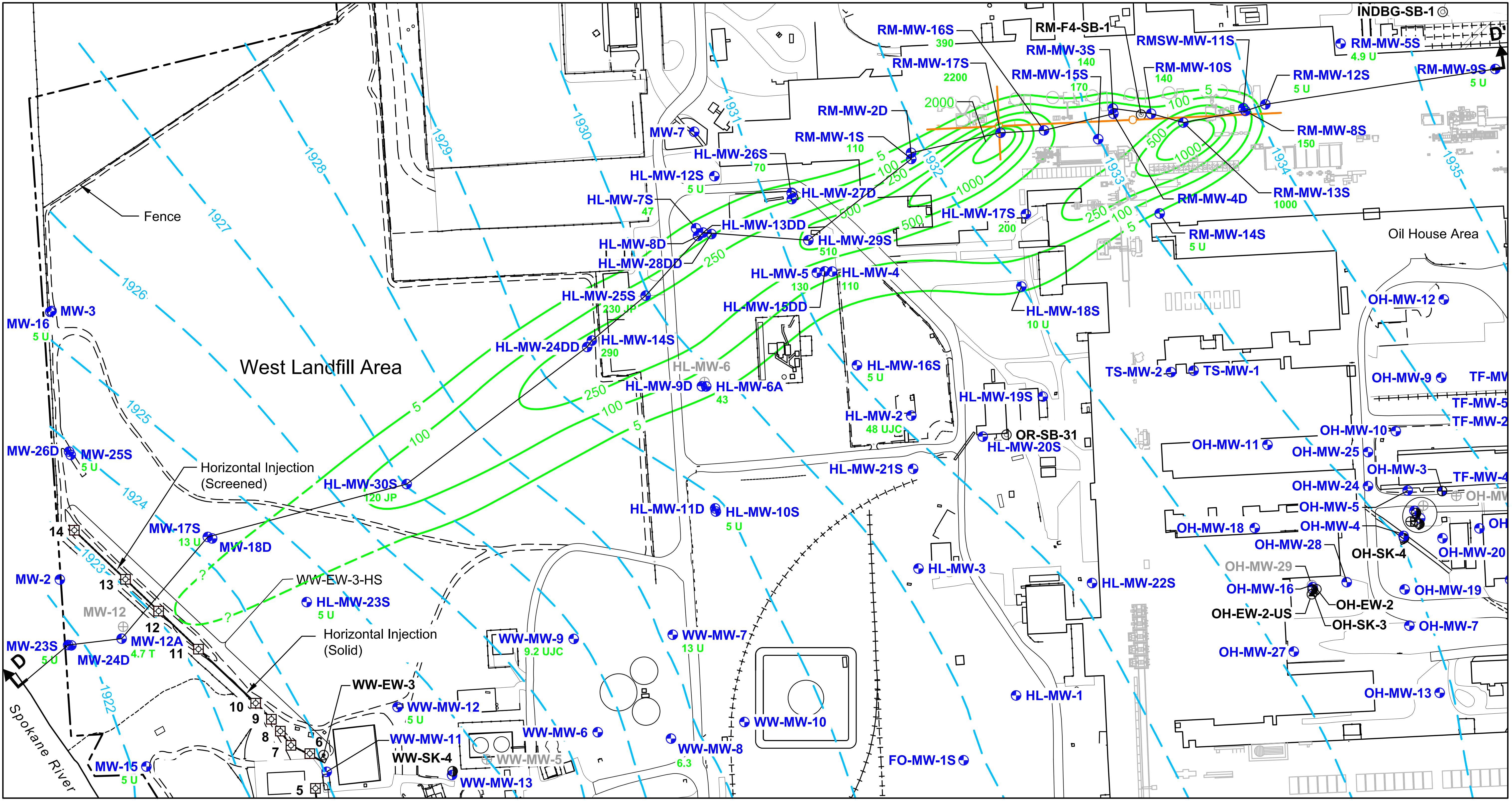
Figure 5-18

EAL 10/22/09 2644114-142.DWG

October 2008 Groundwater Elevation and PCB Concentration Contour Map



EAL 10/22/09 2644114-146.DWG

Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

HL-MW-26S ● Monitoring Well Location and Number

200 PCB Concentration in PPT

U Not Detected Above Reporting Limits

P GC Confirmation Criteria was Exceeded

J Estimated Value

C Non-detect PCB Result Reported at the MDL

T Estimated Value is Between the MDL and MRL

WW-MW-5 ⊕ Abandoned Monitoring Well Location and Number

WW-SK-4 ◑ Skimmer Well Location and Number

OR-SB-31 ◎ Soil Boring Location and Number

11 ⊡ Horizontal Injection Well Stickup Location and Number

1923 — — Groundwater Elevation Contour in Feet (NAVD88)

100 —— PCB Concentration Contour in ng/L (ppt) (Based on Shallow Wells Only)

— — The dashed PCB contour line represents uncertainty. PCBs have been detected on an infrequent, intermittent basis in monitoring wells represented by the dashed line region. Investigations are in progress to provide additional chemical and hydrogeologic information related to conditions within this dashed line region.

D D' Cross Section Location and Designation (See Figure 5-20)

0 200 400

Scale in Feet

Vertical Datum in NAVD88

N

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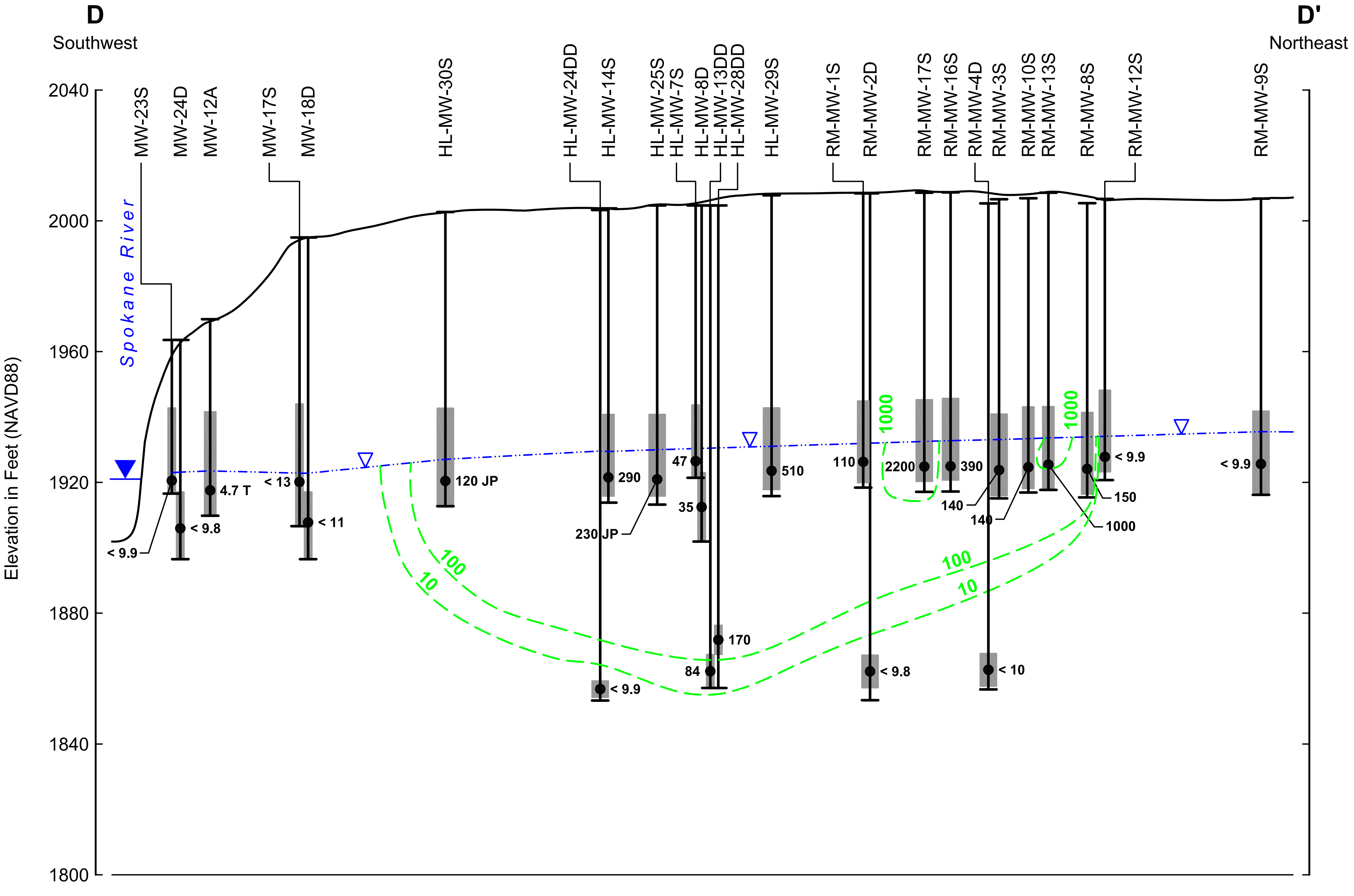
Figure 5-19

Generalized Subsurface Cross Section D-D'

October 2008



MW-17S Exploration Number

Exploration Location

Screened Interval

PCB Concentration in ng/L (ppt) 290 Approximate Sampling Point

100 — — — Interpolated PCB Concentration Contour in ng/L (ppt)

Horizontal Scale in Feet
0 400 800

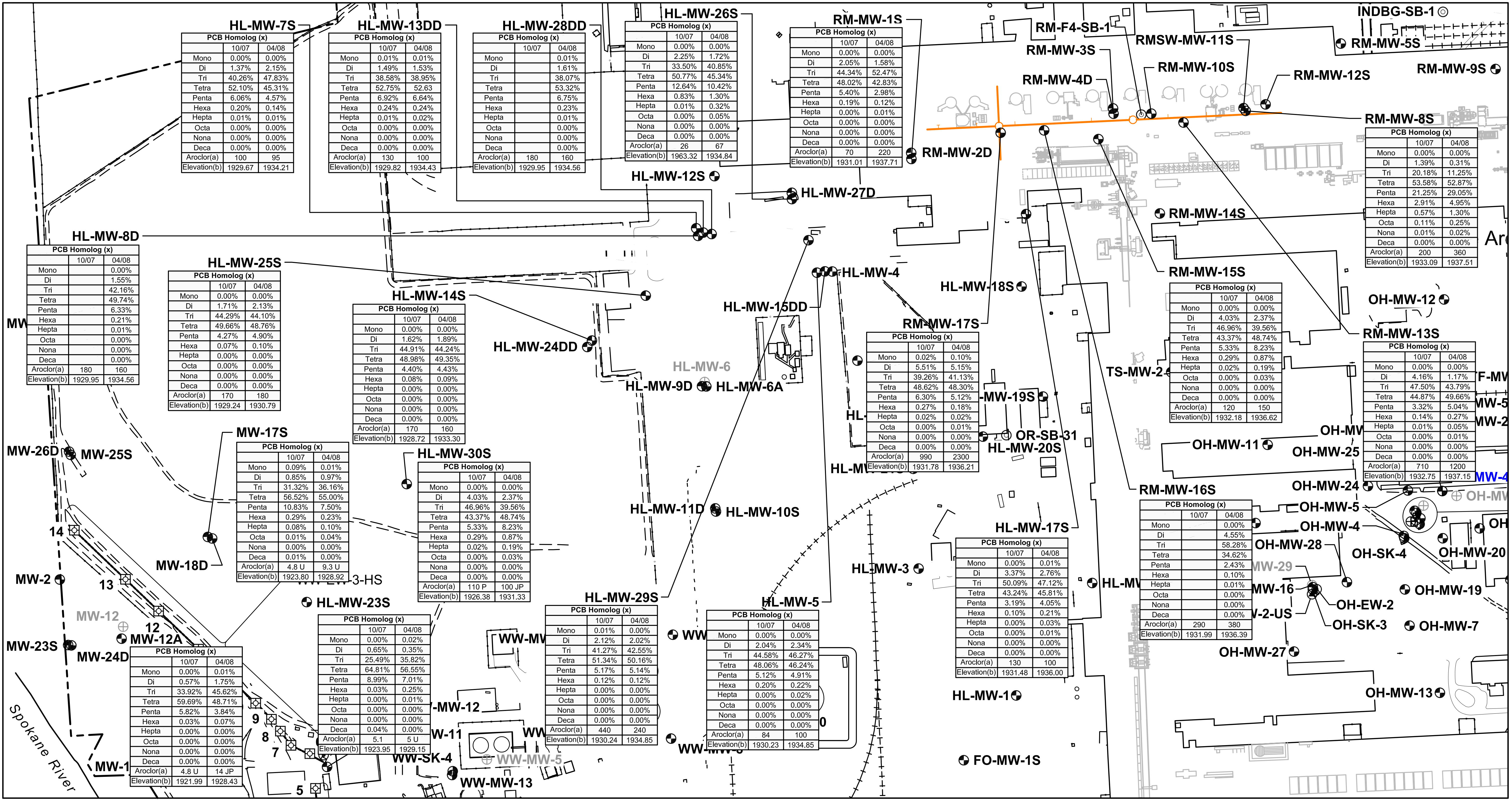
0 40 80
Vertical Scale in Feet
Vertical Exaggeration x 10
Vertical Datum in NAVD88

Notes:

1. Refer to Figure 5-18 for cross section location.
2. Contours are PCB concentrations in ng/L for the October 2008 monitoring event.

EAL 05/13/09 2644114-052.DWG

October 2007 and April 2008 Shallow Groundwater PCB Congener Map Showing Relative Percent Homolog Fractions



HL-MW-7S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	1.37%	2.15%
Tri	40.26%	47.83%
Tetra	52.10%	45.31%
Penta	6.06%	4.57%
Hexa	0.20%	0.14%
Hepta	0.01%	0.01%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	100	95
Elevation(b)	1929.67	1934.21

HL-MW-13DD

PCB Homolog (x)	10/07	04/08
Mono	0.01%	0.01%
Di	1.49%	1.53%
Tri	38.58%	38.95%
Tetra	52.75%	52.63
Penta	6.92%	6.64%
Hexa	0.24%	0.24%
Hepta	0.01%	0.02%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	130	100
Elevation(b)	1929.82	1934.43

HL-MW-28DD

PCB Homolog (x)	10/07	04/08
Mono		0.01%
Di		1.61%
Tri		38.07%
Tetra		53.32%
Penta		6.75%
Hexa		0.23%
Hepta		0.01%
Octa		0.00%
Nona		0.00%
Deca		0.00%
Aroclor(a)	180	160
Elevation(b)	1929.95	1934.56

HL-MW-26S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	2.25%	1.72%
Tri	33.50%	40.85%
Tetra	50.77%	45.34%
Penta	12.64%	10.42%
Hexa	0.83%	1.30%
Hepta	0.01%	0.32%
Octa	0.00%	0.05%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	26	67
Elevation(b)	1963.32	1934.84

RM-MW-1S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	2.05%	1.58%
Tri	44.34%	52.47%
Tetra	48.02%	42.83%
Penta	5.40%	2.98%
Hexa	0.19%	0.12%
Hepta	0.00%	0.01%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	70	220
Elevation(b)	1931.01	1937.71

RM-MW-8S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	1.39%	0.31%
Tri	20.18%	11.25%
Tetra	53.58%	52.87%
Penta	21.25%	29.05%
Hexa	2.91%	4.95%
Hepta	0.57%	1.30%
Octa	0.11%	0.25%
Nona	0.01%	0.02%
Deca	0.00%	0.00%
Aroclor(a)	200	360
Elevation(b)	1933.09	1937.51

HL-MW-8D

PCB Homolog (x)	10/07	04/08
Mono		0.00%
Di		1.55%
Tri		42.16%
Tetra		49.74%
Penta		6.33%
Hexa		0.21%
Hepta		0.01%
Octa		0.00%
Nona		0.00%
Deca		0.00%
Aroclor(a)	180	160
Elevation(b)	1929.95	1934.56

HL-MW-25S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	1.71%	2.13%
Tri	44.29%	44.10%
Tetra	49.66%	48.76%
Penta	4.27%	4.90%
Hexa	0.07%	0.10%
Hepta	0.00%	0.00%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	170	180
Elevation(b)	1929.24	1930.79

HL-MW-14S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	1.62%	1.89%
Tri	44.91%	44.24%
Tetra	48.98%	49.35%
Penta	4.40%	4.43%
Hexa	0.08%	0.09%
Hepta	0.00%	0.00%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	170	160
Elevation(b)	1928.72	1933.30

RM-MW-17S

PCB Homolog (x)	10/07	04/08
Mono	0.02%	0.10%
Di	5.51%	5.15%
Tri	39.26%	41.13%
Tetra	48.62%	48.30%
Penta	6.30%	5.12%
Hexa	0.27%	0.18%
Hepta	0.02%	0.02%
Octa	0.00%	0.01%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	990	2300
Elevation(b)	1931.78	1936.21

RM-MW-15S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	4.03%	2.37%
Tri	46.96%	39.56%
Tetra	43.37%	48.74%
Penta	5.33%	8.23%
Hexa	0.29%	0.87%
Hepta	0.02%	0.19%
Octa	0.00%	0.03%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	120	150
Elevation(b)	1932.18	1936.62

RM-MW-13S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	4.16%	1.17%
Tri	47.50%	43.79%
Tetra	44.87%	49.66%
Penta	3.32%	5.04%
Hexa	0.14%	0.27%
Hepta	0.01%	0.05%
Octa	0.00%	0.01%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	710	1200
Elevation(b)	1932.75	1937.15

MW-17S

PCB Homolog (x)	10/07	04/08
Mono	0.09%	0.01%
Di	0.85%	0.97%
Tri	31.32%	36.16%
Tetra	56.52%	55.00%
Penta	10.83%	7.50%
Hexa	0.29%	0.23%
Hepta	0.08%	0.10%
Octa	0.01%	0.04%
Nona	0.00%	0.00%
Deca	0.01%	0.00%
Aroclor(a)	4.8 U	9.3 U
Elevation(b)	1923.80	1928.92

HL-MW-30S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	4.03%	2.37%
Tri	46.96%	39.56%
Tetra	43.37%	48.74%
Penta	5.33%	8.23%
Hexa	0.29%	0.87%
Hepta	0.02%	0.19%
Octa	0.00%	0.03%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	110 P	100 JP
Elevation(b)	1926.38	1931.33

MW-12A

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.01%
Di	0.57%	1.75%
Tri	33.92%	45.62%
Tetra	59.69%	48.71%
Penta	5.82%	3.84%
Hexa	0.03%	0.07%
Hepta	0.00%	0.00%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	4.8 U	14 JP
Elevation(b)	1921.99	1928.43

HL-MW-23S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.02%
Di	0.65%	0.35%
Tri	25.49%	35.82%
Tetra	64.81%	56.55%
Penta	8.99%	7.01%
Hexa	0.03%	0.25%
Hepta	0.00%	0.01%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.04%	0.00%
Aroclor(a)	5.1	5 U
Elevation(b)	1923.95	1929.15

HL-MW-29S

PCB Homolog (x)	10/07	04/08
Mono	0.01%	0.00%
Di	2.12%	2.02%
Tri	41.27%	42.55%
Tetra	51.34%	50.16%
Penta	5.17%	5.14%
Hexa	0.12%	0.12%
Hepta	0.00%	0.00%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	440	240
Elevation(b)	1930.24	1934.85

HL-MW-5

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.00%
Di	2.04%	2.34%
Tri	44.58%	46.27%
Tetra	48.06%	46.24%
Penta	5.12%	4.91%
Hexa	0.20%	0.22%
Hepta	0.00%	0.02%
Octa	0.00%	0.00%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	84	100
Elevation(b)	1930.23	1934.85

HL-MW-17S

PCB Homolog (x)	10/07	04/08
Mono	0.00%	0.01%
Di	3.37%	2.76%
Tri	50.09%	47.12%
Tetra	43.24%	45.81%
Penta	3.19%	4.05%
Hexa	0.10%	0.21%
Hepta	0.00%	0.03%
Octa	0.00%	0.01%
Nona	0.00%	0.00%
Deca	0.00%	0.00%
Aroclor(a)	130	100
Elevation(b)	1931.48	1936.00

RM-MW-16S

PCB Homolog (x)	10/07	04/08
Mono		0.00%
Di		4.55%
Tri		58.28%
Tetra		34.62%
Penta		2.43%
Hexa		0.10%
Hepta		0.01%
Octa		0.00%
Nona		0.00%
Deca		0.00%
Aroclor(a)	290	380
Elevation(b)	1931.99	1936.39

HL-MW-26S ⊕	Monitoring Well Location and Number
(a)	PCB Concentration in in ng/L (Method 8082)
(b)	Groundwater Elevation in Feet (NAVD 88)
U	Not Detected Above Reporting Limits
P	GC Confirmation Criteria were Exceeded
J	Estimated Value
WW-MW-5 ⊕	Abandoned Monitoring Well Location and Number
WW-SK-4 ◑	Skimmer Well Location and Number
OR-SB-31 ◎	Soil Boring Location and Number
11 ⊠	Horizontal Injection Well Stickup Location and Number
(x)	PCB Congener Homolog Fractions based on EPA Method 1668, in Percent (Blank Corrected Data)

N

0 200 400

Scale in Feet

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Figure 5-21

EAL 05/12/09 2644114-113.DWG

Arsenic Concentrations in Groundwater - Most Recently Measured

2644114-038.DWG

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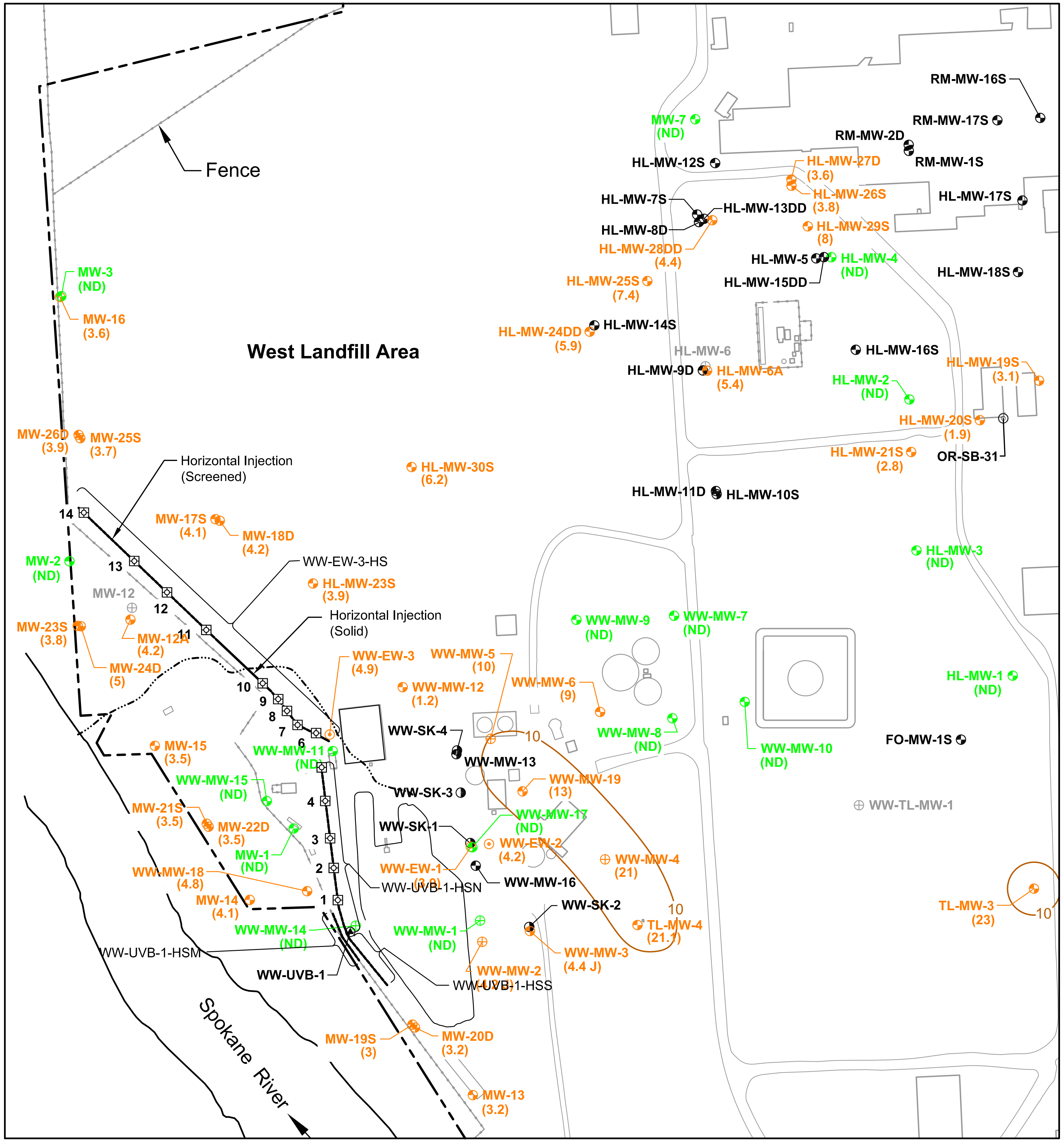
Figure 5-22

Arsenic Concentrations in Groundwater - Most Recently Measured

West Area



Exploration Location and Number

OH-EW-1 ◎ Extraction Well

OH-MW-03 ◐ Monitoring Well

TL-MW-3 ◐ Abandoned Monitoring Well

OH-SK-1 ◑ Skimming Well

(3.0) Arsenic Concentration in ug/L

J Estimated Value

(ND) Not Detected

10 ——— Arsenic Concentration Contour in ug/L

N

0 250 500

Scale in Feet

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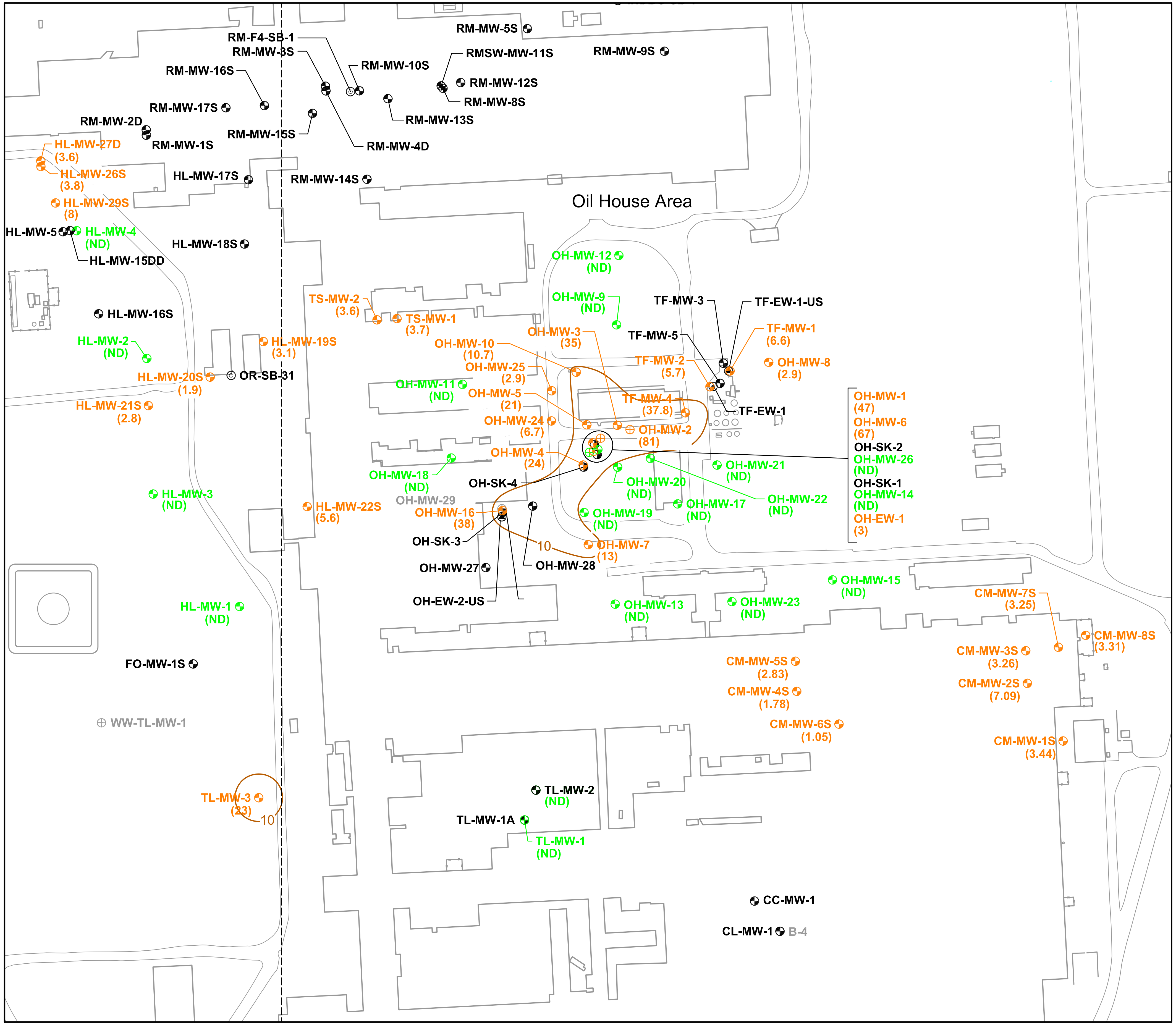
Figure 5-23

EAL 05/12/09 2644114-040.DWG

Arsenic Concentrations in Groundwater - Most Recently Measured

East Area



Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ⊕	Monitoring Well
TL-MW-3 ⊕	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ⊕	Upper Screen Well
(3.0)	Arsenic Concentration in ug/L
J	Estimated Value
(ND)	Not Detected
10 ——	Arsenic Concentration Contour in ug/L

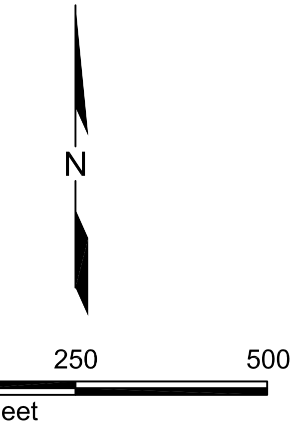


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Figure 5-24

EAL 05/12/09 2644114-039.DWG

Iron Concentrations in Groundwater - Most Recently Measured

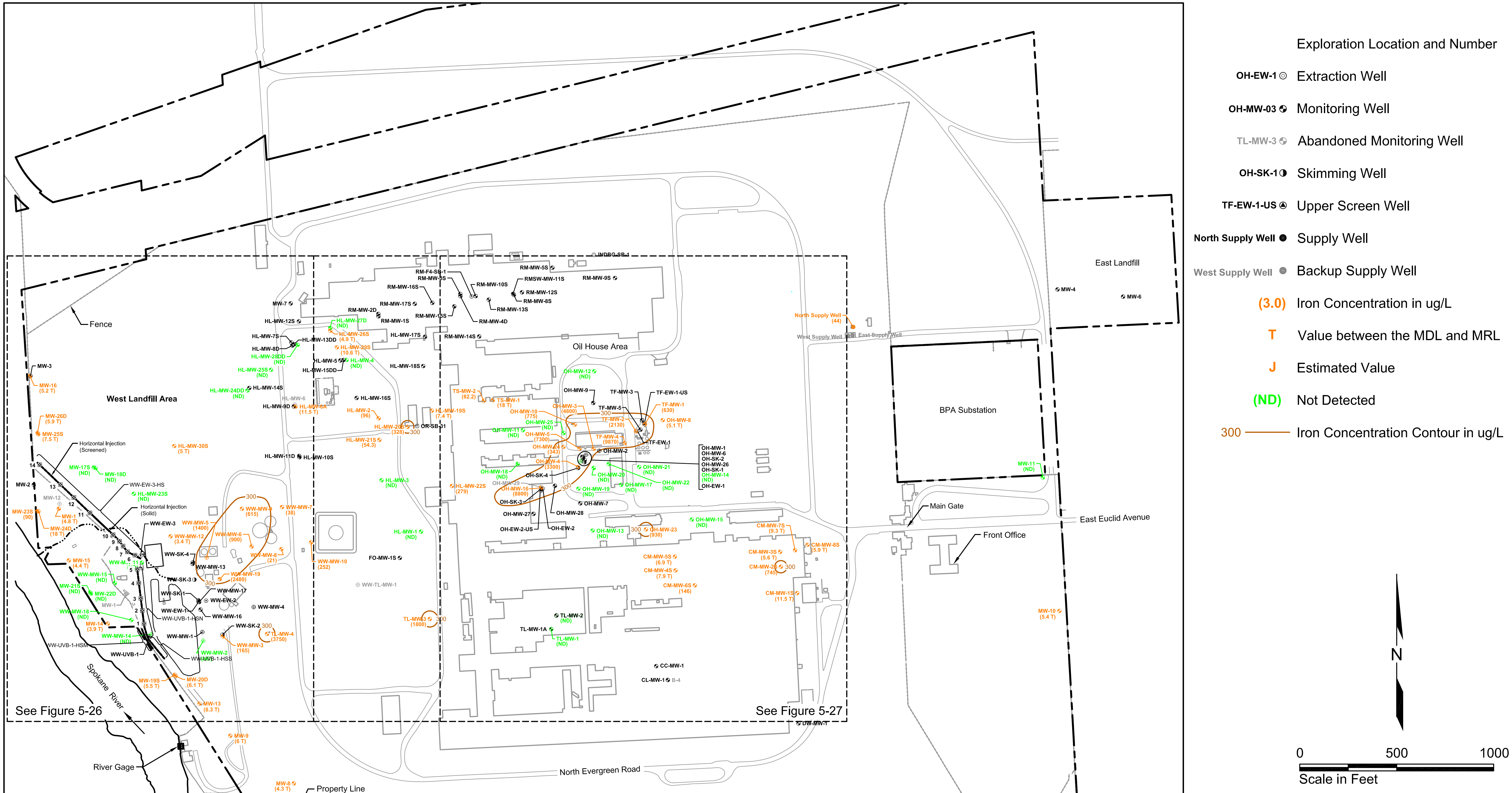

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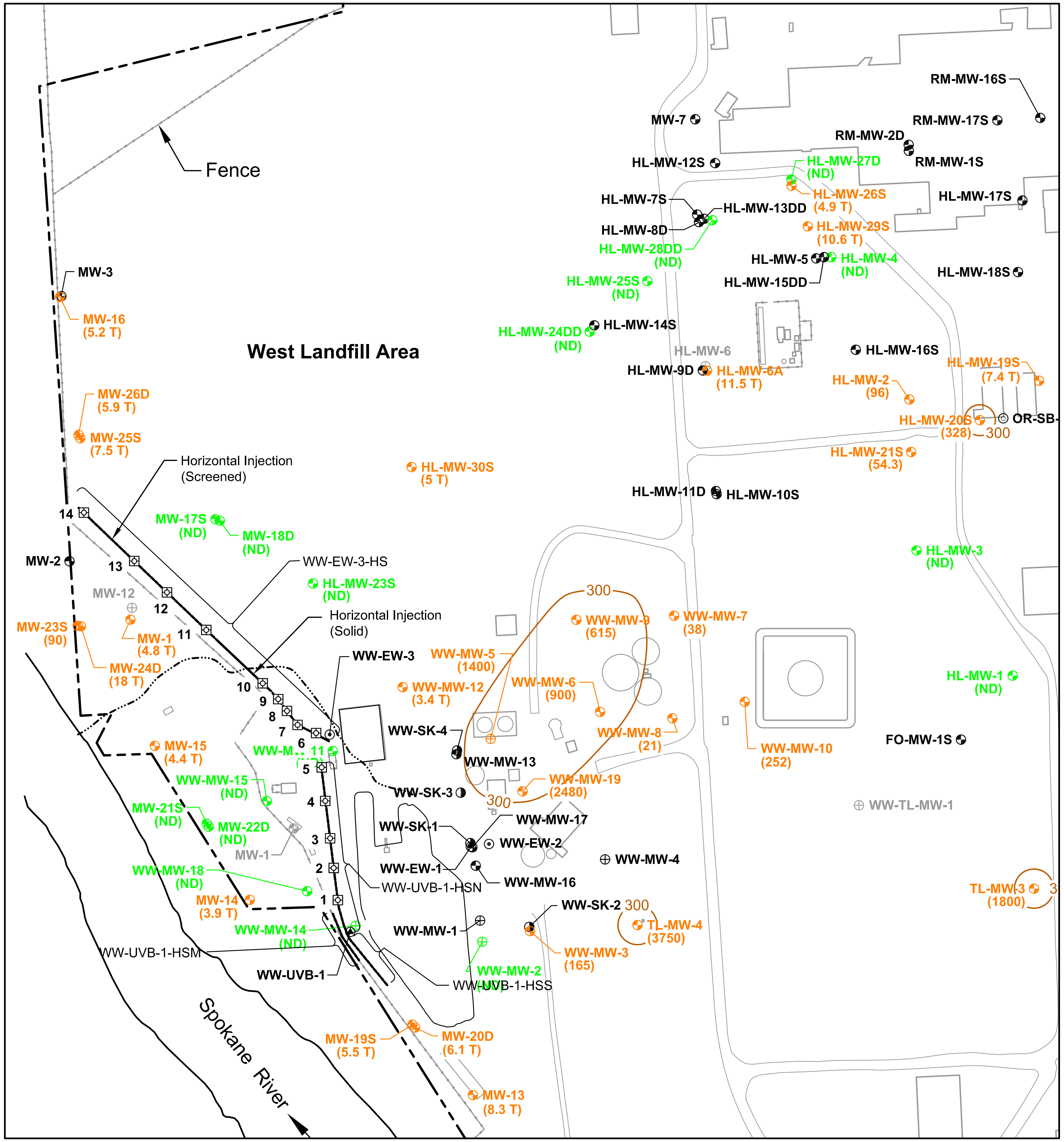
Figure 5-25

EAL 05/12/09 2644114-044.DWG

Iron Concentrations in Groundwater - Most Recently Measured

West Area



Exploration Location and Number

OH-EW-1 ◎	Extraction Well
OH-MW-03 ●	Monitoring Well
TL-MW-3 ●	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
(3.0)	Iron Concentration in ug/L
T	Value between the MDL and MRL
J	Estimated Value
(ND)	Not Detected
300 ———	Iron Concentration Contour in ug/L

N

0 250 500

Scale in Feet

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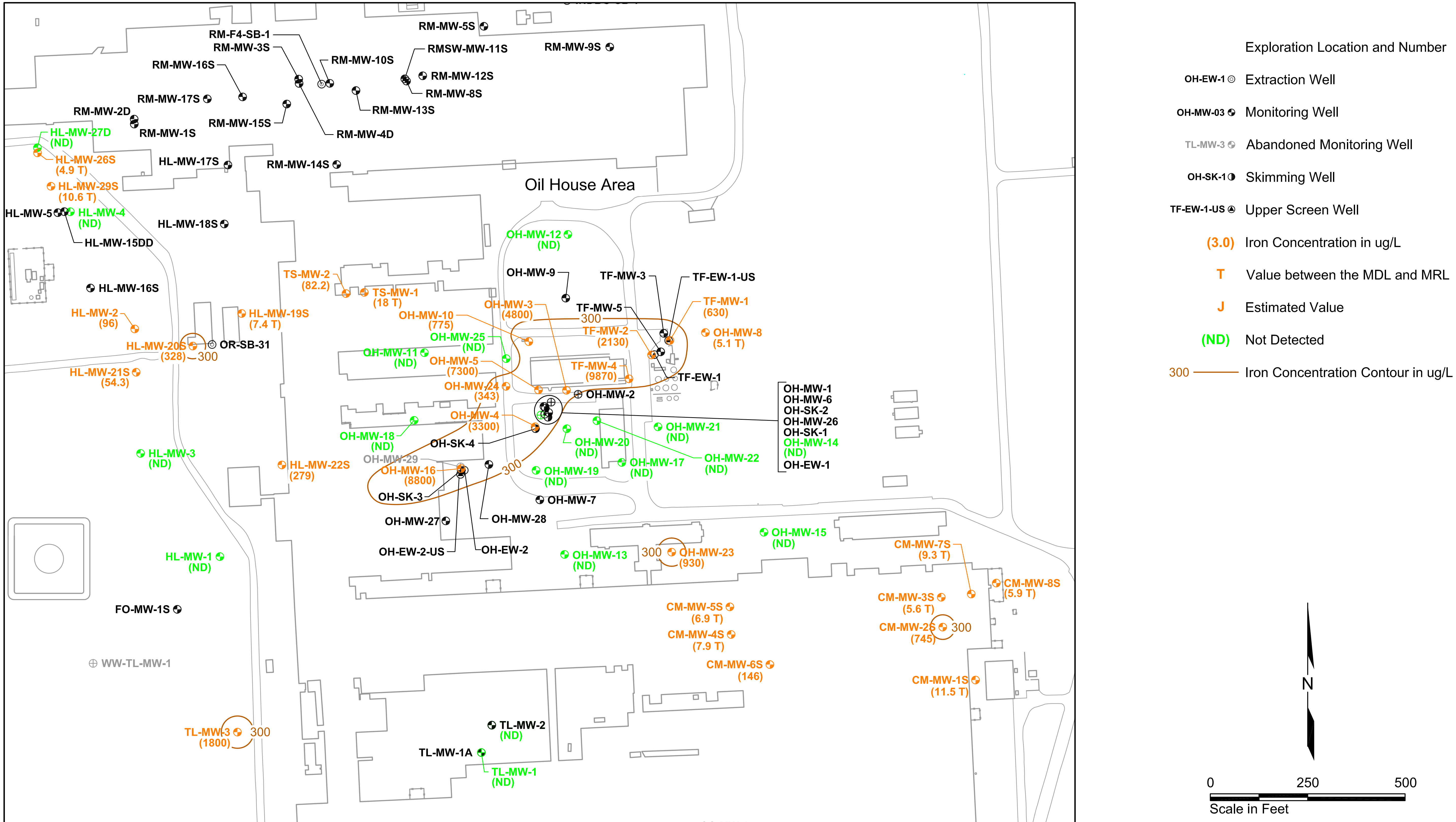
Figure 5-26

EAL 05/12/09 2644114-046.DWG

Iron Concentrations in Groundwater - Most Recently Measured

East Area



EAL 05/12/09 2644114-045.DWG

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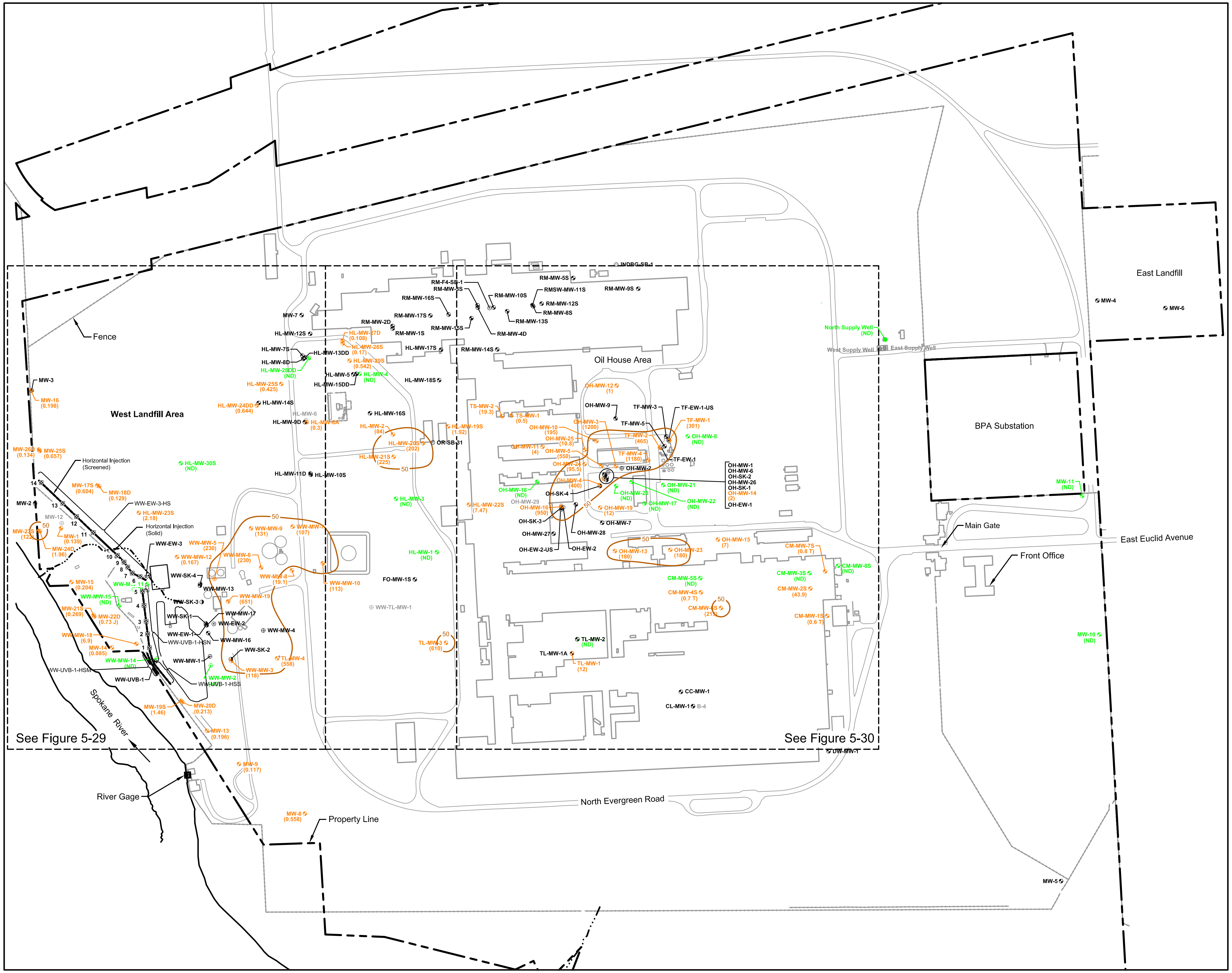
2644-114 *5/09*

Figure 5-27

Manganese Concentrations in Groundwater - Most Recently Measured



	Exploration Location and Number
OH-EW-1 ◎	Extraction Well
OH-MW-03 ◐	Monitoring Well
TL-MW-3 ◐	Abandoned Monitoring Well
OH-SK-1 ◑	Skimming Well
TF-EW-1-US ◎	Upper Screen Well
North Supply Well ●	Supply Well
West Supply Well ●	Backup Supply Well
(3.0)	Manganese Concentration in g/L
T	Value between the MDL and MRL
J	Estimated Value
(ND)	Not Detected
50 ———	Manganese Concentration Contour in ug/L

N

0 500 1000
Scale in Feet

EAL 05/12/09 2644114-041.DWG

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2644-114 *5/09*
Figure 5-28

Manganese Concentrations in Groundwater - Most Recently Measured

West Area

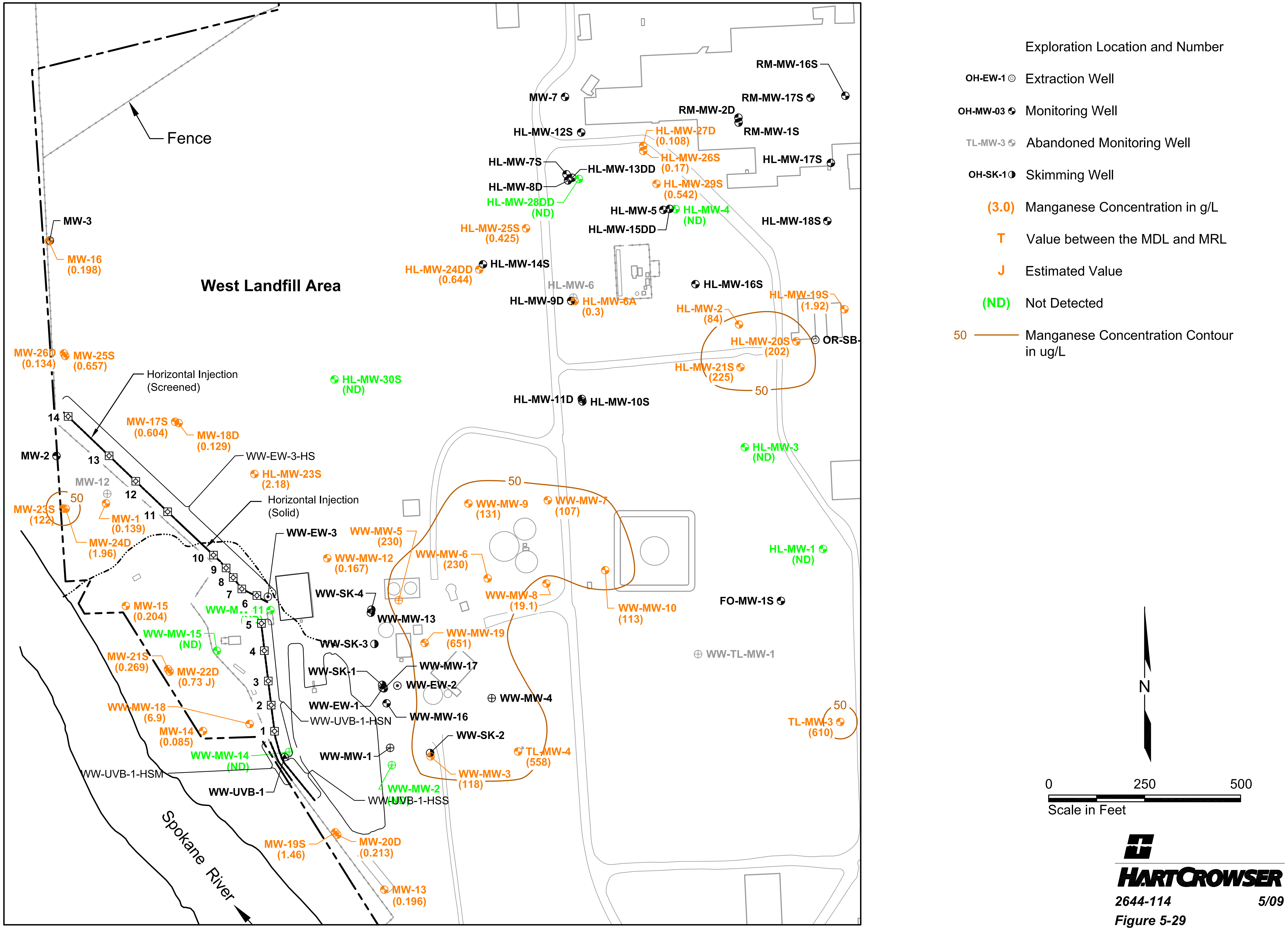

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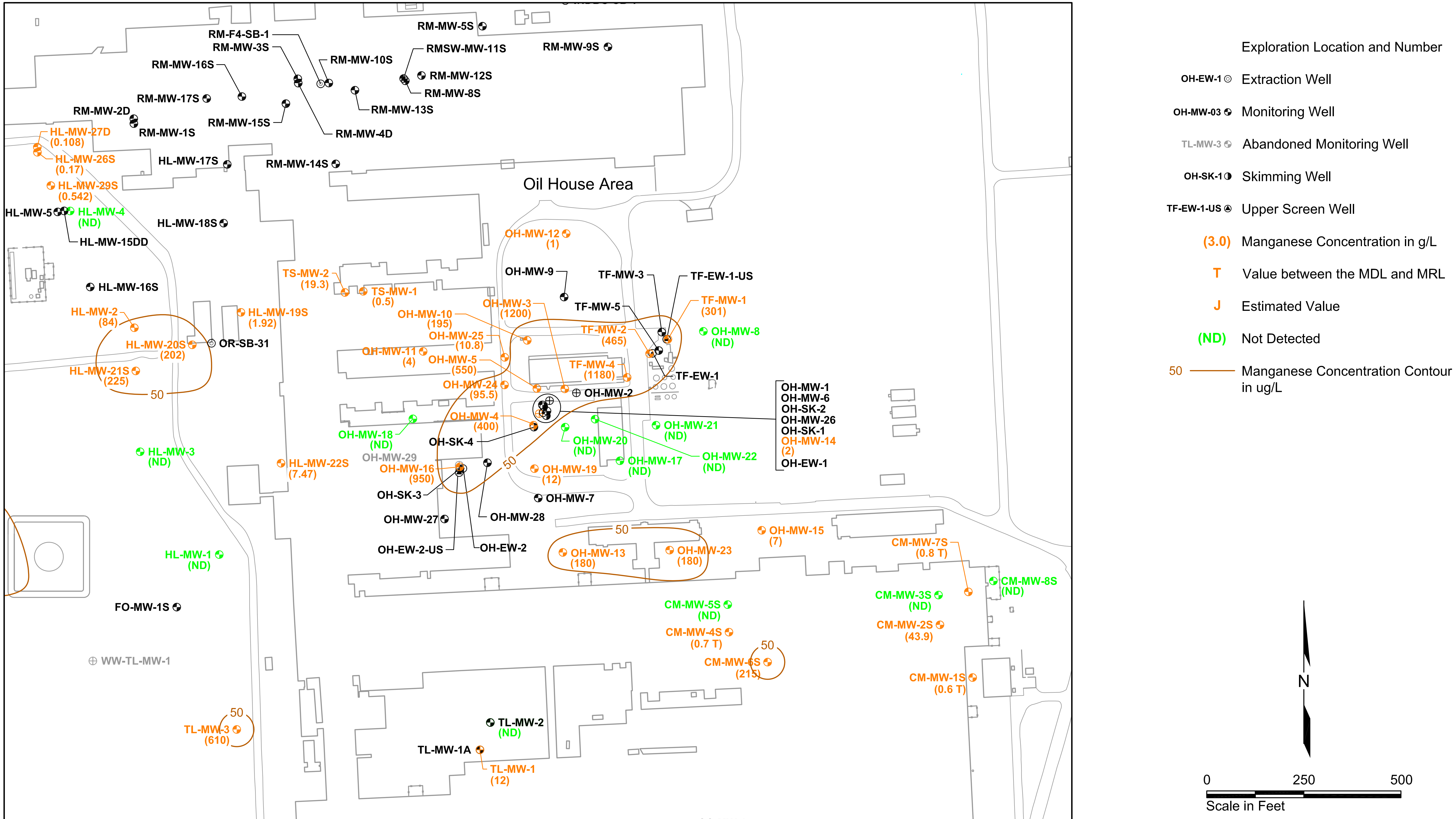
Figure 5-29

EAL 05/12/09 2644114-043.DWG

Manganese Concentrations in Groundwater - Most Recently Measured

East Area



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2644-114 5/09

Figure 5-30

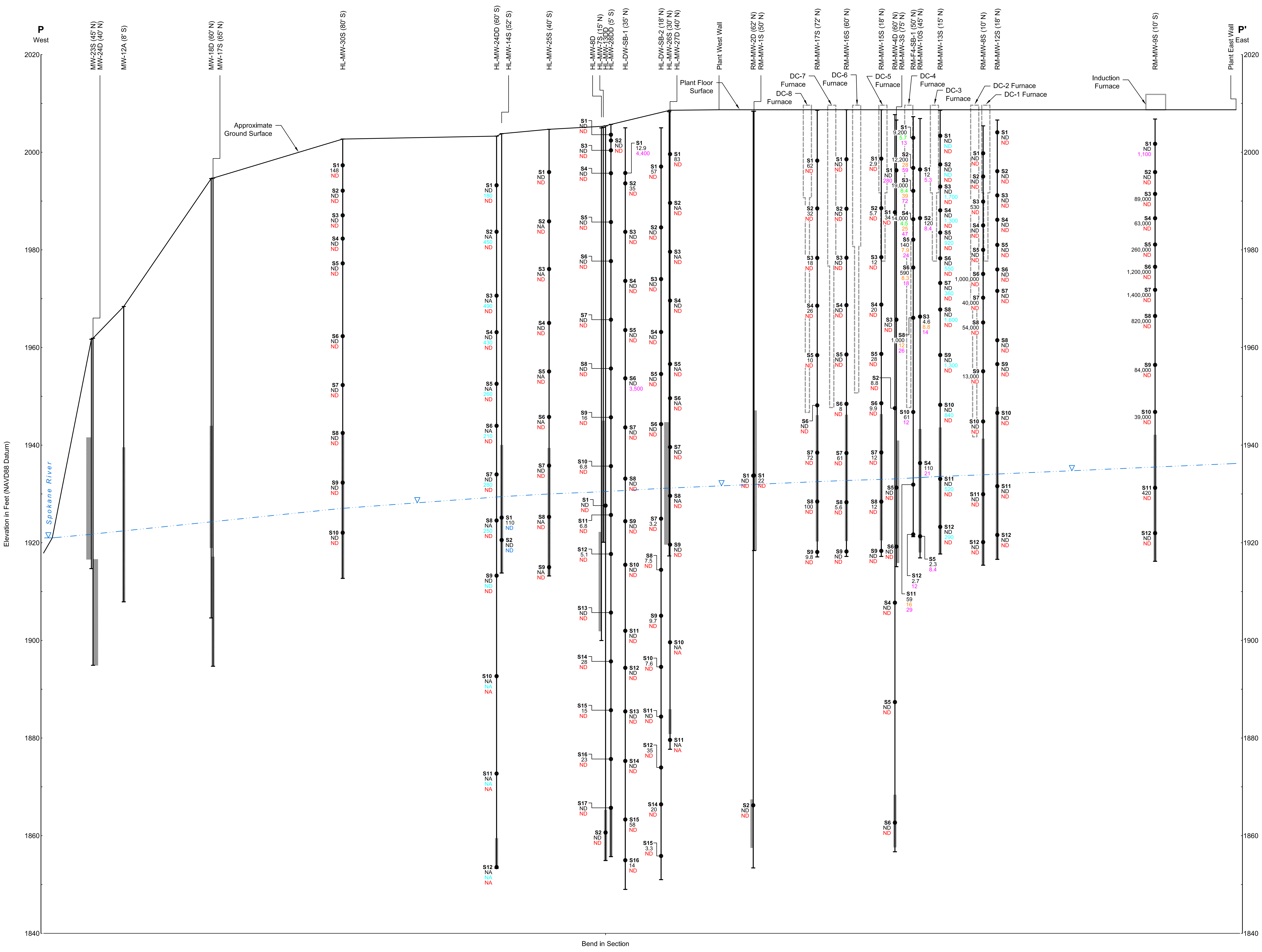
EAL 05/12/09 2644114-042.DWG

Most Recently Detected cPAH Concentrations in Groundwater

EAL 10/22/09 2644114-143.DWG

HARTCROWSER
2644-114 5/09
Figure 5-31

Generalized Subsurface Cross Section P-P'
Showing Concentrations in Soil Samples



HL-MW-30S (80' S)	Exploration Number (Offset Distance and Direction)
	Exploration Location
S1 ●	Soil Sample Number
▮	Screened Interval
▽	Groundwater Level (October 2008)
0.62	Total PCB Concentration in ug/kg
840	Castor Oil in mg/kg
ND	Total Petroleum Hydrocarbon
8.4	Gasoline-Range Petroleum Hydrocarbons in mg/kg
12	Diesel-Range Petroleum Hydrocarbons in mg/kg
18	Heavy Oil-Range Petroleum Hydrocarbons in mg/kg
ND	Not Detected
NA	Not Analyzed

Notes:

1. Where TPH is indicated as ND, none of the various ranges of petroleum hydrocarbons were detected. Where specific-range petroleum hydrocarbon concentrations are shown, if less than three concentrations are presented, other specific-range petroleum hydrocarbons were non-detect or not analyzed.
2. Castor oil concentrations only shown were indentified as such.
3. HL-MW-27D data were plotted, not HL-MW-26S.
4. No chemical data shown for wells HL-MW-7S and HL-MW-8D.

Horizontal Scale in Feet
0 150 300

0 10 20
Vertical Scale in Feet
Vertical Exaggeration x 15

HARTCROWSER
2644-114 ***5/09***
Plate 2

EAL 05/13/09 2644114-140.DWG

CONTENTS

TABLES

CONTENTS (Continued)

Page

FIGURES

6.0 CONTAMINANT FATE AND TRANSPORT

The following discussion outlines the fate and transport of COPCs identified at the Facility and retained for further evaluation after the screening process discussed in Section 5.0. The following constituents have been identified as COPCs at the Facility:

- Free phase petroleum;
- Petroleum hydrocarbons;
- PCBs;
- Metals (arsenic, iron, manganese); and
- cPAHs.

6.1 GENERAL FATE AND TRANSPORT PRINCIPLES

The primary physical and chemical processes that can influence contaminant concentrations and migration include:

- Adsorption to soil;
- Leaching or dissolution into groundwater;
- Volatilization; and
- Degradation.

Organic compounds can undergo all of the processes listed above while inorganics are typically susceptible only to adsorption and leaching. Physical-chemical properties that influence the processes listed above are functions of the compound's molecular weight and chemical structure and include solubility, organic carbon-water partition coefficient (K_{oc}), and the air-water (Henry's law) partition coefficient (H). In general, adsorption increases with increasing molecular weight while solubility, degradation rates, and volatility decrease.

6.1.1 Contaminant Dissolution and Partitioning to Water

Contaminant adsorption to soil, partitioning between soil and water, and dissolution to water are closely related. The mechanism of each of these processes varies depending on whether contamination is present as a saturated, free-phase material in soil, or whether compounds are adsorbed to soil.

Free Phase Release and Residual Saturation

In the case of saturated soil or the presence of free phase petroleum, the effective solubility of the mixture is less than that of the pure compounds and is determined by both their solubility and relative concentration in the mixture according to Raoult's law.

$$Sol_{i(eff)} = Sol_i * X_i$$

Where:

$Sol_{i(eff)}$ = effective solubility for compound i;

Sol_i = solubility of pure compound i; and

X_i = mole fraction of compound i.

Dissolution of Adsorbed Constituents

Compounds adsorbed in soil can undergo leaching and dissolution by infiltrating rain, surface water, or, in the saturated zone, by new, unaffected groundwater moving through a contaminated area.

Organic Compounds

Preferential dissolution of the more soluble, lower molecular weight constituents occurs when contaminants are physically adsorbed to soil and sediment. In this case, the dissolution rate is determined by equilibrium partitioning and is controlled only by the solubility of the individual compounds and their soil/water partition coefficients (K_d). Composition of the mixture does not influence compound solubility. The K_d for each compound is defined as the ratio of soil adsorbed concentration to dissolved concentration and assumed that the sorbed and dissolved concentrations are in equilibrium. The K_d is not routinely available or measured for most organic compounds. Rather, they are calculated from the organic carbon partitioning coefficient (K_{oc}) and the organic carbon fraction (f_{oc}) present in soil using the relationship:

$$K_d = [\text{soil conc}]/[\text{water conc}] = K_{oc} * f_{oc}$$

This empirical relationship is based on the presumption that hydrophobic organic compounds such as PAHs and PCBs adsorb or bind to soil organic matter and not inorganic mineral grains. The equation accurately estimates partition coefficients for soil and sediment organic carbon concentrations between 0.5 and 4 percent. Total organic carbon (TOC) values in the aquifer are generally less than 0.1 percent. Lower values of K_d indicate that compounds are less strongly sorbed to soil and, therefore, preferentially leach or dissolve into the groundwater. The same trend that was observed for saturated or free phase petroleum is predicted for contaminants adsorbed to soil, that is, heavy molecular weight PAHs (HPAHs) and PCBs are strongly adsorbed to soil while light molecular weight PAHs (LPAHs) and gasoline- and diesel-range petroleum hydrocarbons more readily partition to the water phase. Since soil and overlying water chemical concentrations are not in equilibrium due to continual dilution with fresh water and diffusion of dissolved constituents, the dissolution process is ongoing rather than static, and the relative composition of soil contaminants would slowly change over time with concentrations of 2- and 3-ring LPAHs declining relative to HPAH and reducing the overall mobility of the remaining material even farther.

Inorganic Compounds

Inorganics also undergo leaching and dissolution but, unlike organics, their K_d values are not influenced by TOC. Rather, metal solubilities and adsorption can vary widely and are controlled by oxidation state, speciation, associated counter ions, water pH and oxidation-reduction potential, soil particle size, and the type of mineral phase present in the aquifer. Lower values of K_d indicate that metals are less strongly sorbed to soil and, therefore, preferentially leach or dissolve into the aqueous phase. However, because reported metal soil-water partition coefficients cover such a wide range of values, it is not possible to estimate equilibrium groundwater concentrations with any degree of certainty unless site-specific values are determined for K_d.

6.1.2 Contaminant Sorption to Soil

The same processes that govern dissolution of adsorbed contaminants from soil to water also control sorption of dissolved materials to clean or less contaminated soil. Equilibrium partitioning continuously occurs as dissolved constituents, regardless of their source (e.g., released from DNAPL and saturated soil or in contaminated groundwater from upgradient), come in contact with cleaner soil. The K_d is maintained by adsorption of dissolved contaminants from groundwater. Migration of dissolved HPAHs and PCBs is generally considered to be unlikely due their large K_d values. HPAHs and PCBs will be preferentially adsorbed by soil, retarding their migration while gasoline- and diesel-range petroleum hydrocarbons and LPAHs (i.e., naphthalene and 2-methylnaphthalene) will not be as tightly sorbed and may continue to migrate.

6.1.3 Contaminant Retardation and Transport Velocity

The groundwater transport of most organic compounds will be retarded relative to advective groundwater flow due to sorption and interaction with aquifer solid materials. The relative tendency of a chemical to sorb is based on the fraction of organic carbon in the aquifer solids (f_{oc}), the organic carbon partition coefficient (K_{oc}), which is discussed in Section 6.1.1. The difference between the velocity of groundwater and that of a contaminant caused by sorption is described by the coefficient of retardation, R, which is defined as

$$R = \frac{v_x}{v_c}$$

Where:

R = coefficient of retardation;

v_x = average linear groundwater velocity parallel to groundwater flow; and

v_c = average velocity of contaminant parallel to groundwater flow.

The ratio v_x / v_c describes the relative velocity between the groundwater and the dissolved contaminant. When the distribution coefficient $K_d = 0$ (no sorption), the transport velocities of the groundwater and the solute are equal ($v_x = v_c$). If it can be assumed that sorption is adequately described by the distribution coefficient (valid when $f_{oc} > 0.001$), the coefficient of retardation for a dissolved contaminant (for saturated flow) is given by:

$$R = 1 + \frac{\rho_b K_d}{n}$$

Where:

R = coefficient of retardation;

ρ_b = bulk density;

K_d = distribution coefficient; and

n = total porosity.

Substituting the retardation equation into the coefficient of retardation gives:

$$\frac{v_x}{v_c} = 1 + \frac{\rho_b K_d}{n}$$

Solving for the contaminant velocity, v_c, gives:

$$v_c = \frac{v_x}{1 + \frac{\rho_b K_d}{n}}$$

6.1.4 Volatilization

The rate of evaporation of free or adsorbed contaminants is determined by their vapor pressures. For dissolved chemicals, transfer between water and interstitial soil vapor or the atmosphere is controlled by the Henry's law air/water partition constants (H). Compounds with vapor pressures less than 1 mm of mercury and/or Henry's law constants less than approximately 10^{-3} atm-m^3/mole do not exhibit significant partitioning to the vapor phase. Henry's law partition coefficients range from 10^{-3} atm-m^3/mole for LPAHs to 10^{-8} atm-m^3/mole for HPAHs and PCBs indicating little or no transfer from water to air. Likewise, direct evaporation from soil to air is unlikely based on their low vapor pressures.

6.1.5 Degradation

Numerous chemicals in the environment are subject to naturally occurring biotic (biologically based) and abiotic (non-biologically based) transformation reactions that result in the degradation of the chemical. Many organic compounds are subject to biodegradation reactions under aerobic (in the presence of oxygen) and anaerobic (in the absence of oxygen) conditions. During biodegradation, naturally occurring microorganisms in the subsurface transform a chemical to another state as a direct or indirect consequence of their metabolic processes. Biodegradation reactions often break down organic chemicals to less toxic forms.

6.2 FREE PHASE PETROLEUM/PETROLEUM HYDROCARBONS

Petroleum hydrocarbon products are used as fuels, lubricants, and solvents in a broad range of commercial and industrial applications. Commonly known petroleum hydrocarbon products include gasoline, diesel, and oil. Petroleum hydrocarbons are present in soil and groundwater at the Facility, and, of the various types of petroleum hydrocarbons, diesel and heavy oil have been identified as COPCs. The diesel-range petroleum hydrocarbons specifically include Kensol. Kensol is a brand of lubricant, which was historically used at the Facility as a lubricant for cold rolling aluminum and was identified in historical environmental releases at the Facility. Use of Kensol at the Facility has been discontinued and has been replaced with Magiesol, which also is a petroleum-based product with properties similar to Kensol.

6.2.1 Chemical and Physical Properties

Diesel- and heavy oil-range petroleum hydrocarbons consist of complex mixtures of aliphatic and aromatic hydrocarbons. Generally, the composition of diesel- and heavy oil-range petroleum hydrocarbons consist mostly of aliphatic organic compounds (approximately 64 to 90 percent and 73 to 80 percent, respectively), with the remainder consisting of mostly aromatics (ATSDR 1995a and 1997). Other compounds and additives may constitute a lesser percentage of the mixture. The specific composition of the various petroleum hydrocarbon product mixtures is based on physical and performance-based criteria and not necessarily on specific formulas. As a result, product compositions can vary depending on factors such as the properties of the crude oil refined in production, the desired type of end product, the time of year of production, and the addition of supplemental performance-improving compounds. Diesel-range petroleum hydrocarbons generally contain lower molecular weight and shorter chain organic compounds than heavy oil-range petroleum hydrocarbons. Diesel-range petroleum hydrocarbons primarily contain approximately 9 to 20 carbon atoms, whereas heavy oil-range petroleum hydrocarbons may contain approximately 15 to 50 carbon atoms (ATSDR 1995a and 1997). For comparison, gasoline-range petroleum hydrocarbons contain approximately 4 to 13 carbon atoms (ATSDR 1995b).

The chemical and physical properties of diesel and heavy oil depend on the properties of the individual components of the petroleum hydrocarbon mixtures. Table 6-1 summarizes petroleum hydrocarbon chemical and physical properties by equivalent carbon (EC) fraction (i.e., by fractions having intrinsically similar physical and chemical properties), as well as for selected petroleum constituents. Table 6-2 summarizes the properties of selected Kensol and Magiesol formulations. In general, diesel and heavy oil are liquid at room temperature and are less dense than water. Petroleum mixtures may contain constituents that have significant solubility in water, but as a whole the mixtures tend to be sparingly soluble. In general, the shorter chain or more polar constituents exhibit greater aqueous solubility, and the longer chain or less polar constituents have lower or negligible solubility. Similarly, petroleum hydrocarbon mixtures contain components with a range of volatilities, as determined by their respective vapor pressures. Generally, the lighter end and less polar components exhibit greater vapor pressures and thus a greater tendency to evaporate.

The petroleum hydrocarbons historically used at the Facility are generally sparingly soluble in groundwater, with maximum dissolved concentrations expected to be less than 10 mg/L (Lu and Polak 1973, Shiu et al. 1990). Observed dissolved hydrocarbon concentrations range from non-detect (at reporting limits as low as 0.1 to 6 mg/L) in samples from wells with no product accumulation or sheen, up to 92 mg/L in wells with sheen reported, and up to 950 mg/L in samples from wells with free phase petroleum accumulations. It should be noted that the higher concentrations may indicate the likely presence of globules, emulsified oil, or silt with sorbed oil in the sample, which is possibly a consequence of the sampling procedure. This is especially true for samples collected with bailers.

6.2.2 Fate and Transport Mechanisms

Based on the chemical and physical properties of individual constituents of petroleum mixtures, petroleum hydrocarbons can exist in four phases:

- Free phase liquid;
- Dissolved in the aqueous phase;
- Vapor in the gas phase; or
- Adsorbed onto organic solids or soil particles.

The degree of partitioning of the various constituents of petroleum hydrocarbon mixtures is determined by their chemical and physical properties, in addition to their equilibrium partitioning properties, as defined by air-water partition coefficients (Henry's Law constants) and solid-water partition coefficients.

In general, when diesel or heavy oil is released into the subsurface, it passes through progressive stages of migration. At first, the petroleum liquid travels through the unsaturated zone downward by gravity as free phase product, with some lateral spreading caused by capillary forces. In the next stage, if groundwater is present, the downward migration of the petroleum hydrocarbon liquid stops when it reaches the water table because of its low density and general immiscibility with water, but lateral spreading continues near the water table surface from gradients caused by gravity and by capillary forces. Additional spreading is further caused by seasonal fluctuations in the water table elevation, essentially smearing the petroleum hydrocarbon liquid vertically across the soil matrix. As the petroleum hydrocarbon liquid continues to spread, the degree of saturation of the liquid in soil, and the driving forces causing the migration of the liquid, will decrease until the point of residual saturation is attained, which is the point below which the liquid becomes essentially immobile. At residual saturation, the petroleum hydrocarbon liquid exists as discrete globules or droplets trapped in the soil pore spaces.

During the migration of the petroleum hydrocarbon liquid described above, partitioning of the petroleum constituents occurs. In the unsaturated zone, volatile constituents tend to evaporate, less polar constituents sorb onto soil, and droplets of free phase liquid become trapped in soil pore spaces. If the petroleum hydrocarbon liquid comes into contact with groundwater, the soluble constituents dissolve and migrate with groundwater flow. Further partitioning occurs from the dissolved phase as the groundwater travels and the dissolved constituents equilibrate with the vapor and sorbed phases. In general, constituents with lower solubilities but higher vapor pressures will enter the vapor phase (as indicated by higher Henry's Law constants). Constituents that are non-polar tend to associate more strongly with less polar phases, and thus will tend to leave the dissolved phase and sorb onto organic solids in the soil matrix (as indicated by higher solid-water partition coefficients). This sorption process has a retarding effect on the migration of petroleum hydrocarbons with groundwater flow.

As the above processes take place, the composition of the petroleum hydrocarbon mixture changes. The composition of the mixture may change further as constituents of the mixture are subjected to microbial decomposition in both the saturated and unsaturated zones when conditions exist that promote microbial activity, such as aerobic conditions and the bio-availability of necessary nutrients. In general, the lower molecular weight petroleum hydrocarbon constituents are more subject to microbial decomposition than higher molecular weight constituents. Typically microbial degradation occurs at a faster rate in the saturated zone than in the unsaturated zone. In the saturated zone, microbial degradation of petroleum hydrocarbon constituents adds to the retarding effect on migration described above.

Anthropomorphic factors also influence the fate and transport of petroleum hydrocarbons in the subsurface. Processes such as groundwater containment via pumping and recovery of free phase product by pumping or skimming can not only alter or stop the subsurface migration of petroleum hydrocarbons but also removes a portion of their mass from the subsurface.

6.2.3 Observed Conditions

Free Phase Petroleum

The fate of free phase petroleum at the Facility includes:

- Sorption to soil;
- Dissolution and subsequent transport in groundwater;
- Natural and enhanced degradation; and
- Recovery by product skimming equipment.

Free phase petroleum has been mainly detected in site monitoring wells clustered in the general vicinity of the Oil House, the Wastewater Treatment area, and to a lesser degree the Oil Reclamation Building (ORB). The source of free phase petroleum is from accidental spills and releases from petroleum storage and/or distribution facilities. Only floating or light non-aqueous phase liquids (LNAPLs) have been identified at the Facility.

As indicated by historical product measurements, one pool in the Wastewater Treatment area and one pool in the Oil House area, and one small pool in the ORB area are present (Figure 5-9). The two small pools currently present in the Oil House and Wastewater Treatment areas are remnants of historical larger pools that were once observed in these areas (Figure 5-14). Apparent free phase petroleum thicknesses have decreased by as much as 50 to 80 percent or more in wells completed in each area. The small free phase plume in the ORB area was not identified until the mid 2000's and has not been monitored for a long enough period of time to establish a trend. However, known historical sources of petroleum to soil in the ORB area have been eliminated.

While the thickness and distribution of free phase petroleum vary with fluctuating water levels, there is no evidence of lateral movement of the free phase petroleum pools. The existing IRM implemented by Kaiser aids in stabilizing and reducing the free phase petroleum pools through groundwater depression, capture, and biodegradation. As discussed in Sections 5.3, and shown on Figure 5-15 and 5-16, free phase petroleum measurements in the Oil House area wells indicate a general decline in thickness and extent following installation of a water table depression well (OH-EW-1) in late 1993 and initiation of the skimming pump in mid-1994. Because of capillary effects, it is anticipated that recovery efficiency will decline over time and that less than 25 percent of the measurable free phase petroleum may be recoverable (Mercer and Cohen 1990). The remainder of the free phase petroleum will be trapped in soil pore spaces above and below the water table and will eventually biodegrade. Biodegradation of free phase petroleum may proceed at low rates. Degradation of dissolved phase petroleum hydrocarbons is more likely to occur at a much faster rate.

The fact that the two main free phase petroleum pools appear to be immobilized and are shrinking suggests that the forces that tend to cause the pools to spread are in equilibrium with, or are less than, the factors causing dissolution or degradation of the pools, in combination with the containment, skimming, and enhanced biodegradation effects of the IRM.

Dissolved Petroleum Hydrocarbons

The fate of petroleum hydrocarbons dissolved in groundwater at the Facility consists of:

- Sorption to soil;
- Dissolution and subsequent transport in groundwater;
- Containment by groundwater extraction wells;
- Natural and enhanced degradation; and
- Recovery by the existing IRM system.

Dissolved petroleum hydrocarbons are present in groundwater samples collected in the vicinity of the Oil House, Wastewater Treatment area, and ORB areas (Figures 5-1 and 5-3). The dissolved petroleum hydrocarbons originate primarily from dissolution of free phase petroleum, and to a lesser extent from dissolution and mobilization of hydrocarbons sorbed onto soils in the smear zone. Dissolved petroleum hydrocarbon concentrations greater than 1 mg/L extend approximately 1,000 feet downgradient (southwest) of the Oil House area free phase petroleum pool and approximately 200 feet southwest of the Wastewater Treatment area free phase petroleum pool. Site data show that the dissolved hydrocarbon pools are shrinking with time. This observation suggests that equilibrium has been reached between dispersion and degradation on the one hand and advective transport with groundwater on the other. The dissolved plumes will exist for as long as free phase petroleum is present and residual hydrocarbons are present in the smear zone.. The ORB petroleum plume area extends about 400 feet southwest of the ORB. As mentioned earlier, it has not been monitored long enough to determine the status of this plume but we expect its migration potential to be similar to the Oil House and Wastewater petroleum plume areas.

Because of the substantial thickness of the vadose zone (40 to 70 feet) and the relatively high rate of water evaporation compared to precipitation,, infiltration is unlikely to be a major force for mobilizing hydrocarbons via dissolution of residual free phase petroleum during the summer season. However, infiltration from precipitation could be significant mobilizing factor during the winter season (October to March) when 70 percent of the rainfall occurs.

6.3 PCBS

6.3.1 Introduction

PCBs are a class of synthetic chlorinated aromatic compounds, which have had widespread industrial and commercial applications based on their physical and chemical stability as well as their high electrical resistance. These industrially desirable properties have led to the use of PCBs in a wide range of products including dielectric fluids in capacitors and transformers, hydraulic fluid, heat transfer fluids, fire retardants, plasticizers, adhesives, sealants, printing ink, color dispersants, etc. PCBs were first synthesized in the late 1800s but were not produced industrially until 1929. Virtually all PCBs used in the United States were manufactured and sold by Monsanto Chemical Company under the trade name Aroclor until 1977 when production was voluntarily stopped (Hutzinger et al. 1983).

PCBs are present in soil and groundwater at the Facility. PCBs in groundwater are present in the Remelt/Hotline area. The PCBs present in the Oil House and Wastewater Treatment areas are generally thought to be associated with the free phase petroleum pools in these areas, rather than being dissolved in groundwater (Figure 5-3). The Oil House and Wastewater Treatment plumes are associated with petroleum hydrocarbons whereas the Remelt/Hotline plume is notable for the absence of petroleum hydrocarbons. Our discussion of PCBs in groundwater focus on the following three parameters.

- The chemical and physical properties of PCBs;
- The mechanisms influencing the transport of PCBs including the important role of colloidal transport; and
- The vertical distribution of PCBs below the water table.

6.3.2 Chemical Structure and Composition

Aroclor mixtures are designated by a four-digit number. The first two digits indicate the basic structure of each molecule (12 = chlorinated biphenyl; 54 = chlorinated terphenyl; 25 and 44 indicate blends of PCBs and chlorinated terphenyls) and the last two digits specify the average weight percent of chlorine in the Aroclor mixture. For example, Aroclor-1242 is a chlorinated biphenyl that contains approximately 42 percent chlorine. Aroclor 1016 does not follow this convention. This mixture contains 41 percent chlorine by weight but the concentrations of penta-, hexa-, and heptachlorobiphenyls has been significantly reduced compared to Aroclor 1242. Table 6-3 presents the percent chlorine, average number of chlorine atoms per molecule and average molecular weight for a number of commercial Aroclor PCB mixtures.

There are 209 possible individual chlorinated biphenyl compounds with the general chemical formula $C_{12}H_{10n}Cl_{-n}$ as shown on Figure 6-1. Individual PCB compounds, also known as congeners, differ only by the number of chlorine atoms and their relative positions on the biphenyl rings. In addition to their Aroclor designation and proper chemical names, each PCB congener has been assigned a unique identification number ranging from 1 to 209 by the IUPAC numbering system based on structure and degree of chlorination.

Homologs are groups of PCB congeners containing the same number of chlorine atoms. For example, the tetrachlorobiphenyls are the homolog group of PCB congeners (total of 42) that contain four chlorine substituents in any arrangement on the rings. The number of individual congeners in each homolog group is shown in Table 6-4.

The number of chlorine atoms present and their position on the rings have major effects on the physical, chemical, and toxicological properties of the individual compounds. Most Aroclor mixtures contain primarily congeners of tri-, tetra-, and pentachlorobiphenyls with smaller amounts of the di- and hexachlorinated compounds (Hatton 1979). It has been shown that commercial Aroclor mixtures contain 132 of the possible 209 PCB congeners (Schulz et al. 1989).

Homolog-specific composition by number of chlorine atom substitution is shown in Table 6-5 for several Aroclor mixtures.

6.3.3 PCB Applications and Use

PCBs have been used in a wide range of applications and products including:

- Dielectric fluids in capacitors and transformers;
- Hydraulic fluid;
- Turbine and vacuum pump oil;
- Lubricants;
- Metal cutting oils;
- Foundry metal casting molds;
- Heat transfer fluids;
- Fire retardants;
- Thermal insulation material including fiberglass, felt, foam, and cork;
- Plasticizers;
- Adhesives;
- Sealants;

- Binders;
- Surface coatings;
- Textiles;
- Printing ink;
- Carbonless copy paper; and
- Color dispersants.

Common historical uses of PCBs listed by Aroclor are presented in Table 6-6.

6.3.4 Chemical and Physical Properties

PCBs as a class exhibit high thermal stability; strong resistance to oxidation, acids, bases, and other chemical reagents; as well as excellent electrical insulating (dielectric) properties. They generally have low water solubility and vapor pressure and strongly adsorb to organic matter. Properties of individual chlorinated biphenyl congeners are most strongly influenced by their degree of chlorination and molecular weight. Solubility and vapor pressure both decrease with increasing chlorine content. Water solubilities have been reported (Monsanto 1972) for Aroclors 1242 (200 ug/L), 1248 (100 ug/L), 1254 (40 ug/L), and 1260 (25 ug/L) although results are probably biased due to selective dissolution of only the lower molecular weight components in the Aroclor mixtures. Aroclors are denser than water. While pure chlorinated biphenyls are solids at room temperature, Aroclor mixtures are fluid oils (1221, 1232, 1242, 1248), viscous liquids (1254), or sticky resins (1260 and 1262). Physical properties for a number of Aroclors are presented in Table 6-7.

6.3.5 Fate and Transport Properties

Properties that influence the environmental fate and transport of individual chlorinated biphenyl congeners are primarily vapor pressure, solubility, and adsorption or partitioning to solids and organic matter. The inter-relationships among these parameters are illustrated on Figure 6-2. Individual values for these primary fate and transport parameters are most strongly influenced by the degree of chlorination. Solubility and vapor pressure both decrease with increasing chlorine content while adsorption and partitioning to solids and organic matter increase with increasing chlorine content.

While fate and transport property values are often reported in the scientific literature for Aroclors, it is not appropriate to use them for estimating chemical transport since Aroclors are mixtures of approximately 130 individual congeners, each of which has different chemical and physical properties.

Vapor Pressure

PCBs generally have very low vapor pressures. Vapor pressure decreases with increasing chlorine content. Monochlorobiphenyl homologs have the highest vapor pressures whereas decachlorobiphenyl has the lowest vapor pressure.

Vapor pressures for mono- and dichlorobiphenyls range from 1×10^{-3} to 1×10^{-4} torr (mm of mercury) at 25°C. Vapor pressures for tri-, tetra-, and pentachlorobiphenyls range from approximately 10^{-5} to 10^{-6} torr, and vapor pressures for more highly chlorinated congeners typically range from 10^{-6} to 10^{-7} torr. Based on these low vapor pressures, volatilization is not expected to be significant compared to other transport pathways at Kaiser. Vapor pressures for PCB congeners are presented in Table 6-8.

Solubility

PCBs generally have very low water solubility. Solubility rapidly decreases with increasing chlorine content. Monochlorobiphenyl homologs have the highest solubility whereas decachlorobiphenyl has the lowest solubility.

Water solubility for mono and dichlorobiphenyls ranges from 5.9 to 0.08 mg/L. Solubilities for tri-, tetra-, and pentachlorobiphenyls range from 0.14 to 0.0068 mg/L and for more highly chlorinated congeners solubilities are 0.0013 to 0.00011 mg/L.

For Aroclor mixtures or PCBs dissolved in oil, solubility would be lower than reported for the individual pure congeners. In these cases, solubility is proportional to the individual congener mole fraction in the mixture and can be calculated from Raoult's Law assuming the complete composition or the average molecular weight of the mixture is known.

In the absence of significant soil adsorption or partitioning, dissolution into water is potentially a significant transport pathway only for the least chlorinated congeners. Published solubility for individual PCB congeners are presented in Table 6-8.

Water-Air (Henry's Law) Partition Coefficient

The Henry's Law water-air partitioning constant (H) is indicative of the degree of partitioning between water and air and is calculated as:

$$H = \text{Concentration}_{\text{air}}/\text{Concentration}_{\text{water}}$$

PCBs have very low Henry's Law constants ranging from approximately 10^{-4} to 10^{-6} atm-m^3/mole indicating that little partitioning occurs to the gas phase. Henry's Law constants follow the same trend as solubility and vapor pressure, decreasing with increasing chlorine content. Henry's Law constants for individual PCB congeners are presented in Table 6-8.

Adsorption (Soil-Water Partition Coefficient)

PCBs are extremely hydrophobic and adsorb strongly to soil and soil organic matter. The soil-water equilibrium partitioning coefficient, K_d, is the most significant parameter for evaluating the mobility of PCBs from soil to groundwater. At trace concentrations, the soil water partitioning coefficient can be defined as:

$$K_d = C_s/C_w$$

where C_s and C_w are the soil and groundwater concentrations, respectively. For hydrophobic compounds such as PCBs, partitioning is controlled primarily by the organic matter in the soil, although significant adsorption to the soil mineral matrix also occurs. The partitioning coefficient is typically normalized to the soil organic carbon fraction, f_{oc}, where:

$$K_{oc} = K_d/f_{oc}$$

or

$$K_d = K_{oc} \times f_{oc}$$

Reported K_{oc} values for mono- and dichlorobiphenyls range from 2.5×10^4 to 7.6×10^4 L/kg. K_{oc} values for tri-, tetra-, and pentachlorobiphenyls range from approximately 4.7×10^4 to 8.9×10^5 L/kg, K_{oc} values for more highly chlorinated congeners range from 6.2×10^5 to 1.3×10^7 L/kg. Based on these high K_{oc} values, adsorption to soil and colloidal particles is expected to be the most significant factor in PCB transport, particularly if organic matter is present in the soil. Organic carbon-water partition coefficients for PCB congeners are presented in Table 6-8.

Effects of Non-Aqueous Liquid Phases on Congener Properties

In the case of PCB solutions, (e.g., PCBs dissolved in oil or free phase Aroclor mixtures adsorbed to soil) colligative properties such as solubility and vapor pressure are different than those for the pure congeners due to preferential partitioning between the oil phase and water or air. For PCBs in non-aqueous phases, solubility and vapor pressure are proportional to the individual congener mole fraction in the solution and can be calculated from Raoult's Law as shown below for water solubility:

$$\text{Mixture Solubility}_{\text{(individual congener)}} = \text{Solubility}_{\text{(pure congener)}} \text{ x mole fraction}_{\text{(individual congener)}}$$

A similar equation is used to calculate partial vapor pressures of individual PCB congeners from oil solutions or free phase Aroclor mixtures adsorbed to soil. Use of Raoult's Law assumes the complete composition (i.e., components in addition to PCBs of interest) and the average molecular weight of the non-aqueous or adsorbed phase are known. Typically, water solubility and vapor pressure for PCB congeners in non-aqueous solution are lower than those for the pure compounds because the congeners preferentially partition into the solution (oily) phase rather than water or air.

For Aroclor mixtures adsorbed to soil or for PCBs dissolved in oil, use of soil-water partition coefficients to estimate PCB partitioning without applying Raoult's Law will overestimate groundwater concentrations.

6.3.6 Degradation of PCBs

PCBs resist chemical or biological transformation, but biological transformation nonetheless can occur under suitable environmental condition. Highly chlorinated PCBs can undergo a slow process of microbially mediated reductive dehalogenation (Abramowicz 1990; Bedard and Quensen 1995; Boyle et al. 1992; Cerniglia 1992 and 1993; Quensen et al. 1988; Safe 1994; and Tiedje et al. 1993). The presence in the environment of congeners containing fewer chlorine atoms than the parent compounds is evidence that reductive dehalogenation reactions occur in nature. Lightly chlorinated PCBs (those containing one to four chlorine atoms) can be aerobically biodegraded at a rate that decreases as the number of chlorine atoms increases (Harkness et al., 1993). PCBs trapped within free phase petroleum or sorbed onto solids are not accessible to microbial destruction, so the rate of PCB dissolution is an important determinant of the rate of natural attenuation by biodegradation.

PCBs are very stable, or persistent, when released to the environment, and therefore, are slow to degrade. It is unlikely that degradation is occurring to any significant extent in groundwater at the Facility.

6.3.7 Fate and Transport of PCBs in Groundwater

PCBs move in groundwater as flowing free phase liquids, dissolved species, or combined with moving particulates. Usually the transport of dissolved contaminants in groundwater is predicted using the distribution between two phases: the mobile dissolved phase and a stationary sorbed phase associated with the aquifer matrix solids. A high affinity for organic matter and low dissolution rates are typically considered to the most important factors limiting the mobility and transport of PCBs in groundwater. Solubility and volatility also tends to be very low for PCBs, indicating that they are not readily dissolved in groundwater. Furthermore, the high retardation factors that characterize PCBs highlight the tendency for the migration of these chemicals to be greatly slowed by sorption reactions. Typical retardation factors of PCBs indicate that chemical migration rates for dissolved PCBs are typically 50 to 3,500 times slower than the rate of groundwater movement. The presence of the Remelt/Hot Line PCB plume greater than 2,000 feet in length suggests that dissolved phase is not the only process controlling the transport of PCBs.

Colloidal Transport of PCBs

Particulates that can move through soil with groundwater must be small enough to move through the soil pore spaces. Colloids are particles with diameters less than 10 um**,** which have been shown to move through soil pores in a variety of groundwater systems. Because of their physical and chemical properties, colloids are a special class of matter with properties that lie between those of the dissolved and solid states.

There are many potential sources of colloidal material in groundwater. Colloids are formed in soil when fragments of soil, mineral, or contaminants particles become detached from their parent solid material. They can be carried to the water table when water from precipitation percolates downward through the soil. Colloids will also form as fine precipitates when dissolved minerals in groundwater undergo pH or redox potential changes. Colloids are often introduced directly into groundwater from landfills (Baumann et al 2006.), because landfill leachate provides a conducive environment for producing a variety of inorganic and organic colloids and a geochemical environment for mobilizing colloids. Colloids can form as emulsions of small droplets from free phase petroleum or other immiscible liquids. A variety of organic materials can exist as colloids in groundwater such as humic substances and “biocolloids” such as microorganisms (McCarthy and Deguildre 1993; Ryan and Elimelech 1996).

In the low velocity flow of groundwater, particles larger than 2 um tend to settle by gravity. Particles smaller than 0.1 um tend to sorb readily to larger soil particles, becoming retarded or immoblized. Thus, particles in the range of 0.1 to 2 um are thought to be the most mobile in groundwater.

Colloids need to be mobilized either by chemical or physical process. Chemical controls favoring mobilization include changes in solution chemistry such as changes in ionic strength, pH, organic matter, adsoption of ions, and macromolecules that alter surface charge. Physical processes include pumping, sampling, flow velocity, and rapid infiltration.

Colloids have a high surface area to mass ratio due to their very small size. Groundwater concentrations of colloidal material can be as high as 75 mg/L, corresponding to as many as 10^{12} particles per liter. This represents a large surface area available for transporting sorbed contaminants. For migration of a colloidal particle to occur in an aquifer, the diameter of the migrating colloidal particle must be significantly smaller than the diameter of the soil pore. If this is not the case, the particle is filtered from the migrating liquid.

Constituents of low solubility can move with groundwater as colloids or attached by sorption or occlusion with colloids, resulting in unexpected mobility for otherwise low-solubility materials. When constituents are sorbed to colloids, their transport behavior is determined by the properties of the colloid, not the properties of the sorbed constituent.

A groundwater sample from well HL-MW-5 collected in 2004 was subjected to colloidal particle characterization. Analysis indicated a particle grain size ranging from smaller than 0.3 µm to greater than 25 µm in length. The effective diameter of the majority of particles was less than 1.6 µm, indicating that the majority of the particulate matter was in the optimal range for transport. Most of the particulate material analyzed in the sample appeared to be quartz (see Appendix D).

Another line of evidence that supports the concept of colloidal transport in the groundwater at the Facility were the results of the treatability batch tests (Hart Crowser 2004 and 2005a). The tests were performed to assess the effectiveness of several water treatment trains to remove trace concentrations of PCBs from groundwater. In samples treated with activated carbon and a flocculent after acidification to pH levels of 6 and 4, respectively, PCB removal efficiencies of 91.5 and 97.2 percent were achieved. This was a significant improvement to the removal efficiency compared to adding activated carbon alone. The apparent improvement of removal efficiency relative to a decrease in pH was thought to be the results of the effect of pH on the surface charge of colloids and adsorbents. Changes in surface charge affect how colloids and adsorbents react with aqueous species. A decrease in pH could increase the affinity of colloid for adsorbing dissolved PCBs. Additionally, pH affects how colloids interact, with increased particle attraction and flocculation occurring at certain pH levels, thus producing larger particles more easily removed from solution through filtration.

A combination of these effects may have produced the significant PCB removal observed in the test scenario.

Based on the available evidence, colloid particles in groundwater at the Facility likely play an important role in facilitating the transport of PCBs in groundwater.

PCB Congener Model

Objectives and Methodology

Beginning in October 2007, Kaiser initiated groundwater sampling and PCB congener analysis of selected wells within the known groundwater Remelt/Hot Line PCB plume in the northwest portion of the Facility. The purpose of this work was to obtain information to help evaluate whether there may be more PCB source areas contributing to the groundwater PCB plume other than the known sources associated with the Remelt/Hot Line area of the mill and to evaluate the significance of colloidal transport within the PCB plume. As part of this investigation, additional wells were installed downgradient of the Remelt area along the centerline of the PCB plume (i.e., wells HL-MW-29S and HL-MW-30S) to provide better plume characterization downgradient of the Remelt area and within the West Landfill area. Two rounds of groundwater PCB congener sampling were conducted at selected wells during regularly scheduled quarterly groundwater sampling events at the Facility. Section 3 provides a description of the groundwater sample collection and congener analysis procedures.

To facilitate data evaluation, a transient, two-dimensional PCB congener and colloid transport model was developed of the shallow aquifer at the Facility. The model was developed to provide an important computational tool that could be used to analyze the October 2007 and April 2008 congener data sets and advance our understanding of the key PCB transport mechanisms at the Facility. In addition to congener data, the model uses many types of hydrogeologic and chemical data that have been collected during previous investigations (e.g., soil organic carbon, hydraulic conductivity, hydraulic gradient, physical colloid characterization, etc.). Model calibration was focused on using plume centerline concentration variations for total PCBs and specific congener homolog groups.

The PCB congener and colloid transport model is a sophisticated and comprehensive analysis tool that incorporates many chemical transport mechanisms. The model simulates the transport of all 209 PCB congeners simultaneously, both as aqueous phase (i.e., dissolved in groundwater) and colloidal (sorbed to mobile colloids flowing with the groundwater) fractions. Colloid filtration due to interactions with the porous media is also included.

Because of the high groundwater velocities at the Facility, the model further incorporates rate-limited soil to groundwater chemical partitioning (non-equilibrium chemical sorption) and non-equilibrium groundwater to colloid PCB sorption mechanisms. Known chemical properties of PCB compounds were used to assign different soil/water partition coefficients to each congener based on published literature values and adjust these coefficients during model calibration. It is postulated that under typical conditions involving partitioning mechanisms congener homolog groups with similar partitioning coefficients should migrate at predictable rates based on various parameters (e.g., organic carbon content in soil and groundwater, aquifer flow rates, etc.). To determine if there are colloidal transport mechanisms involved with the migration of PCBs in groundwater in the Remelt/Hot Line area at the Facility, we also evaluated the potential for this process to be an important transport mechanism.

We calibrated the model to existing site conditions and the PCB congener data sets. Appendix C provides details of the model calibration process, relevant governing groundwater flow and PCB transport equations, numerical solution techniques, and model input data. The following discussion presents the results of these analyses and our interpretations and conclusions.

Results and Interpretation

Figure 6-3 is a graph of simulated and measured PCB concentrations in groundwater versus distance along the centerline of the plume. The data are analytical results for the two rounds of groundwater PCB congener samples from monitoring wells located close to the plume centerline. The vertical axis of the graph is a logarithmic scale. The square-shaped symbols represent data from the October 2007 sampling round, while the circles denote measurements from the second round in April 2008. The larger red symbols represent the total PCB concentration in each groundwater sample (i.e., sum of all detected congeners). The other color-coded square symbols denote the total measured congener concentrations (corrected for laboratory blank contamination, as necessary) in various PCB homolog groups based on samples collected in October 2007. Similarly, the remaining circular symbols show homolog group concentrations for April 2008. Specifically, the congener color-coding scheme is as follows:

- Monochlorobiphenyls (black);
- Dichlorobiphenyls (cyan);
- Trichlorobiphenyls (blue);
- Tetrachlorobiphenyls (green);
- Pentachlorobiphenyls (reddish purple);
- Hexachlorobiphenyls (orange);

- Heptachlorobiphenyls (purple); and
- Octachlorobiphenyls (dark purple).

Homolog group concentrations that are below the detection limit are plotted as one-half the detection limit. The model results for each of these homolog groups are the curves labeled 1 through 8, respectively. Figure 6-3 does not contain the nona- and decachlorobiphenyls data because these groups were not consistently detected in downgradient wells.

For chemical transport analyses, grouping the congener data into homolog groups is convenient and instructive because the relative mobility of each group of compounds decreases significantly with increasing degree of chlorination when aqueous phase migration in groundwater is the only transport mechanism (i.e., no colloidal transport). The decreased mobility of the more chlorinated compounds, generally referred to as chemical retardation, is caused by the adsorption of the congeners to immobile soil grains and the very low aqueous phase solubilities of the highly chlorinated homolog groups. For example, without colloids, the effective transport rate of heptachlorobiphenyls is about 30 times smaller than the transport rate for trichlorobiphenyl. Across the entire range of homolog groups (i.e., from mono- to decachlorobiphenyls) the relative mobility decreases by a factor of more than 700. Therefore, under “normal” transport conditions where equilibrium soil-water partitioning of PCBs exists and colloidal transport of congeners is not important, we would expect on average that trichlorobiphenyls would travel on the order of 30 times farther downgradient from the source area than heptachlorobiphenyls within a specific time interval.

Transport Model with Colloids

The curves on Figure 6-3 are simulated PCB concentrations along the plume centerline based on the calibrated congener and colloid transport model (Appendix C). The thicker red curve represents total “mobile” PCB concentration (nanograms per liter [ng/L] or parts per trillion [ppt]) in groundwater. The mobile PCB concentration represents the sum of the dissolved (aqueous phase) and colloidal (PCBs adsorbed to colloid particles) PCB mass in a unit volume of water. As discussed above, the remaining eight labeled curves are the model simulated groundwater concentrations for the di- through octachlorobiphenyls homolog groups.

As known from historical plume maps for the site, PCB concentrations decrease significantly with downgradient distance, as reflected on Figure 6-3. A major reason for this reduction is the plume is a transient system in which PCB constituents are migrating very slowly downgradient from the source area and a "steady state" may not have been established. In this type of transient chemical transport regime, concentrations are naturally higher in areas located closer (i.e., smaller travel time) to the source. The gradual transverse mixing of groundwater in the center of the plume with lower PCB concentration areas north and south of the plume centerline, and groundwater deeper in the aquifer, also reduces PCB concentrations with travel distance. This horizontal and vertical mixing of groundwater is a dispersion (i.e., dilution) process that is created by variations in the groundwater flow direction and rate. These variations are due to spatial hydraulic conductivity variations in the aquifer, seasonal changes in the flow direction, vertical fluctuations in the water table elevation, etc. Some additional dilution likely occurs due to rainwater infiltration.

The major difference between the homolog group concentrations at any distance along the plume centerline is the significant concentration reduction with increase in congener chlorination, as evidenced by the vertical separation of the congener curves on the graph. This is caused in large part by the much lower solubility of the highly chlorinated congeners compared to the less chlorinated compounds. A commonly used measure of these concentration differences for a chemical mixture such as PCBs is the congener group mass fraction, M (M = congener concentration/total PCB concentration). Similarly, we may define a homolog mass fraction, M_i, where "i" denotes groups 1 through 10. For example, in the upgradient portion of the plume (well RM-MW-17S) the homolog group mass fractions are:

- M_3 = 40.2 percent;
- M_4 = 48.5 percent;
- M_5 = 5.7 percent (factor of 7.1 lower than M_3);
- M_6 = 0.22 percent (factor of 180 lower than M_3);
- M_7 = 0.020 percent (factor of 2,000 lower than M_3); and
- M_8 = 0.0027 percent (factor of 15,000 lower than M_3).

At downgradient well location (HL-MW-29S):

- M_3 = 41.9 percent;
- M_4 = 50.7 percent;
- M_5 = 5.2 percent (factor of 8.1 lower than M_3);
- M_6 = 0.12 percent (factor of 350 lower than M_3);
- M_7 = 0.0029 percent (April 2008; factor of 14,000 lower than M_3); and
- M_8 = 0.0013 percent (factor of 32,000 lower than M_3).

Farther downgradient in the plume at monitoring well HL-MW-30S:

- M_3 = 46.6 percent;

- M_4 = 48.3 percent; M_5 = 3.5 percent (factor of 13 lower than M_3);
- M_6 = 0.042 percent (factor of 1,100 lower than M_3);
- M_7 = 0.0018 percent (April 2008; factor of 26,000 lower than M_3); and
- M_8 = 0.00068 percent (April 2008; factor of 70,000 lower than M_3).

Figure 6-4 is a graph of simulated and measured PCB congener homolog group mass fractions in groundwater versus distance along the centerline of the plume. In general the largest penta-, hexa-, hepta-, and octachlorobiphenyls concentration reductions (factor of 3 to 4) occur in the first 200 to 300 meters (600 to 900 feet) of the plume due to sorption of these compounds to immobile soil grains (i.e., chemical retardation). The simulated mass fraction curves show this same trend as a downward slope. In the downgradient portion of the plume (distance = 400 to 700 m [1,200 to 2,100 feet]) the measured values of M_5 through M_8 generally remain about the same or increase. The simulated mass fraction curves also show a small upward slope in this region. These differences in the slopes of the mass fraction curves in upgradient and downgradient parts of the PCB plume suggest changes in the dominant mass transport mechanisms as a function of distance along the plume centerline.

As discussed in the following section, the congener mass fraction variations (Figure 6-4) and the persistence of low concentrations of highly chlorinated PCB congeners (Figure 6-3) are consistent with colloid-facilitated transport in the aquifer. These observed trends in congener concentrations and mass fractions cannot be explained by aqueous phase PCB transport alone (i.e., without colloids). Furthermore, the congener data indicate, as expected, the importance of colloidal transport increases with the degree of congener chlorination. This variation results from the greater attraction of the highly chlorinated compounds for the sorption sites on the colloidal particles. For example, due to the greater sorption capacity of the highly chlorinated congeners and their much lower aqueous phase solubilities, colloids in groundwater have the most effect on the transport of (in order of increasing importance): penta-, hexa-, hepta-, octa-, nona-, and decachlorobiphenyls. The transport analyses discussed in the following section, along with the congener data used to calibrate the model, demonstrate these varying degrees of importance of colloidal PCB transport at the Facility.

Transport Model without Colloids

To illustrate the importance of colloidal PCB transport at the Facility, the colloid concentration in the calibrated transport model was set to zero and the other transport parameter values were held constant (i.e., the same as those used for Figures 6-3 and 6-4). The black curves on Figure 6-5 represent the model-simulated centerline concentration variations with no colloids in the groundwater. Without the colloidal transport mechanism the total (mobile) homolog group concentrations shown on Figure 6-5 are greatly reduced. As discussed above, colloid removal has the greatest impact on the most highly chlorinated congeners. For example, the simulated hexa-, hepta-, and octachlorobiphenyls concentrations without colloids are generally several orders of magnitude lower than the groundwater measurements collected from the Facility. Specifically, eliminating colloidal PCB transport would be expected to reduce hexa-, hepta-, and octachlorobiphenyls concentrations below detection limits near wells HL-MW-30S, HL-MW-25S, and HL-MW-29S, respectively. Without colloids, the expected reduction factors for tetra- and trichlorobiphenyl concentrations near HL-MW-14S are on the order of 1.5 and 1.7, respectively. Therefore, the measured distance of downgradient transport of highly chlorinated PCB congeners at the Facility is much greater than the extent of transport that would occur if PCBs were only present in the aqueous phase.

Near the leading edge of the plume (e.g., wells HL-MW-30S and HL-MW-23S) the expected reduction factors for tetra- and trichlorobiphenyls without colloids are on the order of 2.5 and 2.7, respectively. These findings demonstrate an important conclusion of these analyses—the benefits of removing mobile colloids increase significantly with downgradient distance from the source area (i.e., Remelt/Hot Line area). In other words, homolog group concentrations would decrease to a much greater degree in downgradient portions of the plume if the colloidal transport mechanisms were reduced or eliminated.

Colloid removal would also result in a much less-chlorinated PCB mixture in downgradient areas. For example, the April 2008 congener data show that the homolog group mass fractions (M_i) in well HL-MW-23S are:

- M_3 = 35.8 percent;
- M_4 = 56.5 percent;
- M_5 = 7.0 percent;
- M_6 = 0.24 percent;
- M_7 = 0.015 percent; and
- M_8 = 0.0 percent.

The total PCB concentration in this well was 3.45 ng/L. The modeling results on Figure 6-5 indicate that colloid removal could eventually change the homolog mass fractions near well HL-MW-23S to the following:

- M_3 = 44 percent;
- M_4 = 55 percent;
- M_5 = 0.0 percent;

- M_6 = 0.0; and
- M_7 = 0.0 percent.

The corresponding total PCB concentration in this well would be expected to reduce by a factor of 3.3 to a concentration on the order of 1 ng/L without colloidal transport. The expected total PCB concentration reduction near well MW-12A, which is located farther downgradient than well HL-MW-23S, would be greater. The October 2007 congener data show that the homolog group mass fractions (M_i) in well MW-12A are:

- M_3 = 33.9 percent;
- M_4 = 59.7 percent;
- M_5 = 5.8 percent;
- M_6 = 0.034 percent;
- M_7 = 0.0 percent; and
- M_8 = 0.0 percent.

The total PCB concentration in this well was 2.85 ng/L. Similarly, the modeling results on Figure 6-5 indicate that colloid removal could eventually change the homolog mass fractions near well MW-12A to the following:

- M_3 = 46 percent;
- M_4 = 53 percent;
- M_5 = 0.0 percent; and
- M_6 = 0.0 percent.

The corresponding total PCB concentration in the well would be expected to reduce by a factor of 5.0 to a concentration on the order of 0.6 ng/L without colloidal transport.

It is also important to note that these reductions in downgradient PCB concentrations due to colloid removal would be expected to start in a relatively short time period (e.g., a year or two) because colloids move across the Facility almost as quickly as groundwater. Based on site measurements of hydraulic conductivity (K ~ 400 to 800 m/day) and horizontal hydraulic gradient (i ~ 0.003), the groundwater pore velocity ($V_p = K\ i\ /n_e$) is on the order of 4 to 8 m/day, based on an assumed (literature) effective porosity (n_e) of 0.3. Therefore, the groundwater travel time (T) from the Remelt/Hot Line area to well HL-MW-23S (distance, L ~ 560 m) is less than one year ($T = L\ /\ V_p$). Further, the modeling results indicate that the colloids are moving at about the same rate as the groundwater. Therefore, the expected travel time for colloids from Remelt/Hot Line area to well HL-MW-23S is less than 1 year. By comparison, the travel times of the dissolved phase PCB congeners are much greater than the colloidal PCB fraction due to the sorption of aqueous phase PCBs onto immobile soil grains in the aquifer. Basically, the aqueous phase portion of the PCB plume moves much slower than the colloidal fraction. For example, if PCBs were only present as dissolved constituents, a period of decades would be required to observe significant reductions in downgradient (e.g., wells HL-MW-23S and MW-12A) PCB concentrations in response to a source reduction in the Remelt/Hot Line area.

Potential for Secondary Downgradient Source

We analyzed the PCB congener data and the transport modeling results to evaluate the potential contribution of a secondary downgradient source (e.g., the West Landfill). Our analyses do not indicate the presence of an additional downgradient source whose contribution to groundwater contamination is significant compared to the transport of PCBs from the Remelt/Hot Line area. For example, we would expect that a significant source in the West Landfill would cause obvious increases in some or all of the measured PCB congener concentrations near wells HL-MW-30S and HL-MW-23S (Figure 6-3). However, the measured hexa-, penta-, tetra-, and trichlorobiphenyl concentrations in this area do not show such an increase. Conversely, the measured trends of decreasing congener concentrations along the plume centerline are relatively consistent and match fairly closely with the modeled concentration reductions with distance. In addition, the measured longitudinal trends in homolog group mass fractions (Figure 6-4) generally correlate with the simulated mass fraction curves. In other words, the data do not suggest an obvious anomaly in the variations of either congener concentrations or mass fractions along the plume centerline. While our data and transport analyses do not prove that there is not a secondary source whose contribution is relatively small, they demonstrate that colloidal and dissolved phase PCB transport from the upgradient portion of the plume are feasible mechanisms that could be the cause of PCB detections far downgradient of Remelt/Hot Line.

Observed Conditions of PCBs in Groundwater

The fate of PCBs in groundwater consists of:

- Adsorption to soil;
- Dissolution into free phase petroleum;
- Dissolution into groundwater;
- Transport in groundwater in dissolved and collodial phases; and
- Recovery by product skimming equipment with the free phase hydrocarbon (i.e., the existing IRM).

Oil House and Wastewater Treatment Area

PCBs present in groundwater samples from Oil House and Wastewater Treatment area wells are associated with free phase petroleum or dissolved petroleum hydrocarbons. When petroleum hydrocarbons are absent, PCBs have not been detected in groundwater. PCBs were detected in the smear zone soil from six wells in the Oil House, but PCBs have not been detected in the Wastewater Treatment area smear zone soil. This lack of PCB detections in smear zone soils may be an artifact of relatively few smear zone soil samples being collected and of those collected few were analyzed for PCBs.

Given the high octanol/water and soil/water partitioning coefficients, the most likely fate of PCBs in groundwater beneath the Wastewater Treatment and Oil House areas is partitioning to the free phase petroleum. Sorption to soil and/or degradation are also factors reducing the mobility of PCBs in the aquifer.

Transport in groundwater and discharge to the Spokane River is of relatively low potential based on the partitioning coefficients, constituent solubilities, and the effects of the IRM system. PCBs have not been detected in dissolved groundwater from monitoring wells downgradient of areas containing free phase petroleum, including the monitoring wells installed north of the Wastewater Treatment area and along the east bank of the Spokane River.

Remelt/Hot Line PCB Plume

PCB detections in groundwater from the Remelt /Hot Line PCB plume do not appear to be directly associated with petroleum, as no petroleum constituents have been detected in Hot Line area wells. PCBs absorb strongly to solids, and low detections of PCBs are not necessarily indicative of dissolved PCBs in groundwater; however, the detections do not correlate well with concentrations of suspended solids in groundwater samples.

PCBs are present in the unsaturated soils beneath the casting pits in the Remelt area. The reported source of PCBs is PCB-containing hydraulic fluid, which would have been used before the 1971. The only brand of PCB-containing hydraulic oil was marketed in the United States was manufactured by Monsanto under the brand name Pydraul (EPA 2004). Pydraul formulations frequently changed but could contain 20 to 90 percent PCBs by volume with other components including phosphate esters. Monsanto stopped including PCB in Pydraul brand hydraulic oils beginning in 1972 (Monsanto 1993). The absence of petroleum hydrocarbons associated with the PCBs is not surprising since most Pydraul formulations were classified as synthetic oils and did not contain petroleum hydrocarbon.

The source of PCBs detected in groundwater represents dissolved phase in equilibrium with the residual source in soil. Because of the absence of organic material in the soil matrix, PCBs in groundwater are likely transported in both dissolved phase and colloidal, which accounts for the development of a PCB plume extending more than 2,000 feet from its source area.

There is no evidence that PCBs in the Remelt/Hot Line plume have reached the Spokane River, and the PCB plume is not expanding. Continued monitoring of the plume will be required to assess the risk of the plume reaching the Spokane River. It is also recommended that monitoring of surface water from the Spokane River for PCBs be included with the ongoing groundwater sampling program.

PCB concentrations in the Remelt/Hot Line PCB plume are concentrated in shallow monitoring wells. PCBs have been detected to a depth of approximately 80 feet below the water table in two very deep monitoring wells (HL-MW-13DD and HL-MW-28DD). There are at least five scenarios that could attribute to PCB concentrations present at such great a depth.

- **Scenario 1.** Impacted soil from the shallow impacted area was carried down during drilling of the well. This scenario is unlikely because the mechanics of drilling cause soil to move upward out of the borehole. Also the mass of PCB that would be carried down would be relative small; therefore, it is unlikely that concentrations would persistent over time.

- **Scenario 2.** Recharge water is displacing the shallow plume downward with time. This scenario is also unlikely because the infiltration rate from precipitation is too relatively low compared to the substantial thickness of the vadose zone. Additionally, the relatively high rate of water evaporation relative to precipitation in the Spokane area suggest s that recharge is unlikely to be a major force for mobilizing PCBs downward through the aquifer. Because most precipitation takes place during the winter season (October to March) it is possible that sufficient recharge may occur during the winter to influence the mobilization of PCBs.

- **Scenario 3.** The presence of PCBs in groundwater at depth is the result of the dense-non aqueous phase liquid (DNAPL), which has migrated downward through the aquifer. If a PCB DNAPL were present the groundwater concentrations would be higher than the concentrations currently observed. Kaiser believes that the source of PCBs came from hydraulic oil containing a mixture of PCBs and phosphate esters. The phosphate esters are not petroleum-based. The highest PCBs concentrations in groundwater are much lower than the maximum solubility of PCBs in water. Also it is unlikely that a PCB DNAPL would be present without evidence of non petroleum-based oils since the PCB hydraulic oil would likely be a combination of PCBs and non-petroleum-based hydraulic oils.

- **Scenario 4.** PCBs move downward following the orientation and layering of cross stratification following high permeability zones in the aquifer. The Spokane aquifer consists of series of high-energy flood deposits from multiple glacial Lake Missoula flood events. The resulting deposits contain a series of cross-stratification sequences that were deposited on top of the previous flood event deposits. Internally these deposits consisted of cross-bedding typically on the order of tens of feet in height. The stacked, cross-bedded sequences are oriented downward following the prevailing groundwater flow direction. The orientation of the stratification is such that the tendency for PCB to migrate downward through preferential pathways leading to increased vertical migration. The rapid downward migration required to get the present distribution of PCBs argues against this mechanism alone to explain the vertical extent of PCBs.

- **Scenario 5.** Groundwater pumping that extract groundwater at depth can induce downward vertical gradients resulting in downward groundwater flow. There is no evidence that this mechanism is active at the site.

With respect to the fate and transport of the Remelt/Hot Line PCB plume the following conclusions can be made.

- The source area is expected to be PCB-containing hydraulic fluid used in the 1960s and 1970s. Use of the PCB-containing hydraulic fluid was discontinued response to banning of the use of PCBs.

- The PCB-containing hydraulic fluids likely contained both PCBs and non petroleum-based oils in the heavy oil range (i.e., phosphate esters). The hydraulic fluid likely contained at least 50 percent non-petroleum-based oils.

- Petroleum hydrocarbons are absent in the Remelt/Hot Line PCB plume.

- The upper part of the aquifer is very permeable with flow rates of more than 30 feet per day recorded. Because PCBs strongly bind to organic matter, the absence of organic content and the presence of high flow rates have allowed the development of a groundwater PCB plume, which has migrated at least 2,000 feet from its sources area.

- PCBs have been mobilized in both dissolved phase and as absorbed material associated colloidal particles. The plume will persist for a relatively long period of time since is unlikely that significant natural degradation occurs and ongoing source of PCBs to groundwater remains in soil within the Remelt area.

- It is likely that multiple factors account for the vertical distribution of PCBs in the aquifer. There is no conclusive evidence to support one mechanism over another.

6.4 ARSENIC, IRON, AND MANGANESE

Iron and manganese do not constitute a quantifiable environmental risk at the Facility; however, concentrations of these metals do exceed the conservative groundwater screening levels based on protection from taste and odor affects. Arsenic, on the other hand, can pose a risk to human health and the environment because of its potential to cause cancer. Arsenic does exceed the conservative screening level in groundwater from certain areas of the Facility. There are no known uses for arsenic, iron, and manganese in any of the historical production processes used at the Facility.

Arsenic, iron, and manganese are naturally occurring constituents that are often detected in groundwater systems. The source is contained in the particles within the aquifer. In the Spokane Basin, the 90th percentile background soil concentrations for arsenic, iron, and manganese are reported to be 9, 25,000, and 700 mg/kg, respectively (Ecology 1994a). Low level concentrations of arsenic were detected in soil samples analyzed from the Facility.

In general, elevated concentrations of arsenic, iron, and manganese in groundwater are collocated in areas where free phase petroleum or dissolved petroleum hydrocarbons are present (Figures 5-22, 5-25, and 5-28). Microbial degradation of the petroleum hydrocarbons and consequent oxygen uptake decreases dissolved oxygen concentrations in groundwater causing reducing condition. Under reducing conditions, insoluble arsenic, iron, and manganese complexes originally bound to the soil are converted to more soluble complexes, which are released to surrounding groundwater.

Arsenic is naturally present in soil, most commonly adsorbed to iron and aluminum hydrous oxides via ion exchange, although bonding to clays and carbonates is also common (Bodek et al. 1988). It has been reported that co-precipitation with manganese oxides can also occur (Ferguson and Gavis 1972). The solubility of arsenic is, in part, affected by pH and Eh (redox potential) of water (Welch et al. 1988). Under reducing conditions there are two mechanisms that contribute to the release of arsenic from soils into groundwater: 1) increased hydrous iron and manganese oxide solubility; and 2) reduction of arsenate (AsV) to the more soluble arsenite (AsIII) form (Bodek et al. 1988). Arsenite compounds are reported to be 4 to 10 times more soluble than arsenate compounds. Reduction of iron oxyhydroxide (FeOOH) is a microbial process that is driven by microbial metabolism of organic matter, (see Nealson 1997; Ahmann et al. 1997; Banfield et al. 1998; Chapelle 2000; and Lovley and Anderson 2000) and is accompanied by microbial reduction of arsenate to arsenite (Zobrist et al. 2000; Ahmann et al. 1997; Dowdle et al. 1996; and Stolz and Oremland 1999).

Therefore, the elevated arsenic concentrations (greater than 10 ug/L) in groundwater at the Facility are likely the result of the presence of anoxic, reducing conditions, which permit the reduction of iron oxyhydroxides. The naturally occurring arsenic that is sorbed to FeOOH is released to solution when the FeOOH is reduced (Nickson et al. 2000; Ravenscroft et al. 2001).

The most soluble form of iron and manganese is Fe(II) and Mn(II). Under oxidizing and neutral pH conditions, Fe(II) and Mn(II) concentrations in groundwater are low. Under reducing conditions, Fe(III) and Mn(IV) are converted to Fe(II) and Mn(II), respectively, increasing the concentration of iron and manganese in solution. The process is reversible.

In summary, reducing conditions provide favorable conditions for mobilizing arsenic, iron, and manganese. It appears that naturally occurring arsenic, iron, and manganese in soil, which are normally relatively insoluble in groundwater, experience increased solubility in petroleum-impacted areas. As groundwater flow carries dissolved arsenic, iron, and manganese out of the petroleum-affected/depressed oxygen areas, the three metals apparently precipitate from the dissolved phase. Concentrations of the three metals decrease downgradient of the petroleum-affected areas. The fate of the three metals identified as COPC is primarily precipitation as solids on site soils. No pathway to surface water receptors is likely via groundwater transport.

6.5 cPAHs

PAHs are composed of hydrogen and carbon arranged in the form of two or more fused benzene rings in linear, angular, or cluster arrangements, which may or may not have substituted groups attached to one or more rings (Eisler 1987). Low molecular weight PAHs (LPAHs) are more mobile in the environment as compared to the high molecular weight PAHs (HPAHs). HPAHs are relatively immobile because of their large molecular volumes and their extremely low volatility and solubility. The cPAH are classified in the HPAH group (Eisler 1987).

The source of cPAH at the Facility is associated with petroleum hydrocarbons. The fate and transport properties of cPAHs are similar to that of PCBs. cPAHs have low solubility in water, strongly bind to organic matter, and resist natural degradation processes. Because of the lack of organic carbon content in the aquifer, dissolved and collodial transport of cPAHs is likely to be important. It is likely that cPAH will be influenced by colloidal transport in a fashion similar to PCBs.

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Table 6-1 - Petroleum Hydrocarbon Chemical and Physical Properties

Petroleum Fraction/ Constituent	Equivalent Carbon Number	Molecular Weight in g/mol	Density in mg/L	Aqueous Solubility in mg/L	Henry's Law Constant (a)	K_{oc} (b) in L/kg
Aliphatics						
EC > 5-6	5.5	81.0	670,000	36.0	33.0	800
EC > 6-8	7.0	100.0	700,000	5.4	50.0	3,800
EC > 8-10	9.0	130.0	730,000	0.43	80.0	30,200
EC > 10-12	11.0	160.0	750,000	0.034	120.0	234,000
EC > 12-16	14.0	200.0	770,000	7.6E-04	520.0	5.37E+06
EC > 16-21	19.0	270.0	780,000	1.3E-06	4,900	9.55E+09
EC > 21-34	28.0	400.0	790,000	1.5E-11	100,000	1.07E+10
Aromatics						
EC > 8-10	9.0	120.0	870,000	65.0	0.48	1,580
EC > 10-12	11.0	130.0	900,000	25.0	0.14	2,510
EC > 12-16	14.0	150.0	1,000,000	5.8	0.053	5,010
EC > 16-21	19.0	190.0	1,160,000	0.51	0.013	15,800
EC > 21-34	28.0	240.0	1,300,000	6.6E-03	6.7E-04	126,000
Selected Petroleum Hydrocarbon Constituents						
Benzene	6.5	78.0	876,500	1,750	0.228	62.0
Toluene	7.6	92.0	866,900	526.0	0.272	140.0
Ethylbenzene	8.5	106.0	867,000	169.0	0.323	204.0
Total Xylenes	8.67	106.0	875,170	171.0	0.279	233.0
n-Hexane	6.0	86.0	659,370	9.5	74.0	3,410
MTBE	--	88.0	744,000	50,000	0.018	10.9
Napthalenes	11.69	128.0	1,145,000	31.0	0.0198	1,191

Notes:
Data table derived from Table 747-4 (Petroleum EC Fraction Physical/Chemical Values) in WAC 173-340-900 and from Ecology 2007a, Part IX Tables.
a) Dimensionless values.
b) Soil organic carbon water partition coefficient.
EC - Equivalent carbon.
-- Data not available.

Table 6-2 - Kensol and Magiesol Chemical and Physical Properties

Chemical	Boiling Point in °C	Density in lbs/gal	Vapor Pressure in mmHg	Aqueous Solubility in mg/L	Specific Gravity	Flash Point in °C	Viscosity at 100 °F in SUS	API Gravity in degrees
Kensol 30 (a)	154	6.4	<1	Insoluble	0.77	40.5	--	51.4
Kensol 48H (b)	193	6.6	0	Insoluble	0.79	71	31.2	4.74
Kensol 50H (b)	229	6.7	0	Insoluble	0.81	118	34.3	43.8
Kensol 61 (c)	>271	--	0	0	0.82	143	--	--
Kensol 61H (b)	271	6.9	0	0	0.83	135	40.9	39 to 41
Magiesol 52 (d)	269 to 309	6.8	0.01	Insoluble	0.82	127	38.7	42.2

Notes:
Data referenced from the Material Safety Data Sheet (MSDS) for each chemical.
a) CAS Number 8052-41-3.
b) CAS Number 64742-46-7.
c) CAS Number 64741-44-2.
d) CAS Number 8042-47-5.
API - American Petroleum Institute.
SUS - Saybolt Universal Seconds.
-- Data not available.

Table 6-3 - Chlorine Content of Commercial Aroclor PCB Mixtures

Aroclor	% Chlorine	Average Number Chlorine Atoms per Molecule	Average Molecular Weight
1221	20.5 to 21.5	1.15	192
1232	31.5 to 32.5	2.04	221
1242	42	3.1	261
1248	48	3.9	288
1254	54	4.96	327
1260	60	6.3	372
1262	61.5 to 62.5	6.8	389
1268	68	8.7	453

Table 6-4 - Number of Congeners in Each Homolog Group

Chlorinated Biphenyl Homolog Group	Chemical Formula	Number of Congeners
Monochloro Biphenyl	$C_{12}H_9Cl$	3
Dichloro Biphenyl	$C_{12}H_8Cl_2$	12
Trichloro Biphenyl	$C_{12}H_7Cl_3$	24
Tetrachloro Biphenyl	$C_{12}H_6Cl_4$	42
Pentachloro Biphenyl	$C_{12}H_5Cl_5$	46
Hexachloro Biphenyl	$C_{12}H_4Cl_6$	42
Heptachloro Biphenyl	$C_{12}H_3Cl_7$	24
Octachloro Biphenyl	$C_{12}H_2Cl_8$	12
Nonachloro Biphenyl	$C_{12}H_1Cl_9$	3
Decachloro Biphenyl	$C_{12}Cl_{10}$	1
Total		209

Table 6-5 - Composition of Aroclor Mixtures by Degree of Chlorine Substitution

Chlorinated Biphenyl Homolog Composition	Percentage Composition (by weight) in Aroclor Mixtures					
	1221	1016	1242	1248	1254	1260
$C_{12}H_{10}$	11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Monochloro Biphenyl	51	1	1 to 3	< 0.1	< 0.1	< 0.1
Dichloro Biphenyl	32	20	13 to 16	2	0.5	< 0.1
Trichloro Biphenyl	4	57	28 to 49	18	1	< 0.1
Tetrachloro Biphenyl	2	21	25 to 30	40	11 to 21	< 0.1
Pentachloro Biphenyl	< 0.5	1	8 to 22	36	48 to 49	12
Hexachloro Biphenyl	< 0.01	< 0.1	1 to 4	4	23 to 34	38
Heptachloro Biphenyl	< 0.01	< 0.01	< 0.1	< 0.1	6	41
Octachloro Biphenyl	< 0.01	< 0.01	< 0.01	< 0.01	< 0.1	8
Nonachloro Biphenyl	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1
Decachloro Biphenyl	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Table 6-6 - Historical United States PCB Use by Aroclor Mixture

PCB Use	Primary Aroclors Used
Electrical capacitors	1016, 1221, 1254
Electrical transformers	1242, 1254, 1260
Vacuum pumps	1248, 1254
Gas transmission turbines	1221, 1242
Hydraulic fluids	1232, 1242, 1248, 1254, 1260
Plasticizers for resins	1248, 1254, 1260, 1262, 1268
Plasticizers for rubber	1221, 1232, 1242, 1248, 1254, 1268
Adhesives	1221, 1232, 1242, 1248, 1254
Heat transfer fluids	1242, 1248
Wax extenders	1242, 1254, 1268
Dedusting agents	1254, 1260
Carbonless copy paper	1242
Lubricants, metal cutting oils	1254
Pesticide extenders	1254
Inks	1254

Table 6-7 - Physical Properties of Commercial Aroclor Mixtures

Aroclor	% Chlorine	Appearance	Specific Gravity	Distillation Range in °C	% Evaporation 6 hr @100 °C / 5 hr @ 163 °C	Flash Point, CC in °C	Saybolt Viscosity at 100 °F / 130 °F / 210 °F
1221	20.5 to 21.5	clear fluid oil	1.18 to 1.19	275 to 320	1.0 to 1.5 / na	141 to 150	38 to 41 / 35 to 37 / 30 to 31
1232	31.4 to 32.5	clear fluid oil	1.27 to 1.28	290 to 325	1.0 to 1.5 / na	152 to 154	44 to 51 / 39 to 41 / 31 to 32
1242	42	clear fluid oil	1.38 to 1.39	325 to 366	0 to 0.4 / 3.0 to 3.6	176 to 180	82 to 92 / 49 to 56 / 34 to 35
1248	48	clear fluid oil	1.40 to 1.42	340 to 375	0 to 0.3 / 3.0 to 4.0	193 to 196	185 to 240 / 73 to 80 / 36 to 37
1254	54	light yellow viscous liquid	1.49 to 1.51	365 to 390	0 to 0.2 / 1.1 to 1.3	none	1800 to 2500 / 260 to 340 / 44 to 48
1260	60	light yellow soft sticky resin	1.55 to 1.57	385 to 420	0 to 0.1 / 0.5 to 0.8	none	na / 3200 to 4500 / 72 to 78
1262	61.5 to 62.5	light yellow sticky viscous resin	1.57 to 1.58	390 to 425	0 to 0.1 / 0.5 to 0.6	none	
1268	68	off-white powder	1.80 to 1.81	435 to 450	0 to 0.06 / 0.1 to 0.2	none	
2565	65	black brittle resin	1.734	na	0 / 0.2 to 0.3	none	
4465	65	light yellow resin	1.67	230 to 320 (4 mm Hg)	0 to 0.02 / 0.2 to 0.3	none	
5442	42	yellow sticky resin	1.47	215 to 300 (4 mm Hg)	0.01 / 0.2	247	
5460	58.5 to 60.6	amber brittle resin or flakes	1.67	280 to 335 (5 mm Hg)	0 / 0.03	none	

REF: O. Hutzinger, S.Safe, and V.Zitco, The Chemistry of PCBs, CRC Publishing Company 1983

Table 6-8 - PCB Congener Physical Properties

PCB Congener IUPAC No.	Ring Chlorine Position	Koc[a] in L/kg	Solubility[b] in mg/L	Vapor Pressure[b] in mm Hg	Henry's Law Constant[b] in atm-m^3/mole
Monochlorobiphenyls					
1	2	2.5E+04	4.83	1.4E-03	7.4E-04
2	3	3.2E+04	3.63	7.4E-03	6.1E-04
3	4	3.3E+04	1.34	1.1E-02	5.7E-04
Dichlorobiphenyls					
4	2-2'	2.5E+04	1.85	2.8E-03	2.3E-04
5	2,3	5.2E+04	0.997	*1.63E-03*	2.3E-04
6	2-3'	5.1E+04	*0.061*	*1.63E-03*	2.5E-04
7	2,4	4.7E+04	1.15	1.4E-03	2.8E-04
8	2-4'	5.2E+04	1.17	2.1E-03	2.3E-04
9	2,5	4.7E+04	1.12	1.4E-03	2.8E-04
10	2,6	2.5E+04	2.41	*2.44E-03*	2.3E-04
11	3-3'	1.0E+00	0.355	6.5E-04	2.3E-04
12	3,4	7.2E+04	0.0909	*9.73E-04*	1.4E-04
13	3-4'	7.2E+04	0.0888	*8.03E-04*	*2.81E-04*
14	3,5	1.0E+00	*0.321*	*1.02E-03*	2.2E-04
15	4-4'	7.6E+04	*0.185*	5.4E-04	2.0E-04
Trichlorobiphenyls					
16	2,3-2'	7.6E+04	*0.218*	*6.08E-04*	2.0E-04
17	2,4-2'	6.3E+04	0.0833	*4.44E-04*	*2.13E-04*
18	2,5-2'	6.2E+04	0.4	1.1E-03	2.5E-04
19	2,6-2'	4.7E+04	0.324	*1.05E-03*	2.3E-04
20	2,3-3'	1.2E+05	*0.115*	*3.10E-04*	1.6E-04
21	2,3,4	1.0E+00	0.17	*3.11E-04*	*1.86E-04*
22	2,3-4'	1.3E+05	*0.0875*	*2.57E-04*	1.4E-04
23	2,3,5	9.5E+04	*0.142*	*4.22E-04*	*1.89E-04*
24	2,3,6	6.9E+04	0.0833	*5.94E-04*	2.2E-04
25	2,4-3'	1.0E+05	*0.0888*	*2.76E-04*	*1.86E-04*
26	2,5-3'	1.0E+05	0.253	*3.06E-04*	2.0E-04
27	2,6-3'	6.2E+04	*0.205*	*5.83E-04*	*2.06E-04*
28	2,4-4'	1.1E+05	0.27	2.0E-04	2.0E-04
29	2,4,5	9.8E+04	0.163	9.8E-04	2.0E-04
30	2,4,6	1.0E+00	0.252	7.2E-04	*2.20E-04*
31	2,5-4'	1.1E+05	0.143	4.0E-04	1.9E-04
32	2,6-4'	7.6E+04	0.159	*4.34E-04*	2.0E-04
33	3,4-2 '	1.2E+05	*0.115*	1.0E-04	1.6E-04
34	3,5-2'	9.5E+04	0.129	*3.72E-04*	2.0E-04
35	3,4-3'	1.7E+05	*0.0628*	*1.86E-04*	*1.65E-04*
36	3,5-3'	1.0E+00	*0.0695*	*2.19E-04*	1.7E-04
37	3,4-4'	1.8E+05	*0.0444*	*1.36E-04*	1.0E-04
38	3,4,5	1.0E+00	*0.0665*	*2.22E-04*	*1.64E-04*
39	3,5-4'	1.0E+00	*0.049*	*1.88E-04*	*1.67E-04*
Tetrachlorobiphenyls					
40	2,3-2',3'	2.5E+05	0.0156	7.4E-05	1.0E-04
41	2,3,4-2'	2.2E+05	0.0432	*9.56E-05*	1.4E-04
42	2,3-2',4'	2.0E+05	*0.0298*	*8.84E-05*	1.4E-04
43	2,3,5-2'	1.6E+05	0.172	*1.37E-04*	*1.24E-04*
44	2,3-2',5'	2.0E+05	*0.0382*	*1.12E-04*	1.4E-04

Table 6-8 - PCB Congener Physical Properties

PCB Congener IUPAC No.	**Ring Chlorine Position**	**Koc^a** in L/kg	**Solubility^b** in mg/L	**Vapor Pressure^b** in mm Hg	**Henry's Law Constant^b** in atm-m^3/mole
45	2,3,6-2'	1.3E+05	0.146	*2.35E-04*	*1.47E-04*
46	2,3-2',6'	1.4E+05	0.146	*2.31E-04*	*1.40E-04*
47	2,4-2',4'	1.7E+05	*0.0226*	8.6E-05	1.9E-04
48	2,4,5-2'	1.7E+05	0.0164	*1.17E-04*	*1.30E-04*
49	2,4-2',5'	1.7E+05	*0.0322*	8.5E-06	2.1E-04
50	2,4,6-2'	1.0E+05	0.0654	*1.79E-04*	*1.54E-04*
51	2,4-2',6'	1.2E+05	0.0654	*1.69E-04*	1.4E-04
52	2,5-2',5'	1.6E+05	0.0153	*1.51E-04*	2.0E-04
53	2,5-2',6'	1.2E+05	0.0476	2.3E-05	*1.49E-04*
54	2,6-2',6'	8.7E+04	0.0119	*5.14E-04*	2.0E-04
55	2,3,4-3'	2.8E+05	0.0496	*6.33E-05*	*1.06E-04*
56	2,3-3',4'	3.0E+05	*0.0215*	*6.26E-05*	*1.07E-04*
57	2,3,5-3'	2.2E+05	*0.0232*	*7.58E-05*	*1.11E-04*
58	2,3-3',5'	1.0E+00	*0.0228*	*7.04E-05*	*1.05E-04*
59	2,3,6-3'	2.0E+05	*0.0346*	*1.08E-04*	*1.20E-04*
60	2,3,4-4'	3.0E+05	*0.0149*	*4.43E-05*	*1.14E-04*
61	2,3,4,5	1.0E+00	0.014	3.8E-05	*1.17E-04*
62	2,3,4,6	1.0E+00	*0.0321*	*1.02E-04*	2.1E-04
63	2,3,5-4'	2.3E+05	0.0496	*6.51E-05*	*1.20E-04*
64	2,3,6-4'	2.3E+05	*0.0256*	*8.51E-05*	1.4E-04
65	2,3,5,6	1.0E+00	0.0164	*1.44E-04*	*1.27E-04*
66	2,4-3',4'	2.6E+05	*0.0159*	4.6E-05	1.2E-04
67	2,4,5-3'	2.2E+05	0.0217	*6.83E-05*	1.0E-04
68	2,4-3',5'	1.0E+00	*0.0191*	*6.01E-05*	1.09E-04
69	2,4,6-3'	1.0E+00	*0.0258*	*8.26E-05*	2.1E-04
70	2,5-3',4'	2.5E+05	0.041	4.1E-05	1.0E-04
71	2,6-3',4'	2.2E+05	0.0279	*9.95E-05*	*1.31E-04*
72	2,5-3',5'	1.9E+05	*0.0245*	*7.94E-05*	*1.08E-04*
73	2,6-3',5'	1.0E+00	*0.037*	*1.22E-04*	*1.17E-04*
74	2,4,5-4'	2.5E+05	0.00496	*4.96E-05*	1.0E-04
75	2,4,6-4'	1.7E+05	0.0911	*6.04E-05*	*1.33E-04*
76	3,4,5-2'	2.5E+05	*0.0271*	*7.88E-05*	*1.06E-04*
77	3,4-3',4'	4.3E+05	0.000569	1.6E-05	9.4E-06
78	3,4,5-3'	1.0E+00	*0.0146*	*4.38E-05*	*9.34E-05*
79	3,4-3',5'	1.0E+00	*0.0125*	*4.10E-05*	9.0E-05
80	3,5-3',5'	1.0E+00	0.00123	*5.28E-05*	*9.36E-05*
81	3,4,5-4'	3.9E+05	*0.00971*	*3.45E-05*	*1.00E-04*
Pentachlorobiphenyls					
82	2,3,4-2',3'	7.2E+05	*0.00665*	*1.94E-05*	*6.09E-05*
83	2,3,5-2',3'	5.1E+05	*0.00821*	*2.45E-05*	*6.27E-05*
84	2,3,6-2',3'	4.1E+05	0.0542	*4.44E-05*	*7.79E-05*
85	2,3,4-2',4'	6.0E+05	0.00783	*1.49E-05*	6.6E-05
86	2,3,4,5-2'	5.5E+05	0.0098	7.0E-05	*6.54E-05*
87	2,3,4-2',5'	5.8E+05	*0.00698*	1.7E-05	7.4E-05
88	2,3,4,6-2'	3.4E+05	0.012	*4.06E-05*	*8.62E-05*
89	2,3,4-2',6'	4.3E+05	0.0542	*4.01E-05*	*7.87E-05*
90	2,3,5-2',4'	1.0E+00	0.00494	*1.91E-05*	*6.71E-05*
91	2,3,6-2',4'	3.5E+05	0.0221	*2.98E-05*	*8.14E-05*

Table 6-8 - PCB Congener Physical Properties

PCB Congener IUPAC No.	**Ring Chlorine Position**	**Koc**[a] in L/kg	**Solubility**[b] in mg/L	**Vapor Pressure**[b] in mm Hg	**Henry's Law Constant**[b] in atm-m^3/mole
92	2,3,5-2',5'	4.1E+05	0.00494	*2.87E-05*	*6.78E-05*
93	2,3,5,6-2'	3.2E+05	0.013	*5.35E-05*	*8.17E-05*
94	2,3,5-2',6'	3.0E+05	*0.0152*	*4.80E-05*	*7.72E-05*
95	2,3,6-2',5'	3.3E+05	*0.0135*	*4.36E-05*	1.2E-04
96	2,3,6-2',6'	2.4E+05	*0.0326*	*1.12E-04*	*9.99E-05*
97	2,4,5-2',3'	5.5E+05	*0.00742*	*2.12E-05*	7.4E-05
98	2,4,6-2',3'	1.0E+00	0.013	*2.92E-05*	*8.25E-05*
99	2,4,5-2',4'	4.6E+05	0.00366	2.2E-05	7.8E-05
100	2,4,6-2',4'	1.0E+00	0.00714	*2.48E-05*	*8.52E-05*
101	2,4,5-2',5'	4.4E+05	0.0154	2.5E-05	9.0E-05
102	2,4,5-2',6'	3.2E+05	*0.014*	*4.18E-05*	9.0E-05
103	2,4,6-2',5'	2.6E+05	0.0111	*3.64E-05*	*8.78E-05*
104	2,4,6-2',6'	1.0E+00	0.0158	*7.65E-05*	*1.06E-04*
105	2,3,4-3',4'	6.8E+05	0.0034	6.5E-06	*5.79E-05*
106	2,3,4,5-3'	1.0E+00	*0.00477*	*1.53E-05*	*5.58E-05*
107	2,3,4-3',5'	1.0E+00	*0.00417*	*1.28E-05*	*5.64E-05*
108	2,3,4,6-3'	1.0E+00	*0.00427*	*1.32E-05*	*5.36E-05*
109	2,3,5-3',4'	5.1E+05	*0.00647*	*2.10E-05*	*6.51E-05*
110	2,3,6-3',4'	6.5E+05	0.00731	*1.95E-05*	*6.30E-05*
111	2,3,5-3',5'	1.0E+00	*0.00483*	*1.58E-05*	*5.36E-05*
112	2,3,5,6-3'	1.0E+00	0.00567	*2.72E-05*	*6.60E-05*
113	2,3,6-3',5'	1.0E+00	0.00366	*2.36E-05*	*6.12E-05*
114	2,3,4,5-4'	5.9E+05	*0.00366*	*1.16E-05*	*6.41E-05*
115	2,3,4,6-4'	5.8E+05	0.00366	*1.44E-05*	*6.97E-05*
116	2,3,4,5,6	1.0E+00	0.00401	*3.06E-05*	*7.21E-05*
117	2,3,5,6-4'	5.8E+05	0.0043	*2.16E-05*	*6.84E-05*
118	2,4,5-3',4'	5.4E+05	*0.00389*	9.0E-06	*5.99E-05*
119	2,4,6-3',4'	4.9E+05	0.00402	*1.45E-05*	7.4E-05
120	2,4,5-3',5'	1.0E+00	0.0111	*1.29E-05*	5.6E-05
121	2,4,6-3',5'	1.0E+00	0.00392	*1.90E-05*	*6.31E-05*
122	3,4,5-2',3'	6.0E+05	*0.00463*	*1.36E-05*	*5.38E-05*
123	3,4,5-2',4'	5.4E+05	*0.00352*	*1.03E-05*	*5.57E-05*
124	3,4,5-2',5'	5.1E+05	*0.00504*	*1.50E-05*	*5.43E-05*
125	3,4,5-2',6'	5.6E+05	*0.00664*	*2.37E-05*	*5.92E-05*
126	3,4,5-3',4'	8.9E+05	*0.00301*	*8.84E-06*	*5.20E-05*
127	3,4,5-3',5'	1.0E+00	*0.00262*	*9.96E-06*	*4.70E-05*
Hexachlorobiphenyls					
128	2,3,4-2',3',4'	2.1E+06	0.00035	2.6E-06	1.3E-05
129	2,3,4,5-2',3'	1.7E+06	0.00137	*6.09E-06*	2.9E-05
130	2,3,4-2',3',5'	1.4E+06	*0.00187*	*5.28E-06*	3.7E-05
131	2,3,4,6-2',3'	1.0E+06	0.0012	*7.96E-06*	3.9E-05
132	2,3,4-2',3',6'	1.1E+06	0.00808	*7.79E-06*	4.4E-05
133	2,3,5-2',3',5'	1.0E+06	*0.00166*	*7.00E-06*	*3.35E-05*
134	2,3,5,6-2',3'	9.5E+05	0.000899	1.1E-06	4.9E-05
135	2,3,5-2',3',6'	7.9E+05	0.00544	*1.11E-05*	5.6E-05
136	2,3,6-2',3',6'	6.2E+05	0.00451	*2.60E-05*	8.8E-05
137	2,3,4,5-2',4'	1.5E+06	*0.00133*	*4.05E-06*	*3.69E-05*
138	2,3,4-2',4',5'	1.5E+06	*0.00148*	3.8E-06	2.1E-05

Table 6-8 - PCB Congener Physical Properties

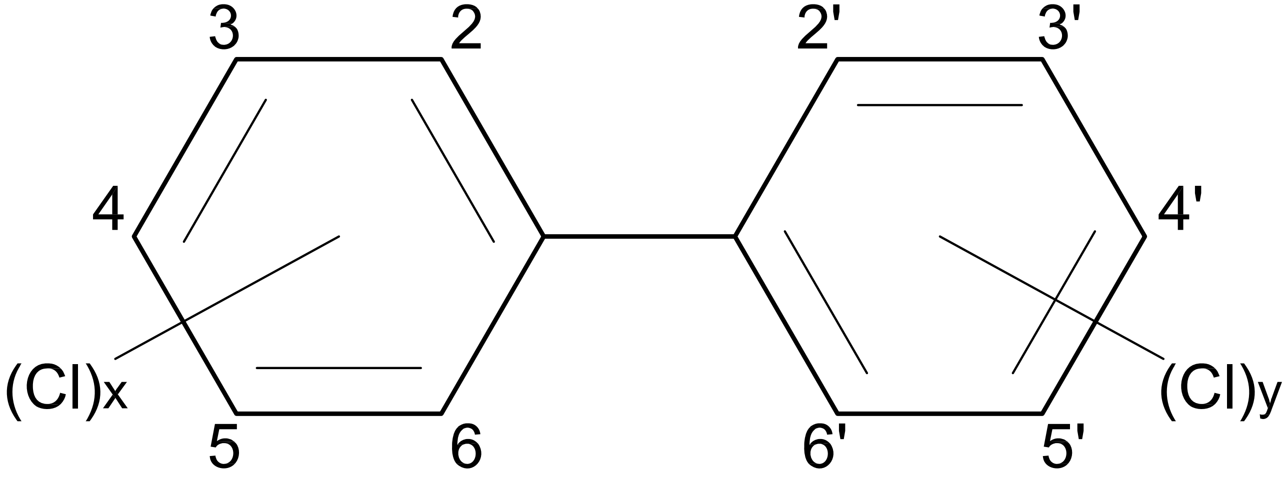
PCB Congener IUPAC No.	**Ring Chlorine Position**	**Koc**[a] in L/kg	**Solubility**[b] in mg/L	**Vapor Pressure**[b] in mm Hg	**Henry's Law Constant**[b] in atm-m^3/mole
139	2,3,4,6-2',4'	8.9E+05	*0.002*	*6.41E-06*	*4.63E-05*
140	2,3,4-2',4',6'	1.0E+00	0.00208	*6.28E-06*	*4.38E-05*
141	2,3,4,5-2',5'	1.3E+06	*0.00206*	*6.21E-06*	2.3E-05
142	2,3,4,5,6-2'	1.0E+00	*0.00337*	*1.11E-05*	*4.22E-05*
143	2,3,4,5-2',6'	1.0E+00	0.00268	*9.95E-06*	3.9E-05
144	2,3,4,6-2',5'	7.9E+05	0.00353	*8.74E-06*	*4.43E-05*
145	2,3,4,6-2',6'	1.0E+00	*0.00589*	*2.00E-05*	*5.71E-05*
146	2,3,5-2',4',5'	1.1E+06	0.000949	*5.34E-06*	2.5E-05
147	2,3,5,6-2',4'	8.3E+05	*0.0026*	*8.64E-06*	5.1E-05
148	2,3,5-2',4',6'	1.0E+00	*0.00222*	*7.71E-06*	*4.30E-05*
149	2,3,6-2',4',5'	8.7E+05	0.00424	8.4E-06	*4.47E-05*
150	2,3,6-2',4',6'	1.0E+00	*0.00455*	*1.63E-05*	*5.93E-05*
151	2,3,5,6-2',5'	7.6E+05	*0.00351*	2.3E-06	5.9E-05
152	2,3,5,6-2',6'	1.0E+00	*0.00698*	*3.02E-05*	*5.82E-05*
153	2,4,5-2',4',5'	1.1E+06	0.00095	3.4E-06	2.3E-05
154	2,4,5-2',4',6'	6.8E+05	0.00274	*6.49E-06*	*4.72E-05*
155	2,4,6-2',4',6'	1.0E+00	0.000408	1.2E-05	*5.84E-05*
156	2,3,4,5-3',4'	1.3E+06	*0.00102*	1.6E-06	*2.98E-05*
157	2,3,4-3',4',5'	1.3E+06	*0.00101*	*2.64E-06*	*2.93E-05*
158	2,3,4,6-3',4'	1.6E+06	*0.00123*	*3.81E-06*	*3.67E-05*
159	2,3,4,5-3',5'	1.0E+00	*0.00112*	*3.79E-06*	2.0E-05
160	2,3,4,5,6-3'	1.0E+00	*0.00182*	*5.96E-06*	2.0E-05
161	2,3,4,6-3',5'	1.0E+00	*0.00155*	*5.39E-06*	*3.48E-05*
162	2,3,5-3',4',5'	1.0E+00	*0.00108*	*3.25E-06*	*2.81E-05*
163	2,3,5,6-3',4'	1.5E+06	0.0012	*5.69E-06*	1.5E-05
164	2,3,6-3',4',5'	1.5E+06	0.00194	*5.43E-06*	*3.25E-05*
165	2,3,5,6-3',5'	1.0E+00	0.00194	*6.51E-06*	2.9E-05
166	2,3,4,5,6-4'	1.8E+06	*0.00102*	*4.19E-06*	1.2E-04
167	2,4,5-3',4',5'	1.0E+06	0.00223	*2.65E-06*	*2.88E-05*
168	2,4,6-3',4',5'	1.0E+00	*0.000926*	*3.50E-06*	*3.40E-05*
169	3,4,5-3',4',5'	1.0E+00	0.00051	*2.45E-06*	*2.50E-05*
Heptachlorobiphenyls					
170	2,3,4,5-2',3',4'	4.6E+06	*0.000376*	6.3E-07	9.0E-06
171	2,3,4,6-2',3',4'	2.7E+06	0.00217	1.4E-06	*2.27E-05*
172	2,3,4,5-2',3',5'	3.2E+06	0.000314	*1.31E-06*	1.3E-06
173	2,3,4,5,6-2',3'	1.0E+00	*0.000783*	*2.47E-06*	1.4E-05
174	2,3,4,5-2',3',6'	2.5E+06	0.00102	*2.45E-06*	1.4E-05
175	2,3,4,6-2',3',5'	1.9E+06	0.000826	*2.05E-06*	*2.02E-05*
176	2,3,4,6-2',3',6'	1.4E+06	0.0028	*4.13E-06*	*2.76E-05*
177	2,3,5,6-2',3',4'	2.6E+06	0.0015	*2.17E-06*	*2.10E-05*
178	2,3,5,6-2',3',5'	1.7E+06	0.00102	*2.49E-06*	2.3E-05
179	2,3,5,6-2',3',6'	1.3E+06	0.00454	*4.99E-06*	2.4E-05
180	2,3,4,5-2',4',5'	3.4E+06	*0.000368*	9.8E-07	1.0E-05
181	2,3,4,5,6-2',4'	2.5E+06	0.000423	*1.66E-06*	*2.36E-05*
182	2,3,4,5-2',4',6'	1.0E+00	0.000826	*1.46E-06*	*2.17E-05*
183	2,3,4,6-2',4',5'	2.0E+06	*0.000478*	*1.47E-06*	*2.18E-05*
184	2,3,4,6-2',4',6'	1.0E+00	*0.000933*	*3.50E-06*	*3.33E-05*
185	2,3,4,5,6-2',5'	2.2E+06	*0.000791*	*2.60E-06*	1.6E-05

Table 6-8 - PCB Congener Physical Properties

PCB Congener IUPAC No.	**Ring Chlorine Position**	**Koc**[a] in L/kg	**Solubility**[b] in mg/L	**Vapor Pressure**[b] in mm Hg	**Henry's Law Constant**[b] in atm-m^3/mole
186	2,3,4,5,6-2',6'	1.0E+00	*0.00122*	*5.44E-06*	*2.83E-05*
187	2,3,5,6-2',4',5'	1.9E+06	*0.000652*	*2.18E-06*	*2.11E-05*
188	2,3,5,6-2',4',6'	1.0E+00	0.00128	*4.12E-06*	*3.05E-05*
189	2,3,4,5-3',4',5'	2.3E+06	0.000753	*8.30E-07*	*1.54E-05*
190	2,3,4,5,6-3',4'	4.6E+06	*0.000358*	*1.08E-06*	*1.88E-05*
191	2,3,4,6-3',4',5'	3.6E+06	0.000314	*9.95E-07*	*1.77E-05*
192	2,3,4,5,6-3',5'	1.0E+00	0.000314	*1.29E-06*	*1.77E-05*
193	2,3,5,6-3',4',5'	3.5E+06	0.000314	*1.24E-06*	*1.71E-05*
Octachlorobiphenyls					
194	2,3,4,5-2',3',4',5'	9.1E+06	0.000272	*3.56E-07*	1.0E-05
195	2,3,4,5,6-2',3',4'	7.2E+06	0.00022	*4.92E-07*	1.1E-05
196	2,3,4,5-2',3',4',6'	5.4E+06	0.000163	*4.98E-07*	1.0E-05
197	2,3,4,6-2',3',4',6'	3.2E+06	0.000341	*8.36E-07*	*1.55E-05*
198	2,3,4,5,6-2',3',5'	4.9E+06	0.000163	*6.02E-07*	1.4E-05
199	2,3,4,5-2',3',5',6'	3.7E+06	0.000341	*1.15E-06*	*1.48E-05*
200	2,3,4,5,6-2',3',6'	3.0E+06	0.000271	*1.01E-06*	1.7E-05
201	2,3,4,6-2',3',5',6'	5.1E+06	0.00022	*5.87E-07*	1.0E-05
202	2,3,5,6-2',3',5',6'	2.7E+06	0.000147	3.9E-06	1.8E-05
203	2,3,4,5,6-2',4',5'	5.4E+06	0.000136	*5.12E-07*	*1.20E-05*
204	2,3,4,5,6-2',4',6'	1.0E+00	0.000142	*8.05E-07*	*1.57E-05*
205	2,3,4,5,6-3',4',5'	9.8E+06	0.0000858	*3.18E-07*	*1.02E-05*
Nonachlorobiphenyls					
206	2,3,4,5,6-2',3',4',5'	1.3E+07	0.000025	*1.37E-07*	*6.49E-06*
207	2,3,4,5,6-2',3',4',6'	7.9E+06	0.0000366	*2.31E-07*	*8.12E-06*
208	2,3,4,5,6-2',3',5',6'	7.2E+06	0.000018	*2.82E-07*	*7.69E-06*
Decachlorobiphenyl					
209	2,3,4,5,6-2',3',4',5',6'	1.0E+00	0.00000743	1.1E-07	*2.18E-06*

IUPAC Nos. 107, 108, and 109 here correspond to BZ Nos. 108, 109, and 107, respectively.
IUPAC Nos. 199, 200, and 201 here correspond to BZ Nos. 201, 199, and 200, respectively.
Italic indicates a predicted or calculated value
a - Data from Hansen et al, 1999
b - Data from Oberg 2001

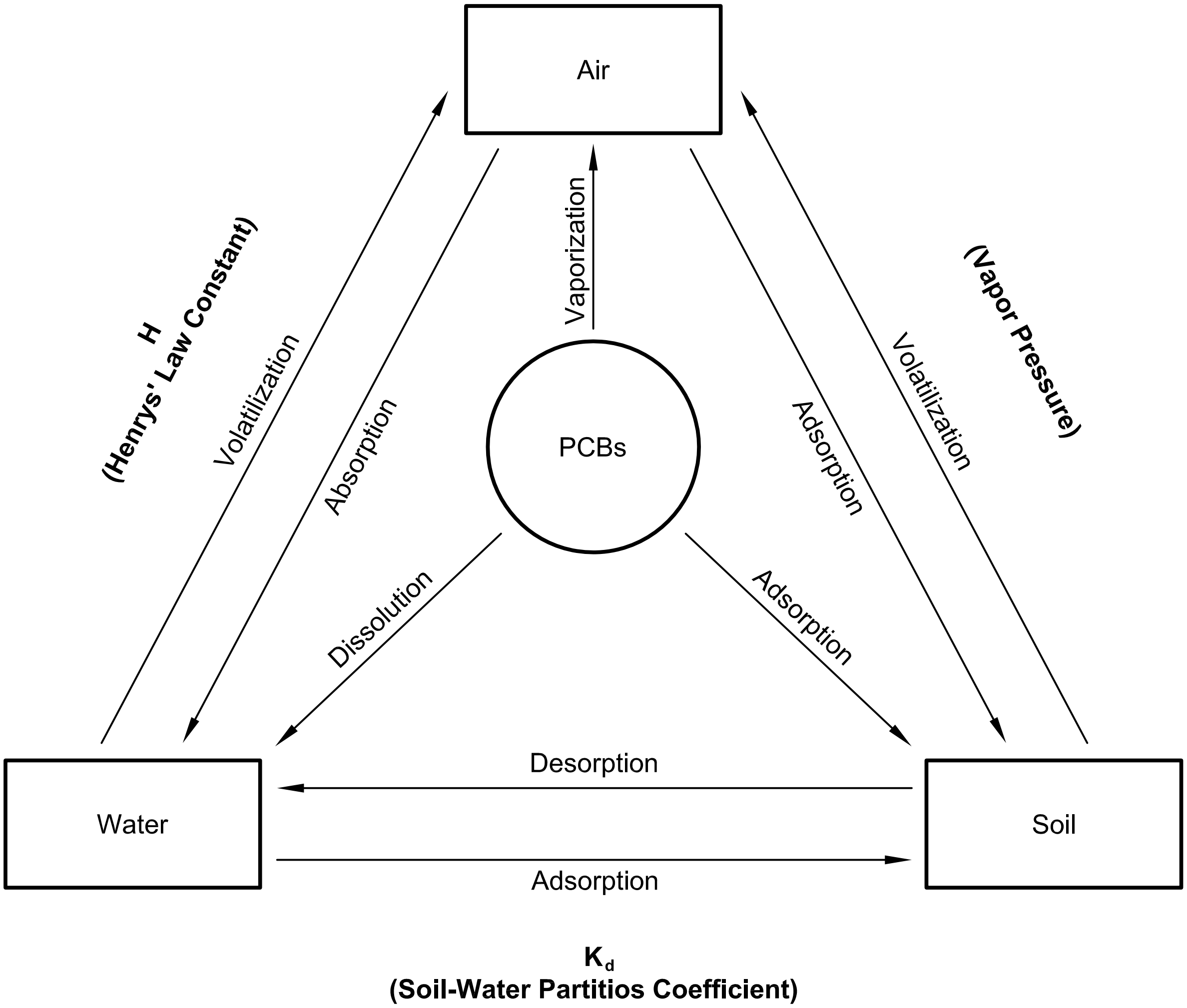
Polychlorinated Biphenyl Structure



Note: x + y = 1 to 10

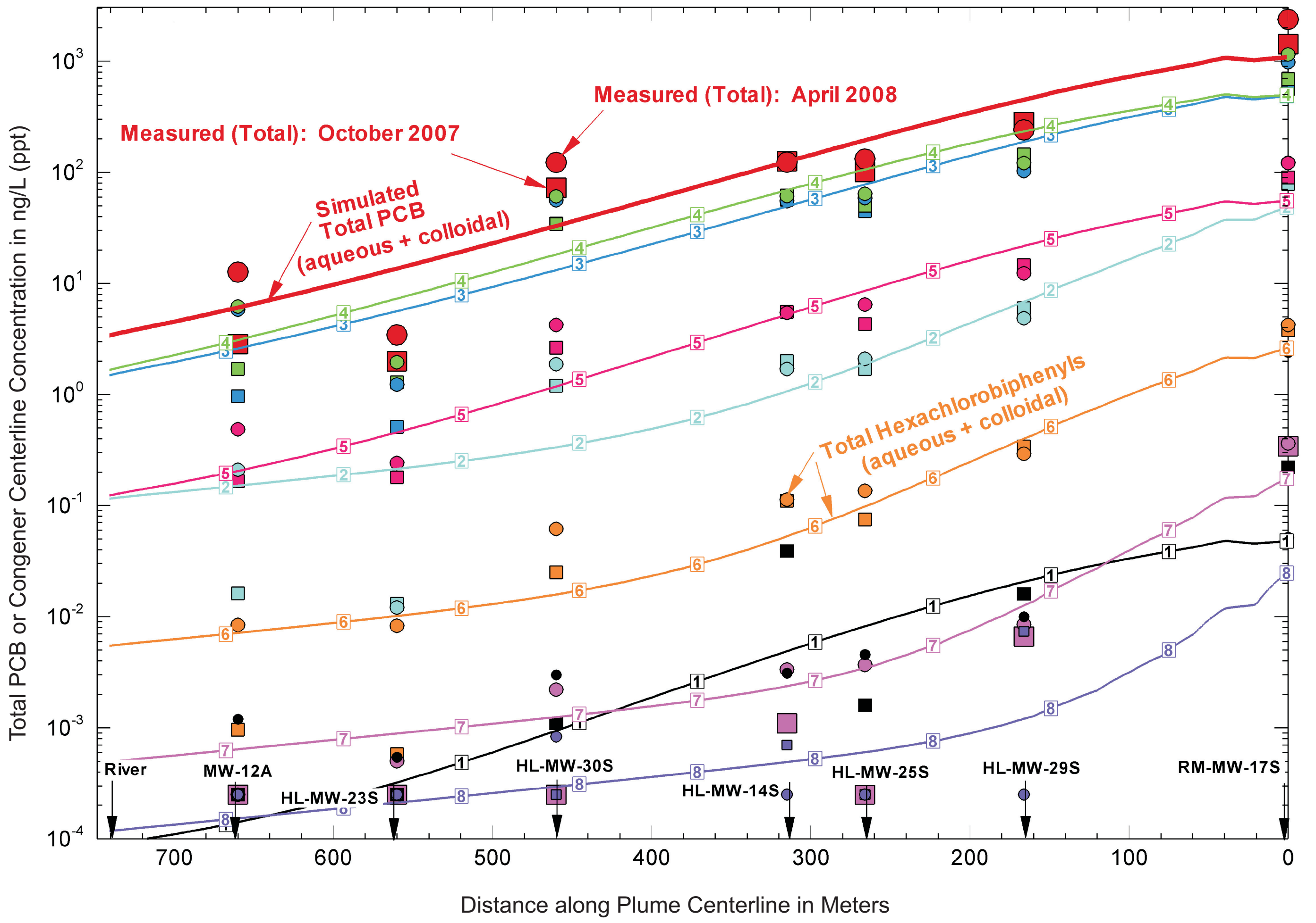
EAL 04/2/09 2644114-062.DWG

PCB Fate and Transport Pathways



EAL 04/2/09 2644114-065.DWG

Total PCB Concentration (Aqueous and Collodial)



Concentration in ng/L

	Measured		Simulated
	October 2007	April 2008	
Total PCBs	■	●	—
Monochlorobiphenyls	■	●	–1–
Dichlorobiphenyls	■	●	–2–
Trichlorobiphenyls	■	●	–3–
Tetrachlorobiphenyls	■	●	–4–
Pentachlorobiphenyls	■	●	–5–
Hexachlorobiphenyls	■	●	–6–
Heptachlorobiphenyls	■	●	–7–
Octachlorobiphenyls	■	●	–8–

EAL 05/18/09 2644114-AN.cdr

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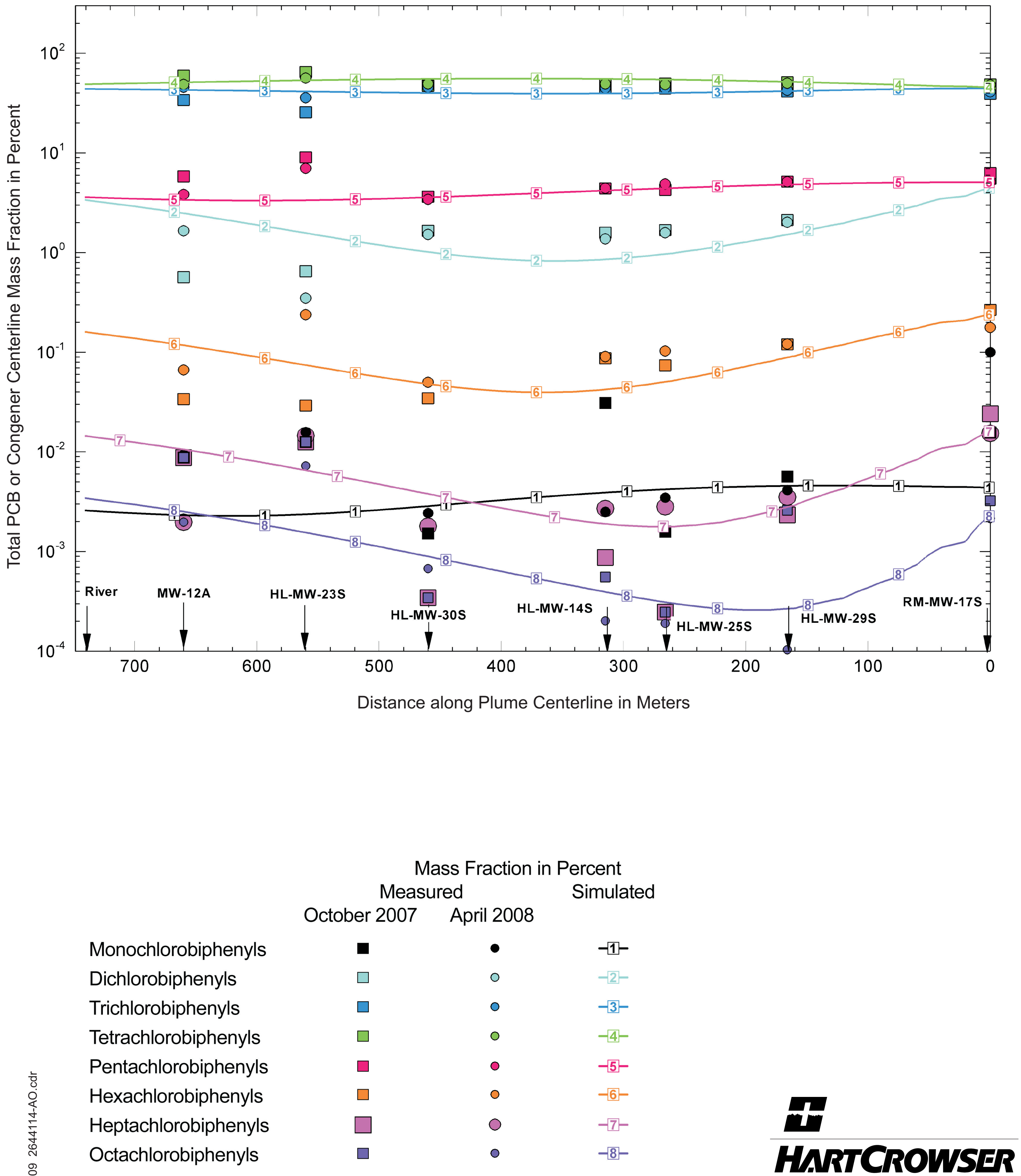
2644-114 ***5/09***
Figure 6-3

PCB Congener Mass Fraction



EAL 05/18/09 2644114-AO.cdr

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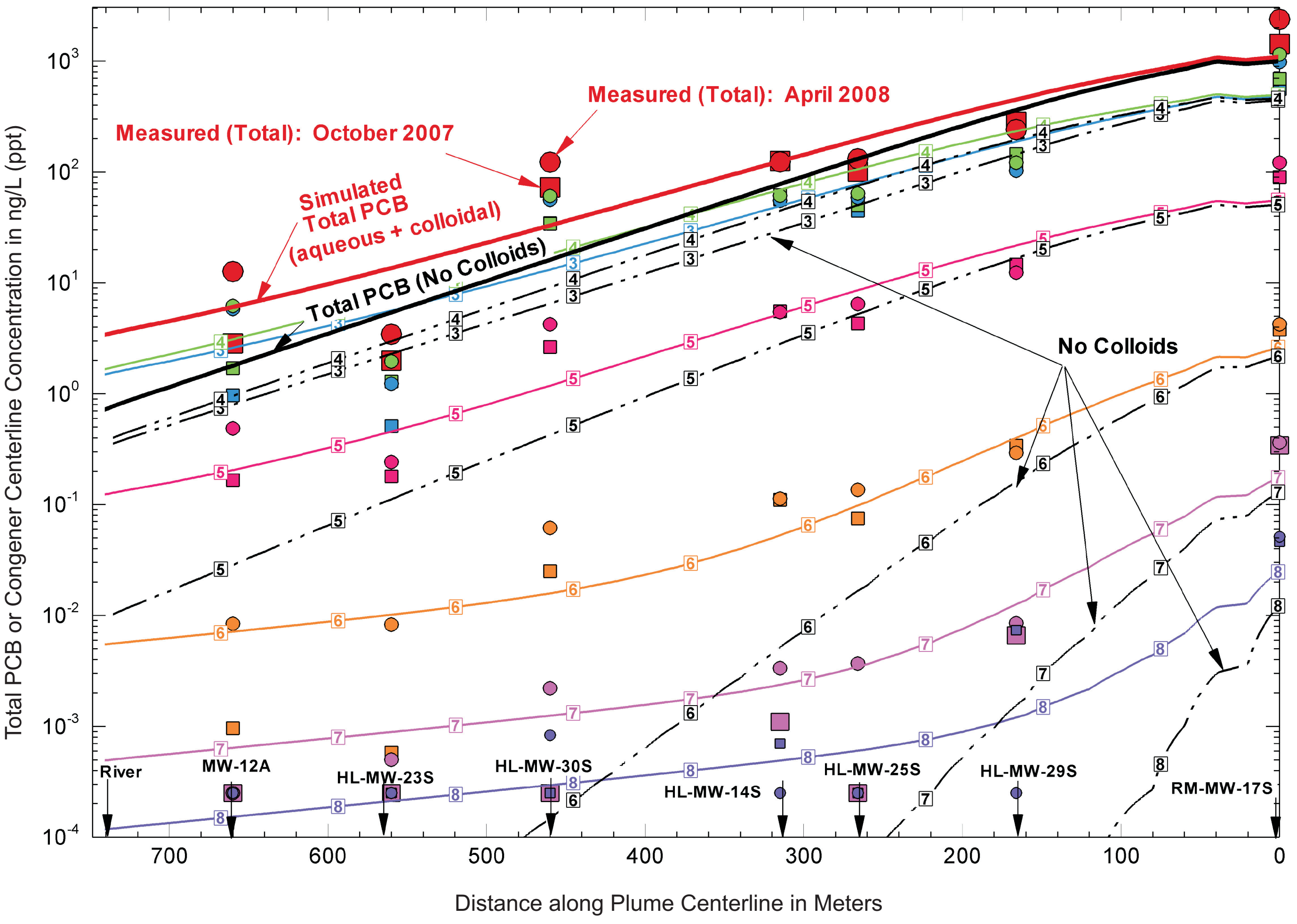
2644-114 ***5/09***

Figure 6-4

Total PCB Concentration with and without Colloids



	Concentration in ng/L		
	Measured		Simulated
	October 2007	April 2008	
Total PCBs	🟥	●	—
Trichlorobiphenyls	■	●	-3-
Tetrachlorobiphenyls	🟩	●	-4-
Pentachlorobiphenyls	■	●	-5-
Hexachlorobiphenyls	🟧	●	-6-
Heptachlorobiphenyls	■	●	-7-
Octachlorobiphenyls	■	●	-8-
Total PCBs (Aqueous and Colloidal)	—		
Total PCBs (No Colloids)	—		
Concentration (No Colloids)	- · - — - · - — - ·		

EAL 05/18/09 2644114-AO.cdr

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2644-114 5/09

Figure 6-5

CONTENTS

7.0 FACILITY GROUNDWATER CONCEPTUAL SITE MODEL

This section presents the hydrogeologic conceptual site model (CSM) developed to describe the groundwater flow regime beneath the Facility. The CSM is based on hydrostratigraphy, water levels, aquifer properties, and geochemical conditions described in Sections 4, 5, and 6. The CSM was developed to interpret the physical, chemical, and dynamic nature of the groundwater system. The CSM was also developed to interpret the processes affecting the transport of chemicals from source areas through the environment to potential human and ecological receptors as well as the fate of chemicals in the transport process.

7.1 HYDROGEOLOGIC SETTING

The Facility overlies the SVRP aquifer, which is an unconfined sand and gravel aquifer of glaciofluvial origin, as discussed in greater detail in Section 4. The local aquifer consists primarily of sandy gravel with occasional sand lenses. Gravels with scattered open work zones, poorly sorted gravels with little to no fines, are present in the upper part of the local aquifer and contribute to the high groundwater flow velocities at the Facility. The saturated thickness of the local aquifer is approximately 200 to 300 feet thick. In general, the hydraulic conductivity of the aquifer decreases with depth.

The following local aquifer properties were estimated based on field calculations, pumping test analytical results, and best fit values from the site-wide groundwater flow model.

Sources of recharge to the local aquifer include infiltration from precipitation, overland flow from storm events, and surface water inflow from the upland areas north and northeast of the Facility. The water table is located 60 to 70 feet below ground surface on the east side of the Facility and 45 to 55 feet in depth toward the west as the surface topography naturally slopes down toward the Spokane River. Local groundwater elevations are strongly influenced by winter/spring precipitation recharge and with changes in river stage. Groundwater elevations fluctuate seasonally and are approximately 3 to 10 feet higher in the spring than in the fall when the water table is typically at its lowest elevations for the year. Other hydrogeologic factors include:

- Vertical groundwater gradients are typically negligible.
- Average horizontal groundwater gradient is 0.004 ft/ft.
- Vertical hydraulic conductivity ranges from 250 to 500 ft/d.
- Average horizontal hydraulic conductivity is 2,500 ft/d.

- Average transmissivity is 1.7 million gpd/ft.
- Effective porosity is 30 percent.
- Average linear velocity is 33 ft/d.

Natural groundwater flow is from northeast to southwest across the Facility and discharges into the Spokane River. The Spokane River is a losing stream from Coeur d'Alene, Idaho, to just upstream of the Facility at Flora Road (RM 89.1), where it changes to a gaining stream until it reaches Greene Street (RM 77.5). The change from a losing to gaining stream is thought to be brought about by the Pines Road Knoll, were the groundwater may either flow around the impermeable rock or upwards into the Spokane River. The volume of groundwater recharge to the Spokane River at the Facility is based on the following estimates and calculations:

- Kahle and Bartolino (2007) estimated the discharge flow rate from the SVRP aquifer to the Spokane River across the 11.6-mile gaining reach, which includes the reach adjacent to the Facility, to be 593 ft^3/sec (cfs) or 0.01 cfs per linear foot of river.

- The distance of the Facility reach along the river is approximately 3,000 feet; therefore, approximately 30 cfs of groundwater is discharging to the River from the aquifer beneath the Facility.

- The volume of groundwater flow across the Facility based on an average hydraulic conductivity of 2,500 ft/day and a gradient of 0.004 ft/ft are estimated to be 83 and 87 cfs during the dry and wet season, respectively; therefore, it is estimated that only one-third to one-half of the groundwater flow discharges to the Spokane River and remainder stays as groundwater in the SVRP aquifer.

The average daily flow rate for the Spokane River at Greenacres stage (RM 90.5) for the 2008 wet and dry season is 13,000 and 1,600 cfs, respectively. The seasonal change in groundwater flow (4 cfs) is considered to be a small contribution to the otherwise large seasonal variations in the river flow rates.

7.2 HYDROGEOCHEMICAL SETTING

This subsection provides a conceptual overview of the main geochemical processes that are considered to be important in groundwater at the Facility. In Sections 5 and 6, source areas of groundwater contamination were attributed directly to activities that have occurred at the Facility during its development and operation. Other impacted areas were identified where elevated presence of inorganic constituents (arsenic, iron, and manganese) cannot be directly related to a release from the Facility. In the latter case, hydrogeochemical processes have played a role in affecting the distribution and occurrences of these constituents. The distribution, fate, and transport of the dissolved constituents are influenced by the nature of their interaction with local groundwater, with aquifer solid phase, and with the hydrogeochemical conditions present.

Groundwater quality at the Facility is measured during monitoring events and is usually within the typical groundwater quality range for fresh waters. The following field groundwater quality parameters range represents the 5th to 95th percentile:

- pH ranges from 7 to 8 with an average of 7.6.
- Temperature ranges from 10 to 13 C, with an average of 11 C.
- Conductivity ranges from 0.2 to 0.4 µS/cm with an average of 0.3 µS/cm.
- Turbidity ranges from 0 to 300 NTU with an average of 50 NTU.
- ORP ranges from -60 to 440 mV with an average of 110 mV.
- Dissolve oxygen ranges from 0.8 to 10 mg/L with an average of 7 mg/L.

MW-10 is an upgradient well in the eastern portion of the Facility. Groundwater sampled and analyzed from this well would be considered background. MW-10 was routinely sampled and analyzed for dissolve arsenic since 1999 and dissolved antimony, iron, and manganese since 2007. Arsenic concentrations ranged from 5.6 to 11.4 ug/L, antimony concentrations ranged from 0.18 to 0.25 ug/L, iron concentrations ranged from 5 to 2590 ug/L, and manganese concentrations ranged from non detect to 54 ug/L. Field water quality parameters were measured periodically and had values that represent typical fresh groundwater conditions

As stated in Section 5 and 6, the following four constituents have been identified as COPCs at the Facility and are described in the CSM:

- Free phase hydrocarbons;
- Petroleum hydrocarbons;
- PCBs;
- Inorganics including arsenic, iron, and manganese; and
- cPAHs.

The Facility's CMS begins with precipitation or runoff from the upland areas entering the local groundwater system that is initially aerobic, indicating contact with the atmosphere. As groundwater flows through the system to petroleum hydrocarbon-impacted areas, oxygen is consumed through microbial degradation of the petroleum hydrocarbons causing a decrease in dissolved oxygen concentrations in groundwater. Reducing conditions increase solubility of the naturally occurring arsenic, iron, and manganese in the soil and they are mobilized in groundwater.

As groundwater flow carries dissolved arsenic, iron, and manganese out of the petroleum hydrocarbon -impacted and oxygen-reduced areas, the metals precipitate out of the dissolved phase. Dissolved arsenic, iron, and manganese concentrations decrease downgradient of the petroleum hydrocarbon plumes.

Free phase petroleum pools and dissolved petroleum hydrocarbon plumes appear to be at a steady state (not migrating), immobilized and are shrinking due to the active remediation occurring in the affected areas (see Section 6).

PCBs, primarily Aroclor 1242 and 1248, occur in groundwater as dissolved constituents, associated with free phase petroleum, or absorbed onto colloidal particulates. As the dissolved PCBs and cPAHs are mobilized and transported through the aquifer, equilibrium reactions causing sorption to, or ion exchange with, the aquifer's soils would be expected to retard migration relative to groundwater in a constituent-specific manner. Constituents at the edges of plumes would be reduced in concentration through physical mixing with groundwater and diffusion away from the plume, causing apparent dispersion and attenuation. It is unlikely that PCB concentrations are influenced by biodegradation because of absence of strongly reducing conditions which are considered to provide favorable conditions for biodegradation in the aquifer.

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