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Remedial Investigation Report for Former Mill E/Koppers Facility Everett, Washington

Volume 1 (Report)

Prepared for

Weyerhaeuser Company

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EXECUTIVE SUMMARY

The Former Mill E/Koppers facility is a 6.6-acre site located on Weyerhaeuser property in Everett, Washington. The site is flat and underlain by distinct geologic and hydrogeologic units. The unsaturated zone is relatively permeable and composed of man-made fill and river dredge fill to an average depth of 4 feet below ground surface. Two permeable sand aquifers separated by a relatively impermeable silt aquitard underlie the fill. Groundwater flow in the aquifers is generally horizontal towards and discharging into the adjacent Snohomish River, at an average groundwater velocity of 2 feet per day. The bulkhead along the Snohomish River significantly impedes groundwater discharge into the river.

Historical practices at the site, primarily wood treatment and maintenance facility operations, have resulted in soil, groundwater, and/or sediment contamination by arsenic, chromium, copper, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, pentachlorophenol, and/or dioxins/furans. Four locations on the site were identified from this investigation as apparent contaminant source areas: the former wood treatment/maintenance building and surrounding area, the blow pit area, along the rail lines, and former Mill E. One off-site source was identified: the former ASARCO smelter site and smelter-related materials placed upgradient of the site.

The primary contaminant transport pathway is from soil to groundwater, with subsequent discharge to the Snohomish River. Modeled ambient air concentrations indicate that current contaminant transport via air is insignificant. Field observations and storm water sampling indicate that storm water runoff is also not a significant pathway. Contaminant receptors (and secondary transport pathways) are the Snohomish River and its sediments.

The blow pit area of the site has the most significant soil and groundwater contamination. Soil contamination from this area has moved downward into groundwater and horizontally toward the Snohomish River. Elevated concentrations of contaminants, primarily arsenic and polycyclic aromatic hydrocarbons, were found in river sediment next to the bulkhead.

Soil upgradient of the site contains arsenic levels that are within the range of Puget Sound regional concentrations, but above area background concentrations for north Everett. Upgradient groundwater (upper sand aquifer) contains elevated arsenic concentrations. This arsenic-contaminated groundwater contributes to groundwater contamination beneath the site.

Indicator hazardous substances related to human health exposure identified in the baseline risk assessment are as follows:

- Arsenic
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(a)pyrene
- Chromium
- Chrysene
- Dioxins/furans
- Indeno(1,2,3-cd)pyrene
- Pentachlorophenol
- TPH as diesel, gasoline and other

The site was evaluated using industrial-use exposure assumptions because a) the site and adjacent properties are zoned M-2 (heavy manufacturing), and b) the site has historically been used for industrial purposes and is expected to remain in industrial use for the foreseeable future. MTCA reasonable maximum exposure (RME) assumptions were employed for the soil evaluation. Groundwater at the site is not used for drinking water purposes and is not expected to be used for this purpose in the foreseeable future. Potential human health exposures from drinking the site's groundwater were therefore not evaluated in the baseline risk assessment.

The estimated hazard index (HI) for noncarcinogenic indicator hazardous substances from ingestion and dermal contact pathways is 0.13. Because this value is less than 1.0, noncarcinogenic health effects from the indicator hazardous substances evaluated in the assessment do not appear to be of concern for the site.

The estimated excess carcinogenic risk for carcinogenic indicator hazardous substances from ingestion and dermal contact pathways is 5×10^{-5}. This level of risk is within the USEPA-established risk range of 1×10^{-4} to 1×10^{-6}; however, it exceeds the MTCA total risk level of 1×10^{-5}.

Principal contaminants of concern for potential impacts to the environment are as follows:

- Arsenic
- Copper
- Pentachlorophenol
- Polycyclic aromatic hydrocarbons

Contaminants transported to the Snohomish River are rapidly attenuated upon discharge through mixing. Elevated concentrations of contaminants were found in sediments in locations immediately adjacent to the site. Concentrations decreased rapidly with depth and distance from the site.

1 INTRODUCTION

This report describes a remedial investigation (RI) conducted by EMCON Northwest, Inc. (EMCON), at the Former Mill E/Koppers Facility — a 6.6-acre site located on Weyerhaeuser Company property in Everett, Washington (Figure 1-1). Wood treating operations were conducted at this site and were shown in previous studies to have resulted in soil and groundwater contamination.

The Department of Ecology (Ecology) has conducted a Site Hazard Assessment of the Weyerhaeuser Company's Everett facility and assessed a No. 1 ranking pursuant to regulations and guidance implementing the Model Toxics Control Act (MTCA). The Former Mill E/Koppers Facility is part of the Weyerhaeuser-Everett site; as such, the RI was conducted following procedures specified in implementing regulations of MTCA, chapter 173-340 WAC. The RI was conducted as an independent action. Procedures described in the National Contingency Plan (40 CFR 300) and associated guidance, developed pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), were also followed in conducting the RI.

The scope of work and rationale for specific site investigation activities are described in detail in *Work Plan for Remedial Investigation/Feasibility Study of Former Mill E/Koppers Facility* (EMCON, 1992; Work Plan). The field investigation took place from July 15 to December 30, 1992, with limited additional soil sampling in August 1993. Groundwater monitoring continued on a quarterly basis through August 1993 and is now being conducted on a semiannual basis. Site investigation procedures are described in Appendix A.

1.1 Purpose of Investigation

The RI was undertaken to better define the nature and extent of site contamination, to evaluate risks to human health and the environment due to site contamination, and to provide sufficient information to identify and evaluate potential remedial technologies and alternatives. Investigation activities included an evaluation of soil, groundwater, surface water, sediment and air; existing site structures and piping; and an upgradient source assessment of arsenic. The upgradient arsenic assessment was conducted due to historic operations of the American Smelting and Refining Company (ASARCO) in the vicinity, and the results of previous investigations that showed elevated concentrations of arsenic in groundwater monitoring wells upgradient of the Former Mill E/Koppers Facility (the site).

1.2 Site Background

1.2.1 Information Sources

The property history was researched by reviewing Weyerhaeuser Corporate archives, which included correspondence, aerial photographs, maps, newspaper and periodical articles, and company newsletters. Department of Ecology (Ecology) Northwest regional files, Ecology industrial files, Ecology archives, Sanborn Map Company historic fire insurance maps (1892, 1893, 1902, 1914, and 1951) and Snohomish County atlases (1942, 1960, 1975, and 1990) were also reviewed. Historical information was also obtained from Weyerhaeuser company files in Everett and from interviews with former employees from Weyerhaeuser's Kraft Mill and Mills B, C, and E.

Information on site history is also provided in Hart Crowser's *Environmental Assessment and Site Characterization Work Plan, Weyerhaeuser Old Machine Shop, Everett Mill E Site* (1989a), and *Site Characterization Report, Weyerhaeuser Old Machine Shop, Everett Mill E Site* (1989b). The Hart Crowser reports include historical site summaries created through review of Sanborn Map Company historic fire insurance maps dating from 1892, U.S. Geological Survey topographic maps from 1941 through 1973, Snohomish County atlases (Anderson Map Company and Metsker Map Company), aerial photographs from the U.S. Army Corps of Engineers and Washington State Department of Natural Resources, and former employee interviews.

1.2.2 Site History

Weyerhaeuser began Everett-area operations with the 1902 purchase of the Bell-Nelson Sawmill, located on Port Gardner Bay. Sawmill capacity expanded with the completion of Mill B in 1915. Mill B was built on property bordering the west bank of the Snohomish River (Figure 1-2). According to a 1939 article published in the Bee and Cee (Weyerhaeuser Company newsletter), construction of Mill B and use of adjacent property to the south of Mill B required filling of the subject property with sand dredged from the Snohomish River in the 1900s. Aerial photographs indicate that the area was used as a log sort and lumber storage yard from 1915 until construction of a wood treatment facility began in 1947. In 1946, Weyerhaeuser leased 6.6 acres south of Mill B to the American Lumber and Treating Company (ALTC) for 7½ years. Construction of the ALTC wood treatment facility began in March 1947 and was completed in July 1948. The wood treatment facility included eight vertical aboveground storage tanks, two 132-foot-long by 6-foot-diameter steel retorts, aboveground and underground piping, and railroad supply lines. Ownership of the wood treatment facility was transferred to the

Koppers Company when they acquired ALTC in the early 1950s. Wood treatment processes continued at the facility until 1963. Wood treatment processes reportedly included the use of creosote and creosote-petroleum solutions, Wolman salts (chromated copper arsenate [CCA]), and "Minolith" fire retardant. Pentachlorophenol was reportedly used at the facility from approximately the mid-1950s until operations were discontinued in 1963 (Beazer, 1994).

Lumber was treated while stacked on narrow-gauge rail cars. The rail cars were moved into the retorts from the south, the retorts were sealed, and a vacuum was applied to remove surface moisture from the wood. Treatment chemicals were introduced into the retorts until filled, and then pressure was applied. Following a holding period to saturate the lumber, the retort was depressurized, the excess liquid was drained from the retort, the retort was unsealed, and the treated lumber was removed. Treated lumber was stored temporarily on site in stacks or on rail cars. Some lumber reportedly was sent to the lumber kilns at Weyerhaeuser Mill B for drying. During retort depressurization, air and liquid apparently were blown into a pit southeast of the treatment building (the blow pit area) (Figure 1-2).

In 1963, the former wood treatment facility was converted into a maintenance facility/machine shop. Conversion to the maintenance facility included removing the two retorts and the aboveground storage tanks (ASTs). The site operated as a maintenance facility from 1963 to 1984. Activities at the maintenance facility included petroleum fueling and maintenance of vehicles and engines. Gasoline, diesel fuel, lube oil, waste oil, and minor quantities of chlorinated and non-chlorinated solvents reportedly were stored and used at the building. Tanks included a 10,000-gallon diesel underground storage tank (UST), a 10,000-gallon gasoline UST, two waste oil USTs, and ASTs for motor and hydraulic oil (Figure 1-2). The petroleum tanks and some petroleum-contaminated soil were removed in 1988.

Mill E was constructed in 1971, and was designed to process small log material (4 to 16 inches in diameter) and construction lumber. Mill B was dismantled in about 1979. Mill E was dismantled in 1988; the foundation remains.

1.2.3 Local History

A complete history of surrounding land uses is not available. The following is a summary of known historical land uses near the site:

- According to an enforcement order issued to ASARCO (No. DE 92TC-N147), a lead smelter and ore refinery operated from approximately 1894 to 1912 on property near what is now the intersection of East Marine View Drive and State Route 529. The Puget Sound Reduction Company began operating the smelter to refine ore for lead, copper, gold, and silver. ASARCO bought the smelter in 1903. The lead smelter operated until 1908. An arsenic processing plant also operated at the smelter site from approximately 1898 until 1912. The smelter and processing plant were dismantled in 1914.

- Burlington Northern Railroad (BNRR) currently operates a rail yard to the west of the facility. Historical photos indicate that this rail yard was a single rail in 1892, was expanded to multiple rail lines by 1910, and has been in operation since that time. The early rail lines were operated by Great Northern.

1.3 Environmental Setting

The site is relatively flat and is bordered on the east by the Snohomish River, on the west by the BNRR switching yard, and on the north and south by Weyerhaeuser facilities.

The climate of the Everett area is predominantly marine temperate, with prevailing westerly winds (Newcomb, 1952). The average annual rainfall is approximately 34 inches, with maximum precipitation in the winter months and a dry period in the summer. The mean annual temperature for Everett is 50.5°F.

The Snohomish River to the east of the site is tidally influenced, with salt wedge intrusion to approximately 5 miles south of the site, beyond the Interstate 5 bridge (Figure 1-1). The mean tide range of the Snohomish River at Everett is approximately 7 feet (Newcomb, 1952). The tides at Everett (with mean lower low water [MLLW] as 0 feet) range from 11.1 feet mean higher high water (MHHW), 10.2 feet mean high water (MHW), 2.8 feet mean low water (MLW), and -4.5 feet extreme low water (ELW) (NOAA, 1991).

Site characteristics are described in detail in Section 2.

1.4 Previous Investigations

Environmental quality data were collected at the site during several investigations conducted between October 1988 and June 1990 by Weyerhaeuser and Hart Crowser. Investigations included the collection of soil, groundwater, river sediment, and seep samples. In-situ and laboratory hydraulic conductivity tests were also performed. A chronology of these investigations and a summary of findings are presented in the Work Plan. The results of all chemical analyses, except for soil and product samples collected by Weyerhaeuser in 1988, may be found in three reports by Hart Crowser (1989a, 1989b, 1991).

Soil, groundwater, seep, and river sediment samples all contained detectable concentrations of compounds used in historical practices at the site. The highest concentrations detected were centered at and east of the former wood treatment/ maintenance building. Concentrations decreased at a short distance upgradient (west) of the former operations, but were elevated downgradient (towards Snohomish River) of the former operations.

1.5 Report Organization

The RI report is organized as follows: site characteristics are described in Section 2; Section 3 discusses the nature and extent of contamination of soil, groundwater, surface water, sediments, and air; results of a baseline risk assessment are provided in Section 4; and a discussion of the conceptual site model and contaminant migration pathways is provided in Section 5.

2 SITE CHARACTERISTICS

2.1 Surface Topography and Features

2.1.1 Site Topography

The site is located on level dredge fill adjacent to the Snohomish River, 2 miles upstream from the river mouth at Port Gardner in Puget Sound. The river has become channelized into a main stream with several shallow sloughs separated by marshy islands. The main stream of the river flows adjacent to the site and is approximately 750 feet wide. The site is within the low-lying floodplain of the river, which is bounded on the west and east by steeply sloped ridges and hills reaching to 500 feet above mean sea level. The site is relatively flat and slopes gently towards the west, away from the river.

The site may be accessed by a spur road and trestle bridge over the BNRR leading from East Marine View Drive. The BNRR forms the western property boundary. Approximately 35 percent of the site is covered by vegetation consisting primarily of grasses, weeds, and small shrubs/trees. Most vegetation is found along the western portion of the site. Limited quantities of logs and wood debris are placed around the site.

2.2 Climate

2.2.1 Regional

The climate of Everett, Washington is classified as Modified West Coast Marine. Everett is on the Puget Sound, approximately 100 miles inland from the Pacific Ocean coastline, and 27 miles from the Strait of Juan de Fuca. The Olympic Mountains, lying between Everett and the ocean coast, form a significant barrier to on-shore wind flow, although wind and precipitation tend to be diverted to the north and south of the mountains. Everett lies in the Puget Sound Convergence Zone, a region of complex wind patterns where northerly and southerly wind flows meet, often producing strong winds and heavy, intense rainfall.

The Cascade Range, lying 50 miles to the east, forms a steep topographic barrier to marine air flow and receives significant precipitation. Surface runoff is directed into numerous westerly flowing rivers such as the Snohomish River. The Cascade Range also forms a barrier against westerly flow of colder and drier continental air masses.

Wind direction is typically from the southeast in the fall and winter and from the west in the spring and summer. The coastal marine air dominates the moisture and temperature patterns, producing cool, wet, mild winters and warm, often dry, summers.

2.2.2 Local

Winds, storms, and temperatures are typically mild year-round in the Everett area. Occasionally, winter storms will bring heavy rainfall, strong winds, or snow fall. The annual average daily temperature is 50.5°F. Average daily temperatures in July are 62.9°F and in January are 38.4°F.

Precipitation in the Everett area is primarily in the form of rain. The average annual rainfall is 34 inches, the majority falling between the months of October to March.

2.3 Surface Water Hydrology

Area-wide and site-specific hydrologic information was obtained from geologic articles, maps and charts, consultant reports, and site observations during the RI.

2.3.1 Surface Water

While surface water intermittently ponds on site during prolonged rainfall, no perennial surface water bodies exist on the site. The only surface water body near the site is the Snohomish River, which forms the eastern site boundary along the bulkhead. The river is the major surface flow in the region, draining a basin that extends to the crest of the Cascade Mountains and covering approximately 1,700 square miles. The average annual flow of the river, measured near Monroe by the USGS, is 280 m^3/sec (9,890 cfs) (Williams et al., 1985). The Snohomish River estuary includes four main branches: Ebey Slough, Steamboat Slough, Union Slough, and the lower Snohomish River channel. The Snohomish River channel carries the major portion of the total river flow.

Tidal elevation information for Everett (NOAA, 1991) indicates a mean higher high water of 11.1 feet, mean high water of 10.2 feet, mean low water of 2.8 feet, and extreme low water of -4.5 feet, all referenced to mean lower low water. During the dry season, tidal saltwater intrusions to the Snohomish River have been observed as far upstream as 6.8 miles from Preston Point.

2.3.2 Seep Water

Localized seeps emanate from the bulkhead, pilings, and exposed sediments adjacent to the bulkhead, and discharge to the Snohomish River along the length of the site. Seeps were observed flowing from small openings in the bulkhead, which separates the site from the Snohomish River, upward from the base of pilings, and directly from sediments. The flow rate of individual seeps was highly variable, ranging from nearly nonexistent up to approximately 1 to 2 gpm. The most active seep was located south of the site near sampling location SR-1 (Drawing No. 1, in pocket). Additional seeps with flow rates of approximately 0.1 to 0.5 gpm were observed at sample locations SR-14, SR-7, SR-6, SR-9, and SR-13. A 6-inch-diameter pipe that penetrates through the bulkhead was observed flowing at approximately 1.5 gpm at sampling location SR-5.

Observation of seep flow rates was possible only during outgoing and low tide conditions. Based on groundwater potentiometric surface, sediment elevation, and tidal elevations, it appears the seep water is from groundwater discharge, sediment dewatering, or a combination of the two. The rates of seep flow are likely influenced by tidal elevation.

2.3.3 Storm Water

Attempts were made to locate as-built drawings or blueprints of storm water drainage systems at the site, but none were located. Three site surveys were conducted during rainfall events to examine potential contaminant migration routes via storm water runoff.

The initial survey was conducted on August 6, 1992, and subsequent surveys were conducted on November 16, 1992, and January 19, 1993. Rainfall during the 24-hour site survey periods was a trace on August 6, 0.58 inches on November 16, and 0.05 inches on January 19. Rainfall data were obtained from the National Oceanic and Atmospheric Administration (NOAA) weather station located at the city of Everett Wastewater Treatment Plant in Everett.

Existing storm water conveyance structures are shown on Figure 2-1. Two piping systems were observed at the northeast corner of the site between MW-31, HC-10, and HC-6. These two piping systems appear to connect in the vicinity of HC-10 and subsequently discharge to the Snohomish River through an oil/water separator east of HC-10D. Four catch basins were observed in this area. These four catch basins had wood walls, and the two located north of the property line had metal grate coverings. The two catch basins north of the property line appeared to connect and drain through an 8-inch-diameter pipe into the oil/water separator. These catch basins also appeared to connect, and water was observed flowing to the north. These catch basins appeared to connect with the pipes for the two catch basins located north of the property line. Two additional pipes entered the catch basin closest to MW-31, both from the east, i.e., from the direction of former Mill E. Sections of pipe within each catch basin were broken, allowing observation of water flow and sediment characteristics.

During periods of high tide, water was observed backed up into all four of the catch basins at the northeast corner of the site. As the tide dropped below the elevation of the piping, water flow was observed in the piping. Because the extent of the piping is unknown, and there appears to be direct communication between the piping and the Snohomish River, it is uncertain if flow through these pipes represents site runoff or if the flow is due to river water saturating soils adjacent to the pipes and subsequently dewatering. Sediment build-up within the 8-inch-diameter pipes was approximately 3 inches in the areas within the catch basins. Some caving and slumping of fill was also observed around the broken areas of the pipes.

Two catch basins were observed to the west of SB-26, northeast of the former wood treatment building. These wood-walled catch basins had a 12-inch-diameter, concrete pipe penetrating through each. This piping opened directly into the south basin and was accessible through a "T" pipe fitting in the north basin. Sediments were 2 to 5 inches thick, and no water flow was observed at either of these two catch basins. The sediments had a faint creosote-like odor and iridescent sheen. Connections with other storm drain piping could not be determined.

2.4 Regional Geology

Regional geologic information was obtained from geologic articles, maps, and consultant reports. Everett is located at the northern end of the north-northwesterly trending Snohomish River valley. The valley is a geomorphic depression lying between glacially deposited and modified hills. The valley lies in the Puget Sound lowland, a tectonic/geomorphic depression between the Olympic Mountains and the Cascade Range. The Snohomish River is one of several major rivers draining to the west from the Cascade Range into the Puget Sound. The site is located on the flood plain of the Snohomish River, where several hundred feet of alluvial sands, gravels, silts, and clays were deposited in a tidally influenced, estuarine-fluvial environment (Booth, 1984).

The geology of the Everett area is predominantly unconsolidated pleistocene glacio-marine and glacio-fluvial sediment over a basement of Tertiary marine sediment and volcanic rocks.

A summary of the regional geology and geologic history of Snohomish County is presented in Sweet-Edwards/EMCON (1991).

2.5 Site Geology

Site-specific geologic information was obtained primarily from previous investigations and this RI. Geologic investigations included drilling and sampling numerous test pits, soil borings, and monitoring wells on and adjacent to the site.

The sediment underlying the site consists of man-made fill and dredge fill overlying natural estuarine and fluvial sediment. For the purposes of this report, the natural sediment has been subdivided into silt and sand units, although there is some interbedding within each unit. Analyses of each material are presented below.

Subsurface site investigations by Hart Crowser (1989a, 1989b, 1991) and EMCON have identified four distinct geologic units. Eighty-five soil borings have been drilled and 32 test pits have been excavated at the site to date. Forty-six of the borings have been drilled and completed as monitoring wells, piezometers, or test wells. Boring logs of previous investigations by Hart Crowser are found in the above-referenced documents. Boring and test pit logs from the recent investigation are presented in Appendix A. Drawing No. 1 presents the locations of all borings and test pits on site to date.

Fill materials and native fluvial and estuarine sediment encountered during the investigations are divided into the following geologic units which are listed from youngest to oldest:

- Grade Fill and Mixed Fill unit
- Upper Sand unit (dredge fill)
- Upper Silt unit (estuarine)
- Lower Sand unit (fluvial)

2.5.1 Grade Fill and Mixed Fill

Grade fill or mixed fill was encountered at the surface at most of the test pit and soil boring locations. Grade fill material apparently was placed at the site after 1974 to improve the working surface. The fill is composed of sandy gravel, asphalt, angular pebbles and cobbles of crushed rock, wood debris, and bark. The top few inches contain abundant organic and wood debris and are vegetated in many areas. The grade fill forms a very dense, although permeable, layer at the surface. The fill thickness ranges from less than 1 foot (SB-5 and SB-25) to 4 feet (SB-23). No grade or mixed fill was placed in the upgradient arsenic assessment area (see Section 3.8). Figure 2-2 depicts the extent of grade fill and mixed fill at the site. The thickness of the fill units at the site is represented in a figure in Appendix B.

Additional fill types (mixed fill) have been identified beneath the former wood treatment/maintenance building and at other locations near former Mill E, west and north of the building, and along former rail lines. A concrete slab was encountered under a portion of the building at borings SB-19, SB-20, MW-28, and MW-28B, from approximately 1.5 to 3 feet below the concrete floor. The fill between the concrete slabs is light gray to black, fine to coarse sand with some gravel. Light gray, dry, sandy gravel (similar in texture to dry concrete mix) was encountered at borings SB-11, SB-11B, SB-23, and SB-5A, and in trenches TR-3A,B and TR-4A,B. The fill was noted from approximately 1 to 2 feet below ground surface (bgs) in SB-11 and SB-11B and from 6 inches to 2.5 feet bgs in SB-23.

A contour map of the base of the grade fill and mixed fill is presented in Appendix B. The map indicates that the ground surface was generally level over the entire site before fill placement.

2.5.2 Upper Sand

The upper sand unit is composed of gray brown to black, fine to medium sand with trace coarse sand. The upper sand averages 5 to 6 feet thick and ranges from less than 1 (TP-22; MW-28B) to 10.5 (TW-1) feet thick. The average thickness of the upper sand unit to the west of the site in the upgradient arsenic assessment area is 2.5 feet. The sand is typically uniform in texture and composition. Thin lenses, less than 2 inches, of coarser or finer sand are encountered in most borings. Historical records indicate that sand dredged from the Snohomish River was deposited on estuarine tidal flats of the Snohomish River from at least Mills B and C, located north of the site, to the south end landfill, located approximately 500 feet to the south of the site. Faint horizontal bedding and a general coarsening of grain size (up to fine gravel) with depth, was seen in most soil borings, confirming a hydraulic emplacement of the dredge fill. Dredge sands were encountered below fill units in all test pits and soil borings. The groundwater table is found in the upper sand at an average depth of 4 feet below the surface.

A figure showing the base of the upper sand unit is presented in Appendix B. This surface is designated as the first occurrence of organic silt below medium sand and represents the former natural surface upon which dredge fill was emplaced. The topography of the surface indicates an undulating natural surface with topographic lows west of the building and near TW-1, and topographic highs near SB-17 and SB-12. The base of the upper sand is approximately 2.5 feet bgs in the upgradient arsenic assessment area.

2.5.3 Upper Silt

The upper silt unit was encountered in all borings penetrating the base of the upper sand at the site. The silt unit is composed of stiff, low plasticity to non-plastic, gray-brown to dark brown silt with abundant organic matter (wood fragments and rootlets) in the upper layers of the unit. Lenses of fine sand, sandy silt, and silty sand, 0.1 to

0.2 feet thick, were encountered in most borings and were found at all depths in the unit. The upper silt typically has a hydrogen sulfide-like odor.

Additional information on the thickness of the upper silt unit is presented in Appendix B. The average thickness is 8 feet and ranges from 1 foot (HC-15) to 17 feet (SB-17). The thickness was estimated where borings did not fully penetrate the silt. Hart Crowser (1991) reported that the upper silt unit was absent in boring HC-5. However, the upper silt unit was encountered at 10 feet below ground surface and was approximately 9 feet thick in SB-5 adjacent to HC-5. It appears that a thick trough of silt lies in a north-south orientation approximately beneath the building. This trough may be a cut off and filled, former river channel.

A figure showing the base of the upper silt is presented in Appendix B. This surface marks the stratigraphic boundary between depositional environments of high energy fluvial to low energy tide flat/estuarine. The interpretation of this surface was based on the deepest occurrence of silt overlying medium to coarse sand. The surface topography indicates that the natural surface sloped to the west.

2.5.4 Lower Sand

The lower sand unit was encountered in all borings advanced below the base of the upper silt unit. The lower sand unit is composed of medium to coarse sand with trace gravel and wood debris and appears coarser and denser than the upper sand unit. Zones of coarse sand and fine gravel were encountered in several borings at approximately 5 to 8 feet below the base of the upper silt unit.

The base of the lower sand unit may have been intercepted in boring MW-11D2. The thickness of the lower sand unit at this boring is 63 feet. The lower sand is interpreted to be fluvial sediment deposited by the Snohomish River and probably extends beneath the entire site. The thickness increases towards the Snohomish River.

At least 3 feet of silt were encountered in MW-11D2 and MW-23D2 at approximately 75 and 65 feet bgs. In MW-11D2, the lower silt is gray, medium plasticity clay and silt with trace fine sand and wood debris. Boring MW-11D2 did not penetrate the lower silt layer. The silt may be more representative of a lacustrine environment than a fluvial-estuarine one. In MW-23D2, the lower silt layer is gray, non-plastic, thinly laminated, sandy silt with fine sand, rootlets, and shell fragments. This unit may be more representative of a marine tide flat. These silt layers may not be continuous as a single layer below the site.

Medium to coarse sand was encountered in boring MW-23D2 below the lower silt layer. This sand is similar in texture to sand above the lower silt layer. The sand layer was encountered from 67 to 99 feet bgs at the boring termination depth. The base of the lower sand unit was not encountered in MW-23D2.

Stratigraphic depths elevations and thicknesses of the geologic units at the site are tabulated in Appendix B. Figures 2-3, 2-4, and 2-5 present geologic cross-sections of the site.

2.5.5 Physical and Chemical Soil Parameters

Selected soil samples collected from the upper sand, upper silt, and lower sand units were tested for physical and chemical parameters such as total organic carbon, grain size, and vertical hydraulic conductivity (Appendix C). Results appear to be consistent with expected ranges of values reported in the scientific literature.

2.5.6 Site Geology Characterization Summary

Characteristics of the site geology can be summarized as follows:

- The grade fill and mixed fill unit, composed primarily of 1 to 4 feet of sand, gravel, and wood debris, was emplaced over much of the site both before and after wood treating operations.

- The upper sand unit is composed primarily of 1 to 10.5 feet (averaging 5 to 6 feet) of fine to medium sand dredged from the adjacent river and placed upon the former native topographic surface. The dredge sand is bedded, coarsens with depth (up to fine gravel), and is saturated below 4 feet.

- The upper silt unit is composed of 1 to 17 feet (averaging 8 feet) of dark brown, organic-rich silt with interbedded lenses of fine sand. The silt is interpreted as a former estuarine tide flat deposited by the Snohomish River.

- The lower sand unit is composed of medium to coarse sand to a depth of at least 65 feet and up to 99 feet below ground surface. Lenses of coarse sand and gravel were observed in the uppermost 5 to 8 feet. Silt layers were encountered at 65 and 75 feet below ground surface.

2.6 Regional Hydrogeology

Groundwater flow in the Puget Sound region can generally be divided into regional, intermediate, and local flow systems. The regional and intermediate flow systems in the vicinity of the site are found in the underlying tertiary marine sediment and volcanic rocks and in Pleistocene, unconsolidated, glacially derived sediment. Groundwater flow is controlled by the composition, stratigraphy, and structure of the formations. The systems are recharged in areas where the units are exposed (i.e., in the uplands to the west and east of the Sound), and discharge groundwater into Puget Sound.

Local flow systems occur in the fluvial and estuarine sediments, and in the man-made fill. They are influenced by surface topography and composition, precipitation patterns, underground utilities, and local surface water bodies. Local flow systems are recharged by precipitation and discharge from deeper flow systems. Discharge is primarily to the Snohomish River.

2.7 Site Hydrogeology

The following site hydrogeologic characterization is divided into a discussion of the site groundwater flow systems. The site hydrostratigraphy description includes the extent and permeability of each unit. The site hydraulics description includes aquifer and aquitard hydraulic conductivities, and groundwater flow directions and velocities.

2.7.1 Hydrostratigraphic Units

Four hydrostratigraphic units have been identified. These are, in order of increasing depth, grade fill and mixed fill, upper sand, upper silt, and lower sand. The occurrence and character of each unit are discussed.

Grade Fill and Mixed Fill. As described in Section 2.5.1, the entire site appears to be underlain by fill material composed primarily of sandy gravel with or without abundant wood debris. The grade fill is not considered a barrier to vertical infiltration. Some of the mixed fill near the building has been compacted, and ponded water was observed on the surface at some locations. Following significant rainfall events, surface water was ponded over compacted gravel and silt near the building and in shallow ponds near SB-10 and SB-23. The grade and mixed fill units were unsaturated in all areas during the RI, but may be part of the capillary fringe during maximum water table elevations at SB-17, SB-23, SB-24, and MW-27.

Upper Sand Aquifer. The upper sand hydrostratigraphic unit underlies the grade and mixed fill below the entire site. The unit is predominantly composed of fine to medium sand with coarse sand and fine gravel increasing at the base of the unit. A geologic description is included in Section 2.5.2. The upper sand aquifer is unconfined.

The average water table depth is about 4 feet bgs. A capillary fringe is estimated to extend a few inches above the water table. The water table apparently fluctuates an average of 2.5 feet between seasonal maximum and minimum elevations.

The upper sand geologic unit is partially saturated at all areas below the site, and completely saturated at SB-17, SB-23, SB-24, and MW-27. The saturated thickness ranges from less than 2 feet to more than 6 feet during this period. The saturated thickness is expected to increase by 2.5 feet in the wet season.

The upper sand aquifer is monitored by 30 on-site monitoring wells screened from the base of the unit to above the water table. Several off-site wells have been installed in dredge sand interpreted to be continuous with the upper sand on site.

The upper sand aquifer is recharged by surface infiltration of precipitation and discharges to the units below and to the east into the Snohomish River. Discharge to the river is restricted by the timber and sheet pile bulkhead along the shoreline. The bulkhead acts as a slightly permeable barrier to groundwater flow and has formed or altered the upper sand aquifer by damming infiltrated precipitation within it. Removal of the bulkhead would likely allow the static water elevation within the aquifer to reach a new equilibrium at the average river elevation.

Upper Silt Aquitard. The upper silt hydrostratigraphic unit underlies the upper sand aquifer and is composed of soft to stiff low plasticity to nonplastic silt. Section 2.5.3 describes the lithology and the extent of the unit. No monitoring wells were installed in the upper silt aquitard. Soil samples and vertical permeability measurements indicate that the unit impedes groundwater flow. However, sand stringers within the aquitard may be conduits for vertical flow. Timber pilings may also be conduits if they were driven through the silt at former Mill E or the building. The unit is a leaky aquitard between the two sand aquifers.

The upper silt aquitard was fully saturated at the time of drilling. The unit is recharged by the upper sand aquifer, and discharges groundwater downward to the lower sand aquifer and to the east into the Snohomish River.

Lower Sand Aquifer. The lower sand hydrostratigraphic unit is a saturated layer of medium to coarse sand with scattered lenses of fine sand, fine gravel, and silty sand. A geologic description is found in Section 2.5.4.

The lower sand aquifer is monitored by nine wells screened at its top (wells labeled with a "D" suffix) and two wells screened at its base (labeled with a "D2" suffix). Water elevations are influenced by tidal fluctuation of the Snohomish River. The tidal influence decreases with distance from the river.

The lower sand unit is considered to be a partially confined aquifer because it is bounded above and below by beds of distinctly lower permeability. At lowest tides, the lower sand becomes unconfined at monitoring well locations HC-1D, HC-10D, HC-15D, MW-9D, and MW-31D.

The lower sand aquifer is likely recharged from intermediate and local sources below and lateral to the unit, and by downward flow from the upper sand aquifer. The unit discharges into the Snohomish River during most of the tidal cycle, but may be recharged by the river during high tides.

The lower silt layers within the lower sand aquifer are locally and possibly continuous low permeability barriers, impeding vertical hydraulic flow within the lower sand aquifer.

2.7.2 Groundwater Elevations

Groundwater elevations within the upper sand aquifer vary seasonally due to increased winter precipitation and infiltration. They range from 2 to 6 feet above mean sea level across the site. Hydrographs of water elevation data collected during July to December 1992 are presented in Appendix A. The average elevation increase was 2.0 feet during this time period.

2.7.3 Tidal Influence

The Snohomish River and 11 wells in the upper and lower sand aquifers were monitored for 3 days to observe tidally influenced groundwater fluctuations. The Snohomish River elevation fluctuated about 7 feet on average over a tidal cycle. During the same time period, groundwater elevations in the upper sand aquifer fluctuated less than 0.3 feet in wells adjacent to the river, and groundwater elevations in the lower sand aquifer fluctuated from 4 to 6 feet (wells HC-11D and HC-23D, respectively). Figures representing the change of tidal lag and tidal efficiency with distance to the river are presented in Appendix A. The time lags ranged from 40 minutes (MW-23D2) to 117 minutes (HC-11D), increasing with distance from the river. The tidal response (or efficiency) ranged from 58 percent (MW-23D2) to 34 percent (HC-11D), decreasing with distance from the river.

2.7.4 Hydraulic Conductivity

Three methods were used to estimate the hydraulic conductivity (K) of the upper sand, upper silt, and lower sand units. The horizontal K of the upper sand was estimated using short-term in situ, rising head tests (slug tests) and an aquifer pumping test. The vertical K of the upper silt was measured by conducting laboratory permeameter tests on undisturbed core samples. The horizontal K of the lower sand was measured using short-term slug tests.

Upper Sand Aquifer. Slug testing was performed in three wells by Hart Crowser (1989b) and in ten wells by EMCON during this RI. Slug test results are presented in Appendix A. The hydraulic conductivity estimated from these tests ranged from 0.001 to 0.031 cm/sec, averaging 0.007 cm/sec.

The aquifer pumping test at TW-1 provides an estimate for hydraulic conductivity in the blow pit area. The maximum distance over which drawdown (0.3 feet) was observed in the 760-minute test at 9 gpm was 45 feet at P-1. Estimates of horizontal hydraulic conductivity from this test range from 0.03 to 0.08 cm/sec, averaging 0.054 cm/sec, using time-drawdown and drawdown recovery calculations. This average is more representative of the aquifer property than estimates from slug tests because a larger portion of the aquifer was evaluated in the pumping test.

No vertical hydraulic conductivity measurements were conducted on the upper sand aquifer. The vertical hydraulic conductivity is estimated to be two to ten times lower than horizontal hydraulic conductivity in uniform medium sand aquifers (Freeze and Cherry, 1979).

Upper Silt Aquitard. The vertical hydraulic conductivity of the upper silt aquitard was measured from a sample collected at HC-11D by Hart Crowser, and at two locations from two samples collected by EMCON (SB-12 and SB-26). Results of the permeability tests are presented in Appendix A. The average vertical hydraulic conductivity of the upper silt aquitard is 2.2 x 10^{-7} cm/sec. Higher permeability lenses of sand and silty sand within the upper silt aquitard may provide conduits (preferred pathways for groundwater flow). Therefore, the upper silt is considered to be a leaky aquitard, and overall horizontal and vertical hydraulic conductivity may be two to four orders of magnitude higher than represented in the permeability tests.

Lower Sand Aquifer. The average horizontal hydraulic conductivity of the lower sand unit is estimated from slug test results (Appendix A) at 0.05, with a range of 0.006 to 0.09 cm/sec. These values are typical for a sand aquifer (Freeze and Cherry, 1979). No vertical hydraulic conductivity measurements were taken from the lower sand aquifer. The vertical hydraulic conductivity is estimated to be two to ten times lower than the horizontal hydraulic conductivity (Freeze and Cherry, 1979).

Average hydraulic conductivity values are summarized on Table 2-1.

2.7.5 Hydraulic Gradients

Horizontal Gradients. Horizontal hydraulic gradients in the upper sand aquifer were determined from July 1992 water table elevation maps. The gradient appeared uniform from July to December 1992. The elevation data used to construct the plots are contained in Appendix A. The average horizontal hydraulic gradient for this time period is 0.0037 ft/ft towards the Snohomish River, measured from points near HC-11 to MW-23. The hydraulic gradient ranged from 0.0034 to 0.0039 ft/ft (Table 2-2; Figure 2-6).

Horizontal hydraulic gradients in the lower sand aquifer vary with the tide cycle. Average gradients were determined from groundwater elevation data. Potentiometric plots of high tide and low tide are contained in Appendix A. The average horizontal hydraulic gradients for high and low tides are 0.0033 ft/ft to the west and 0.0032 ft/ft to the east, respectively (Table 2-2). The gradient was measured between monitoring wells HC-11D and HC-23D. The average groundwater elevation was estimated by using a statistical averaging technique to smooth out tidal fluctuations (Serfes, 1991). The analysis and results are presented in Appendix A. The average hydraulic gradient corrected for tidal fluctuation is oriented perpendicular to the Snohomish River at a gradient of 0.00046 ft/ft to the east. A representation of the overall average net horizontal gradient in the lower sand aquifer is presented in Figure 2-7.

Vertical Gradients. Vertical hydraulic gradients between the upper sand and lower sand aquifers were calculated at several of the monitoring points with multiple screen depths. The vertical gradients vary from 0.52 ft/ft downward at low tide to 0.014 ft/ft upward at high tide. In general, the average vertical gradient is apparently downward at all wells. The vertical gradient is upward during maximum high tides at all multiple screen locations except at HC-11. The average vertical gradient was estimated from the average groundwater elevation in the wells screened in the lower sand aquifer.

The average vertical hydraulic gradients ranged from 0.18 to 0.24 ft/ft downward. A summary of horizontal and vertical gradients is presented in Table 2-2. The difference in groundwater elevation between the upper sand and lower sand units decreases with proximity to the Snohomish River. However, the vertical gradient is spatially variable across the site, due to variable thicknesses of the upper silt aquitard.

There is apparently little or no vertical gradient within the lower sand aquifer between the top and the base of the aquifer. Groundwater elevations between wells HC-11D and MW-11D2, and between wells HC-23D and MW-23D2, are nearly equal.

2.7.6 Effective Porosity

Estimating effective porosity values is necessary to calculate groundwater flow velocities. Due to the difficulty in measuring this parameter reliably, effective porosity has been estimated from literature values for similar soil types (Todd, 1959). The effective porosity of both aquifers at the site is estimated to be 0.30.

2.7.7 Groundwater Flow Velocity

Horizontal Flow Velocity. Table 2-3 lists the estimated average horizontal linear velocity values for the upper sand and lower sand aquifers. The velocities are spatially variable, due to variations in hydraulic conductivity, range from 0.56 to 2.7 feet/day, and average 1.8 feet/day in the upper sand aquifer. Because grain size and porosity appear to increase at the base of the upper sand aquifer, it is assumed that hydraulic conductivity will also be higher at the base of the aquifer. Therefore, the base of the unit may be a zone of higher groundwater flow velocities, and groundwater within the upper sand aquifer may flow preferentially within this zone. The estimated velocities in the lower sand aquifer range from 0.2 to 2.8 feet/day at high and low tide, averaging 1.6 feet/day. The magnitude of the velocity is the same at high and low tides although the direction is reversed (westerly at high tide, easterly at low tide). The net (tidal corrected) velocity is to the east, ranging from 0.03 to 0.4 foot/day, and averaging 0.2 foot/day.

Vertical Flow Velocity. Table 2-3 lists the estimated average vertical linear velocity values between the upper sand and lower sand aquifers across the upper silt aquitard. Vertical velocities range from 6.2×10^{-4} ft/day downward at low tide, 1.1×10^{-5} ft/day upward at high tide, and average 3.1×10^{-4} ft/day downward over the tidal cycle. When groundwater elevations in the upper sand and lower sand are equal, usually at high tides, the vertical flow velocity is zero.

Advective groundwater flow between the top and base of the lower sand aquifer is assumed to be insignificant because of the low or nonexistent vertical gradient.

2.7.8 Aquifer Storage

The storage in unconfined aquifers, such as the upper sand aquifer, is typically similar to the effective porosity. Aquifer pumping tests in unconfined aquifers usually require several days of groundwater extraction to provide data to estimate storage or specific yield. The storage estimate from the aquifer pumping test is expected to be low because the test was not run to this time length. An estimate of 0.30 is generally accepted for medium sand unconfined aquifers (Todd, 1959).

An aquifer pumping test was not performed in the lower sand aquifer, and the storage capacity of the lower sand aquifer was not determined. An estimate of 0.0005 is generally accepted for medium sand confined aquifers (Freeze and Cherry, 1979).

2.7.9 Groundwater Flow Directions

Horizontal groundwater flow directions were assessed from groundwater elevation data collected monthly, from July to December 1992, from monitoring wells screened in the upper and lower sand aquifers. Horizontal groundwater flow in the upper sand aquifer is typically perpendicular to the Snohomish River (Figure 2-6). The groundwater elevation map represents average head (pressure) within the aquifer and describes average groundwater flow directions. However, groundwater flow paths along the base of the aquifer may more closely follow the topography of the base of the aquifer (Appendix B) and may move preferentially towards points of discharge at the Snohomish River bulkhead (i.e., at seeps).

The horizontal groundwater flow directions in the lower sand aquifer vary with the tide cycle, trending to the west at high tide and to the east at low tide. A plot of the average potentiometric surface of the aquifer was prepared using groundwater elevation data averaged over 3 days (Figure 2-7). The average groundwater flow direction in the lower sand aquifer appears to be perpendicular to the Snohomish River shoreline in an easterly direction.

Groundwater flow occurs along a preferred path of maximum permeability and hydraulic gradient. Horizontal groundwater flow velocities in the two aquifers are approximately 2 feet per day, and vertical groundwater velocity across the aquitard is about 3.1×10^{-4} feet per day, or four orders of magnitude lower than flow velocities. Therefore, groundwater flow below the site is predominately in the horizontal direction. It is probable that vertical groundwater flow does occur at certain locations at the site where sand lenses within the upper silt aquitard may transmit groundwater between the aquifers, especially in areas where the upper silt aquitard is thin (for example, between HC-15 and MW-30). Additional conduits between the two aquifers may exist along timber pilings driven through the upper silt aquitard.

2.7.10 Recharge/Discharge Relationships

Recharge can occur through direct infiltration of incident precipitation, infiltration of collected water, and leakage from utility corridors. Evaluation of hydrographs (see Appendix A) indicates that water levels respond to seasonal precipitation. Since most of the site and areas to the west (upgradient) are unpaved, infiltration of incident precipitation is expected to occur. Infiltration of leakage from utilities is unknown, but is most likely localized, if it occurs.

Perching layers may exist in the grade fill/mixed fill units, although they are not considered to significantly retard downward recharge.

A portion of recharging water appears to flow from the upper sand to the lower sand aquifers, as indicated by downward gradients across the site. The recharging water is incorporated into horizontal flow in the lower sand aquifer.

Discharge appears to occur at the site. In general, groundwater enters the aquifer through recharge and under-flow from off site. It appears to flow to the east away from the site and into the Snohomish River. Discharge may be most significant in the upper zone in the vicinity of HC-10 near the oil/water separator, and also to the south, towards HC-2 and HC-1, near the end of the bulkhead south of the site.

2.7.11 Site Hydrogeology Characterization Summary

Characterization of the site hydrogeology can be summarized as follows:

- The dredge fill, tide flat/estuarine silt, and fluvial sediment (upper sand, upper silt, and lower sand units) make up the main hydrostratigraphic units in the area.

- The grade fill and mixed fill units may inhibit infiltration or store perched water in localized areas of the site. Otherwise the fill units do not impede recharge by infiltration of precipitation.

- The water table depth is approximately 4 feet bgs and fluctuates a maximum of 2.5 feet annually in selected wells.

- Horizontal groundwater flow in the upper sand aquifer is generally towards the east at an average linear velocity of 1.8 feet/day.

- Horizontal groundwater flow in the lower sand aquifer is tidally influenced and generally moves to the east at an average linear velocity of 0.2 feet/day.

- Downward vertical gradients between the upper and lower sand aquifers exist everywhere at the site except at maximum high tides.

- Downward flow between the aquifers is impeded by the upper silt aquitard except where the silt is thin or containing significant sand interbeds.

- Man-made features in the upper sand (storm drains, bulkhead), upper silt aquitard (bulkhead, pilings), and lower sand aquifer (bulkhead, pilings) affect the natural groundwater flow regime, providing conduits or barriers to groundwater flow.

2.8 River Sediment

Results of the review of previous environmental studies of the Snohomish River and observations of site conditions during sediment sampling are summarized below. Additional information is provided in Appendix D.

2.8.1 Review of Historical Data

Historical dredging files available at the U.S. Army Corps of Engineers (Corps) in July 1992 indicate that dredging of the Snohomish River occurs every 2 to 3 years. The Snohomish River channel is maintained from the mouth at Jetty Island to a settling basin upstream of the I-5 bridge. The most recent dredging conducted in the channel reach offshore of the site occurred in 1988. The Snohomish River channel is maintained near the east bank of the Snohomish River. Sediments between the west bank and a line of dolphins located approximately 150 feet east of the west bank are not dredged. Although sediments tend to accumulate along the west bank of the river, the Corps does not dredge this area.

Chemical analysis of the dredge material is not performed by the Corps. Grain-size profiles generally showed fine to medium, poorly graded sand. Total organic carbon (TOC) analysis generally showed concentrations less than 2 percent.

Everett Harbor Action Program: Analysis of Toxic Problem Areas, and *Evaluation of Potential Contaminant Sources* (PTI Environmental Services and Tetra Tech, 1988; Tetra Tech, 1988) include generalized results for sediment sampling conducted in the Snohomish River. Samples collected near the site did not show elevated concentrations of contaminants relative to reference stations. Potential sources of contaminants identified in the area of the site include three combined sewer overflows from the city of Everett, the outfall to the Everett Wastewater Treatment Plant, and two wood treatment facilities. The wood treatment facilities identified as potential sources include Buse Timber, on Smith Island, and Canyon Lumber, west of the Snohomish River on Everett Avenue, near the entrances to Steamboat and Union sloughs.

2.8.2 Phase I Sediment Sampling

Phase I sediment samples (sampling described in Appendix A) were collected at locations exposed during low tides. Sediments were characteristic of a depositional environment, generally a very loose to loose, dark gray to black, sandy silt. A strong hydrogen sulfide odor was noted at sampling locations south of approximately location SR-09 (Drawing No. 1). A surface layer of reduced sediments, ranging in thickness from approximately 0.02 to 0.25 feet, was noted at all sampling locations except SR-01, SR-02, and SR-13. Black sediments with orange mottling were observed at locations SR-01, SR-02, SR-13, and SR-14, indicating a high iron content. The elevation of the sediment surface immediately east of the bulkhead ranged from approximately 11 to 15 feet lower than the ground surface at the site. North of station SR-07, in the main channel of the Snohomish River, sediments to the west of the bulkhead generally sloped steeply down to the east, forming a channel approximately 6 to 10 feet deeper than the sediment along the bulkhead.

An iridescent sheen was observed on sediments at locations SR-06, SR-07, SR-10, SR-11, SR-12, and SR-13, and a creosote odor was noted at locations SR-05, SR-07, SR-10, and SR-11. The sheen may have been the result of natural wood decay processes, since accompanying odors of petroleum and/or creosote were not noted at all locations.

2.8.3 Phase II Sediment Sampling

Phase II sediment sampling was initiated based on observations of potential sediment contamination during Phase I sediment sampling. Phase II sediment sampling locations (SR-16 through SR-32) were selected to provide representative samples from more dynamic river locations and to assist in delineating the horizontal extent of contamination.

Samples collected at locations SR-16 through SR-25 were similar in texture to Phase I sediment samples. Sediments from these locations were generally loose, black to dark gray or brown sandy silts, with fines increasing with depth. Samples collected from locations SR-27 through SR-32 were generally dark gray or brown to black silty sands. The proportion of silt and clay tended to increase with depth. A layer of reducing sediment, generally from the surface to a depth of approximately 0.20 foot, was observed at all sampling locations.

Repeated attempts were made to collect samples from close inshore locations at SR-27 through SR-32, but large amounts of wood debris, including sunken logs, branches, and bark, prevented efficient operation of sampling devices at these locations.

2.8.4 Sediment Characterization Summary

Characteristics of the Snohomish River sediments near the site can be summarized as follows:

- Sediments were dark gray to black sandy silt and silty sand.
- Reduced surface sediments, indicative of poorly oxygenated sediment, were observed throughout the study area.
- Dredging does not influence sediment characteristics in the study area.
- Groundwater flow and sediment dewatering appear to occur at localized sites. (i.e., seeps) through the bulkhead

2.9 Pavement and Structures

As previously noted, the site was formerly an estuarine tideflat adjacent to the Snohomish River. It was filled in the early 1900s, using sand dredged from the river bottom. The bank of the Snohomish River has been stabilized along the length of the site with a bulkhead of timber and steel sheet pilings. The eastern and southern areas of the site have been covered by 1 to 3 feet of mixed wood and gravel grade fill.

The 6.6-acre site is covered by one 7,800-square-foot building (former wood treatment building), a 21,000-square-foot concrete slab (former Mill E building site), and approximately 6,000 square feet of asphalt pavement. Approximately 14 percent of the site is covered with pavement (Drawing No. 1). The former wood treatment/ maintenance building will be referred to as the "building" in this report.

2.10 Land Use

The site is located on Weyerhaeuser property. Both the site and Weyerhaeuser property have been used for industrial purposes since development. The site is not currently in use and operations at the Weyerhaeuser property have been curtailed. The Weyerhaeuser property, and specifically the site, are planned for continued industrial use.

The site and adjacent property are currently zoned "M-2, Heavy Manufacturing" by the city of Everett (Appendix E).

3 NATURE AND EXTENT OF CONTAMINATION

3.1 Data Sources

The soil, groundwater, sediment, and surface water data used for evaluation of the nature and extent of site contamination were derived from field investigations conducted between July 15 and December 30, 1992. Additional soil investigations were performed in August 1993 to more closely define the limits of contamination. Results are reported in the sections that follow. Groundwater monitoring was conducted on a quarterly basis from August 1992 through August 1993, and is now being conducted on a semiannual basis. Results of the quarterly groundwater sampling events (five rounds) are reported in the sections that follow.

A summary of site historical activities, chemicals used on site, and the results of previous site investigations was provided in the Work Plan and is not repeated herein. A detailed description of site investigation procedures are provided in Appendix A. Sampling locations are shown on Drawing No. 1.

3.2 Data Validation and Evaluation Procedures

Validation of all laboratory results was conducted using the procedures specified in the Sampling and Analysis Plan (SAP) of the Work Plan. A description of the data validation review, database entry, quality assurance/quality control (QA/QC) of data summaries, and statistical analyses is provided in Appendix F. Data validation reports are on file at EMCON Northwest, Inc. Statistics were calculated following Ecology (1992) guidelines. The distributions of compounds were evaluated using probability plots with STSTAT® or Ecology's MTCASTAT software. The 95 percent upper confidence limit on the mean (UCL95) was then calculated using standardized methods. For data that showed neither a normal nor a lognormal distribution, or where the calculated UCL95 was greater than the maximum detected concentration, the maximum detected concentration was selected to represent the UCL95.

Raw data and statistical summaries for all media evaluated in this RI are tabulated in Appendix G. Laboratory reports are on file at EMCON Northwest, Inc.

3.3 Soil

Soil samples were collected at the surface in the grade fill and mixed fill units. Subsurface samples were collected at the base of these two fill units, in both the unsaturated and saturated zones of the upper sand unit, and at the top of the upper silt unit. Sample locations were selected to evaluate impacts of historical practices; location rationale is described in detail in the Work Plan. Soil samples were analyzed for metals (arsenic, chromium, copper, lead, mercury), PCBs, TPH, VOCs, SVOCs, and dioxins/ furans.

PCBs were detected in soil at only two locations, at a maximum concentration of 0.041 mg/kg. Based on these limited detections, PCBs are not discussed further in this report. Laboratory results for all PCB analyses are provided in Appendix G.

3.3.1 Fill

Field Observations. Strong creosote-like odors were noted in the grade and mixed fill at SB-17, SB-10, SB-23, SB-24, and MW-33, and hydrocarbon-like odors were noted in SB-20 and SB-22. Non-aqueous phase liquid (NAPL) was observed in the mixed fill in SB-18 from 6 inches to 3.5 feet bgs.

Metals. The average concentrations of metals in Puget Sound soils are presented in Table 3-1. A statistical summary of metals detected in site soil samples is presented in Table 3-2. Average arsenic concentrations in the fill units are within regional levels, but exceed an average concentration (20 mg/kg) estimated by Ecology for the north Everett area (Dave Nazy, Ecology, personal communication with Steve Nelson, EMCON, November 1992). Figure 3-1 presents the distribution of arsenic in the fill units. The maximum concentrations of arsenic appear to be related to the narrow gauge rails and the building.

The average chromium concentration is within the range of Puget Sound regional values. Chromium concentrations appear to be highest on site along former rail lines and at the building. Average copper and lead concentrations are above Puget Sound regional values, and these metals are randomly distributed within the fill units. Mercury was detected in only one sample (0.08 mg/kg).

TPH. A statistical summary of TPH compounds (gasoline, diesel fuel, and other [heavy oil]) in the fill units is presented in Table 3-3. The highest concentrations of TPH compounds are found primarily at the base of the mixed fill around and below the building (Figures 3-2 to 3-4). Grade fill TPH concentrations were significantly lower than TPH concentrations in the mixed fill, with the exception of samples collected near former Mill E and east of the building.

Volatile Organic Compounds. A statistical summary of VOC results for the fill units is presented in Table 3-4. Only five VOCs, primarily petroleum hydrocarbon-related (BTEX), were detected in the fill unit. The single detection of 2-butanone is considered a laboratory contaminant.

Semivolatile Organic Compounds. Table 3-5 presents a statistical summary of SVOCs in the fill units. Twenty-two of 64 SVOCs were detected in fill unit samples. Pentachlorophenol was detected in 17 of 25 samples and carcinogenic polycyclic aromatic hydrocarbons (CPAHs) were detected in 19 of 25 samples.[1]

The SVOCs detected in the fill units are found primarily along former rail lines and around or below the building. The higher concentrations of SVOCs are found at the base of the fill units. Figures 3-5 and 3-6 present the distribution of pentachlorophenol and total CPAHs at the site.

3.3.2 Upper Sand

Field Observations. Strong hydrocarbon-like odors were noted at SB-9, SB-16, SB-18, SB-20, SB-22, SB-24, SB-37, MW-27, MW-28, and TP-17, all in the vicinity of the building.

Strong creosote-like odors, iridescent sheens, and dark brown staining were noted in unsaturated soil and at the water table at SB-10, SB-11, SB-12, SB-13, SB-15, SB-17, SB-23, SB-25, SB-36, MW-33, P-1, P-2, and TW-1. These observations are interpreted to indicate locations of LNAPL.

Strong creosote-like odors, iridescent sheens, and dark brown or black staining were noted at the base of the upper sand (saturated soil) at the aforementioned LNAPL locations (except SB-10, SB-12, and SB-17) and at SB-6, SB-8, SB-26, SB-38, and SB-40. In the latter 5 borings, no evidence of LNAPL was observed in the unsaturated zone or at the water table. These observations are interpreted as locations of DNAPL.

Floating Product. LNAPL was measured and sampled on May 18, 1993, at three wells: TW-1 (1.57 feet of dark brown product with a creosote odor), P-1 (0.34 feet, similar to TW-1), and HC-12 (0.14 feet of faint yellow product with a petroleum odor). Analytical results are presented in Appendix G. LNAPL at HC-12 contained approximately 55 percent TPH-diesel and 12 percent TPH-other. LNAPL at P-1 contained approximately 55 percent TPH-diesel, 16 percent noncarcinogenic PAHs (NCPAHs), 0.79 percent PCP, 2,500 mg/L CPAH, and 170 mg/L TPH-gasoline.

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[1] CPAHs are benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

LNAPL at TW-1 contained approximately 80 percent TPH-diesel, 20 percent NCPAH, and 1 percent PCP.

Metals. A statistical summary of the metals results is provided in Table 3-6. The average concentrations of metals in the upper sand unit are comparable to the average regional concentrations, except for arsenic. Arsenic concentrations in the upper sand unit are higher than the average concentration identified by Ecology for north Everett. Figure 3-7 presents the distribution of arsenic in this unit. The maximum concentrations of arsenic appear to be related to the blow pit area, the former narrow gauge rails, and the building.

Chromium concentrations appear to be highest along the former rail lines and at the building. The site-wide average concentration is similar to Puget Sound regional soil levels. Copper and lead are distributed randomly within the upper sand unit. Their average concentrations are lower than Puget Sound regional soil levels. Mercury was detected at only one location, at 0.16 mg/kg.

Total Petroleum Hydrocarbons. Table 3-7 presents a statistical summary of TPH compounds in the upper sand unit. The highest concentrations of gasoline and diesel fuel are found primarily at the former blow pit area, around the building, around former Mill E, and to a lesser extent along former rail lines (Figures 3-8 to 3-10). Other petroleum hydrocarbons, identified as heavy oils, were detected near the building, former Mill E, and along former rail lines.

The concentrations of gasoline and diesel fuel in the upper sand unit are similar to concentrations in the fill units near the building. However, concentrations of the lighter TPH compounds in the upper sand unit in the blow pit area are two to three orders of magnitude higher than those in the fill units. The concentrations of heavier TPH compounds in the upper sand unit at the building are greater than those in the fill units. Concentrations of heavier TPH in the upper sand unit elsewhere at the site are significantly lower than those in the fill units.

Volatile Organic Compounds. Table 3-8 presents a statistical summary of VOCs in the upper sand unit. The same five VOCs found in the fill units were detected in the upper sand unit, at approximately the same average concentrations. In addition, styrene was detected in three of thirty samples, and 2-butanone was detected in two of thirty samples. The compound 2-butanone is considered a laboratory contamination.

Semivolatile Organic Compounds. Table 3-9 presents a statistical summary of SVOCs in the upper sand unit. Twenty-seven of 64 SVOCs were detected in 53 upper sand unit samples. Pentachlorophenol was detected in 25 of 53 samples. CPAHs were detected in 31 of 53 samples.

SVOCs detected in the upper sand unit are found primarily in the former blow pit area, along former rail lines and around or below the building. The highest concentrations of SVOCs are found in the former blow pit area. Figures 3-11 and 3-12 present the distribution of pentachlorophenol and total CPAHs in the upper sand unit.

The SVOC concentrations in the upper sand unit are one to two orders of magnitude higher than in the fill units.

Dioxins/Furans. Table 3-10 presents a statistical summary of the dioxin/furan results. The 2,3,7,8-tetrachlorodibenzodioxin (TCDD) congener was not detected in any of the 17 samples. The 2,3,7,8-tetrachlorodibenzofuran (TCDF) congener was detected in 6 of 17 samples. Dioxin and furan congeners containing 7 and 8 chlorine atoms, the hepta and octa congeners, were the most frequently detected dioxins and furans. The highest dioxin/furan concentrations (i.e., octa congeners) were found in the blow pit area.

TCLP Analyses. TCLP analyses were performed on select samples from the upper sand unit for purposes of evaluating the leachability of compounds from the soil. TCLP results are presented in Appendix G. Metals, VOCs and SVOCs were analyzed by the TCLP method. No VOCs were detected. Arsenic concentrations ranged from 0.1 to 0.7 mg/L, and chromium concentrations ranged from 0.01 to 0.08 mg/L. Barium was detected at 0.6 and 0.8 mg/L. Mercury and lead were not detected above their respective detection limits of 0.001 and 0.05 mg/L. Of the SVOCs, only pentachlorophenol was detected, with TCLP concentrations ranging from 0.011 to 0.06 mg/L.

3.3.3 Upper Silt

Field Observations. Strong petroleum hydrocarbon-like odors were noted at the top of the upper silt unit in borings SB-8, SB-9, SB-16, SB-18, and MW-23. Strong creosote-like odors and iridescent staining were noted at the top of the upper silt unit at those borings where DNAPL was observed at the base of the upper sand.

Arsenic. Soil samples were collected at the top of the upper silt unit for arsenic analysis. Eight samples were collected at eight borings. Arsenic concentrations ranged from 18.2 to 1,250 mg/kg, with a geometric mean of 72 mg/kg. Arsenic in the upper silt unit was randomly distributed at the site.

3.4 Groundwater

Groundwater samples were collected from wells installed in the upper sand and lower sand aquifers. The sample locations were selected to evaluate impacts of historical practices; well location rationale is described in detail in the Work Plan. Groundwater samples were analyzed for total and dissolved metals (arsenic, chromium, copper, lead, mercury), TPH, VOCs, and SVOCs.

The nature and the extent of contamination in groundwater in the two aquifers is summarized in the following sections. The results of five groundwater sampling events are discussed.

3.4.1 Local and Regional Groundwater Geochemistry

Metals are naturally present in groundwater. Table 3-11 summarizes the concentrations of the metals of concern naturally present in groundwater (Dragun, 1988) and occurring upgradient of the site. For the purposes of this investigation, monitoring wells HC-4, HC-11, HC-11D, MW-11D2, HC-17, HC-24, HC-25, and HC-26 were selected to represent background groundwater quality (Drawing No. 1). Wells screened in the upper sand aquifer are referenced in summary tables as shallow wells, and wells screened in the lower sand aquifer are referenced in summary tables as deep wells.

3.4.2 Upper Sand Aquifer

Metals. Statistical summaries of total and dissolved metals detected in on-site groundwater samples are presented in Tables 3-12 and 3-13. Concentrations of total metals are nearly identical to concentrations of dissolved metals in the first two quarterly sampling events. Total suspended solids (TSS) concentrations are low, averaging 23 mg/L for both rounds. Based on these results, total metals concentrations have been used to represent groundwater quality.

The average arsenic concentration in the upper sand aquifer at the site (2.17 mg/L) is greater than the average upgradient concentration (0.443 mg/L). Arsenic concentrations at each well and the average site-wide arsenic concentrations fluctuate seasonally. The arsenic concentrations generally decrease with the rising water table during the rainy season (November to May) and increase as the water table drops during the dry season. This inverse relationship may be attributed to dilution of groundwater by infiltrated precipitation.

Table 3-13 summarizes the average arsenic concentrations in each on-site well. Figure 3-13 presents the distribution of arsenic in the upper sand aquifer samples. The highest concentrations of arsenic were detected in and downgradient of the blow pit area. Arsenic levels were lower along the former narrow-gauge rail lines and near the building.

Elevated groundwater arsenic concentrations generally are spatially correlated with elevated soil arsenic concentrations.

The average chromium concentration in the upper sand aquifer (Table 3-12) is greater than chromium detections in upgradient wells. Elevated chromium concentrations are coincident with elevated arsenic concentrations.

The average copper concentration in the upper sand aquifer is approximately 50 percent greater than the background concentration. Copper is randomly distributed across the site within groundwater of the upper sand aquifer.

The average lead concentration is similar to the mean background concentrations. Lead is randomly distributed across the site within groundwater of the upper sand aquifer. Mercury was detected only once, at a concentration equal to the method detection limit (MDL), in a November 1992 sample. Iron was detected at an average concentration of 25.8 mg/L from the six samples collected in November 1992. Iron analyses were performed for groundwater treatability purposes.

TPH. A statistical summary of TPH-total and individual components (gasoline, diesel, and heavy oil) in the upper sand aquifer is presented in Table 3-14. Average TPH-total concentrations in the upper sand at the site are presented in Table 3-13. The highest concentrations of TPH were detected primarily below the blow pit area and around the building (Figure 3-14). Significantly lower TPH concentrations were detected near the former Mill E and at HC-10. Heavier TPH compounds are less widespread in the upper sand aquifer than lighter compounds and are primarily found near former Mill E (e.g., HC-12). In general, elevated groundwater TPH concentrations are spatially correlated with elevated soil concentrations.

Average site TPH concentrations are seasonally variable. The TPH concentrations generally increase with the rising water table during the rainy season (November to May) and decrease as the water table drops during the dry season. This relationship may be due to leaching of residual TPH in unsaturated soil by the infiltration of precipitation, a rising water table, or both. Average site-wide TPH concentrations fluctuate seasonally and appear to be correlated with groundwater elevations. This correlation may be due to leaching of residual TPH in unsaturated soil by infiltrating precipitation, a rising water table, or both.

Volatile Organic Compounds. A statistical summary of VOCs in the upper sand aquifer is presented in Table 3-15. Only six VOCs, primarily petroleum hydrocarbon-related (BTEX), were detected in the upper sand aquifer. The acetone and 2-butanone detected in August 1992 samples are considered laboratory contaminants. In general, BTEX compounds were found near the building and former Mill E.

Semivolatile Organic Compounds. Table 3-16 present a statistical summary of SVOCs in the upper sand aquifer. Thirty of sixty-four SVOCs were detected in ninety-two samples. PCP was detected in 39 samples, and CPAHs were detected in 12 samples.

Seasonal fluctuation of SVOC concentrations, except for pentachlorophenol, are similar to those of TPH; an increase in SVOC concentrations appear to correlate with a rise in the water table. The same mechanism of leaching of residual SVOCs is attributed to the increase.

SVOCs are found primarily in and downgradient of the blow pit area, east of the building, and southeast of former Mill E at MW-31. Elevated concentrations of SVOCs in groundwater are spatially correlated to elevated SVOCs in soil.

Figure 3-15 presents the distribution of PCP in the upper sand aquifer. PCP in the upper sand aquifer is found primarily in the blow pit area, near the building, and along former rail lines. Average concentrations of PCP in on-site wells are presented in Table 3-13.

Average site-wide PCP concentrations fluctuate seasonally, similar to the seasonal variation of arsenic concentrations. The same mechanism of dilution of dissolved PCP by infiltration of precipitation or a rising water table may be attributed to the increase.

3.4.3 Lower Sand Aquifer

Metals. A statistical summary of metals in the lower sand aquifer is presented in Tables 3-12. TSS values in the lower sand aquifer are low, averaging 14 mg/L for both rounds, and total metal concentrations are nearly identical to dissolved metal concentrations. Based on these results, total metals concentrations have been used to represent groundwater quality.

The average arsenic concentration in the lower sand aquifer (0.163 mg/L) is about two orders of magnitude greater than the background concentration (0.0012 mg/L). The maximum concentrations of arsenic were found near and downgradient of the blow pit area (i.e., at HC-15D and HC-23D). Slightly elevated arsenic concentrations were found in wells along the former rail lines beside the bulkhead. Seasonal variations of arsenic concentrations in the lower sand aquifer are similar to those in the upper sand aquifer. The average arsenic concentration in the lower sand aquifer (0.163 mg/L) is an order of magnitude less than the average arsenic concentration in the upper sand aquifer (2.17 mg/L).

The average concentration of chromium (Table 3-12) in the lower sand aquifer is about two times the average background concentration. Elevated chromium concentrations are coincident with elevated arsenic concentrations. The average concentration of chromium in the lower sand aquifer is four times lower than the average chromium concentration in the upper sand aquifer.

The average copper concentration in the lower sand aquifer (0.0026 mg/L) is near MDLs. Copper was not detected in upgradient well HC-11D, and only sporadically in lower sand aquifer wells on site (detections ranged from 0.0012 to 0.014 mg/L). The average copper concentration in the lower sand aquifer is about three times lower than the average copper concentration in the upper sand aquifer.

The average concentration of lead in the lower sand aquifer is near MDLs. Lead was detected only once at the MDL (0.0013 mg/L) in upgradient well HC-11D, and infrequently in the lower sand aquifer beneath the site (maximum detection of 0.008 mg/L).

Mercury was not detected in any samples. Iron was detected at an average concentration of 12 mg/L in the two samples collected in November 1992.

TPH. A statistical summary of TPH-total and individual components (gasoline, diesel, heavy oil) in the lower sand aquifer is presented in Table 3-14. Seasonal variations in the average site TPH concentrations are inversely correlated to groundwater elevations, possibly indicating dilution effects of dissolved TPH. Mean TPH concentrations in the lower sand aquifer are two to ten times lower than those in the upper sand aquifer.

TPH-diesel was the primary petroleum component detected. TPH-diesel was found primarily at and downgradient of the blow pit area (i.e., HC-15D, HC-23D, and MW-31D).

Volatile Organic Compounds. A statistical summary of VOCs in the lower sand aquifer is presented in Table 3-15. Only four VOCs, all petroleum hydrocarbon-related (BTEX), were detected in the lower sand aquifer. Concentrations of VOCs are seasonally variable but exhibit no seasonal trends. Mean VOC concentrations in the lower sand aquifer samples are about 50 percent lower than mean VOC concentrations in the upper sand aquifer.

In general, VOCs are found primarily in association with TPH at and downgradient of the blow pit area (i.e., at HC-15D, HC-23D, MW-31D). Trace levels (near the detection limit) of toluene and total xylene were detected in deep well MW-23D2 in the first two sampling events (August 1992 and November 1992) only.

Semivolatile Organic Compounds. Table 3-17 presents a statistical summary of SVOCs in the lower sand aquifer. Thirteen of sixty-four SVOCs were detected in forty-two lower sand aquifer samples. PCP was detected in seven samples from two wells. CPAHs were not detected in any wells installed in the lower sand aquifer.

In general, average SVOC concentrations were seasonally variable but exhibited no seasonal trends. Average SVOC concentrations in the lower sand aquifer samples were an average of five to ten times lower than average SVOC concentrations in the upper sand aquifer.

The SVOCs were found primarily near and downgradient of the blow pit area (i.e., at HC-15D, HC-23D), and southeast of former Mill E (MW-31D).

PCP was detected in only two wells, both located below or downgradient of the blow pit area (HC-15D and MW-23D2). PCP was detected in MW-23D2 in the August 1992 and November 1992 sampling events only.

3.5 Surface Water

3.5.1 Snohomish River

Surface water samples were analyzed for metals (As, Cr, Cu, Pb, Hg), TPH, and SVOCs. Results for compounds detected in these samples are provided in Table 3-18.

Arsenic was detected in two of eight samples at 0.0017 mg/L. Copper was detected in five of eight samples at concentrations ranging from 0.0035 to 0.0064. Lead was detected in one sample at 0.002 mg/L. Chromium and mercury were not detected in any samples.

Only one of eight samples contained detectable concentrations of petroleum hydrocarbons (RW-01), at 0.07 mg/L TPH-gasoline. This sample was collected upgradient from the site during ebb tide, and may therefore represent an off-site source.

No SVOCs were detected in surface water samples collected from the Snohomish River.

3.5.2 Seeps

Seep samples were collected at seven locations and analyzed for metals (As, Cu, Cr, Pb, Hg), TPH, VOCs, SVOCs, and total suspended solids (TSS). Results for compounds detected in these samples are provided in Table 3-19.

Arsenic was detected in all seven samples, at concentrations ranging from 0.0068 to 0.174 mg/L. Chromium was detected in six of seven samples, ranging from 0.0054 to 0.0248 mg/L. Copper was detected in five of seven samples, ranging from 0.0067 to 0.0313 mg/L. Lead was detected in five of seven samples at concentrations ranging from 0.0009 to 0.387 mg/L. Mercury was detected in one sample, at 0.0002 mg/L.

Petroleum hydrocarbons were detected in only one seep sample, at 0.083 mg/L TPH-gasoline.

VOCs were detected in only one sample, and only the compounds benzene, toluene, ethylbenzene, and xylenes, were detected. Concentrations are provided in Table 3-19.

Seven SVOCs were detected in one sample, and naphthalene alone was detected in one other sample. Specific SVOCs and the detected concentrations are provided on Table 3-19.

TSS concentrations ranged from 10 to 310 mg/L.

The sources of seep water were not conclusively determined, but appear to be a combination of groundwater and river water dewatering from site soils during ebb tide.

3.5.3 Storm Water and Storm Drain Sediments

Storm water samples were analyzed for metals (As, Cu, Cr, Pb, Hg), TPH, SVOCs, and TSS. A summary of those compounds detected in the storm water samples is provided in Table 3-20. Arsenic, copper, and lead were the only metals detected in storm water samples. TSS concentrations were 4 and 3 mg/L. Petroleum hydrocarbons and SVOCs were not detected in either storm water sample.

Storm drain sediment samples were analyzed for total and TCLP metals (As, Cu, Cr, Pb, Hg), TPH, and SVOCs. Results for metals detected in storm drain sediment samples are provided in Table 3-21. Results for TPH and SVOC compounds detected in storm drain sediment samples are provided in Table 3-22.

Metals results for storm drain sediment samples were compared to metals concentrations in soil in the grade fill and upper sand units (Tables 3-2 and 3-6) to evaluate relative concentrations. Arsenic and chromium concentrations in storm drain sediment samples were lower than the averages for the fill unit and upper sand unit. Copper concentrations were estimated at concentrations higher than the average fill unit and upper sand unit concentrations, but lower than the maximum fill unit concentration. The lead concentration in sample SWR-SD2 (97.8 mg/kg) was nearly equal to the maximum lead concentration in the fill unit (103 mg/kg). Sample SWR-SD3 showed a lead concentration (131 mg/kg) higher than the maximum fill unit concentration. Both storm drain sediment samples showed lead concentrations higher than the maximum upper sand unit lead concentration (14.8 mg/kg).

TC metals results for storm drain sediment samples showed no detections except for barium and lead in sample SWR-SD2. The TC barium and lead concentrations were lower than regulatory criteria.

TPH-gasoline and TPH-other (heavy oil) were detected in both storm drain sediment samples. Gasoline was detected at 0.64 and 0.94 mg/kg, and heavy oil was detected at 520 and 940 mg/kg.

A comparison of storm drain sediment SVOC results (Table 3-22) to the average concentrations of these contaminants for the fill and upper sand units (Tables 3-5 and 3-9) indicates that storm drain sediment concentrations are generally an order of magnitude lower than concentrations in these units.

3.6 Sediment

Surface sediment and sediment core samples were collected from 30 locations adjacent to the site in the Snohomish River and from one upstream location. Sediments were analyzed for metals (As, Cr, Cu, Pb, Hg), VOCs, SVOCs, TOC, and additional selected parameters. Sample locations were selected based on potential migration pathways as described in the Work Plan. Statistical summaries of metals and SVOC results for sediment samples are presented in Tables 3-23 and 3-24, respectively.

3.6.1 River Sediment Results

Results for sediment samples are discussed below. Sediment sampling depths were measured from the sediment surface.

Metals. Arsenic, chromium, copper, and lead were detected in all 72 surface sediment and core samples, and mercury was detected in three samples. The average concentrations of chromium and copper were equivalent to the average concentration for the background surface and (3) core sediment samples. Average arsenic and lead concentrations were elevated by a factor of 2 or more, relative to the average for the background sediment samples. Seven of seventy-two sediment samples, collected from three stations (SR-01, SR-02, and SR-05), showed concentrations of arsenic that were more than twice the average arsenic concentration. Chromium and lead concentrations were relatively uniform across the sample area. Only one sediment sample, a core collected at station SR-12, showed a copper concentration more than twice the average sediment copper concentration. A sediment core sample collected from station SR-22 showed a mercury concentration that was more than twice the average sediment mercury concentration.

Volatile Organic Compounds. Acetone and 2-butanone were detected in 60 of 68 and 26 of 68 sediment samples, respectively. Acetone and 2-butanone were also detected in a background sediment sample. Potential sources for acetone and 2-butanone were evaluated by comparing sediment sample results to other media. In the first two groundwater sampling events, acetone was detected in 5 of 60 samples, and 2-butanone was detected in only 1 of 60 samples. Acetone was not detected in soil samples, and

2-butanone was detected in only 3 of 46 soil samples. Although these two compounds were not consistently detected in either method blanks or field blanks, the results reported for sediment samples appear to be a sampling artifact. One potential source of these contaminants may have been the butyl acrylate tubing used for collecting core samples.

VOCs detected in sediment samples included carbon disulfide at stations SR-05, SR-10, SR-11, and SR-12. Carbon disulfide was detected at estimated concentrations ranging from 0.003 to 0.013 mg/kg in sediment core samples from these stations, and at an estimated concentration of 0.003 mg/kg in the surface sediment at station SR-12. Benzene, ethylbenzene, and total xylenes were reported at concentrations of 0.003 mg/kg, 0.020 mg/kg, and 0.022 mg/kg, respectively, in the surface sediment from location SR-07. The sediment core sample collected from 0 to 1.0 foot at station SR-07 showed ethylbenzene at an estimated concentration of 0.004 mg/kg. The sediment core sample collected from a depth of 1.0 to 1.80 feet at station SR-07 showed benzene, toluene, ethylbenzene, and total xylenes at estimated concentrations of 0.012 mg/kg, 0.004 mg/kg, 0.030 mg/kg, and 0.044 mg/kg, respectively.

No other VOCs were detected in the sediment samples. Results of the VOC analyses are provided in Appendix G. A statistical summary of sediment VOC analyses was not prepared due to the low frequency of detected compounds.

Semivolatile Organic Compounds. Laboratory results for SVOCs in sediment are summarized in Table 3-24. Twenty-five SVOCs were detected. SVOCs that were detected in more than 40 percent of the samples included phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, and benzo(b)fluoranthene. SVOCs that were detected in sediments at a frequency between 10 and 25 percent included naphthalene, 2-methylnaphthalene, acenaphthene, dibenzofuran, anthracene, benzo(k)fluoranthene, and benzo(a)pyrene.

The SVOCs detected in sediments were generally associated with seeps and storm drain outfalls. Concentrations of SVOCs tended to decrease rapidly with depth.

Two samples were analyzed for TCLP VOCs, SVOCs, and metals. All sediment sample TCLP results were non-detected. These two samples were also analyzed for sulfides for potential waste characterization purposes. Sulfide concentrations were 150 mg/kg and 285 mg/kg.

3.6.2 Summary

The most frequently detected compounds were arsenic and PAHs. The highest concentrations of contaminants were found in association with seeps and storm drain outfalls. Concentrations of contaminants decreased with depth and with distance from the shoreline.

3.7 Air

Three potential air pathways currently exist for contaminant transport: wind-entrained soil particles, volatilization of contaminants from soil, and volatilization of contaminants from groundwater. Each air pathway was evaluated by using emission models. Evaluation procedures are described in Appendix A. The Wind Erosion Equation (Woodruff and Siddoway, 1965) was the basis for determining wind-entrained soil particle emissions. The Chemdat7 computer model (USEPA, 1989) was used to examine the volatilization of contaminants from the soil and from groundwater. The airborne concentration of contaminants was estimated by using the computerized Fugitive Dust Model (Winges, 1992). Results of the air evaluation are discussed below. Ambient air concentrations were modeled for on site, fence line, and adjacent property locations (receptors). Receptor rationale, calculations, and additional detailed information are provided in Appendix H.

3.7.1 Particle Emission Rate

The Wind Erosion Equation is designed to determine the potential for soil erosion from a field (see Appendix A discussion). For the site, it was assumed that the topography was level with no soil ridges and no surface crusting. Wind direction was assumed to follow the longest unsheltered field length (i.e., from the southern end of the site toward the existing training center to the north). The grade fill was assumed to be bare with no vegetative cover. Site surface soil samples were used to determine particle size distribution. Regional climactic factors included Thornthwaite's precipitation-evaporation (P-E) ratio of 136 (USEPA, 1977) and a mean hourly wind speed of 10.2 miles per hour at a height of 30 feet (NOAA, 1974). The annual emission rate, calculated using the Wind Erosion Equation, was estimated at 0.5 ton/acre-year.

3.7.2 Volatilization Emission Rate

The Chemdat7 model was used to determine the volatilization of contaminants from the unsaturated soil and the upper sand aquifer. The model assumes that emissions from the surface of the soil are limited by the diffusion of vapors through the pore spaces and that an equilibrium concentration of organic vapors exists within these pore spaces.

Volatilization from Unsaturated Soil

The air pathway for the volatilization of organic compounds from the unsaturated soil was modeled by the "Open Landfill" option of Chemdat7. The results are written in terms of emission fractions. The emission rate was calculated by multiplying each emission fraction by the weight fraction of the constituent, and the waste loading (see Appendix H).

Volatilization from Upper Sand Aquifer

The air pathway for the volatilization of organic compounds from the upper sand aquifer and the gas-phase transfer through the overlying soil layer were modeled by the "Closed Landfill" option of Chemdat7. The model output is in grams per year. The results of the emission rate equations were then used to determine ambient air concentrations.

3.7.3 Estimated Ambient Air Concentrations

The emission rates and the estimated annual ambient air concentrations for each air pathway and receptor location are provided in Tables 3-25, 3-26, and 3-27. The highest concentrations are located at the fence line receptor. As the wind flows across the site, contaminants are entrained, reaching a maximum concentration level at the downwind fence line receptor. As the wind continues along the adjacent property, the concentration decreases due to dissipation.

The annual and 24-hour concentrations are compared in Table 3-28 to the corresponding acceptable source impact levels (ASILs) of chapter 173-460 WAC. ASILs are applied to new or modified air emission sources for permitting purposes and are not directly applicable to the site. They were used for comparative purposes to evaluate potential risks posed to receptors through the air pathway. As shown, the modeled ambient air contaminant concentrations for each air pathway are lower than the corresponding ASIL.

The potential 8-hour worker exposure was also evaluated by comparison with the corresponding NIOSH permissible exposure limit (PEL) and ACGIH threshold limit value (TLV). Results are provided in Table 3-29. As shown, the corresponding maximum ambient contaminant concentrations are all well below the specified limits.

3.8 Upgradient Arsenic Assessment

As noted in Section 1.2, from approximately 1893 to 1914, the Puget Sound Reduction Company, and subsequently ASARCO, operated a lead smelter and ore refinery at a location near what is now the intersection of East Marine View Drive and State Route 529. An arsenic processing plant was operated by ASARCO at this site from approximately 1898 to 1913. The location of the former smelter/refinery is approximately 1,700 feet to the northwest of the building (Figure 3-16).

The upgradient arsenic assessment was conducted to evaluate the smelter operations as a potential source of arsenic contamination at the site. In addition to a review of available literature, EMCON collected samples to identify upgradient arsenic sources such as slag, as well as to determine an area background concentration for soil and groundwater for comparison with those concentrations detected on site. Results are summarized below.

3.8.1 Soil

Soil samples were collected near the former smelter (SAIC, 1991a, 1991b; Hydrometrics, 1994) and in two areas upgradient of the site (Hart Crowser, 1989b, 1991; EMCON, this report). The samples were analyzed for total arsenic and TCLP arsenic. The sample location areas and the former smelter area are presented on Figure 3-16.

Hart Crowser collected three soil samples from upgradient sample locations for analysis of arsenic at soil borings HC-24, HC-25, and HC-26. The arsenic concentrations ranged from 4.8 to 17 mg/kg.

The three soil investigations conducted to date in the ASARCO smelter area resulted in collection and analysis of over 750 soil samples (SAIC, 1991a, 1991b; Hydrometrics, 1994). Area background concentrations for the north Everett area were estimated from nine shallow (less than 2 feet bgs) soil samples collected from seven locations at a distance of 1,700 to 7,000 feet from the former smelter operation. Average background shallow soil arsenic concentrations were estimated (SAIC, 1991a) to be about 16 mg/kg. Arsenic concentrations in the immediate area of the former smelter site (Figure 3-16) ranged from nondetection to 622,500 mg/kg, averaging 426 mg/kg (Hydrometrics, 1994). Samples collected at a distance of 500 to 1,000 feet from former smelter operations ranged from nondetection to 994 mg/kg, averaging 23 mg/kg. The results of these investigations are summarized in *Draft Everett Smelter Site Remedial Investigation* (Hydrometrics, 1994). Results of soil sampling and analysis for arsenic presented by Hydrometrics are similar to SAIC with respect to background arsenic concentrations.

Preliminary findings of the investigation at the former smelter conclude that soil has been significantly impacted at the smelter site by elevated arsenic, lead, and cadmium. Impacts were attributed to smelter-related materials including demolition debris, slag, and smelter flue dust. Metals concentrations decrease with distance from the smelter, but still exceed local background concentrations. Elevated metals concentrations at a distance from the smelter were attributed to particle emissions from the smelter stack and redistribution of soil material from the smelter site. The lateral extent of impacted soil from these sources was not completely characterized in the ASARCO RI; an extended investigation is planned (Hydrometrics, 1994).

Upgradient soil samples were collected in the EMCON 1993 investigation from 20 locations in an area west of the site, approximately 400 feet from the former wood treatment building and 1,500 feet from the former smelter site (Figure A-6). This area is considered to meet the criteria described in WAC 173-340-708(b) for "area background." The area has the same basic characteristics as the soil on the site and has not been impacted by releases from the site. Samples were collected from 1 to 2 feet bgs. The soil type (gray, fine to medium poorly graded sand) is similar to that of the upper sand unit. A statistical summary of the results is provided in Table 3-30. The summary also includes the three Hart Crowser samples, five samples from other Weyerhaeuser soil investigations, and four samples from this remedial investigation. Arsenic concentrations ranged from 3.3 to 954 mg/kg, with an average concentration of 56 mg/kg and an upper 90th percentile value of 73.3 mg/kg. TCLP arsenic was detected in only 1 of 22 samples at the MDL (0.1 mg/L).

3.8.2 Slag

Slag outcrops are located near well WP-1 on Weyerhaeuser property (Figure 3-16). Slag fragments have been noted on the soil surface up to 50 feet away from the outcrop across the BNRR. Slag fragments have been noted in test pit and soil boring samples collected from dredge fill immediately adjacent to known slag outcrops (Hart Crowser, 1991). Cinders, slag fragments, or both were observed on the surface at up to 400 feet from the slag outcrop and at the upgradient arsenic assessment area. The fragments have not been analyzed for arsenic. Analysis of the composite sample of railroad ballast (UAB-1) collected in the upgradient area of the site showed a low level of arsenic (1.6 mg/kg), indicating the existing railroad ballast is probably not composed of slag material.

3.8.3 Groundwater

At the time of this RI, the only groundwater monitoring wells downgradient of the former smelter site were located on Weyerhaeuser property. ASARCO installed several wells in the vicinity and downgradient of the former smelter site, including the area west of the site between East Marine View Drive and the BNRR. These wells provide water quality data for the area upgradient of Weyerhaeuser property, plus data with which to define an area background concentration for arsenic and other metals. The wells were completed in February 1993. Sampling results indicate that groundwater in the upper sand and lower sand aquifers contains elevated arsenic concentrations, especially immediately downgradient of the smelter. The elevated arsenic concentrations are probably the result of infiltration of ponded surface water and precipitation that has leached arsenic from soil and smelter-related materials (e.g., demolition debris, slag, flue dust). The ASARCO RI indicates that smelter-related materials may be widespread in the vicinity of the former smelter. Therefore, elevated arsenic concentrations in groundwater are also expected to be found at a distance from the smelter, and not necessarily immediately downgradient of the former smelter site. The maximum arsenic concentration in the monitoring well installed by ASARCO in the upper sand aquifer upgradient of the Former Mill E/Koppers Facility site (MW-2, on BNRR property) is 0.054 mg/L (Hydrometrics, 1994). Total arsenic concentrations up to 36.1 mg/L and 14.6 mg/L have been detected in the upper sand and lower sand aquifers downgradient of the smelter site.

There are seven wells located in the upper sand aquifer on Weyerhaeuser property upgradient of the former Mill E/Koppers Facility site, and two wells located in the lower sand aquifer. Arsenic concentrations in the upgradient upper sand aquifer ranged from

0.0008 to 2.87 mg/L with an average concentration of 0.443 mg/L (Table 3-31). The upper 90th percentile value is 1.59 mg/L. Monitoring well WP-1, located in the upper sand aquifer immediately downgradient of the slag outcrop, was sampled and contained arsenic concentrations of about 1.2 mg/L.

The maximum arsenic detection in the lower sand aquifer upgradient of the site was 0.0063 mg/L at HC-11D.

The upgradient arsenic concentrations are randomly distributed. Arsenic concentrations in groundwater samples collected from monitoring wells installed in the same hydrostratigraphic unit as the demolition waste landfill on Weyerhaeuser property (located 1,700 feet from the site, and 500 feet from the former smelter) averaged less than 0.01 mg/L (Sweet-Edwards/EMCON, 1988).

3.8.4 Upgradient Arsenic Assessment Summary

Arsenic contamination in surface and subsurface soils is significant at and near the former ASARCO smelter site. Arsenic in groundwater was detected in both shallow and deep monitoring wells located downgradient from the slag outcrop and the former smelter. It can be concluded that soil and groundwater in the vicinity of the former smelter have been impacted by historic ASARCO operations.

The following points can be made regarding upgradient arsenic concentrations in soil and groundwater:

Soil

- The average concentration of arsenic in soil in the upgradient assessment area (56 mg/kg) is within the range of Puget Sound regional soil concentrations (i.e., less than 100 mg/kg) but above the north Everett area background soil concentration (16 mg/kg).
- Cinders and/or slag fragments were noted in surface soil in the upgradient assessment area, although they were not observed in any subsurface samples from soil borings or test pits collected to date.

Groundwater

- Arsenic in groundwater samples collected upgradient of the ASARCO smelter (background samples) were below MDLs (Hydrometrics, 1994). Arsenic in samples collected downgradient of the smelter from both the upper and lower sand aquifers were significantly higher than background concentrations.

- The groundwater arsenic concentration in the upper sand aquifer upgradient of the former Mill E/Koppers Facility site is approximately 0.054 mg/L (Hydrometrics, 1994). Average arsenic in the upper sand aquifer immediately upgradient of the site (on Weyerhaeuser property) is 0.443 mg/L and maximum concentrations are 2.87 mg/L (EMCON, this report). Arsenic-contaminated groundwater flows from the upgradient assessment area to the site, and therefore contributes to groundwater contamination beneath the site.

- Groundwater arsenic concentrations in the lower sand aquifer upgradient of the site were at or below the MDL and are not considered to contribute to arsenic contamination in the lower sand aquifer at the site.

Summary

Elevated arsenic in shallow soil and groundwater upgradient of the site indicate that sources of arsenic exist in the assessment area and possibly on non-Weyerhaeuser property to the west.

No historical records for the upgradient assessment area were found that indicate use or management of arsenic-containing processes or wastes by Weyerhaeuser.

Additional soil and groundwater information is forthcoming from investigations of the former Mill B areas (EMCON) and of the former smelter area (Hydrometrics). This information is being compiled for an evaluation of upgradient sources and further definition of background concentrations of arsenic.

3.9 Summary of Nature and Extent of Site Contamination

- Concentrations of arsenic in soil and groundwater are higher than background levels. Elevated concentrations of chromium, TPH, BTEX, CPAHs, PCP, and dioxins/furans (soil only) were also observed. PCBs were detected at only two locations in concentrations less than 0.05 mg/kg.

- Surface water samples collected both adjacent to, and upriver from, the site showed elevated concentrations of copper. Metal concentrations in seep water samples were elevated relative to river water samples; SVOCs were detected at two seep sampling locations.

- Storm drain sediments showed elevated concentrations of lead relative to site soils.

- Seven river sediment sampling locations, all immediately adjacent to the shoreline, showed arsenic or PAH concentrations that were elevated relative to average sediment concentrations. The highest concentrations were found in association with seeps and storm drain outfalls along the shoreline.

- Modeled ambient air contaminant concentrations are significantly lower than corresponding ASILs, PELs, and TLVs.

The sources of soil and groundwater arsenic contamination are related to on-site wood treatment operations and to off-site sources. Off-site sources may be directly related to smelter operations by direct deposition of arsenic-contaminated material (e.g., smelter ash and/or slag) on or upgradient of the site, or indirectly related to the smelter operations by placement of arsenic-contaminated material with the dredge sand and other fill materials of the upper sand unit.

Sources of soil and groundwater TPH and BTEX contamination are apparently related to former wood treatment operations, rail lines, former maintenance shop (garage) operations, and former Mill E operations. Sources of soil and groundwater CPAH and PCP contamination, and soil dioxin/furan contamination, are related to former wood treatment operations including activities along rail lines.

To characterize the level of risk potentially posed by the site in its existing condition, a baseline exposure assessment was conducted using the laboratory results described in this section. This exposure assessment is described in the section that follows.

4 BASELINE RISK ASSESSMENT

A baseline risk assessment was conducted to evaluate potential impacts to human health and the environment posed by selected contaminants encountered in soil, surface water, groundwater, and sediments at or adjacent to the site. This assessment was conducted following the steps outlined in the Work Plan, and in accordance with human health assessment procedures specified in WAC 173-340-708 and -745. Where not specified in MTCA, assumptions and methodologies used in the assessment are consistent with USEPA guidance documents for risk assessments (USEPA 1989a, 1989d, 1990, 1991b, and 1991d). The characterization of risks to human health is described in Sections 4.1 through 4.5. To evaluate potential risks to the environment, hazardous substances detected at the site were compared to published environmental criteria. This evaluation is described in Section 4.6.

4.1 Background

4.1.1 Land Use

The site is zoned M-2, heavy manufacturing, by the city of Everett. Immediately west and south of the site is Weyerhaeuser property, which is also zoned M-2, heavy manufacturing. This land use is expected to continue for the foreseeable future. East and north of the site is the Snohomish River.

This baseline risk assessment consisted of evaluating the site using an industrial scenario for the following reasons (WAC 173-340-745):

- The site is zoned for industrial use.
- The site has a history of industrial use.
- Adjacent properties are currently used and designated for use for industrial purposes.
- The site is expected to be used for industrial purposes for the foreseeable future due to site zoning.

4.1.2 Groundwater Use

Groundwater beneath the site is not currently used as a public or private drinking water source is not expected to be used for this purpose in the future for the following reasons. Municipal drinking water in the site area is derived from surface water, and the reserves are considered adequate. Groundwater flow is towards the Snohomish River; however, the river is not used as a source of drinking water. As noted above, the site is zoned for industrial purposes and is expected to continue to be used for industrial purposes for the foreseeable future.

It is unlikely that state and county health officials would approve a water well on the site for the following reasons:

- On-site wells in either the upper or the lower sand aquifer would require variances to meet construction standards (WAC 173-160-205) due to shallow depths to groundwater and difficulty preventing infiltration of surface water into a well.
- Upgradient arsenic concentrations (approximately 0.443 mg/L) in the upper sand aquifer are elevated.
- The naturally occurring background concentrations of iron (18 and 14 mg/L in the upper and lower aquifers, respectively) exceed the secondary maximum contaminant level of 0.3 mg/L (USEPA, 1992a).
- The naturally occurring background concentration of total dissolved solids in the lower sand aquifer upgradient of the site, which would be more suitable for the location of a well, has exceeded 10,000 mg/L.

For all these reasons, use of groundwater as drinking water was not evaluated under the potential future land use scenario.

4.2 Identification of Indicator Hazardous Substances

After evaluating and screening the data collected in the RI, indicator hazardous substances were selected for use in the baseline risk assessment. Indicator hazardous substances are defined as the subset of hazardous substances at a site selected for the "purpose of characterizing the site or establishing cleanup requirements for that site" (WAC 173-340-200). Indicator hazardous substances were selected so that substances representative and characteristic of the site would be evaluated in this assessment.

4.2.1 Soil

The following compounds were selected as indicator hazardous substances in soil:

- Arsenic
- Benzo(a)anthracene
- Benzo(b) fluoranthene
- Benzo(k) fluoranthene
- Benzo(a)pyrene
- Chromium VI
- Chrysene
- Dioxins/Furans
- Indeno (1,2,3-cd)pyrene
- Pentachlorophenol
- TPH-gasoline, diesel, or other

For the purposes of this assessment, surface soil was considered to extend 0 to 5 feet bgs. This depth is representative of construction activities that could take place on site (e.g., for utility placement), resulting in the excavation of soil. Excavated soil could then be distributed at the soil surface and made available for direct contact. Groundwater occurs at approximately 4 feet bgs, which would generally preclude construction at lower depths.

Maximum concentrations of hazardous substances in all soil samples collected between 0 and 5 feet bgs (fill and upper sand units) were used in selecting indicator hazardous substances. Statistical summaries of metals, VOCs, and SVOCs detected in the fill and upper sand units are provided in Tables 4-1, 4-2, and 4-3, respectively.

The selection of indicator hazardous substances was based on the criteria described below.

Chemical Toxicity. The maximum detected concentration of each compound in soil was compared to screening levels developed for soil using MTCA cleanup levels (see Table 4-4). MTCA Method C Industrial Soil Cleanup Levels were divided by 100 to obtain conservative screening levels. The following compounds were not evaluated further in the baseline risk assessment because maximum concentrations of the compounds in site soil were less than their respective health-based screening levels:

- 4-Methylphenol
- 2,3-Dimethylphenol
- Naphthalene
- 2-Methylnaphthalene
- 2-Chloronaphthalene
- Acenaphthylene
- Acenaphthene
- 4-Nitrophenol
- Dibenzofuran
- Dibenz(a,h)anthracene
- Diethylphthalate
- Fluorene
- Phenanthrene
- Anthracene
- Fluoranthene
- Pyrene
- Butylbenzylphthalate
- Bis(2-ethylhexyl)phthalate
- Di-n-octyl phthalate
- Toluene

- Benzo(g,h,i)perylene
- Benzene
- 2-Butanone
- Ethylbenzene
- Styrene
- Xylenes
- Chromium III
- Copper
- Lead
- Mercury

The compounds remaining after comparisons with screening concentrations (Table 4-4) were evaluated further for availability of critical toxicity values on USEPA's Integrated Risk Information System (IRIS), frequency of detection, and background concentrations.

Critical Toxicity Values. Per WAC 173-340-708(7) and (8), toxicity data established by USEPA and available through IRIS shall be used. Where these data are not available through IRIS, Ecology must establish these values pursuant to procedures specified in chapter 173-340 WAC. As discussed in Section 4.4, when toxicity data for a compound were not available from the IRIS database and no alternative values had been established by Ecology, the compound was eliminated from this assessment based on WAC 173-340-708 provisions.

The following compounds were not evaluated further because critical toxicity values are not available on IRIS and Ecology has not established values:

- Carbazole
- Dioxins/Furans
- TPH as gasoline, diesel, or other (heavy oil)

There are seven PAHs considered by USEPA to be carcinogenic: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a) pyrene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Toxicity data are available on IRIS only for benzo(a)pyrene, but the other carcinogenic PAHs (CPAHs) were assumed to be of equal carcinogenic potency to benzo(a)pyrene and were retained as indicator hazardous substances (with the exception of dibenz(a,h)anthracene, which was screened out based on comparison with the Method C screening level). Although toxicity equivalency factors (which relate the other CPAHs to benzo(a)pyrene) are available, they are not recognized by Ecology. The assumption that all of the CPAHs are as potent as benzo(a)pyrene probably overestimates risk.

Frequency of Detection. A frequency of detection is the ratio of the number of times a compound was detected to the number of times it was analyzed. A compound was considered for inclusion as an indicator hazardous substance if the frequency of detection was more than 5 percent. None of the chemicals failing the toxicity screen was eliminated based on frequency of detection.

Background Concentrations. A compound was considered for inclusion as an indicator if mean concentration at the site exceeded the naturally occurring level. Mean concentrations of arsenic, chromium, copper, and lead in site soil (Table 4-1) were compared to their concentrations in the Puget Sound area (Table 3-1). The mean concentrations of arsenic and copper exceed their background levels identified for the north Everett area. Copper was eliminated from the risk assessment because the maximum concentration was less than its associated health-based screening level.

4.2.2 Groundwater

As previously noted, it appears unlikely that groundwater will be used as a public or private drinking water source. Consequently, potential impacts associated with ingestion, inhalation, and dermal contact with groundwater during normal household use were not evaluated. Compounds in groundwater could, however, volatilize and diffuse through soil and into the air. Therefore, the compounds detected in groundwater were considered for inclusion as indicator hazardous substances for the vapor inhalation pathway, only.

Volatilization of VOCs in groundwater to ambient air was evaluated in Section 3.7. Air concentrations were compared to ASILs, PELs, and TLVs. Since modeled ambient air concentrations for all receptors were well below these standards, inhalation of vapors from groundwater was eliminated from the risk assessment, and no indicator hazardous substances were chosen for groundwater.

4.3 Exposure Assessment

This section evaluates the potential pathways of human exposure to indicator hazardous substances identified at the site. In general, an exposure pathway consists of four elements: a source of hazardous substance release into the environment; an environmental medium for transport of the hazardous substance (i.e., air, groundwater, surface water, or soil); a point of potential human exposure (exposure point); and a route of exposure of the hazardous substance into the receptor (i.e., inhalation, ingestion, or dermal contact).

The human exposure assessment contains discussions of potential receptors, potential routes of exposure, exposure scenarios, intake factors for each scenario, and the concentrations of indicator hazardous substances at the exposure points.

4.3.1 Potential Receptors

As stated previously, the site is considered an industrial site for the following reasons:

- It is zoned for industrial use.
- It has been used historically for industrial purposes.

- Adjacent properties are currently used and zoned for industrial purposes.
- It is expected to be used for industrial purposes for the foreseeable future.

Current Exposures. At present, the site is not in use and access is restricted by security guards and a fence that surrounds the Weyerhaeuser property. Although the former wood treatment building still exists at the site, it is not in use. Because the site is not currently used, the hypothetical future exposures discussed below are expected to be higher than current exposures. Therefore, current land use was not evaluated in this baseline risk assessment.

Hypothetical Future Exposures. Although the site is currently vacant, it is zoned M-2 and could be developed for industrial use. Hypothetical future workers at the site are therefore considered potential receptors, at risk because of their proximity to site-related compounds. For this reason, hypothetical future on-site worker exposure was quantitatively evaluated for this assessment in a reasonable maximum exposure (RME) scenario consistent with WAC 173-340-745 and -750. It was assumed that on-site workers would be employed for 20 years and would be continuously exposed to compounds through incidental ingestion of soil, dermal contact with soil, inhalation of airborne dust, and inhalation of chemicals volatilizing from unsaturated soil. Volatilization of VOCs from groundwater to ambient air was eliminated based on the screening conducted in Section 3.7. It was assumed that the soil from 0 to 5 feet bgs at the site would be excavated or otherwise made available for exposure. It was also assumed that chemical concentrations would remain constant over the entire exposure period, with no degradation over time. The last assumption is conservative for most organic chemicals.

Exposures to fugitive dust from surface soil and vapors from unsaturated soil were also evaluated (Section 3.7). The modeled ambient air concentrations of both dust and vapor forms were compared to the ASILs, PELs, and TLVs. Because concentrations were well below these standards for all receptors, inhalation exposures to hazardous substances in soil were eliminated from further consideration in the risk assessment.

Sensitive Human Subpopulations. The USEPA has defined sensitive subpopulations as those with a significantly higher probability of developing an illness. This classification may be given to people with a greater susceptibility than the general population (e.g., young children, the elderly, or persons with a preexisting disease) or those who are subject to peculiar exposure (e.g., children who intentionally eat soil or people who fish for subsistence).

Sensitive subpopulations such as children or the elderly are not expected to be impacted by the compounds detected at the site. The nearest area zoned for residential use is approximately 0.25 mile west of the site. No nursing homes, schools, or hospitals are located within 0.5 mile of the site.

4.3.2 Potential Exposure Routes

Three routes of exposure to indicator hazardous substances in soil are incidental ingestion, dermal contact, and inhalation. As previously noted, inhalation exposure pathways were eliminated from the risk assessment based on screening evaluations. The remaining routes apply to the site as follows.

Ingestion. Direct ingestion of soil is usually associated with children, either from pica behavior (ingestion or abnormal mouthing of objects, including soil) or hand-to-mouth contact during play. Soil could also be incidentally ingested by adults when eating, smoking, or drinking at the site. Since the site is vacant and access is restricted by a security guard and a fence, direct exposure to soil is considered unlikely and a current land use scenario was not evaluated.

Hypothetical future on-site workers are considered potentially at risk because of the likelihood of coming into contact with the soil. Exposures of hypothetical future on-site workers to chemicals detected on site were therefore quantitatively evaluated.

Exposure by soil ingestion to other potential receptors, such as area residents, site visitors, trespassers, and nearby workers were not quantified. Because the nearest residence is approximately 0.25 mile west of the site, and the Weyerhaeuser site is fenced and access is restricted by security guards, residential populations are not expected to have direct contact (i.e., dermal and ingestion exposures) with soil. Site visitors and trespassers are expected to have less contact with on-site soil than the hypothetical future on-site workers. The workers on nearby sites are expected to work outside the site area and would therefore have no direct exposure. Consequently, potential impacts to residents, site visitors, trespassers, and nearby workers are expected to be significantly less than those of hypothetical future on-site workers.

As stated previously, it was assumed that the site would be used for industrial purposes in the future. It was also assumed that the soil on site would remain exposed for 20 years. This represents an RME scenario: the highest exposure that is reasonably expected to occur (WAC 173-340-708[3]). Exposure assumptions are consistent with WAC 173-340-745 and -750. Where additional exposure assumptions were required, they were obtained from USEPA guidance (USEPA, 1989b, 1990, 1991b).

Dermal Contact. Based on the reasons stated above for ingestion, dermal exposures to soil were evaluated for hypothetical future on-site workers only. The extent of dermal exposure is determined in part by the concentrations of compounds in soil, the surface area of the body in contact with the soil, the chemical class (i.e., metals or semivolatile organic chemicals), and the presence or absence of abrasions on the skin. Soil adherence factors, dermal absorption factors, and critical toxicity factors also have to be used to calculate exposure through dermal contact.

Because this is not specified in MTCA regulations, a default soil adherence factor suggested by USEPA was used to evaluate dermal exposures. Factors such as climate, soil type, organic content of soil, and soil particle size were not considered when the default soil adherence factor was estimated.

Dermal absorption can be altered by a variety of mechanisms, including compound solubilization and the amount of sweat on the skin. Since dermal absorption factors are not always available for specific compounds, some conservative default values were used in this assessment. Exposure assumptions are consistent with WAC 173-340-745 and -750. Where additional exposure assumptions were required, they were obtained from USEPA guidance documents.

USEPA has not yet established critical toxicity factors for evaluating dermal exposure. It was necessary to adjust oral toxicity factors for use in evaluating the dermal route. An oral toxicity factor is presented in terms of the dose applied to the animal, without consideration of how much of the dose is actually absorbed in the gastrointestinal tract. A dermal exposure, on the other hand, is evaluated as an absorbed dose. An applied dose is neither equivalent to, nor consistent with, an absorbed dose. Therefore, the oral toxicity factor was adjusted using percent absorption in the gastrointestinal tract to obtain a toxicity factor based on absorbed dose. This adjusted toxicity factor (orally absorbed dose) was used for evaluating the dermally absorbed dose.

For these reasons, dermal exposures calculated in this assessment are considered extremely conservative and should be viewed with caution. Dermal risks were not calculated for the CPAHs, because they have been shown to cause skin cancer in animals at the site of contact; i.e., the practice of estimating an absorbed dose does not apply to chemicals acting at the site of contact. There is no approved method for adjusting the oral CPF to apply to the site of contact, so it is not possible to calculate risks for dermal contact with the CPAHs.

4.3.3 Intake Assessment

This section presents the exposure point concentrations and intake assumptions used to quantify exposures to soil and air. An RME exposure scenario was used to estimate the potential adverse health effects for hypothetical future on-site workers (adults).

Exposure Point Concentrations. Because groundwater is generally encountered at 4 feet bgs, the data for surface and subsurface soils (between 0 and 5 feet bgs) were combined for the evaluation of potential incidental ingestion and dermal contact exposures to hypothetical on-site workers.

USEPA states that the goal of the RME is to combine upper-bound and mid-range exposure factors so that the result represents an exposure scenario that is both protective and reasonable, not the worst possible case (USEPA, 1991d). MTCA defines RME as "the highest exposure that is reasonably expected to occur" (WAC 173-340-708[3]). USEPA states that the concentration of the compound used in the RME should be a conservative estimate of the average concentration for the media over the exposure period (USEPA, 1991d). For determining compliance with cleanup levels, MTCA statistical guidance (Ecology, 1992) requires testing of the statistical distribution of values. If the distribution is either normal or lognormal, the upper 95 percent confidence limit on the mean (UCL95) is used to determine compliance. If the distribution is neither normal nor lognormal, nonparametric statistics or the maximum concentration can be used to determine compliance.

To be consistent with USEPA and Ecology guidance on statistics, the distributions of indicator hazardous substances were tested to determine if they were normal or lognormal. For normal and lognormal distributions, the exposure point concentration was set at the UCL95 or the maximum concentration, whichever was lower. For distributions that were neither normal nor lognormal, the exposure point concentration was set at the maximum concentration.

Exposure Assumptions. Exposure assumptions for ingestion were obtained from WAC 173-340-745. Exposure assumptions for dermal contact were obtained from USEPA (1989b, 1991b, 1991d, 1992e) and were chosen to be as consistent as possible with WAC 173-340-745. The specific assumptions, the equations used to calculate chemical intakes, and the results of intake calculations are presented in Appendix I.

4.4 Toxicity Assessment

As previously noted, critical toxicity values include references doses (RfDs) for noncarcinogenic health effects and carcinogenic potency factors available from USEPA's IRIS database (WAC 173-340-708[7] and [8]). When toxicity data for a compound are not available in the IRIS database, Ecology, in consultation with the Science Advisory Board, Department of Health, and USEPA, may establish an alternative value using methods described by USEPA (1989a; WAC 173-340-708[7] and [8]). When toxicity data for a compound were not available in IRIS and no alternative values had been established by Ecology, the compound was eliminated from this baseline risk assessment based on WAC 173-340-708 provisions.

4.4.1 Carcinogenic Effects

The USEPA Carcinogen Assessment Group (CAG) has developed cancer potency factors for compounds classified as known, potential, or possible human carcinogens. Cancer potency factors (CPFs) are developed to estimate the theoretical upper-bound excess lifetime cancer risks associated with various levels of lifetime exposure to chemicals that could be human carcinogens.

The CAG utilizes a weight-of-evidence classifications system to identify compounds as carcinogens. Chemicals are placed into one of the following categories:

- Group A—Human Carcinogen. Sufficient evidence exists from epidemiological studies to support a causal association between exposure and cancer.
- Group B1—Probable Human Carcinogen. Limited evidence of carcinogenicity in humans exists from epidemiological studies.
- Group B2—Probable Human Carcinogen. Sufficient evidence of carcinogenicity in animals exists, but there is inadequate evidence of carcinogenicity in humans.
- Group C—Possible Human Carcinogen. Limited evidence of carcinogenicity in animals exists.
- Group D—Not Classifiable as to Human Carcinogenicity. Inadequate data to perform a classification.
- Group E—No Evidence of Carcinogenicity in Humans. No evidence of carcinogenicity is apparent in at least two adequate animal tests (in different species) or in both adequate epidemiological and animal studies.

CPFs are developed by for chemicals in Groups A, B1, B2, or C. A CPF is expressed as the inverse of milligrams of chemical per kilogram body weight per day $(mg/kg/day)^{-1}$. Most CPFs are derived by using the upper 95 percent confidence limit on the slope of the dose-response curve (response per unit intake) obtained from a linearized multistage model of animal data.

CPFs are provided in Table 4-5 for the indicator hazardous substances evaluated in this assessment.

4.4.2 Noncarcinogenic Effects

Critical toxicity values for compounds that exhibit adverse noncarcinogenic health effects are RfDs determined by the USEPA RfD Work Group. RfD values have been verified by peer review of available information. Development of an RfD is based on the assumption that a threshold exists for noncarcinogenic effects; concentrations below this threshold are considered unlikely to cause significant adverse health effects. An RfD is expressed in the units of milligrams of chemical per kilogram of body weight per day. RfDs are route-specific (i.e., RfDs may differ between ingestion, inhalation, and other routes of exposure).

Table 4-5 provides available RfDs for the indicator hazardous substances evaluated in this assessment.

4.5 Human Health Risk Characterization

This section discusses the potential for adverse noncarcinogenic health effects and excess carcinogenic risks associated with soil ingestion and dermal contact with soil.

4.5.1 Potential Noncarcinogenic Health Effects

Noncarcinogenic health effects resulting from exposure to either a single indicator hazardous substance or to a combination of indicator hazardous substances were evaluated by calculating a Hazard Quotient (HQ) and a Hazard Index (HI), respectively. An HQ is the ratio of an estimated chemical intake (i.e., chronic daily intake) for a particular route of exposure to a chemical-specific RfD. An HI is the sum of HQs for multiple chemical exposures and multiple exposure routes.

As stated previously, an RfD (chronic exposure) is a USEPA-established value that represents a chemical-specific, exposure-specific dose to which nearly all human populations may be exposed for a period of up to 365 days per year for 70 years without experiencing adverse health effects. As discussed previously, oral RfDs were adjusted for gastrointestinal absorption for calculating dermal HQs.

An HQ is calculated as follows:

$$HQ = \frac{CDI}{RfD} \qquad \text{(Equation 4-1)}$$

where:

HQ = Hazard quotient (unitless)
CDI = Chronic daily intake (mg/kg/day; calculated in Appendix I)
RfD = Reference dose (mg/kg/day; from Table 4-5)

An HI considers exposure to a mixture of compounds having potential adverse noncarcinogenic health effects based on the assumption that the effects of compound mixtures are additive (WAC 173-340-708[5]). An HI for mixtures is thus calculated by summing the HQs for all noncarcinogenic compounds over all exposure routes. The calculated HI or HQ can then be compared to the MTCA allowable HI or HQ of 1.0 (WAC 173-340-745).

The HI is calculated as follows:

$$HI = \sum_{i=1}^{n_i} \sum_{j=1}^{n_j} HQ_{i,j} \qquad \text{(Equation 4-2)}$$

where:

HI = Hazard index (unitless)

$HQ_{i,j}$ = Hazard quotient for the i^{th} route and j^{th} compound (unitless)

For any single compound or combination of compounds where the HQ or HI exceeds unity (1.0), there may be concern for potential health risks. Table 4-6 presents the HQs for the future on-site worker receptor. Since the total HI is 0.13, per the above calculations, noncarcinogenic health effects from the indicator hazardous substances evaluated in this assessment do not appear to be of concern for the site.

4.5.2 Potential Excess Carcinogenic Risks

A carcinogenic risk is expressed as an excess lifetime cancer risk: the incremental probability of an individual developing cancer over his/her lifetime as a result of exposure to the potential carcinogen. This incremental excess risk is in addition to the nationally observed risk of cancer (2.5×10^{-1} or one person in four), which is due to such factors as dietary habits, smoking, and natural radiation. Cancer risks are usually expressed in scientific notation: $1E\text{-}5 = 1 \times 10^{-5} = 0.00001 = 1/100{,}000$.

Given the standard USEPA assumptions of linearity in the individual dose-response curve, the potential excess carcinogenic risks associated with hypothetical exposures at the site were calculated as follows:

$$CR = CPF \times CDI \qquad \text{(Equation 4-3)}$$

where:

CR = Potential excess carcinogenic risks (unitless)

CPF = Oral or inhalation carcinogenic potency factor ($[\text{mg/kg/day}]^{-1}$; see Table 4-5)

CDI = Chronic daily intake (mg/kg/day; calculated in Appendix I)

The calculated excess carcinogenic risk was compared to the human health risk range of 1×10^{-4} to 1×10^{-6} established by the USEPA (USEPA, 1991f). This range translates to an acceptable excess risk of cancer for one person in 10,000 to one person in 1,000,000. The calculated excess carcinogenic risk was also compared to the established MTCA total excess cancer risk of 1×10^{-5} (one person in 100,000; WAC 173-340-745).

Because exposure to potentially carcinogenic compounds is considered to be cumulative, the potential excess carcinogenic risks were summed. A total potential excess carcinogenic risk was calculated as follows:

$$TCR = \sum_{i=1}^{n_i} \sum_{j=1}^{n_i} CR_{i,j} \qquad \text{(Equation 4-4)}$$

where:

TCR = Total potential excess carcinogenic risk (unitless)
$CR_{i,j}$ = Potential excess carcinogenic risk for the ith route and jth chemical (unitless)

As discussed previously, oral CPFs were adjusted for gastrointestinal absorption and used to estimate the potential excess carcinogenic risks for dermal exposures. Risk results for the future on-site worker are summarized in Table 4-7.

The total cancer risk for the indicator hazardous substances evaluated in this assessment is 5×10^{-5}, which is within the USEPA established risk range under CERCLA (USEPA, 1991f), but is greater than the total site risk of 1×10^{-5} established by MTCA. The site risk is dominated by the ingestion route of exposure, which accounts for 80 percent of the total. The chemicals contributing most of the total risk are arsenic (24 percent), chrysene (22 percent), benzo(a)anthracene (15 percent), benzo(b)fluoranthene (13 percent), and benzo(a)pyrene (10 percent). The CPAHs as a group comprise 76 percent of the total cancer risk.

4.6 Environmental Risk Characterization

In order to characterize potential risks to the environment posed by the site in its existing condition, hazardous substances detected in groundwater, surface water, and sediments were compared to published environmental criteria. In the discussions below, groundwater and surface water results are compared to ambient water quality criteria (USEPA, 1986; 40 CFR Part 131.36; chapter 173-201A WAC). Sediment results are compared to the Sediment Management Standards of chapter 173-204 WAC. Through these comparisons, primary indicator hazardous substances for environmental risks have been identified.

4.6.1 Groundwater

Groundwater discharging to the Snohomish River is an environmental exposure pathway. To characterize potential impacts to the river from site groundwater contaminants, average concentrations observed in monitoring wells adjacent the river were compared to ambient water quality criteria (WQC). This comparison is provided because the site is next to the river, and groundwater flow direction is generally easterly toward the river. Tables 4-8 through 4-15 present the average concentrations over five quarterly sampling events for detected contaminants in the wells adjacent the river ("perimeter wells").[2] Table 4-16 presents both state and federal, marine and freshwater WQC, for all groundwater contaminants detected more than once in the perimeter wells. Because salinity in the Snohomish River adjacent to the site varies from marine to freshwater, the lowest federal or state, marine or freshwater, WQC was used to evaluate groundwater contaminant concentrations.

Upper Sand Aquifer

Mean concentrations of arsenic and copper in the upper sand aquifer (Table 4-8) exceed their most stringent WQC. The mean arsenic concentration of 2.90 mg/L is greater than the lowest WQC of 0.036. It is noted that upgradient (off-site) groundwater arsenic concentrations, averaging 0.443, also exceed this criterion. The copper mean of 0.0068 mg/L is greater than the lowest WQC of 0.0025 mg/L.

The total TPH concentration (as gasoline, diesel, and other) of 6.06 mg/L (Table 4-9) is below the state's water quality guideline of 10 mg/L for oil and grease (Ecology, 1987). BTEX compounds were detected in approximately half of the samples collected from the perimeter wells (Table 4-10). Mean concentrations were 0.407, 0.549, 0.037, and 0.154 mg/L, respectively. There are currently no promulgated WQC for these compounds.

PCP was detected in approximately half of the samples collected from the perimeter wells (Table 4-11). The mean PCP concentration of 1.07 mg/L is greater than the lowest WQC of 0.0079 mg/L. Fourteen other SVOCs were detected more than once in perimeter wells; only acenaphthalene has an associated WQC. The mean acenaphthene concentration of 0.048 is less than the lowest WQC of 0.710.

Lower Sand Aquifer

Mean concentrations of arsenic and chromium detected in the lower aquifer (Table 4-12) are below the lowest associated WQC. Lead averaged 0.0026 mg/L, not significantly greater than the lowest WQC of 0.0025 mg/L.

The total TPH concentration (as gasoline, diesel, and other) of 4.09 mg/L (Table 4-13) is below the state's water quality guideline of 10 mg/L. BTEX compounds were detected in approximately half the samples collected from the perimeter wells (Table 4-14). Mean

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[2] Perimeter wells, upper sand aquifer: HC-10, MW-31, HC-07, MW-23, HC-09, MW-32, HC-02, HC-01; lower sand aquifer: HC-10D, MW-31D, HC-23D, MW-9D, and HC-01D.

concentrations were 0.060, 0.006, 0.037, and 0.014 mg/L, respectively. As noted above, there are currently no promulgated WQC for these compounds.

PCP was not detected in any lower aquifer samples collected from perimeter wells. Eight SVOCs were detected more than once in these wells (Table 4-15); only acenaphthalene has an associated WQC. The mean acenaphthene concentration of 0.036 mg/L is less than the lowest WQC of 0.710 mg/L.

4.6.2 Surface Water

Storm water discharging to the Snohomish River is an environmental exposure pathway. To characterize potential impacts to the river from storm water discharges, results of storm water sample analyses were also compared to WQC. To evaluate potential effects of groundwater or storm water discharges to the river, and to assess existing water quality, results of river water analyses were also compared to WQC.

Storm Water

As reported in Section 3.5.3, arsenic, copper, and lead were the only contaminants detected in the storm water samples. Of these metals, only copper was detected above the most stringent WQC of 0.0025 mg/L. It was detected at concentrations of 0.0059 and 0.0081 mg/L.

Snohomish River

All results for metals analyses (As, Cr, Cu, Pb, and Hg) were less than water quality criteria, except copper. The lowest water quality criterion for copper is 0.0025 mg/L. The MDL for copper was 0.0034 mg/L for samples RW-02 and RW-05 (a duplicate of RW-08), so it was not possible to compare results with the lowest water quality criteria. Samples RW-01, RW-03, RW-04, RW-06, and RW-07 all showed copper concentrations greater than 0.0025 mg/l. RW-01 was collected upstream of the site, indicating that background copper concentrations exceed the criteria.

Only one of seven surface water samples collected from the Snohomish River contained detectable concentrations of petroleum hydrocarbons (RW-01), at 0.07 mg/L TPH-gasoline. No water quality criterion is available for TPH-gasoline; however, this concentration is well below the state's oil and grease water quality guideline of 10 mg/L. This sample was collected upgradient from the site during ebb tide, and may therefore represent an off-site source.

4.6.3 Exposure Assessment

Based on the RI data, storm water discharging to the river is not a significant exposure pathway. Only copper was detected in storm water concentrations above the most stringent WQC. The upgradient river water sample also exceeded this criterion.

As described above, mean concentrations of arsenic, copper, and pentachlorophenol in the upper sand aquifer exceed the lowest associated WQC in the perimeter wells. Mean concentrations of arsenic and copper in the lower sand aquifer exceed the lowest associated WQC in these wells. These exceedances give an indication of the potential for contaminant impacts to the river via the groundwater pathway. They do not reflect the mixing and dilution that is achieved when groundwater moves to the river. This mixing and dilution may be reflected in the lack of arsenic or pentachlorophenol detections in samples collected directly from the river adjacent the site. In these samples, all detected contaminants were below WQC except for copper. Copper was also detected upstream of the site, and may indicate that background copper concentrations exceed the criteria.

Mixing that is achieved when groundwater moves to the river can also be estimated. Groundwater flowing from the upper sand aquifer discharges to the Snohomish River via direct flow through, around, or under the bulkhead, or indirectly via the lower sand aquifer. The net horizontal groundwater discharge of the upper sand aquifer was estimated from the Darcy equation:

$$Q_{gw} = K_h \, x \, i_h \, x \, A$$

where:

K_h = horizontal hydraulic conductivity of 0.1 ft/minute
i_h = horizontal hydraulic gradient of 0.0037 ft/ft
A = cross-sectional area (bulkhead length x average saturated thickness) of 900 ft x 4 ft

The calculated net horizontal groundwater discharge of the upper sand aquifer is 1.3 ft^3/minute. In comparison, the average annual flow of the Snohomish River is 600,000 ft^3/minute (Williams, et al., 1985). The river is approximately 700 feet wide adjacent to the site. A 1-foot-wide section of the river would transmit approximately 850 ft^3/minute. Assuming that discharging groundwater mixes within 1 foot of the bulkhead, the mixing ratio of surface water to groundwater is about 650:1. As such, the concentration of contaminants could be reduced by 650 times upon discharge and mixing with the river, if the mixing zone is 1 foot wide. Assuming a 650:1 mixing ratio, arsenic, copper, and pentachlorophenol concentrations would be expected to be well below WQC at a distance of 1 foot from the bulkhead.

4.6.4 Sediment

Laboratory results for sediment samples collected from the Snohomish River were evaluated by comparison to Sediment Management Standards (chapter 173-204 WAC). Sediment standards for marine water rather than low salinity, or freshwater were used for comparative purposes. The selection of marine, low salinity, or freshwater standards is based on pore water salinities. Marine sediment standards were judged to be appropriate based on saltwater intrusion into the Snohomish River to locations upstream of the site, and also because low salinity and freshwater sediment standards have not been established. The marine sediment standards reflect potential exposures to both the environment and human health.

Sediment Management Standards

The sediment management standards identify Marine Sediment Quality Standards (SQSs) — Chemical Criteria (Table I, WAC 173-204-320) for initial sediment quality designation purposes. Sediments with chemical concentrations which exceed any one applicable SQS chemical criterion are designated as having adverse effects on biological resources or posing significant human health threats and fail the SQSs pending confirmatory designation through biological testing. The sediment management standards also identify Marine Sediment Cleanup Screening Levels (CSLs) and Minimum Cleanup Levels — Chemical Criteria (Table III, WAC 173-204-520). The CSLs are used to identify "station clusters of potential concern" and "station clusters of low concern." The CSLs are also used with a hazard assessment to identify and rank station clusters of potential concern as sediment "cleanup sites."

Sediment chemistry results for a study area are evaluated by calculating the average concentration for a contaminant at three stations within the study area. If the average concentration is greater than the CSL, the sampling stations are identified by Ecology as a station cluster of potential concern. If the contaminant concentrations are less than the CSL, but greater than the SQS, the station cluster identified by Ecology is of low concern. A hazard assessment is then conducted by Ecology on these station clusters of potential concern. The hazard assessment is used to determine whether a station cluster poses sufficient hazards to human health and the environment to be officially identified as a "site." Once a site is identified, it can be placed on the state contaminated sediment site list, and regulatory actions regarding cleanup can begin.

River Sediment Results

Results for sediment samples with detected concentrations of contaminants greater than sediment quality standards are summarized in Table 4-17 and discussed below. Sediment sampling depths were measured from the sediment surface.

Metals. Arsenic, chromium, copper, and lead were detected in all 72 samples, and mercury was detected in only 3 samples. The average concentrations of chromium, copper, and mercury were equivalent to background sediments collected from station SR-33, and average arsenic and lead concentrations were elevated relative to the background sediment samples. Seven of seventy-two sediment samples (including two sets of field duplicates), collected from three stations (SR-01, SR-02, and SR-05), showed concentrations of arsenic greater than the sediment quality standards (see Table 4-17). Surface sediment from stations SR-01 and SR-05, plus core samples from SR-05 collected from the surface to an average depth of 1.87 feet, showed arsenic concentrations greater than the cleanup screening level. Sediment sample chromium and lead concentrations were all less than the sediment quality standards. One sediment core sample, collected at station SR-12 from a depth of 1.0 to 2.25 feet below the sediment surface, showed a copper concentration greater than the sediment quality standard and cleanup screening level. Two of the three detected mercury results were less than the sediment quality standard. The sediment core sample collected from a depth of 1.0 to 2.19 feet at station SR-22 showed a mercury concentration that was greater than the sediment quality standard, but less than the cleanup screening level (see Table 4-17).

Volatile Organic Compounds. Acetone and 2-butanone were detected in 60 of 68 and 26 of 68 sediment samples, respectively. Based on the detection frequency for these two compounds in sediment versus other media (i.e., soils, surface water, and groundwater), acetone and 2-butanone detections appear to be sampling artifacts.

VOCs detected in sediment samples collected adjacent to the site included carbon disulfide at 4 of 30 stations, and benzene, toluene, ethylbenzene, and total xylenes at 1 of 30 stations. Carbon disulfide was detected at estimated concentrations ranging from 0.003 to 0.013 mg/kg in sediment core samples from stations SR-05, SR-10, SR-11, and SR-12, and at an estimated concentration of 0.003 mg/kg in the surface sediment at station SR-12. Benzene, ethylbenzene, and total xylenes were reported at concentrations of 0.003 mg/kg, 0.020 mg/kg, and 0.022 mg/kg, respectively, in the surface sediment from location SR-07. The sediment core sample collected from 0 to 1.0 feet at station SR-07 showed ethylbenzene at an estimated concentration of 0.004 mg/kg. The sediment core sample collected from a depth of 1.0 to 1.80 feet at station SR-07 showed benzene, toluene, ethylbenzene, and total xylenes at estimated concentrations of 0.012 mg/kg, 0.004 mg/kg, 0.030 mg/kg, and 0.044 mg/kg, respectively.

No other VOCs were detected in the sediment samples. Results of the VOC analyses are provided in Appendix G . A statistical summary of sediment VOC analyses was not prepared based on the low frequency of detected compounds.

Semivolatile Organic Compounds. Seven of fourteen sampling stations in the Phase I sediment sampling showed detected concentrations of SVOCs greater than CSL chemical criteria. One of sixteen stations in the Phase II sediment sampling, plus the background station, showed detected concentrations of SVOCs greater than SQS chemical criteria.

The concentrations of naphthalene, acenaphthene, dibenzofuran, fluorene, and the sum of low molecular weight polycyclic aromatic hydrocarbons (LPAH) (naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, and anthracene) in the surface sediment sample from station SR-07 were greater than the SQS for these compounds. The concentrations of naphthalene and acenaphthene were also greater than the sediment CSL. Although the sum of the detected concentrations of LPAH was less than the SQS, calculating the sum by adding the sample quantitation limits for undetected LPAH compounds (per chapter 173-204 WAC guidelines) to the total raised the sum LPAH concentration above the SQS. The sediment core sample collected from a depth of 0 to 1.0 feet at station SR-07 showed concentrations of naphthalene, acenaphthene, dibenzofuran, and fluorene greater than the SQS, but only the concentration of acenaphthene was greater than the sediment CSL. The sediment core sample collected from a depth of 1.0 to 1.80 feet at station SR-07 showed only acenaphthene at a concentration greater than the SQS.

Triplicate surface sediment samples were collected at station SR-10. One of the three surface sediment samples showed concentrations of SVOCs greater than SQS. The concentrations of naphthalene, 2-methylnaphthalene, dibenzofuran, fluorene, phenanthrene, and sum LPAH were greater than the SQS, and the concentration of acenaphthene was greater than the CSL for this one sample.

Only acenaphthene and sum LPAH concentrations in the surface sediment from station SR-11 were greater than the SQS. The only LPAH detected was acenaphthene, but the addition of quantitation limits for the other LPAH resulted in a total concentration greater than the SQS for LPAH. The sediment core sample collected from 1.0 to 2.25 feet at station SR-11 showed a concentration of dibenzofuran that was greater than the SQS and a concentration of fluorene greater than the CSL.

The core sample collected from a depth of 0 to 1.45 feet at station SR-13 showed concentrations of naphthalene, 2-methylnaphthalene, acenaphthene, and sum LPAH that were greater than the SQS. Naphthalene was the only compound detected in this sample that showed a concentration greater than the CSL. The sum LPAH for detected compounds was less than the sediment quality standard, but addition of the quantitation limit values for undetected compounds to the sum LPAH resulted in a value greater than the SQS.

The sediment core sample collected from a depth of 0 to 1.0 feet at station SR-18 showed bis(2-ethylhexyl)phthalate at a concentration greater than the SQS, and the core sample collected from a depth of 1.0 to 1.76 feet showed pentachlorophenol at a concentration greater than the SQS.

The highest frequency of compound detection was seen for high molecular weight polycyclic aromatic hydrocarbons (HPAH); however, none of the detected concentrations reported for HPAH were greater than the SQS. One of four background sample results showed a contaminant concentration that was greater than the SQS. The concentration of pentachlorophenol in a background sediment core sample collected from a depth of 1.0 to 2.0 feet at station SR-33, was greater than the SQS.

Results for some samples and compounds were reported with sample quantitation limits that were greater than the sediment quality standards chemical criteria. For SQS based on mg/kg total organic carbon (mg/kg TOC), this was a result of the laboratory method used and low TOC concentrations. The laboratory method was selected to provide results that were directly comparable to other site media. Some sediment samples had concentrations of TOC that were less than 1 percent. When converting sample results from mg/kg to mg/kg TOC, the results are divided by the decimal percent TOC. The resulting quantitation limits (mg/kg TOC) for low TOC value samples were greater than the sediment quality criteria.

Most compounds with sediment sample quantitation limits greater than SQS were not detected or were detected at a very low frequency in soil and groundwater samples collected at the site. These compounds include 1,4-dichlorobenzene, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobutadiene, N-nitrosodiphenylamine, hexachlorobenzene, and butylbenzylphthalate. As can be seen from an examination of the detected concentrations of contaminants in sediments (e.g., phenol, acenaphthene, pentachlorophenol, and chrysene), the method detection limits for compounds were up to 10 times lower than the sample quantitation limits reported. The high sample quantitation limits reported do not allow a comparison with some of the sediment quality standards.

Summary

Detected contaminants with concentrations greater than sediment quality standards included arsenic, copper, mercury, LPAH, dibenzofuran, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, and pentachlorophenol. These were detected at 10 of 30 sampling locations.

- Seven stations, all immediately adjacent to the shoreline, showed one or more contaminants that exceed CSLs.
- Three contaminants (arsenic, naphthalene, and acenaphthene) exceed Ecology's screening criteria for identification of a station cluster of potential concern.

- Three stations (SR-01, SR-05, and SR-10) with contaminants that exceed CSLs are associated with storm water discharge points. Three stations (SR-07, SR-11, and SR-13) with contaminants that exceed CSLs are associated with seep water discharge points.

- Contaminant concentrations decrease rapidly with depth at all locations except SR-05.

- Phase II sampling locations did not show chemical concentrations greater than CSLs, indicating sediment contamination occurs only in near shore sediments.

Background samples showed low concentrations of HPAH, and the background sediment core sample collected from a depth of 1.0 to 2.0 feet below the sediment surface showed a concentration of pentachlorophenol greater than the SQS and greater than any of the sediment samples collected adjacent to the site.

4.7 Risk Assessment Summary

Results of the human health risk assessment indicate that the HI for the site is approximately 0.13. Because it is less than 1.0, noncarcinogenic health effects from the indicator hazardous substances evaluated in this assessment are, according to the regulatory criteria considered, not of concern for the site. The total potential excess cancer risk for the site is approximately 5×10^{-5}. This risk is within the USEPA-established risk range of 1×10^{-4} to 1×10^{-6}; however, it exceeds the MTCA-established risk level of 1×10^{-5}.

Results of the environmental risk characterization indicate the following:

- Groundwater beneath the site and storm water runoff from the site contain contaminants at concentrations greater than associated ambient water quality criteria. Background concentrations of arsenic in groundwater also exceed associated water quality criteria.

- Metals detected in surface (river) water samples are less than ambient water quality criteria with the exception of copper. The one detection of TPH as gasoline was substantially below the state's water quality guideline for oil and grease and may reflect an off-site source.

- Primary sediment contaminants are arsenic, naphthalene, and acenaphthene, exceeding Ecology's screening criteria for a station cluster of potential concern. Six of seven sampling stations showing contaminant concentrations greater than CSLs are associated with seep and storm water discharge points.

Results of the human health and environmental risk evaluations were used to refine a conceptual site model. The conceptual site model summarizes primary contaminant sources, potential migration pathways for site contaminants, and potential receptors of these contaminants. The conceptual site model is described in Section 5.

5 CONCEPTUAL SITE MODEL AND CONTAMINANT MIGRATION

5.1 Conceptual Site Model

A conceptual site model was developed for the site based on historic site operations, data from preliminary studies, data collected during the remedial investigation, and results of the baseline risk assessment. This model, shown in Figure 5-1, summarizes potential contaminant sources, release mechanisms, routes of exposure, and receptors. Source areas and their associated constituents are summarized in Table 5-1.

The primary constituents of concern identified at the site are metals (arsenic and chromium), TPH (as gasoline, diesel, and other), and SVOCs (PCP and CPAHs). The fate and transport of these contaminants depend upon the physical and chemical characteristics of the contaminant, the physical characteristics of the site (e.g., piping, pavement), and the physical and chemical characteristics of site soils, surface water, groundwater, and sediments. Wood treating chemicals are often mixed with "carrying agents" to enhance their application. Chemicals mixed with carrying agents or other chemicals will behave differently than when in their pure form. Processes affecting the fate and transport of contaminants are discussed below.

5.2 Migration Routes

5.2.1 Soil

Potential sources of soil contamination include historic spills or leaks from tanks, piping systems, drippage along rail lines or in storage areas, and from the former wood treatment building and maintenance facility operations. During retort depressurization, air and liquid apparently were blown into the blow pit area. The ASARCO smelter site is a potential off-site source. Historical deposition of smelter-related material containing arsenic was widespread in the north Everett area. Smelter-related material may have been deposited on the site or in the upgradient assessment area as windblown particulate, components of fill, or both. Field observations and lab analyses indicate that contaminants have migrated into and through the soil, reaching groundwater. Contaminant movement to soil and groundwater represents a primary migration pathway.

5.2.2 Groundwater

Potential sources of groundwater contamination include those identified for soil and upgradient arsenic sources. Contaminants found in unsaturated soil are also generally present in groundwater beneath and downgradient of the source areas. Groundwater flow, and therefore contaminant transport, within the upper sand aquifer is primarily horizontal towards the Snohomish River. Some flow and transport are downward through the upper silt aquitard into the lower sand aquifer, particularly beneath and downgradient of the blow pit area, where the upper silt aquitard is thin. Net groundwater flow and contaminant transport within the lower sand aquifer are also primarily horizontal towards the Snohomish River. However, the flow direction in the lower sand aquifer is reversed twice daily by tidal influence. Dispersion effects, which will spread groundwater contaminants laterally, are greater in the lower sand aquifer than in the upper sand aquifer due to the tidal influence.

5.2.3 Seeps

Seeps were observed at the bulkhead and along the west bank of the Snohomish River adjacent to the site. The total volume of water discharging from the seeps was not quantified. Based on a comparison of the specific conductance of the seep water, groundwater, and river water, the seeps appear largely to result from bank storage discharges from tidal fluctuations in the river. The seeps represent a transport pathway for contaminants from groundwater and soil to the Snohomish River.

5.2.4 Storm Water Runoff

The primary source of storm water contamination is surface soil. Currently, most rainfall at the site infiltrates directly or forms areas of ponded water that subsequently infiltrate into site soil. Storm water runoff, combined with river water which flushes through the piping system with tidal cycles, was observed as a point source discharge at one location: the oil/water separator that discharges to the Snohomish River at the northeast corner of the site.

The topography of the site prior to the addition of grade fill may have resulted in point source discharges of storm water to the Snohomish River. However, historic discharge points of storm water runoff could not be determined. Portions of the site were also periodically inundated with flood water from the Snohomish River, which could also transport contaminants.

Two other discharges to the Snohomish River were observed. Water was observed discharging from a pipe at the upstream sediment sampling location SR-01 next to an oil/water separator, and via a pipe penetrating the bulkhead at sediment sampling location SR-05. The discharge next to the oil/water separator at SR-01 is from a piping system that drains an area west of the site, and does not represent a direct transport pathway for site storm water. The pipe penetrating the bulkhead at SR-05 does not appear to represent a direct storm water runoff migration route. However, the discharges at locations SR-01 and SR-05 may represent historical storm water transport pathways. As previously noted, the extent of the site drainage system could not be determined. The integrity of the system is unknown; however, infiltration of groundwater into a damaged system could provide a contaminant transport pathway to the Snohomish River.

5.2.5 Sediments

Potential sources of sediment contamination are groundwater, seep, and storm water discharges. The Snohomish River and its sediments may form a sink for contaminant deposition. Low energy (depositional) environments and high energy (dispersive) environments in the Snohomish River adjacent to the site fluctuate with tides, river flow, and seasonal factors. Low energy conditions were observed for nearshore areas during the RI. Periodic flooding of the Snohomish River can change nearshore depositional environment by eroding and resuspending sediment.

5.2.6 Air

Entrainment and transport of contaminants in air can occur through volatilization at the soil surface, volatilization of contaminants from groundwater, or by transport of contaminated particulate. As described in Section 3.7, volatilization of contaminants and particulate entrainment do not appear to be significant transport pathways.

5.3 Contaminant Migration

5.3.1 General Characteristics of Contaminant Migration

Contaminants migrate from source areas to receptors by means of several media- and contaminant-specific mechanisms unique to a site. Fate and transport processes expected at wood treating sites have been previously identified by USEPA (53 FR 53305). These processes are summarized below.

Advection, or transport with moving water, is the predominant mechanism for migration of water soluble metals and dissolved organic compounds from soil to and within groundwater. Organic compounds such as PAHs and PCP are generally insoluble in water. However, the mixtures of these compounds with a petroleum-based carrier are more mobile than pure compounds due to an increase in solubility and a decrease in viscosity. The density of the mixtures may be lighter than water, leading to a light, nonaqueous phase liquid, or LNAPL, that floats on the water table, or may be heavier than water, leading to a dense, nonaqueous phase liquid, or DNAPL, that migrates below the water table independent of groundwater flow. Dissolved phase transport of these organic compounds in groundwater may also be facilitated by sorption to colloidal solids that move with groundwater flow or by cosolvency with dissolved, natural organic or petroleum compounds in groundwater.

Reduction of contaminant concentrations by chemical breakdown (biodegradation, photolysis, or hydrolysis), chemical isolation (bioconcentration or soil adsorption), and mass transfer (volatilization or precipitation) are all expected to occur at the site to some degree, although rates or significance of these processes have not been evaluated. Detailed discussions of these processes may be found in the literature (e.g., USEPA, 1992c).

A general discussion of site contaminant migration is provided below.

5.3.2 Metals

Elevated arsenic and chromium concentrations were found in soil at all on-site source areas except former Mill E. Soil samples collected at the top of the upper sand and the top of the upper silt did not contain organic concentrations significantly greater than the site mean arsenic concentrations, indicating that the tops of these two units were not significant receptors of arsenic-contaminated particulate or fill from smelter operations. Elevated arsenic and chromium concentrations in groundwater were found below and downgradient of the same source areas indicating advective transport of metals with minimal retardation. The significantly lower concentrations of metals in the lower sand aquifer were likely due to restricted hydraulic connection between the two aquifers and/or sorption of metals to clay and organic particles in the upper silt aquitard.

Arsenic, copper, and lead were detected in storm water samples. Storm water would rapidly mix with surface water upon discharge to the Snohomish River, dispersing these metals. Precipitation of dissolved metals and subsequent adsorption may occur, depending on the chemistry of the river water.

Storm drain sediment samples showed elevated lead concentrations relative to site soil. Transport via suspended particulate in storm water appears to be a significant migration route for lead. Arsenic, chromium, copper, and lead were detected in seep samples. TSS concentrations ranged from 10 to 310 mg/L, indicating that migration of metals may occur by dissolved and/or particulate transport mechanisms. Particulate-phase metals may disperse in the Snohomish River through advection, or may flocculate and settle. Dissolved-phase contaminants may undergo dilution or precipitation reactions, depending on water chemistry conditions during discharge.

Elevated concentrations of arsenic were reported in surface sediment from sampling stations SR-01, SR-02, and SR-05, and in the sediment core samples from station SR-05. Saline sediment pore water may react with the seep water discharge, leading to precipitation and deposition of arsenic at these storm drain and seep water discharge locations. Based on the elevated arsenic concentrations at SR-01, SR-02, and SR-05, discharge pipes may represent historical sources of contamination, and precipitation of arsenic with localized deposition may be occurring.

TPH. TPH as gasoline and diesel were detected in wide distribution in subsurface soil at the site. The occurrence of TPH as heavy oil (TPH-other) was less widespread. Floating product (up to 1 foot in TW-1) was observed in three wells and was primarily composed of TPH. Floating product was observed only in the blow pit area and near former Mill E, and has not migrated significantly as a nonaqueous phase liquid beyond these two source areas. Dissolved TPH (as gas, diesel, and heavy oil) was detected in wells at and downgradient of the four on-site source areas. Dissolved TPH in groundwater has moved by advection to the Snohomish River, but transport rates have probably been reduced by sorption to organic carbon and degradation by biologic and physical processes.

TPH as gasoline was found at one seep sampling location (station SR-07). The concentration of TPH-gasoline in the seep water sample was much lower than the average gasoline concentration in groundwater. TPH-gasoline migration and discharge to the Snohomish River from seeps may occur as dissolved TPH and/or TPH adsorbed onto particulate. Concentrations of TPH-gasoline would be rapidly diluted after discharge from the seep.

TPH was not detected in storm water samples. Concentrations of TPH in storm drain sediment samples indicate transport of contaminants adsorbed to particulate and that particulate deposition occurred in the drainage system prior to storm water discharge to the Snohomish River.

VOCs. BTEX compounds were found in few locations in subsurface soil, usually in association with TPH-gasoline near the building and former Mill E. BTEX compounds volatilize from surface and shallow soil. Dissolved BTEX in groundwater has moved by advection to the Snohomish River, but transport rates have probably been reduced by sorption to organic carbon and degradation by biologic and physical processes.

SVOCs. PCP was found in subsurface soils below the four apparent on-site source areas. PCP was detected in groundwater primarily below and downgradient of the blow pit area. PCP in pure form is relatively immobile in groundwater. PCP migration from the building and the blow pit area indicate that PCP transport was facilitated by a petroleum-based carrier in which the PCP was dissolved. PCP was not detected in storm water runoff or storm drain sediment samples, but was detected in the seep water at one location (SR-07). PCP was found in a sediment core sample collected from a location between the site and Ferry-Baker Island and was also detected in a core sample collected at the background sampling location from a similar depth horizon (1.0 to 2.0 feet below the sediment surface). This suggests that the elevated PCP concentrations may not be due to site sources. Sediments below the 1-foot-depth horizon are not likely to be disturbed over time.

PAHs were detected in soil and groundwater below the four on-site source areas, primarily in the blow pit area and near the building. PAHs were also detected in groundwater downgradient of these areas, indicating facilitated advective transport similar to PCP.

Floating product in wells at the blow pit area and near former Mill E contain PCP and PAHs mixed with TPH. As stated above, the floating product has not moved significantly away from these two source areas.

Dark brown to black, iridescent soil staining and strong odors noted at the base of the upper sand unit, were interpreted as DNAPL coating the soil grains. Analysis of DNAPL-coated soil indicated significant concentrations of PAH, TPH, and PCP. Because the density of DNAPL is greater than water, it flowed vertically through the upper sand aquifer to the top of the silt aquitard and then spread on top of the sand/silt contact. The upper sand aquifer is thickest and deepest below the blow pit and has formed a topographic depression into which DNAPL has likely collected. It appears that DNAPL has not migrated significantly beyond this topographic depression. DNAPL was also noted at the base of the upper sand unit northeast of the building and below former Mill E. This suggests an additional significant source of soil contamination near the building, unrelated to the blow pit.

PAHs were not detected in storm water runoff samples, but were found in the storm drain sediment samples. Snohomish River surface sediment at station SR-10 showed elevated concentrations of PAHs. Based on a comparison of laboratory results of storm drain and river sediment, storm water particulate does not appear to deposit directly near the point of oil/water separator discharge to the Snohomish River. Particulate size, settling velocity, and contaminant characteristics determine the fate of contaminants migrating through the storm water drainage system to the river. The depositional areas for contaminants are dependant on variable factors, including river flow and tidal conditions. The suite of contaminants may vary based on contaminant characteristics.

Naphthalene, acenaphthene, and fluorene concentrations greater than cleanup screening levels were found at four sediment sampling locations. Sources of these PAHs appear to be migration of contaminants via groundwater flow to locations SR-07, SR-10, and SR-11 from source areas on site, and possibly an off-site source for location SR-13. The suite of PAHs detected at elevated concentrations were generally those with lower molecular weights. Migration of PAHs from the sediments to other areas of the Snohomish River system may occur from sediment resuspension and advective dispersion. Moderate biodegradation and naturally occurring deposition and bioturbation of clean sediment can be expected to decrease surface sediment contaminant concentrations over time.

Dioxins/Furans. Dioxins/furans, primarily the hepta and octa congeners, were mainly detected in soil in and near the blow pit area. No 2,3,7,8-TCDD was detected. Dioxin/furan compounds are generally attributed to, and found in association with, PCP. They are practically insoluble and nonvolatile, and are not readily degraded.

5.4 Summary

Four apparent on-site source areas (the blow pit area, former wood treatment/maintenance building, rail lines, and former Mill E), and an apparent off-site source (ASARCO smelter site and smelter-related materials) have been identified. Principal contaminants of concern for potential risks to human health are arsenic, chromium, and CPAHs. Principal contaminants of concern for potential risks to the environment are arsenic, copper, PCP, and PAHs. TPH and dioxins/furans (except 2,3,7,8-TCDD) were found in elevated concentrations on site; MTCA assessment methods do not prescribe a method for quantification of associated risks for these compounds. The primary migration pathway for contaminants is from soil to groundwater to the Snohomish River; secondary pathways are from seeps and storm water to the river. Contaminant receptors (and secondary contaminant transport pathways) are the Snohomish River and its sediments.

Advection, or transport with moving water, is the predominant on-site mechanism for migration of metals and dissolved organic compounds from soil to groundwater and within groundwater. Dissolved TPH, PAHs, and PCP have moved by advection from the source areas and soil containing light and dense NAPL, to the river. The advection rate has probably been reduced by sorption of these compounds to organic carbon in the soil and by degradation processes.

Pure phase (NAPL) flow has occurred to a limited extent. LNAPL, composed primarily of TPH, PAHs, and PCP, has not migrated along the water table to any significant distance (i.e., greater than 50 feet) from the source areas. DNAPL, also composed primarily of TPH, PAHs, and PCP, has migrated vertically downward from the building and blow pit area into the upper sand aquifer and along the top of the upper silt aquitard. A topographic depression beneath the blow pit area has likely collected DNAPL, and has probably limited any significant flow of DNAPL beyond this depression.

The detection of low-solubility PAHs and PCP with TPH in LNAPL, DNAPL, and in groundwater samples downgradient of the source areas, suggests that transport of these compounds has been facilitated by mixing with petroleum, primarily diesel-range hydrocarbons.

The site is currently not in use and therefore presents a low risk to human health. If it were in use, the site would exceed the MTCA-established human health risk level of 1×10^{-5}. Contaminants transported to the Snohomish River are rapidly attenuated upon discharge through mixing. Sediment samples collected from 7 of 30 locations in the Snohomish River immediately adjacent to the site exceed sediment cleanup screening levels (CSLs). Sediment contaminant concentrations decrease rapidly with depth and distance from the site.

REFERENCES

ATSDR. 1989. *Toxicological Profile For Arsenic.* Agency for Toxic Substances and Disease Registry. PB89-185706. March.

Beazer. 1994. Letter dated July 12, 1994, from Beazer East, Inc. to Weyerhaeuser Company.

Booth, Derek B. 1984. *Surficial Geology of the West Half of the Skykomish River Quadrangle, Snohomish and King Counties, Washington.* U.S. Geological Survey Open-File Report 84-213, 36 p., 1 plate, scale 1:50,000.

Dexter et. al. 1981. *NOAA Technical Memorandum OMPA-13.*

Dragun. 1988. *The Soil Chemistry of Hazardous Materials.* The Hazardous Materials Control Research Institute, Silver Springs, Maryland.

Ecology. 1987. *Discharges Containing Oil and Grease of Mineral Origin.* Water Quality 9. September 1987.

Ecology. 1991. *Gastrointestinal Absorption of Arsenic from Arsenic Contaminated Soil and Lead Cleanup Levels.* Memo from L. Kissinger to M. Abbett. September 12, 1991.

Ecology. 1992. *Statistical Guidance for Ecology Site Managers.* Publication 92-54. August. Toxics Cleanup Program, Olympia. Supplemented August 11, 1993.

EMCON. 1992. *Work Plan for Remedial Investigation/Feasibility Study of Former Mill E/Koppers Facility.* November 1992.

EMCON. 1993. *Former Mill E/Koppers Facility Supplemental Remedial Investigation Work Plan.* September 1993.

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater.* Prentice-Hall. New Jersey. 604p.

Hart Crowser. 1989a. Environmental Assessment and Site Characterization Work Plan. Weyerhaeuser Old Machine Shop, Everett Mill E Site.

TetraTech. 1988. *Everett Harbor Action Program: Evaluation of Potential Contaminant Sources.* TC-3338-26. September, 1988.

Todd. 1959. *Groundwater Hydrology* Second Edition. John Wiley & Sons. 534p.

USEPA. 1974. *Protocols for Calculating VOC Emissions from Land Applications Using Emission Models.* USEPA Contract No. 68-02-3850. December.

USEPA. 1977a. *Compilation of Air Pollutant Emission Factors*, AP-42. Third Edition. August 1977.

USEPA. 1977b. *Guidelines for Air Quality Maintenance Planning and Analysis, Volume 10 (Revised): Procedures for Evaluating Air Quality Impact of New Stationary Sources.* USEPA-450/4-77-001.

USEPA. 1982. *Wood preservative pesticides: creosote, pentachlorophenol, and inorganic arsenicals (wood uses).* Position Document 2/3. United States Environmental Protection Agency. USEPA 540/9-82-004.

USEPA. 1983. *Treatability Manual, Volume 1.* USEPA-600/2-82-001a. February.

USEPA. 1985. *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Sites.* USEPA/600/8-85/002. February.

USEPA. 1986a. *Quality Criteria for Water 1986.* United States Environmental Protection Agency. USEPA 440/5-86-001, Office of Water Regulations and Standards.

USEPA. 1986b. *Superfund Public Health Evaluation Manual.* USEPA/540/1-86/060. October.

USEPA. 1987a. *Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF) - Air Emission Models.* December 1987.

USEPA. 1987b. *Method for Estimating Fugitive Particulate Emissions from Hazardous Waste Sites.* USEPA/600/2-87/066. August.

USEPA. 1987c. *Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF) Air Emission Models.* USEPA-450/3-87-026. December.

USEPA. 1988. *Superfund Exposure Assessment Manual.* USEPA/540/1-88/001. April.

USEPA. 1989a. *Risk Assessment for Superfund, Human Health Evaluation Manual, Part A. Interim Final.* United States Environmental Protection Agency. USEPA 9285/701A.

Hart Crowser. 1989b. Site Characterization Report, Weyerhaeuser Old Machine Shop, Everett Mill E Site, Volumes I and II.

Hart Crowser. 1991. *Phase 1c Site Characterization Report.* Weyerhaeuser Everett Mill E Site, Everett, Washington.

Holtz, Robert D., and William D. Kovacs. 1981. *An Introduction to Geotechnical Engineering*. Prentice Hall, Inc. Englewood Cliffs, New Jersey.

Hydrometrics. 1994. *Draft Everett Smelter Site, Remedial Investigation.* June 30, 1994.

Kao, J.K., F.K Patterson, and J. Hall. 1985. *Skin penetration and metabolism of topically applied chemicals in six mammalian species, including man: An in vitro study with benzo(a)pyrene and testosterone.* Toxicol Appl Pharmacol 81: pp 502-516.

Newcomb, Reuben C. 1952. *Ground Water Resources of Snohomish County, Washington.* U.S. Geological Survey Water Supply Paper 1135, 133p.

NOAA. 1974. *Climates of the States, Volume 2.* Water Information Center, Inc. Port Washington, New York.

NOAA. 1991. *Everett Harbor, Nautical Chart 18444.* National Oceanic and Atmospheric Administration. Washington, D.C.

PTI and TetraTech. 1988. *Everett Harbor Action Program: Analysis of Toxic Problem Areas.* Prepared for USEPA Region 10.

Ryan, E.A., E.T. Hawking, B. Magee, and S.L. Santos. 1987. "Assessing Risk from Dermal Exposure at Hazardous Waste Sites." In: *Superfund '87 Proceedings of the 8th National Conference, November 16-18, 1987, Washington, D.C.* Sponsored by the Hazardous Materials Control Research Institute, Silver Springs, Maryland.

SAIC. 1991a. *Final Report of the Everett Slag Site, Everett, Washington.*

SAIC. 1991b. Unpublished Data. Attachment to Hydrometrices 1994.

Serfes, Michael E. 1991. *Determining the Mean Hydraulic Gradient of Groundwater Affect by Tidal Fluctuations.* Groundwater, Vol. 29, No.4 July-August 1991.

Sweet-Edwards/EMCON. 1988. *Technical Addendum, Hydrogeologic Investigation, Weyerhaeuser Everett Kraft Mill.* November, 1988.

Sweet-Edwards/EMCON. 1991. *Snohomish County Groundwater Characterization Study.* July, 1991.

USEPA. 1989b. *Exposure Factors Handbook.* United States Environmental Protection Agency. USEPA/600/8-89/043. May.

USEPA. 1989c. *CHEMDAT7: Air Emission Models.* Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

USEPA. 1989e. *Risk Assessment for Superfund, Volume II Environmental Evaluation Manual. Interim Final.* United States Environmental Protection Agency. USEPA 540/1-89/001. March.

USEPA. 1989f. *Air Emissions from Petroleum UST Cleanups.* June.

USEPA. 1990a. *Statement of Work RI/FS Risk Assessment, Exposure Parameters.* United States Environmental Protection Agency Region 10. January.

USEPA. 1990b. *Air/Superfund National Technical Guidance Study Series. Volume 2. Estimation of Baseline Air Emission Superfund Sites (Revised).* USEPA-450/1-89-0020.

USEPA. 1991b. *USEPA Region 10 Supplemental Risk Assessment Guidance for Superfund.* United States Environmental Protection Agency Region 10. August 10.

USEPA. 1991c. *Health Effects Assessment Summary Tables - Annual FY 1991.* United States Environmental Protection Agency. January.

USEPA. 1991d. *Risk Assessment for Superfund, Volume I: Human Health Evaluation Manual. Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.* United States Environmental Protection Agency. March.

USEPA. 1991e. *Fugitive Dust Model.* United States Environmental Protection Agency, Support Center for Regulatory Air Models. Research Triangle, N.C.

USEPA. 1991f. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.* OSWNER Directive 9355.0-30. Memo from D.R. Clay, Assistant Administrator, to Regional Directors of Hazardous Waste Management Divisions. Washington, D.C. April 22, 1991.

USEPA. 1992a. *Drinking Water Regulations and Health Advisories.* Online. United States Environmental Protection Agency, Office of Water. April.

USEPA. 1992b. *Dermal Exposure Assessment: Principles and Applications. Interim Report.* USEPA/600/8-91/011B. Office of Health and Environmental Assessment, Washington, D.C.

USEPA. 1992c. *Contaminants and Remedial Options at Wood Preserving Sites.* USEPA/600/R-92/182. October.

Williams, J.R., H.E. Pearson, and J.D. Wilson. 1985. *Streamflow Statistics and Drainage-Basin Characteristics for the Puget Sound Region, Washington. Volume II. Eastern Puget Sound to the Canadian Border.* U.S. Geological Survey Open-File Report 84-144-B. U.S. Department of the Interior, Tacoma, Washington. 420p.

Winges, Kirk D. 1992. *Fugitive Dust Model Manual.* Prepared for the United States Environmental Protection Agency Region 10, Seattle, Washington. September.

Woodruff, N.P. and F.H. Siddoway. 1965. *A Wind Erosion Equation.* Published in Soil Science Society Proceedings.

Table 2-1

Summary of Aquifer and Aquitard Hydraulic Conductivity

Hydrogeologic Unit	Minimum	Maximum	Average
Horizontal Hydraulic Conductivity (cm/sec)			
Upper Sand Aquifer	1.8×10^{-2}	7.3×10^{-2}	5×10^{-2}
Lower Sand Aquifer	6×10^{-3}	9×10^{-2}	5×10^{-2}
Vertical Hydraulic Conductivity (cm/sec)			
Upper Silt Aquitard	9.7×10^{-8}	3.3×10^{-7}	2.2×10^{-7}

Table 2-2

Summary of Hydraulic Gradients

Hydrogeologic Unit	Minimum	Maximum	Average
Horizontal Hydraulic Gradients (ft/ft)			
Upper Sand Aquifer	0.0033	0.0039	0.0037
Lower Sand Aquifer			
Low Tide	b	b	0.0033 (west)
High Tide	b	b	0.0032 (east)
Net[a]	b	b	0.00046 (east)
Vertical Hydraulic Gradients (ft/ft)			
Lower Silt Aquitard			
Low Tide	0.28 (down)	0.52 (down)	0.40 (down)
High Tide[c]	0.077 (down)	0.014 (up)	0.007 (up)
Net[a]	0.18 (down)	0.24 (down)	0.20 (down)

[a] Corrected for tidal influence.
[b] Not estimated, highly variable.
[c] Vertical gradient is zero at some wells.

Table 2-3

Summary of Average Linear Velocities

Hydrogeologic Unit	Minimum	Maximum	Average
Average Horizontal Velocities (ft/day)			
Upper Sand Aquifer	0.56	2.7	1.8
Lower Sand Aquifer			
Low Tide (east)	0.2	2.8	1.6
High Tide (west)	0.2	2.8	1.6
Net (east)	0.03	0.4	0.2
Average Vertical Velocities (ft/day)			
Lower Silt Aquitard			
Low Tide	—	—	6.2 x 10^{-4} (down)
High Tide	—	—	1.1 x 10^{-5} (up)
Net	—	—	3.1 x 10^{-4} (down)

NOTE: — Not estimated; highly variable due to tidal fluctuation and heterogeneous stratigraphy.

Table 3-1

Average Concentrations of Metals in Puget Sound Soil

Metal	Concentration in Soil[a] (mg/kg)
Arsenic	< 100 (20 in North Everett area)[b]
Chromium	80
Copper	20
Lead	15

[a] From Dexter, 1981.

[b] Dave Nazy, personal communication, November 1992 with Steve Nelson, EMCON.

Table 3-2

Statistical Summary of Metals in Soil — Fill

Element	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
Fill								
Arsenic	31	31	6.8	187	53.1	82.9	—	—
Chromium	20	20	15.6	243	54.7	74.8000	—	—
Copper	20	20	15.3	79.2	40.2	52.8	—	—
Lead	20	20	7.8	103	26.6	40.0	—	—
Mercury	3	20	0.08	0.13	0.11	*	0.07	0.21

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-3

Statistical Summary of Total Petroleum Hydrocarbons in Soil — Fill

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
Fill								
Gasoline	16	20	1.0	2200	476	*	1	5.7
Diesel	10	20	40	3700	904	*	NR	NR
Heavy Oil	17	20	2.0	7900	1544	*	NR	NR

NOTE: * = Default to maximum value per statistical guidance.
NR = Indicates value was not reported.

Table 3-4

Statistical Summary of Volatile Organic Compounds in Soil — Fill

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
Fill								
Chloromethane	0	16	—	—	—	—	0.011	5.10
Bromomethane	0	16	—	—	—	—	0.011	5.10
Vinyl Chloride	0	16	—	—	—	—	0.011	5.10
Chloroethane	0	16	—	—	—	—	0.011	5.10
Methylene Chloride	0	16	—	—	—	—	0.011	5.10
Acetone	0	16	—	—	—	—	0.011	5.10
Carbon Disulfide	0	16	—	—	—	—	0.011	5.10
1,1-Dichloroethane	0	16	—	—	—	—	0.011	5.10
1,2-Dichloroethene (total)	0	16	—	—	—	—	0.011	5.10
Chloroform	0	16	—	—	—	—	0.011	5.10
1,2-Dichloroethane	0	16	—	—	—	—	0.011	5.10
2-Butanone	1	16	4.90	—	—	—	0.011	5.10
1,1,1-Trichloroethane	0	16	—	—	—	—	0.011	5.10
Carbon Tetrachloride	0	16	—	—	—	—	0.011	5.10
Bromodichloromethane	0	16	—	—	—	—	0.011	5.10
1,2-Dichloropropane	0	16	—	—	—	—	0.011	5.10
cis-1,3-Dichloropropene	0	16	—	—	—	—	0.011	5.10
Trichloroethene	0	16	—	—	—	—	0.011	5.10
Dibromochloromethane	0	16	—	—	—	—	0.011	5.10
1,1,2-Trichloroethane	0	16	—	—	—	—	0.011	5.10
Benzene	2	16	0.320	2.10	—	*	0.011	5.10
Bromoform	0	16	—	—	—	—	0.011	5.10
4-Methyl-2-Pentanone	0	16	—	—	—	—	0.011	5.10
2-Hexanone	0	16	—	—	—	—	0.011	5.10
Tetrachloroethene	0	16	—	—	—	—	0.011	5.10
1,1,2,2-Tetrachloroethane	0	16	—	—	—	—	0.011	5.10
Toluene	5	16	0.005	37.0	3.77	*	0.011	5.10
Chlorobenzene	0	16	—	—	—	—	0.011	5.10
Ethylbenzene	5	16	0.008	15.0	1.98	*	0.011	5.10
Styrene	0	16	—	—	—	—	0.011	5.10
Total Xylenes	6	16	0.022	140	21.2	*	0.011	5.10

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-5

Statistical Summary of Semivolatile Organic Compounds in Soil — Fill

Page 1 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
Fill								
Phenol	0	25	—	—	—	—	0.330	28
bis(2chloroethyl)Ether	0	25	—	—	—	—	0.330	28
2-Chlorophenol	0	25	—	—	—	—	0.330	28
1,3-Dichlorobenzene	0	25	—	—	—	—	0.330	28
1,4-Dichlorobenzene	0	25	—	—	—	—	0.330	28
1,2-Dichlorobenzene	0	25	—	—	—	—	0.330	28
2-Methylphenol	0	25	—	—	—	—	0.330	28
2,2-oxybis(1-Chloropropane)	0	25	—	—	—	—	0.330	28
4-Methylphenol	0	25	—	—	—	—	0.330	28
N-nitroso-Di-n-Propylamine	0	25	—	—	—	—	0.330	28
Hexachloroethane	0	25	—	—	—	—	0.330	28
Nitrobenzene	0	25	—	—	—	—	0.330	28
Isophorone	0	25	—	—	—	—	0.330	28
2-Nitrophenol	0	25	—	—	—	—	0.330	28
2,4-Dimethylphenol	0	25	—	—	—	—	0.330	28
bis(2-Chloroethoxy)Methane	0	25	—	—	—	—	0.330	28
2,4-Dichlorophenol	0	25	—	—	—	—	0.330	28
1,2,4-Trichlorobenzene	0	25	—	—	—	—	0.330	28
Naphthalene	18	25	0.049	98.0	9.55	90.9	0.330	28
4-Chloroaniline	0	25	—	—	—	—	0.330	28
Hexachlorobutadiene	0	25	—	—	—	—	0.330	28
4-Chloro-3-Methylphenol	0	25	—	—	—	—	0.330	28
2-Methylnaphthalene	16	25	0.074	120	9.97	67.5	0.330	28
Hexachlorocyclopentadiene	0	25	—	—	—	—	0.330	28
2,4,6-Trichlorophenol	0	25	—	—	—	—	0.330	28
2,4,5-Trichlorophenol	0	25	—	—	—	—	0.810	67
2-Chloronaphthalene	0	25	—	—	—	—	0.330	28
2-Nitroaniline	0	25	—	—	—	—	0.810	67
Dimethyl phthalate	0	25	—	—	—	—	0.330	28
Acenaphthylene	5	25	0.060	4.40	2.10	*	0.330	28
2,6-Dinitrotoluene	0	25	—	—	—	—	0.330	28
3-Nitroaniline	0	25	—	—	—	—	0.810	67
Acenaphthene	16	25	0.061	280	14.7	39.6	0.330	28
2,4-Dinitrophenol	0	25	—	—	—	—	0.810	67

Table 3-5

Statistical Summary of Semivolatile Organic Compounds in Soil — Fill

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
4-Nitrophenol	0	25	—	—	—	—	0.810	67
Dibenzofuran	13	25	0.120	120	7.79	16.6	0.330	28
2,4-Dinitrotoluene	0	25	—	—	—	—	0.330	28
Diethylphthalate	1	25	0.130	—	—	—	0.330	28
4-Chlorophenyl-phenylether	0	25	—	—	—	—	0.330	28
Fluorene	18	25	0.045	250	13.9	45.4	0.330	5.20
4-Nitroaniline	0	25	—	—	—	—	0.810	67
4,6-Dinitro-2-Methylphenol	0	25	—	—	—	—	0.810	67
N-Nitrosodiphenylamine	0	25	—	—	—	—	0.330	28
4-Bromophenyl-phenylether	0	25	—	—	—	—	0.330	28
Hexachlorobenzene	0	25	—	—	—	—	0.330	28
Pentachlorophenol	17	25	0.055	11.0	6.06	*	0.810	67
Phenanthrene	21	25	0.074	570	31.9	194	0.330	82
Anthracene	20	25	0.056	560	31.6	111	0.330	1.40
Carbazole	13	25	0.074	120	7.52	13.8	0.330	15
Di-n-Butylphthalate	0	25	—	—	—	—	0.330	28
Fluoranthene	21	25	0.082	450	32.4	252	0.330	1.40
Pyrene	22	25	0.048	380	26.7	261	0.330	1.40
Butylbenzylphthalate	0	25	—	—	—	—	0.330	28
3,3'-Dichlorobenzidine	0	25	—	—	—	—	0.330	28
Benzo(a)anthracene	19	25	0.160	75.0	6.04	15.9	0.330	3.90
Chrysene	20	25	0.330	76.0	7.14	23.1	0.330	3.90
bis(2-Ethylhexyl)phthalate	1	25	0.150	—	—	—	0.355	28
Di-n-Octyl Phthalate	0	25	—	—	—	—	0.330	28
Benzo(b)Fluoranthene	18	25	0.230	38.0	5.20	15.6	0.330	15
Benzo(k)Fluoranthene	16	25	0.097	30.0	2.79	6.56	0.330	15
Benzo(a)Pyrene	16	25	0.093	30.0	3.20	10.5	0.330	15
Indeno(1,2,3-cd)Pyrene	10	25	0.086	11.0	2.61	7.74	0.330	28
Dibenz(a,h)Anthracene	1	25	0.110	—	—	—	0.330	28
Benzo(g,h,i)Perylene	9	25	0.206	7.70	2.31	5.10	0.330	28

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-6

Statistical Summary of Metals in Soil — Upper Sand

Element	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
Upper Sand								
Arsenic	60	60	4.0	459	81.6	111	—	—
Chromium	32	32	18.2	906	93.8	*	—	—
Copper	32	32	11.7	23.6	16.0	17.0	—	—
Lead	32	32	2.4	14.8	6.96	8.61	—	—
Mercury	1	32	0.16	—	—	—	0.08	0.11

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-7

Statistical Summary of Total Petroleum Hydrocarbons in Soil — Upper Sand

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg) Low	Detection Limits (mg/kg) High
Upper Sand								
Gasoline	40	45	0.40	11,000	840	*	1.0	50
Diesel	30	45	4.0	3,800	666	*	2.0	19
Heavy Oil	24	45	3.0	20,000	1,115	*	2.0	770

NOTE: * = Default to maximum value per statistical guidance.

Table 3-8

Statistical Summary of Volatile Organic Compounds in Soil - Upper Sand

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limits (mg/kg)	Detection Limits (mg/kg)	
							Low	High
Upper Sand								
Chloromethane	0	30	—	—	—	—	0.010	5.30
Bromomethane	0	30	—	—	—	—	0.010	5.30
Vinyl Chloride	0	30	—	—	—	—	0.010	5.30
Chloroethane	0	30	—	—	—	—	0.010	5.30
Methylene Chloride	0	30	—	—	—	—	0.010	5.30
Acetone	0	30	—	—	—	—	0.010	5.30
Carbon Disulfide	0	30	—	—	—	—	0.010	5.30
1,1-Dichloroethane	0	30	—	—	—	—	0.010	5.30
1,2-Dichloroethene (total)	0	30	—	—	—	—	0.010	5.30
Chloroform	0	30	—	—	—	—	0.010	5.30
1,2-Dichloroethane	0	30	—	—	—	—	0.010	5.30
2-Butanone	2	30	0.009	0.010	—	—	0.010	5.30
1,1,1-Trichloroethane	0	30	—	—	—	—	0.010	5.30
Carbon Tetrachloride	0	30	—	—	—	—	0.010	5.30
Bromodichloromethane	0	30	—	—	—	—	0.010	5.30
1,2-Dichloropropane	0	30	—	—	—	—	0.010	5.30
cis-1,3-Dichloropropene	0	30	—	—	—	—	0.010	5.30
Trichloroethene	0	30	—	—	—	—	0.010	5.30
Dibromochloromethane	0	30	—	—	—	—	0.010	5.30
1,1,2-Trichloroethane	0	30	—	—	—	—	0.010	5.30
Benzene	3	30	0.006	1.50	0.418	*	0.010	5.30
Bromoform	0	30	—	—	—	—	0.010	5.30
4-Methyl-2-Pentanone	0	30	—	—	—	—	0.010	5.30
2-Hexanone	0	30	—	—	—	—	0.010	5.30
Tetrachloroethene	0	30	—	—	—	—	0.010	5.30
1,1,2,2-Tetrachloroethane	0	30	—	—	—	—	0.010	5.30
Toluene	10	30	0.004	24.0	2.35	*	0.010	1.30
Chlorobenzene	0	30	—	—	—	—	0.010	5.30
Ethylbenzene	9	30	0.009	64.0	3.33	*	0.010	1.30
Styrene	3	30	1.80	46.0	1.95	*	0.010	5.10
Total Xylenes	13	30	0.004	180	14.8	*	0.010	0.056

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-9

Statistical Summary of Semivolatile Organic Compounds in Soil — Upper Sand

Page 1 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
							Upper Sand	
Phenol	0	53	—	—	—	—	0.340	50
bis(2chloroethyl)Ether	0	53	—	—	—	—	0.340	50
2-Chlorophenol	0	53	—	—	—	—	0.340	50
1,3-Dichlorobenzene	0	53	—	—	—	—	0.340	50
1,4-Dichlorobenzene	0	53	—	—	—	—	0.340	50
1,2-Dichlorobenzene	0	53	—	—	—	—	0.340	50
2-Methylphenol	0	53	—	—	—	—	0.340	50
2,2-oxybis(1-Chloropropane)	0	53	—	—	—	—	0.340	50
4-Methylphenol	1	53	0.053	—	—	—	0.340	50
N-nitroso-Di-n-Propylamine	0	53	—	—	—	—	0.340	50
Hexachloroethane	0	53	—	—	—	—	0.340	50
Nitrobenzene	0	53	—	—	—	—	0.340	50
Isophorone	0	53	—	—	—	—	0.340	50
2-Nitrophenol	0	53	—	—	—	—	0.340	50
2,4-Dimethylphenol	1	53	0.048	—	—	—	0.340	50
bis(2-Chloroethoxy)Methane	0	53	—	—	—	—	0.340	50
2,4-Dichlorophenol	0	53	—	—	—	—	0.340	50
1,2,4-Trichlorobenzene	0	53	—	—	—	—	0.340	50
Naphthalene	28	53	0.069	3,000	130	2,100	0.340	50
4-Chloroaniline	0	53	—	—	—	—	0.340	50
Hexachlorobutadiene	0	53	—	—	—	—	0.340	50
4-Chloro-3-Methylphenol	0	53	—	—	—	—	0.340	50
2-Methylnaphthalene	28	53	0.061	1,800	74.0	650	0.340	50
Hexachlorocyclopentadiene	0	53	—	—	—	—	0.340	50
2,4,6-Trichlorophenol	0	53	—	—	—	—	0.340	50
2,4,5-Trichlorophenol	0	53	—	—	—	—	0.810	100
2-Chloronaphthalene	1	53	1.80	—	—	—	0.340	50
2-Nitroaniline	0	53	—	—	—	—	0.810	100
Dimethyl phthalate	0	53	—	—	—	—	0.340	50
Acenaphthylene	6	53	1.00	12.0	2.77	5.01	0.340	50
2,6-Dinitrotoluene	0	53	—	—	—	—	0.340	50
3-Nitroaniline	0	53	—	—	—	—	0.810	100
Acenaphthene	27	53	0.066	630	3.48	226	0.340	150

Table 3-9

Statistical Summary of Semivolatile Organic Compounds in Soil — Upper Sand

Page 2 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
2,4-Dinitrophenol	0	53	—	—	—	—	0.810	100
4-Nitrophenol	1	53	1.60	—	—	—	0.810	120
Dibenzofuran	26	53	0.057	380	21.7	106	0.340	50
2,4-Dinitrotoluene	0	53	—	—	—	—	0.340	50
Diethylphthalate	0	53	—	—	—	—	0.340	50
4-Chlorophenyl-phenylether	0	53	—	—	—	—	0.340	50
Fluorene	29	53	0.042	450	27.5	179	0.340	50
4-Nitroaniline	0	53	—	—	—	—	0.810	100
4,6-Dinitro-2-Methylphenol	0	53	—	—	—	—	0.810	100
N-Nitrosodiphenylamine	0	53	—	—	—	—	0.340	50
4-Bromophenyl-phenylether	0	53	—	—	—	—	0.340	50
Hexachlorobenzene	0	53	—	—	—	—	0.340	50
Pentachlorophenol	25	53	0.042	410	27.6	49.7	0.810	120
Phenanthrene	32	53	0.040	980	62.1	*	0.340	50
Anthracene	27	53	0.059	180	19.0	102	0.340	50
Carbazole	21	53	0.038	45.0	6.90	17.3	0.340	50
Di-n-Butylphthalate	0	53	—	—	—	—	0.340	50
Fluoranthene	34	53	0.084	340	26.8	230	0.340	50
Pyrene	35	53	0.110	270	23.2	156	0.340	50
Butylbenzylphthalate	1	53	16.0	—	—	—	0.340	50
3,3'-Dichlorobenzidine	0	53	—	—	—	—	0.340	50
Benzo(a)anthracene	29	53	0.044	55.0	6.32	16.8	0.340	50
Chrysene	31	53	0.045	47.0	7.04	23.0	0.340	50
bis(2-Ethylhexyl)phthalate	6	53	0.049	0.550	3.70	*	0.340	100
Di-n-Octyl Phthalate	1	53	0.218	—	—	—	0.340	50
Benzo(b)Fluoranthene	27	53	0.040	30.0	5.45	11.7	0.340	50
Benzo(k)Fluoranthene	17	53	0.041	77.0	4.47	10.2	0.340	50
Benzo(a)Pyrene	19	53	0.048	19.0	3.64	9.26	0.340	50
Indeno(1,2,3-cd)Pyrene	9	53	0.082	7.90	3.16	6.94	0.340	50
Dibenz(a,h)Anthracene	1	53	0.140	—	—	—	0.340	50
Benzo(g,h,i)Perylene	7	53	0.140	11.0	3.24	6.26	0.340	50

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-10

Statistical Summary of Dioxins and Furans in Soil — Upper Sand

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
2378-TCDD	0	17	—	—	—	—	1.1E-07	1.5E-06
2378-TCDF	6	17	1.8E-07	5.2E-06	9.1E-07	1.8E-06	1.4E-07	1.8E-06
12378-PeCDF	0	17	—	—	—	—	4.3E-08	3.2E-06
12378-PeCDD	3	17	2.6E-06	9.9E-06	1.3E-06	2.3E-06	1.3E-07	6.8E-07
23478-PeCDF	0	17	—	—	—	—	8.0E-08	3.3E-06
123478-HxCDF	4	17	1.9E-06	8.1E-04	8.4E-05	9.7E-03	5.6E-08	2.3E-06
123678-HxCDF	0	17	—	—	—	—	1.0E-07	1.1E-05
123478-HxCDD	2	17	2.1E-07	2.0E-05	—	—	1.0E-07	1.7E-06
123678-HxCDD	10	17	1.0E-06	2.8E-03	3.5E-04	3.7E-01	1.9E-07	6.9E-07
123789-HxCDD	9	17	4.7E-07	2.4E-04	2.6E-05	4.9E-04	1.2E-07	1.3E-06
234678-HxCDF	1	17	3.0E-04	—	—	—	6.6E-08	3.8E-06
123789-HxCDF	0	17	—	—	—	—	7.0E-08	5.6E-06
1234678-HpCDF	17	17	4.6E-07	3.8E-02	3.6E-03	3.8E+00	—	—
1234789-HpCDD	17	17	6.7E-06	2.5E-01	2.6E-02	2.9E+01	—	—
1234789-HpCDF	8	17	4.3E-06	2.2E-03	2.6E-04	1.0E+00	3.4E-08	2.8E-06
OCDD	17	17	3.9E-05	2.6E+00	3.6E-01	1.1E+03	—	—
OCDF	17	17	3.5E-06	8.2E-01	1.2E-01	5.5E+03	—	—
2378 HxCDF(total)	5	17	1.9E-06	8.2E-04	1.0E-04	5.0E-03	2.9E-07	9.5E-06
2378 HxCDD(total)	11	17	1.7E-06	2.8E-03	3.8E-04	4.9E-02	5.4E-07	2.4E-06
2378 HpCDF(total)	17	17	4.6E-07	4.0E-02	3.8E-03	4.9E+00	—	—

NOTE: All data from analyses by Weyerhaeuser Analytical and Testing Services.
All totals detection limits are the sum of the detection limits for individual congeners.
Minimums and maximums are for detected values.
— = Indicates no relevant value.

Table 3-11

Background Groundwater Concentrations for Metals of Concern

Compound	Expected Natural Concentration (mg/L)[a]	Average Upgradient Concentration — Upper Sand Aquifer (mg/L)
Metals		
Arsenic	<1 - 30	0.443
Chromium	<1 - 5	0.0032[b]
Copper	<1 - 30	0.0048
Lead	<15	0.0026

[a] Dragun, 1988.
[b] HC-11D only.

Table 3-12

Statistical Summary of Metals in Groundwater

Element	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)		
							Low	High	
TOTAL METALS									
Shallow Wells									
Arsenic hit	93	93	0.0043	17	2.17 ✓	4.93	—	—	.005
Chromium hit	61	93	0.0014	0.461	0.0273	0.0354	0.0014	0.0221	.05
Copper OK	58	93	0.00095	0.0345	0.0074	0.0099	0.0034	0.0196	.60
Lead hit	44	93	0.0007	0.047	0.0032	0.0037	0.0005	0.0041	.005
Mercury OK	1	44	0.00011	—	—	—	0.0001	0.0004	.062
Deep Wells									
Arsenic	39	42	0.0010	1.54	0.163	*	0.0017	0.0046	
Chromium	26	42	0.0024	0.034	0.0074	0.0112	0.0007	0.0123	
Copper	13	42	0.0012	0.0139	0.0026	0.0036	0.00068	0.0064	
Lead	10	42	0.0009	0.0080	0.0010	*	0.0005	0.0045	
Mercury	0	18	—	—	—	—	0.0001	0.0004	
DISSOLVED METALS									
Shallow Wells									
Arsenic	44	44	0.0040	17	2.10	7.42	—	—	
Chromium	18	44	0.0031	0.113	0.0132	*	0.0029	0.0147	
Copper	5	44	0.0037	0.0171	0.0026	*	0.0034	0.123	
Lead	7	44	0.0009	0.0029	0.0017	*	0.0005	0.0069	
Mercury	0	44	—	—	—	—	0.0001	0.0002	
Deep Wells									
Arsenic	14	18	0.0039	1.26	0.138	*	0.0007	0.0032	
Chromium	6	18	0.0034	0.0286	0.0063	*	0.0029	0.0348	
Copper	1	18	0.0041	—	—	*	0.0034	0.0064	
Lead	1	18	0.0010	—	—	—	0.0005	0.0047	
Mercury	0	18	—	—	—	—	0.0001	0.0002	

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

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Table 3-13

Average Groundwater Concentrations of Selected Compounds in On-site Wells, Upper Sand Aquifer

Monitoring Well	Number of Samples	Total Arsenic mg/L	TPH mg/L	Pentachlorophenol mg/L
HC-1	5	0.30	0.27[a]	0.029[a]
HC-2	5	0.063	0.23[a]	0.026[a]
HC-3	2	1.2	0.05[a]	0.030[b] ✓
HC-5	2	0.14	0.2[b]	0.030[b] ✓
HC-6	5	0.50	5.5	0.31[c]
HC-7	5	0.19	0.9	0.026[b]
HC-9	5	4.8	2.5	0.11
HC-10	5	0.12	9.4	0.025
HC-12	2	2.6	39	0.053[a]
HC-13	5	6.8	35	1.4
HC-14	2	0.37	0.85	0.027[b]
HC-15	5	2.7	109	1.1
HC-16	5	2.4	17	0.26
HC-21	2	0.32	0.4[b]	0.002[a]
HC-22	5	1.2	22	0.12
MW-23	5	15.5	32	5.1
MW-27	5	0.2	20	0.026[b]
MW-30	5	0.2	0.44	0.025
MW-31	5	1.8	3.9	3.3
MW-32	5	0.43	1.0	0.51
MW-33	5	0.81	19	0.45

[a] Only one detection.
[b] No detections; highest MDL value.
[c] No detections; average MDL value.

Table 3-14

Statistical Summary of TPH in Groundwater

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit	Detection Limits (mg/L)	
							Low	High
Shallow Wells								
Gasoline	57	93	0.05	72	5.18	*	0.05	0.50
Diesel	66	93	0.23	280	9.09	*	0.13	0.40
Heavy Oil	29	93	0.38	74	2.81	*	0.2	2.5
Total (G, D, and Oil)	76	93	0.05	308	15.8	80	0.20	0.50
Deep Wells								
Gasoline	22	42	0.05	34	2.88	*	0.05	0.5
Diesel	19	42	0.17	10	1.44	*	0.10	0.25
Heavy Oil	3	42	0.1	0.47	0.18	*	0.2	0.5
Total (G, D, and Oil)	25	42	0.05	42	4.33	20	0.2	0.5

NOTE: * = Default to maximum value per statistical guidance.

Table 3-15

Statistical Summary of VOCs (BTEX only) in Groundwater

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Shallow Wells								
Benzene	55	93	0.0010	3.20	0.310	*	0.010	0.050
Toluene	55	93	0.0008	7.20	0.706	*	0.010	0.010
Ethylbenzene	53	93	0.0020	0.560	0.105	*	0.010	0.050
Xylenes	58	93	0.0007	3.90	0.600	*	0.010	0.050
Deep Wells								
Benzene	19	42	0.0008	1.60	0.175	*	0.010	0.010
Toluene	17	42	0.0005	5.40	0.470	*	0.010	0.050
Ethylbenzene	17	42	0.0010	0.380	0.056	*	0.010	0.010
Xylenes	20	42	0.0010	2.10	0.186	*	0.010	0.010

NOTE: * = Default to maximum value per statistical guidance.

Table 3-16

Statistical Summary of Semivolatile Organic Compounds in Groundwater — Upper Sand Aquifer

Page 1 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit	Method Detection Limits	
							Low	High
Phenol	22	92	0.002	0.230	0.113	*	0.010	4.30
bis(2chloroethyl)Ether	0	92	—	—	—	—	0.010	4.30
2-Chlorophenol	0	92	—	—	—	—	0.010	4.30
1,3-Dichlorobenzene	0	92	—	—	—	—	0.010	4.30
1,4-Dichlorobenzene	0	92	—	—	—	—	0.010	4.30
1,2-Dichlorobenzene	0	92	—	—	—	—	0.010	4.30
2-Methylphenol	21	92	0.001	0.229	0.117	*	0.010	4.30
2,2-oxybis(1-Chloropropane)	0	92	—	—	—	—	0.010	4.30
4-Methylphenol	32	92	0.003	1.10	0.144	*	0.010	4.30
N-nitroso-Di-n-Propylamine	0	92	—	—	—	—	0.010	4.30
Hexachloroethane	0	92	—	—	—	—	0.010	4.30
Nitrobenzene	0	92	—	—	—	—	0.010	4.30
Isophorone	0	92	—	—	—	—	0.010	4.30
2-Nitrophenol	0	92	—	—	—	—	0.010	4.30
2,4-Dimethylphenol	27	92	0.004	0.226	0.115	*	0.010	4.30
bis(2-Chloroethoxy)Methane	0	92	—	—	—	—	0.010	4.30
2,4-Dichlorophenol	12	92	0.003	0.227	0.122	*	0.010	4.30
1,2,4-Trichlorobenzene	0	92	—	—	—	—	0.010	4.30
Naphthalene	60	92	0.006	150	3.73	*	0.010	0.390
4-Chloroaniline	0	92	—	—	—	—	0.010	4.30
Hexachlorobutadiene	0	92	—	—	—	—	0.010	4.30
4-Chloro-3-Methylphenol	0	92	—	—	—	—	0.010	4.30
2-Methylnaphthalene	53	92	0.001	43	0.805	*	0.010	0.400
Hexachlorocyclopentadiene	0	92	—	—	—	—	0.010	4.30
2,4,6-Trichlorophenol	1	92	0.141	—	—	—	0.010	4.30
2,4,5-Trichlorophenol	21	92	0.003	0.165	0.259	*	0.025	11
2-Chloronaphthalene	0	92	—	—	—	—	0.010	4.30
2-Nitroaniline	0	92	—	—	—	—	0.025	11
Dimethyl phthalate	0	92	—	—	—	—	0.010	4.30
Acenaphthylene	4	92	0.013	0.035	0.120	*	0.010	4.30
2,6-Dinitrotoluene	0	92	—	—	—	—	0.010	4.30
3-Nitroaniline	0	92	—	—	—	—	0.025	11
Acenaphthene	41	92	0.002	13	0.343	*	0.010	3.00

Table 3-16

Statistical Summary of Semivolatile Organic Compounds in Groundwater — Upper Sand Aquifer

Page 2 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit	Method Detection Limits	
							Low	High
2,4-Dinitrophenol	0	92	—	—	—	—	0.025	11
4-Nitrophenol	0	92	—	—	—	—	0.025	11
Dibenzofuran	28	92	0.001	5.90	0.199	*	0.010	3.00
2,4-Dinitrotoluene	0	92	—	—	—	—	0.010	4.30
Diethylphthalate	1	92	0.008	—	—	—	0.010	4.30
4-Chlorophenyl-phenylether	0	92	—	—	—	—	0.010	4.30
Fluorene	27	92	0.001	6.30	0.247	*	0.010	3.00
4-Nitroaniline	0	92	—	—	—	—	0.025	11
4,6-Dinitro-2-Methylphenol	0	92	—	—	—	—	0.025	11
N-Nitrosodiphenylamine	0	92	—	—	—	—	0.010	4.30
4-Bromophenyl-phenylether	0	92	—	—	—	—	0.010	4.30
Hexachlorobenzene	0	92	—	—	—	—	0.010	4.30
Pentachlorophenol	39	92	0.002	7.50	0.622	*	0.025	1.40
Phenanthrene	28	92	0.001	18	0.525	*	0.010	3.00
Anthracene	15	92	0.013	4.10	0.190	*	0.010	4.30
Carbazole	24	92	0.001	1.20	0.131	*	0.010	4.30
Di-n-Butylphthalate	0	92	—	—	—	—	0.010	4.30
Fluoranthene	15	92	0.001	10	0.310	*	0.010	4.30
Pyrene	19	92	0.001	10.0	0.294	*	0.010	3.00
Butylbenzylphthalate	0	92	—	—	—	—	0.010	4.30
3,3'-Dichlorobenzidine	0	92	—	—	—	—	0.010	4.30
Benzo(a)anthracene	9	92	0.018	1.90	0.150	*	0.010	4.30
Chrysene	12	92	0.001	1.90	0.143	*	0.010	4.30
bis(2-Ethylhexyl)phthalate	4	92	0.001	0.026	0.120	*	0.010	4.30
Di-n-Octyl Phthalate	1	92	0.004	—	—	—	0.010	4.30
Benzo(b)Fluoranthene	6	92	0.026	1.50	0.138	*	0.010	4.30
Benzo(k)Fluoranthene	6	92	0.009	0.370	0.116	*	0.010	4.30
Benzo(a)Pyrene	5	92	0.017	1.00	0.130	*	0.010	4.30
Indeno(1,2,3-cd)Pyrene	4	92	0.009	0.440	0.120	*	0.010	4.30
Dibenz(a,h)Anthracene	1	92	0.095	—	—	—	0.010	4.30
Benzo(g,h,i)Perylene	4	92	0.004	0.400	0.119	*	0.010	4.30

NOTE: — = Indicates no relevant value.
• = Default to maximum value per statistical guidance.

Table 3-17

Statistical Summary of Semivolatile Organic Compounds in Groundwater Samples — Lower Sand Aquifer

Page 1 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit	Method Detection Limits	
							Low	High
Phenol	6	42	0.001	0.871	0.057	*	0.010	1.20
bis(2chloroethyl)Ether	0	42	—	—	—	—	0.010	1.20
2-Chlorophenol	0	42	—	—	—	—	0.010	1.20
1,3-Dichlorobenzene	0	42	—	—	—	—	0.010	1.20
1,4-Dichlorobenzene	0	42	—	—	—	—	0.010	1.20
1,2-Dichlorobenzene	0	42	—	—	—	—	0.010	1.20
2-Methylphenol	2	42	0.017	0.900	0.057	*	0.010	1.20
2,2-oxybis(1-Chloropropane)	0	42	—	—	—	—	0.010	1.20
4-Methylphenol	3	42	0.078	0.910	0.056	*	0.010	1.20
N-nitroso-Di-n-Propylamine	0	42	—	—	—	—	0.010	1.20
Hexachloroethane	0	42	—	—	—	—	0.010	1.20
Nitrobenzene	0	42	—	—	—	—	0.010	1.20
Isophorone	0	42	—	—	—	—	0.010	1.20
2-Nitrophenol	0	42	—	—	—	—	0.010	1.20
2,4-Dimethylphenol	3	42	0.005	0.022	0.049	*	0.010	1.20
bis(2-Chloroethoxy)Methane	0	42	—	—	—	—	0.010	1.20
2,4-Dichlorophenol	0	42	—	—	—	—	0.010	1.20
1,2,4-Trichlorobenzene	0	42	—	—	—	—	0.010	1.20
Naphthalene	18	42	0.001	14	1.44	*	0.010	0.025
4-Chloroaniline	0	42	—	—	—	—	0.010	1.20
Hexachlorobutadiene	0	42	—	—	—	—	0.010	1.20
4-Chloro-3-Methylphenol	0	42	—	—	—	—	0.010	1.20
2-Methylnaphthalene	23	42	0.002	1.10	0.176	*	0.010	0.025
Hexachlorocyclopentadiene	0	42	—	—	—	—	0.010	1.20
2,4,6-Trichlorophenol	0	42	—	—	—	—	0.010	1.20
2,4,5-Trichlorophenol	0	42	—	—	—	—	0.025	3.00
2-Chloronaphthalene	0	42	—	—	—	—	0.010	1.20
2-Nitroaniline	0	42	—	—	—	—	0.025	3.00
Dimethyl phthalate	0	42	—	—	—	—	0.010	1.20
Acenaphthylene	1	42	0.002	—	—	—	0.010	1.20
2,6-Dinitrotoluene	0	42	—	—	—	—	0.010	1.20
3-Nitroaniline	0	42	—	—	—	—	0.025	3.00
Acenaphthene	19	42	0.001	0.240	0.039	*	0.010	0.080

Table 3-17

Statistical Summary of Semivolatile Organic Compounds in Groundwater Samples — Lower Sand Aquifer

Page 2 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit	Method Detection Limits	
							Low	High
2,4-Dinitrophenol	0	42	—	—	—	—	0.025	3.00
4-Nitrophenol	0	42	—	—	—	—	0.025	3.00
Dibenzofuran	12	42	0.003	0.900	0.054	*	0.010	1.20
2,4-Dinitrotoluene	0	42	—	—	—	—	0.010	1.20
Diethylphthalate	0	42	—	—	—	—	0.010	1.20
4-Chlorophenyl-phenylether	0	42	—	—	—	—	0.010	1.20
Fluorene	14	42	0.001	0.890	0.052	*	0.010	1.20
4-Nitroaniline	0	42	—	—	—	—	0.025	3.00
4,6-Dinitro-2-Methylphenol	0	42	—	—	—	—	0.025	3.00
N-Nitrosodiphenylamine	0	42	—	—	—	—	0.010	1.20
4-Bromophenyl-phenylether	0	42	—	—	—	—	0.010	1.20
Hexachlorobenzene	0	42	—	—	—	—	0.010	1.20
Pentachlorophenol	4	42	0.005	2.10	0.126	*	0.025	0.780
Phenanthrene	9	42	0.001	0.881	0.054	*	0.010	1.20
Anthracene	0	42	—	—	—	—	0.010	1.20
Carbazole	13	42	0.020	0.899	0.057	*	0.010	1.20
Di-n-Butylphthalate	0	42	—	—	—	—	0.010	1.20
Fluoranthene	0	42	—	—	—	—	0.010	1.20
Pyrene	0	42	—	—	—	—	0.010	1.20
Butylbenzylphthalate	0	42	—	—	—	—	0.010	1.20
3,3'-Dichlorobenzidine	0	42	—	—	—	—	0.010	1.20
Benzo(a)anthracene	0	42	—	—	—	—	0.010	1.20
Chrysene	0	42	—	—	—	—	0.010	1.20
bis(2-Ethylhexyl)phthalate	0	42	—	—	—	—	0.010	1.20
Di-n-Octyl Phthalate	0	42	—	—	—	—	0.010	1.20
Benzo(b)Fluoranthene	0	42	—	—	—	—	0.010	1.20
Benzo(k)Fluoranthene	0	42	—	—	—	—	0.010	1.20
Benzo(a)Pyrene	0	42	—	—	—	—	0.010	1.20
Indeno(1,2,3-cd)Pyrene	0	42	—	—	—	—	0.010	1.20
Dibenz(a,h)Anthracene	0	42	—	—	—	—	0.010	1.20
Benzo(g,h,i)Perylene	0	42	—	—	—	—	0.010	1.20

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 3-18

Compounds Detected in Snohomish River Water Samples (mg/L)

Sample No.	TPH-Gasoline		As		Cu		Pb	
RW-01	0.07		0.0017	J	0.0064		0.0009	UJ
RW-02	0.05	U	0.0017	J	0.0034	U	0.0009	UJ
RW-03	0.05	U	0.0017	U	0.0063		0.0009	UJ
RW-04	0.05	U	0.0017	U	0.0042		0.002	J
RW-05	0.05	U	0.0017	U	0.0034	U	0.0009	UJ
RW-06	0.05	U	0.0017	UJ	0.0035		0.0009	UJ
RW-07	0.05	U	0.0017	U	0.0035		0.0009	UJ
RW-08 (dup of 05)	0.05	U	0.0017	U	0.0034	U	0.0009	UJ

Table 3-19

Compounds Detected in Seep Samples (mg/L)

Sample No.	SR-01-SW	SR-05-SW	SR-06-SW	SR-07-SW	SR-09-SW	SR-13-SW	SR-14-SW
Inorganic Compounds							
Arsenic	0.0361	0.0365	0.0068	0.174	0.049	0.0115	0.0133
Chromium	0.004 U	0.0054	0.0087	0.009	0.0248	0.0101	0.012
Copper	0.0039 U	0.0039 U	0.0106	0.0067	0.019	0.0313	0.0132
Lead	0.0009 J	0.0009 UJ	0.0026 J	0.0009 UJ	0.0052 J	0.387	0.0014 J
Mercury	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002	0.0002 U
Organic Compounds							
TPH-gasoline	.034 UJ	.011 UJ	.01 UJ	0.083 J	.06 UJ	.04 UJ	.046 UJ
Benzene	.010 U	.010 U	.010 U	0.120	.010 U	.010 U	.010 U
Ethylbenzene	.010 U	.010 U	.010 U	0.070	.010 U	.010 U	.010 U
Toluene	.010 U	.010 U	.010 U	0.014 J	.010 U	.010 U	.010 U
Total Xylenes	.010 U	.010 U	.010 U	0.120	.010 U	.010 U	.010 U
Acenaphthene	.010 U	.010 U	.010 U	0.085 J	.010 U	.010 U	.010 U
Dibenzofuran	.010 U	.010 U	.010 U	0.026 J	.010 U	.010 U	.010 U
2,4-Dimethylphenol	.010 U	.010 U	.010 U	0.030 J	.010 U	.010 U	.010 U
Fluorene	.010 U	.010 U	.010 U	0.018 J	.010 U	.010 U	.010 U
2-Methylnaphthalene	.010 U	.010 U	.010 U	0.210	.010 U	.010 U	.010 U
Naphthalene	.010 U	.010 U	.010 U	1.60	.008 J	.010 U	.010 U
Pentachlorophenol	.025 U	.025 U	.025 U	0.073 J	.025 U	.025 U	.025 U
Total Suspended Solids (TSS)	10	30	300	100	180	310	190

Table 3-20

Compounds Detected in Storm Water Samples (mg/L)

Sample No.	As	Cu	Pb	TSS
SWR-01G	0.0017 U	0.0081	0.0019	4
SWR-02G	0.0059	0.0059	0.0021	3

Table 3-21

Metals Detected in Storm Drain Sediment Samples (mg/kg)

Sample No.	As	Cr	Cu	Pb	Hg	Ba
Total Metals						
SWR-SD2	47.0	30.3 J	44.5 J	97.8	0.08	NT
SWR-SD3	9.6	39.6 J	54.1 J	131.0	0.06 U	NT
TCLP Metals						
SWR-SD2	0.1 U	0.01 U	NT	0.1	0.001 U	0.9
SWR-SD3	0.1 U	0.01 U	NT	0.05 U	0.001 U	0.5 U

NOTE: NT = Not tested

Table 3-22

TPH and SVOCs Detected in Storm Drain Sediment Samples (mg/kg)

Sample No.	SWR-SD2		SWR-SD3	
TPH-gasoline	0.64		0.94	
TPH-other (heavy oil)	520		940	
Anthracene	0.52	J	5.40	U
Benz(a)anthracene	1.10	J	5.40	U
Benzo(a)pyrene	1.10	J	5.40	U
Benzo(b)fluoranthene	1.20	J	5.40	U
Bis(2-ethylhexyl)phthalate	0.50	J	0.61	J
Carbazole	0.57	J	5.40	U
Chrysene	1.20	J	5.40	U
Fluoranthene	3.30	J	0.66	J
Fluorene	0.50	J	5.40	U
Naphthalene	0.50	J	5.40	U
Phenanthrene	3.90	J	0.65	J
Pyrene	3.30	J	0.80	J

Table 3-23

Statistical Summary of Metals in River Sediments

Element	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	Detection Limits (mg/kg)	
						Low	High
Arsenic	72	72	4.8	541	38.5	—	—
Chromium	72	72	19.3	63.7	35.8	—	—
Copper	72	72	14.1	503	44.8	—	—
Lead	72	72	3.5	134	18.1	—	—
Mercury	3	72	0.13	0.51	0.14	0.08	0.21

NOTE: Numbers include field replicate samples.
— Indicates no relevant value.

Table 3-24

Summary of Semivolatile Organic Compounds in River Sediment

Compound	Units	Number Detected	Number Analyzed	Detected Concentration		Sample Quantitation Limits	
				Minimum	Maximum	Low	High
Phenol	µg/kg	5	72	54	150	380	7,300
bis(2chloroethyl)Ether	mg/kg	0	72	—	—	0.380	7.30
2-Chlorophenol	mg/kg	0	72	—	—	0.380	7.30
1,3-Dichlorobenzene	mg/kg	0	72	—	—	0.380	7.30
1,4-Dichlorobenzene	mg/kg TOC	0	72	—	—	11.6	380
1,2-Dichlorobenzene	mg/kg TOC	0	72	—	—	11.6	380
2-Methylphenol	µg/kg	0	72	—	—	380	7,300
2,2-oxybis(1-Chloropropane)	mg/kg	0	72	—	—	0.380	7.30
4-Methylphenol	µg/kg	0	72	—	—	380	7,300
N-nitroso-Di-n-Propylamine	mg/kg	0	72	—	—	0.380	7.30
Hexachloroethane	mg/kg	0	72	—	—	0.380	7.30
Nitrobenzene	mg/kg	0	72	—	—	0.380	7.30
Isophorone	mg/kg	0	72	—	—	0.380	7.30
2-Nitrophenol	mg/kg	0	72	—	—	0.380	7.30
2,4-Dimethylphenol	µg/kg	0	72	—	—	380	7,300
bis(2-Chloroethoxy)Methane	mg/kg	0	72	—	—	0.380	7.30
2,4-Dichlorophenol	mg/kg	0	72	—	—	0.380	7.30
1,2,4-Trichlorobenzene	mg/kg TOC	0	72	—	—	11.6	380
Naphthalene	mg/kg TOC	11	72	2.4	218	11.6	380
4-Chloroaniline	mg/kg	0	72	—	—	0.380	7.30
Hexachlorobutadiene	mg/kg TOC	0	72	—	—	11.6	380

Table 3-24

Summary of Semivolatile Organic Compounds in River Sediment

Compound	Units	Number Detected	Number Analyzed	Detected Concentration		Sample Quantitation Limits	
				Minimum	Maximum	Low	High
4-Chloro-3-Methylphenol	mg/kg	0	72	—	—	0.380	7.30
2-Methylnaphthalene	mg/kg TOC	9	72	4.6	52	11.6	380
Hexachlorocyclopentadiene	mg/kg	0	72	—	—	0.380	7.30
2,4,6-Trichlorophenol	mg/kg	0	72	—	—	0.380	7.30
2,4,5-Trichlorophenol	mg/kg	0	72	—	—	0.920	18.0
2-Chloronaphthalene	mg/kg	1	72	1.9	—	0.380	7.30
2-Nitroaniline	mg/kg	0	72	—	—	0.920	18.0
Dimethyl phthalate	mg/kg TOC	0	72	—	—	11.6	380
Acenaphthylene	mg/kg TOC	1	72	3.1	—	11.6	380
2,6-Dinitrotoluene	mg/kg	0	72	—	—	0.380	7.30
3-Nitroaniline	mg/kg	0	72	—	—	0.920	18.0
Acenaphthene	mg/kg TOC	10	72	2.4	83	11.6	380
2,4-Dinitrophenol	mg/kg	0	72	—	—	0.920	18.0
4-Nitrophenol	mg/kg	1	72	0.077	—	0.920	18.0
Dibenzofuran	mg/kg TOC	8	72	3.1	47	11.6	380
2,4-Dinitrotoluene	mg/kg	0	72	—	—	0.380	7.30
Diethylphthalate	mg/kg TOC	0	72	—	—	11.6	380
4-Chlorophenyl-phenylether	mg/kg	0	72	—	—	0.380	7.30
Fluorene	mg/kg TOC	10	72	2.2	93	11.6	380
4-Nitroaniline	mg/kg	0	72	—	—	0.920	18.0
4,6-Dinitro-2-Methylphenol	mg/kg	0	72	—	—	0.920	18.0

Table 3-24

Summary of Semivolatile Organic Compounds in River Sediment

Compound	Units	Number Detected	Number Analyzed	Detected Concentration		Sample Quantitation Limits	
				Minimum	Maximum	Low	High
N-Nitrosodiphenylamine	mg/kg TOC	0	72	—	—	11.6	380
4-Bromophenyl-phenylether	mg/kg	0	72	—	—	0.380	7.30
Hexachlorobenzene	mg/kg TOC	0	72	—	—	11.6	380
Pentachlorophenol	µg/kg	2	72	64	570	920	18,000
Phenanthrene	mg/kg TOC	34	72	1.9	228	12.7	380
Anthracene	mg/kg TOC	13	72	2.3	36	11.6	380
Carbazole	mg/kg	6	72	0.076	1.6	0.300	7.30
Di-n-Butylphthalate	mg/kg TOC	1	72	3.2	—	11.6	380
Fluoranthene	mg/kg TOC	48	72	1.6	106	12.7	380
Pyrene	mg/kg TOC	54	72	2.3	161	16.2	380
Butylbenzylphthalate	mg/kg TOC	0	72	—	—	11.6	380
3,3'-Dichlorobenzidine	mg/kg	0	72	—	—	11.6	380
Benzo(a)anthracene	mg/kg TOC	31	72	1.4	38	12.7	380
Chrysene	mg/kg TOC	45	72	1.5	45	12.7	380
bis(2-Ethylhexyl)phthalate	mg/kg TOC	53	72	2.2	72	11.6	200
Di-n-Octyl Phthalate	mg/kg TOC	0	72	—	—	11.6	380
Benzo(b)Fluoranthene	mg/kg TOC	34	72	1.3	59	11.6	380
Benzo(k)Fluoranthene	mg/kg TOC	13	72	1.9	32	12.7	380
Benzo(a)Pyrene	mg/kg TOC	15	72	2.0	32	11.6	380
Indeno(1,2,3-cd)Pyrene	mg/kg TOC	1	72	22.7	—	11.6	380
Dibenz(a,h)Anthracene	mg/kg TOC	0	72	—	—	11.6	380

Table 3-24

Summary of Semivolatile Organic Compounds in River Sediment

Page 4 of 4

Compound	Units	Number Detected	Number Analyzed	Detected Concentration		Sample Quantitation Limits	
				Minimum	Maximum	Low	High
Benzo(g,h,i)Perylene	mg/kg TOC	1	72	17.3	—	11.6	380
Sum LPAH	mg/kg TOC	35	72	1.9	575	54	2,660
Sum HPAH	mg/kg TOC	59	72	2.8	440	71	3,800
Total Benzofluoranthenes	mg/kg TOC	36	72	1.3	91	5.5	760

NOTE: mg/kg TOC = Milligrams per kilogram normalized to total organic carbon.

Table 3-25

Annual Air Concentration
Air Pathway: Fugitive Dust from Surface Soil

Constituent	Annual Emission Rate ($\mu g/m^2 2$-s)	Ambient Air Concentration			
		On-site ($\mu g/m^3$)	Fenceline ($\mu g/m^3$)	Adjacent Property 50 ft ($\mu g/m^3$)	Adjacent Property 100 ft ($\mu g/m^3$)
Arsenic	5.3E-05	3.1E-05	3.8E-05	2.8E-05	2.4E-05
Naphthalene	2.3E-05	1.3E-05	1.6E-05	1.2E-05	1.0E-05
Pentachlorophenol	9.2E-06	5.4E-06	6.5E-06	4.8E-06	4.2E-06
Polycyclic Aromatic Hydrocarbons:					
Benzo(a)anthracene	4.1E-06	2.4E-06	2.9E-06	2.2E-06	1.9E-06
Chrysene	3.7E-06	2.2E-06	2.6E-06	1.9E-06	1.7E-06
Benzo(b)fluoranthene	3.1E-06	1.8E-06	2.2E-06	1.6E-06	1.4E-06
Benzo(k)fluoranthene	3.0E-06	1.7E-06	2.1E-06	1.6E-06	1.3E-06
Benzo(a)pyrene	2.7E-06	1.6E-06	1.9E-06	1.4E-06	1.2E-06
Indeno(1,2,3-cd)pyrene	4.6E-06	2.7E-06	3.2E-06	2.4E-06	2.1E-06
Dibenz(a,h)anthracene	4.6E-06	2.7E-06	3.2E-06	2.4E-06	2.1E-06
Benzo(g,h,i)perylene	4.6E-06	2.7E-06	3.2E-06	2.4E-06	2.1E-06
Total PAH	3.0E-05	1.8E-05	2.1E-05	1.6E-05	1.4E-05

Table 3-26

Annual Air Concentration
Air Pathway: Volatilization from Unsaturated Soil

Constituent	Annual Emission Rate (g/m^2-s)	Ambient Air Concentration On-site ($\mu g/m^3$)	Fenceline ($\mu g/m^3$)	Adjacent Property 50 ft ($\mu g/m^3$)	100 ft ($\mu g/m^3$)
Naphthalene	6.2E-09	2.5E-02	3.1E-02	2.5E-02	2.2E-02
Pentachlorophenol	5.8E-11	2.3E-04	2.9E-04	2.4E-04	2.0E-04
Polycyclic Aromatic Hydrocarbons:					
Benzo(a)anthracene	5.6E-14	2.2E-07	2.7E-07	2.3E-07	1.9E-07
Chrysene	7.5E-13	3.0E-06	3.7E-06	3.1E-06	2.6E-06
Benzo(b)fluoranthene	8.2E-12	3.3E-05	4.0E-05	3.3E-05	2.9E-05
Benzo(k)fluoranthene	4.3E-15	1.7E-08	2.1E-08	1.8E-08	1.5E-08
Benzo(a)pyrene	5.9E-14	2.4E-07	2.9E-07	2.4E-07	2.1E-07
Indeno(1,2,3-cd)pyrene	3.5E-15	1.4E-08	1.7E-08	1.4E-08	1.2E-08
Dibenz(a,h)anthracene	1.0E-16	4.1E-10	5.1E-10	4.2E-10	3.6E-10
Benzo(g,h,i)perylene	1.0E-14	4.2E-08	5.2E-08	4.3E-08	3.7E-08
Total PAH	9.1E-12	3.7E-05	4.5E-05	3.7E-05	3.2E-05
Dioxins/Furans	5.3E-15	2.2E-08	2.6E-08	2.2E-08	1.9E-08
Styrene	1.5E-07	5.9E-01	7.3E-01	6.0E-01	5.1E-01

Table 3-27

Annual Air Concentration
Air Pathway: Volatilization from Upper Sand Aquifer

Constituent	Annual Emission Rate (g/m^2-s)	Ambient Air Concentration			
		On-site	Fenceline	Adjacent Property	
		(μg/m^3)	(μg/m^3)	50 ft (μg/m^3)	100 ft (μg/m^3)
Benzene	1.2E-09	4.7E-03	5.7E-03	4.7E-03	4.1E-03
Toluene	3.7E-10	1.5E-03	1.8E-03	1.5E-03	1.3E-03
Ethylbenzene	2.5E-09	1.0E-02	1.2E-02	1.0E-02	8.7E-03
Total Xylenes	2.2E-09	8.8E-03	1.1E-02	8.9E-03	7.7E-03

Table 3-28

Ambient Air Concentration at Fenceline Receptor

Constituent	Air Pathway: Fugitive Dust ($\mu g/m^3$)	Air Pathway: VOC from Soil ($\mu g/m^3$)	Air Pathway: VOC from Groundwater ($\mu g/m^3$)	Air Pathway: Time Weighted Average	ASIL ($\mu g/m^3$)
Arsenic	3.8E-05	—	—	Annual	0.00023
Naphthalene	4.3E-05	8.2E-02	—	24-hr	166.5
Pentachlorophenol	1.7E-05	7.7E-04	—	24-hr	1.7
Polycyclic Aromatic Hydrocarbons:					
Benzo(a)anthracene	2.9E-06	2.7E-07	—	—	NS
Chrysene	2.6E-06	3.7E-06	—	—	NS
Benzo(b)fluoranthene	2.2E-06	4.0E-05	—	—	NS
Benzo(k)fluoranthene	2.1E-06	2.1E-08	—	—	NS
Benzo(a)pyrene	1.9E-06	2.9E-07	—	—	NS
Indeno(1,2,3-cd)pyrene	3.2E-06	1.7E-08	—	—	NS
Dibenz(a,h)anthracene	3.2E-06	5.1E-10	—	—	NS
Benzo(g,h,i)perylene	3.2E-06	5.2E-08	—	—	NS
Total PAH	2.1E-05	4.5E-05	—	Annual	0.0006
Styrene	—	1.9E+00	—	24-hr	716
Dioxins/Furans	—	2.6E-08	—	Annual	3.0E-08
Benzene	—	—	5.7E-03	Annual	0.12
Toluene	—	—	4.8E-03	24-hr	1248.8
Ethylbenzene	—	—	3.3E-02	24-hr	1448.6
Total Xylenes	—	—	2.9E-02	24-hr	1448.6

NOTE: — = Indicates no relevant value.
NS = No standard.

Table 3-29

8-Hour Air Concentration at Fenceline Receptor

Constituent	Air Pathway			OSHA PEL 8-hour	ACGIH TLV 8-hour (mg/m^3)
	Fugitive Dust ($\mu g/m^3$)	VOC from Soil ($\mu g/m^3$)	VOC from Groundwater ($\mu g/m^3$)	(mg/m^3)	
Arsenic	1.8E-04	—	—	0.01	0.01
Naphthalene	7.5E-05	1.4E-01	—	50	52
Pentachlorophenol	3.0E-05	1.3E-03	—	0.5	0.5
Polycyclic Aromatic Hydrocarbons:					
Benzo(a)anthracene	1.4E-05	1.3E-06	—	NS	NS
Chrysene	1.2E-05	1.7E-05	—	0.2[a]	NS
Benzo(b)fluoranthene	1.0E-05	1.9E-04	—	NS	NS
Benzo(k)fluoranthene	9.8E-06	1.0E-07	—	NS	NS
Benzo(a)pyrene	9.0E-06	1.4E-06	—	NS	NS
Indeno(1,2,3-cd)pyrene	1.5E-05	8.2E-08	—	0.2[a]	NS
Dibenz(a,h)anthracene	1.5E-05	2.4E-09	—	NS	NS
Benzo(g,h,i)perylene	1.5E-05	2.4E-07	—	NS	NS
Total PAH	1.0E-04	2.1E-04	—	NS	NS
Styrene	—	3.4E+00	—	426	213
Dioxins/Furans	—	1.2E-07	—	NS	NS
Benzene	—	—	2.7E-02	3.2	32
Toluene	—	—	8.4E-03	200	188
Ethylbenzene	—	—	5.7E-02	435	434
Total Xylenes	—	—	5.1E-02	435	434

NOTE: NS No Standard.
— = Indicates no relevant value.

[a] Coal tar pitch volatiles — sum total.

Table 3-30

Summary of Arsenic in Upgradient Soil

Sample Location Area	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	Number of Samples
North Everett Background[a]	7.3	36.4	16	9
Smelter Site - Surface Soil[b]	6	8,000	970	49
Smelter Site - Subsurface Soil[b]	3	53,000	2,700	119
Smelter Vicinity - Surface Soil[b]	4	560	400	34
Smelter Vicinity - Subsurface Soil[b]	2.5	1,000	145	60
Upgradient Assessment Area (Background)[c]	3.3	954	56.4	32

NOTE: ASARCO RI not complete at the time of this RI.

[a] Dave Nazy, Ecology, personal communication with Steve Nelson, EMCON, November 1992 (SAIC 1991; Ecology 1991).

[b] SAIC, 1991, 1991a, 1991b.

[c] 90th percentile = 73.3 mg/kg.

Table 3-31

Summary of Total Arsenic in Groundwater — Upgradient Wells

Upgradient Wells	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Number of Detections/Samples
Upper Sand[a]	0.0008	2.87	0.443	39/41
Lower Sand[b]	0.0008	0.0063	0.0012	2/10

[a] Wells HC-4, HC-11, HC-17, HC-24, HC-25, HC-26, MW-35; 90th percentile = 1.59 mg/L.
[b] Well HC-11D; MDL = 0.0006 mg/L to 0.0017 mg/L.

Table 3-32

Water Quality Criteria for Detected Compounds
(mg/L)

Compound	Federal				State			
	Freshwater		Marine		Freshwater		Marine	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Acenaphthene	—	—	0.970	0.710	—[a]	—	—	—
Arsenic	0.360[b]	0.190[b]	0.069[b]	0.036[b]	0.360[b]	0.190[b]	0.069[b]	0.036[b]
Benzene	—	—	—	—	—	—	—	—
Bis(2-ethylhexyl)phthalate	—	—	—	—	—	—	—	—
Carbazole	—	—	—	—	—	—	—	—
Chromium (Hex)	0.016	0.011	1.10	0.050	0.016	0.011	1.10	0.050
Chromium (Tri)[d]	1.70[c]	0.210[c]	10.3	—	1.736[c]	0.207[c]	—	—
Copper	0.018[c]	0.012[c]	0.0029	0.0029	0.0153[c]	0.0102[c]	0.0025	—
2,4-Dichlorophenol	—	—	—	—	—	—	—	—
2,4-Dimethylphenol	—	—	—	—	—	—	—	—
Dibenzofuran	—	—	—	—	—	—	—	—
Ethylbenzene	—	—	—	—	—	—	—	—
Fluorene	—	—	—	—	—	—	—	—
Lead	0.082[c]	0.0032[c]	0.140	0.0056	0.0561[c]	0.0022[c]	0.1511	0.0058
Naphthalene	—	—	—	—	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—	—	—	—
2-Methylphenol	—	—	—	—	—	—	—	—
4-Methylphenol	—	—	—	—	—	—	—	—
Pentachlorophenol	0.020[e]	0.013[e]	0.013	—	0.015[f]	0.0095[f]	0.013	0.0079
Phenanthrene	—	—	—	—	—	—	—	—
Phenol	—	—	—	—	—	—	—	—
Toluene	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—
2,4,5 Trichlorophenol	—	—	—	—	—	—	—	—
Xylenes	—	—	—	—	—	—	—	—

[a] — means no criterion.
[b] Values based on total recoverable fraction of the metal.
[c] Hardness dependent criteria (100 µm/L used).
[d] Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by the total-recoverable chromium.
[e] pH dependent criteria (7.8 pH used).
[f] pH dependent criteria (7.5 pH used).

Table 4-1

Statistical Summary of Metals in Soil — Fill and Upper Sand Units

Element	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
All Samples								
Arsenic	99	99	4.0	1250	82.8	98.3	—	—
Chromium	52	52	15.6	906	78.8	*	—	—
Copper	52	52	11.7	79.2	25.3	*	—	—
Lead	52	52	2.4	103	14.5	18.0	—	—
Mercury	4	52	0.08	0.16	0.10	*	0.07	0.21

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 4-2

Statistical Summary of Volatile Compounds in Soil — Fill and Upper Sand Units

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit (mg/kg)	Detection Limits (mg/kg)	
							Low	High
All Samples								
Chloromethane	0	46	—	—	—	—	0.010	5.30
Bromomethane	0	46	—	—	—	—	0.010	5.30
Vinyl Chloride	0	46	—	—	—	—	0.010	5.30
Chloroethane	0	46	—	—	—	—	0.010	5.30
Methylene Chloride	0	46	—	—	—	—	0.010	5.30
Acetone	0	46	—	—	—	—	0.010	5.30
Carbon Disulfide	0	46	—	—	—	—	0.010	5.30
1,1-Dichloroethane	0	46	—	—	—	—	0.010	5.30
1,2-Dichloroethene (total)	0	46	—	—	—	—	0.010	5.30
Chloroform	0	46	—	—	—	—	0.010	5.30
1,2-Dichloroethane	0	46	—	—	—	—	0.010	5.30
2-Butanone	3	46	0.009	4.90	0.553	*	0.010	5.30
1,1,1-Trichloroethane	0	46	—	—	—	—	0.010	5.30
Carbon Tetrachloride	0	46	—	—	—	—	0.010	5.30
Bromodichloromethane	0	46	—	—	—	—	0.010	5.30
1,2-Dichloropropane	0	46	—	—	—	—	0.010	5.30
cis-1,3-Dichloropropene	0	46	—	—	—	—	0.010	5.30
Trichloroethene	0	46	—	—	—	—	0.010	5.30
Dibromochloromethane	0	46	—	—	—	—	0.010	5.30
1,1,2-Trichloroethane	0	46	—	—	—	—	0.010	5.30
Benzene	5	46	0.006	2.10	0.426	*	0.010	5.30
Bromoform	0	46	—	—	—	—	0.010	5.30
4-Methyl-2-Pentanone	0	46	—	—	—	—	0.010	5.30
2-Hexanone	0	46	—	—	—	—	0.010	5.30
Tetrachloroethene	0	46	—	—	—	—	0.010	5.30
1,1,2,2-Tetrachloroethane	0	46	—	—	—	—	0.010	5.30
Toluene	15	46	0.004	37.0	2.85	*	0.010	5.10
Chlorobenzene	0	46	—	—	—	—	0.010	5.30
Ethylbenzene	14	46	0.008	64.0	2.86	*	0.010	5.10
Styrene	3	46	1.80	46.0	1.44	*	0.010	5.10
Total Xylenes	19	46	0.004	180	17.0	*	0.010	5.10
Gasoline	61	70	0.40	11,000	690	*	1.0	50

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 4-3

Statistical Summary of Semivolatile Organic Compounds in Soil — Fill and Upper Sand Units

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit	Detection Limits (mg/kg)	
							Low	High
All Samples								
Phenol	0	73	—	—	—	—	0.330	50
bis(2chloroethyl)Ether	0	73	—	—	—	—	0.330	50
2-Chlorophenol	0	73	—	—	—	—	0.330	50
1,3-Dichlorobenzene	0	73	—	—	—	—	0.330	50
1,4-Dichlorobenzene	0	73	—	—	—	—	0.330	50
1,2-Dichlorobenzene	0	73	—	—	—	—	0.330	50
2-Methylphenol	0	73	—	—	—	—	0.330	50
2,2-oxybis(1-Chloropropane)	0	73	—	—	—	—	0.330	50
4-Methylphenol	1	73	0.053	—	—	—	0.330	50
N-nitroso-Di-n-Propylamine	0	73	—	—	—	—	0.330	50
Hexachloroethane	0	73	—	—	—	—	0.330	50
Nitrobenzene	0	73	—	—	—	—	0.330	50
Isophorone	0	73	—	—	—	—	0.330	50
2-Nitrophenol	0	73	—	—	—	—	0.330	50
2,4-Dimethylphenol	1	73	0.048	—	—	—	0.330	50
bis(2-Chloroethoxy)Methane	0	73	—	—	—	—	0.330	50
2,4-Dichlorophenol	0	73	—	—	—	—	0.330	50
1,2,4-Trichlorobenzene	0	73	—	—	—	—	0.330	50
Naphthalene	42	73	0.049	3,000	87.8	444	0.330	50
4-Chloroaniline	0	73	—	—	—	—	0.330	50
Hexachlorobutadiene	0	73	—	—	—	—	0.330	50
4-Chloro-3-Methylphenol	0	73	—	—	—	—	0.330	50
2-Methylnaphthalene	40	73	0.061	1,800	53.3	189	0.330	50
Hexachlorocyclopentadiene	0	73	—	—	—	—	0.330	50
2,4,6-Trichlorophenol	0	73	—	—	—	—	0.330	50
2,4,5-Trichlorophenol	0	73	—	—	—	—	0.810	120
2-Chloronaphthalene	1	73	1.80	—	—	—	0.330	50
2-Nitroaniline	0	73	—	—	—	—	0.810	120
Dimethyl phthalate	0	73	—	—	—	—	0.330	50
Acenaphthylene	10	73	0.060	12.0	2.57	*	0.330	50
2,6-Dinitrotoluene	0	73	—	—	—	—	0.330	50
3-Nitroaniline	0	73	—	—	—	—	0.810	120
Acenaphthene	39	73	0.061	630	25.1	74.2	0.330	150
2,4-Dinitrophenol	0	73	—	—	—	—	0.810	120

Table 4-3

Statistical Summary of Semivolatile Organic Compounds in Soil — Fill and Upper Sand Units

Compound	Number Detected	Number Analyzed	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	95% Upper Confidence Limit	Detection Limits (mg/kg) Low	Detection Limits (mg/kg) High
4-Nitrophenol	1	73	1.60	—	—	—	0.810	120
Dibenzofuran	36	73	0.057	380	15.9	35.8	0.330	50
2,4-Dinitrotoluene	0	73	—	—	—	—	0.330	50
Diethylphthalate	1	73	0.130	—	—	—	0.330	50
4-Chlorophenyl-phenylether	0	73	—	—	—	—	0.330	50
Fluorene	44	73	0.042	450	21.8	70.4	0.330	50
4-Nitroaniline	0	73	—	—	—	—	0.810	120
4,6-Dinitro-2-Methylphenol	0	73	—	—	—	—	0.810	120
N-Nitrosodiphenylamine	0	73	—	—	—	—	0.330	50
4-Bromophenyl-phenylether	0	73	—	—	—	—	0.330	50
Hexachlorobenzene	0	73	—	—	—	—	0.330	50
Pentachlorophenol	40	73	0.042	410	17.7	28.3	0.810	120
Phenanthrene	49	73	0.040	980	47.3	232	0.330	82
Anthracene	45	73	0.056	560	23.2	64.2	0.330	50
Carbazole	32	73	0.038	120	5.81	11.4	0.330	50
Di-n-Butylphthalate	0	73	—	—	—	—	0.330	50
Fluoranthene	50	73	0.082	450	27.4	128	0.330	50
Pyrene	52	73	0.048	380	22.9	101	0.330	50
Butylbenzylphthalate	1	73	16	—	—	—	0.330	36
3,3'-Dichlorobenzidine	0	73	—	—	—	—	0.330	50
Benzo(a)anthracene	46	73	0.044	75.0	5.43	12.2	0.330	50
Chrysene	48	73	0.045	76.0	6.47	17.9	0.330	50
bis(2-Ethylhexyl)phthalate	6	73	0.049	0.550	3.31	*	0.340	100
Di-n-Octyl Phthalate	1	73	0.218	—	—	—	0.330	50
Benzo(b)Fluoranthene	41	73	0.040	38.0	4.47	10.6	0.330	50
Benzo(k)Fluoranthene	32	73	0.041	77.0	4.06	7.08	0.330	50
Benzo(a)Pyrene	33	73	0.048	30.0	3.52	7.71	0.330	50
Indeno(1,2,3-cd)Pyrene	16	73	0.086	11.0	3.08	5.79	0.330	50
Dibenz(a,h)Anthracene	2	73	0.110	0.140	—	—	0.330	50
Benzo(g,h,i)Perylene	14	73	0.206	11.0	3.04	5.47	0.330	50
Diesel	44	70	2.0	13,000	1,040	*	2.0	19
Heavy Oil	43	70	2.0	20,000	1,340	16,550	2.0	8,300

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 4-4

Comparison of Concentrations of Compounds Detected in Soil to Health-Based Screening Levels

Page 1 of 2

Compound	Maximum Concentration Detected (mg/kg)	Method C[a] Screening Level (mg/kg)	Maximum Exceeds Screen?
Semivolatile Organic Compounds			
4-Methylphenol	0.053	1,750	
2,4-Dimethylphenol	0.048	700	
Naphthalene	3,000	NL	
2-Methylnaphthalene	1,800	NL	
2-Chloronaphthalene	1.8	NL	
Acenaphthylene	12	NL	
Acenaphthene	630	2,100	
4-Nitrophenol	1.6	NL	
Dibenzofuran	380	NL	
Diethylphthalate	0.13	28,000	
Fluorene	450	1,400	
Pentachlorophenol	410	10.9	Yes
Phenanthrene	980	NL	
Anthracene	560	10,500	
Carbazole	120	65.6	Yes
Fluoranthene	450	1,400	
Pyrene	380	1,050	
Butylbenzylphthalate	16	7,000	
Benzo(a)anthracene	75	0.18	Yes
Chrysene	76	0.18	Yes
Bis(2-ethylhexyl)phthalate	0.550	93.7	
Di-n-octyl phthalate	0.218	NL	
Benzo(b)fluoroanthene	38.0	0.18	Yes
Benzo(k)fluoroanthene	77.0	0.18	Yes
Benzo(a)pyrene	30.0	0.18	Yes
Indeno(1,2,3-cd)pyrene	11.0	0.18	Yes
Dibenz(a,h)anthracene	0.140	0.18	
Benzo(g,h,i)perylene	11.0	NL	

Table 4-4

Comparison of Concentrations of Compounds Detected in Soil to Health-Based Screening Levels

Page 2 of 2

Compound	Maximum Concentration Detected (mg/kg)	Method C[a] Screening Level (mg/kg)	Maximum Exceeds Screen?
Diesel	13,000	200[b]	Yes
Fuel oil	20,000	200[b]	Yes
Volatile Organic Compounds			
Benzene	2.10	45.3	
2-Butanone	4.90	21,000	
Ethylbenzene	64.0	3,500	
Styrene	46.0	6,900	
Toluene	37.0	7,000	
Total xylenes	180	70,000	
Gasoline	11,000	100[b]	Yes
Metals			
Arsenic	1,250	1.88	Yes
Chromium (III)	906	35,000	
Chromium (VI)	906	175	Yes
Copper	79.2	1,300	
Lead	103	1,000[b]	
Mercury	0.16	NL	

NOTE: NL = Not listed on IRIS.

[a] MTCA Method C Cleanup Levels conservatively divided by 100.
[b] MTCA Method A value used because the chemical is not listed on IRIS.

Table 4-5

Critical Toxicity Values

Compound	Reference Doses (RfD)[a]		Effect of Concern Inhalation; Oral	Slope Factors (CPF)[a]		Tumor Site Inhalation; Oral
	Inhalation (mg/kg/day)	Oral (mg/kg/day)		Inhalation $(mg/kg/day)^{-1}$	Oral $(mg/kg/day)^{-1}$	
Arsenic	NA	0.0003	NA; keratosis	15	1.75	Lung; skin
Benzo(a)pyrene[b]	NA	NA	NA; NA	NA	7.3	NA; stomach
Chromium VI	NA	0.005	NA; none reported	42	NA	Lung; NA
Pentachlorophenol	NA	0.03	NA; liver and kidney	NA	0.12	NA; liver, adrenal gland, blood vessels

NOTE: NA = Not available.

[a] From *Integrated Risk Information System*, May 1994.
[b] The following polycyclic aromatic hydrocarbon (PAHs) are assumed to be equipotent to benzo(a)pyrene: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Table 4-6

Total Noncarcinogenic Risks for Future On-site Worker Reasonable Maximum Exposure

Compound	Hazard Quotients[a]		Hazard Index[b]	Percent of Total
	Incidental Ingestion	Dermal Contact		
Arsenic	3.7E-02	3.9E-02	7.7E-02	58
Benzo(a)anthracene	NA	NA	NA	0
Benzo(b)fluoranthene	NA	NA	NA	0
Benzo(k)fluoranthene	NA	NA	NA	0
Benzo(a)pyrene	NA	NA	NA	0
Chromium VI	5.2E-02	4.4E-03	5.6E-02	42
Chrysene	NA	NA	NA	0
Indeno(1,2,3-cd)pyrene	NA	NA	NA	0
Pentachlorophenol	2.7E-04	2.3E-05	2.9E-04	0
TOTAL	0.09	0.04	0.13	100

NOTE: NA = Not applicable.

[a] From Appendix I.

[b] Sum of hazard quotients for ingestion and dermal.

Table 4-7

Total Carcinogenic Risks for Future On-site Worker Reasonable Maximum Exposure

Compound	Potential Excess Carcinogenic Risks[a]		Total Excess Risk[b]	Percent of Total
	Incidental Ingestion	Dermal Contact		
Arsenic	5.2E-06	5.5E-06	1.1E-05	24
Benzo(a)anthracene	6.8E-06	NA	6.8E-06	15
Benzo(b)fluoranthene	5.9E-06	NA	5.9E-06	13
Benzo(k)fluoranthene	3.9E-06	NA	3.9E-06	9
Benzo(a)pyrene	4.3E-06	NA	4.3E-06	10
Chromium VI	NA	NA	NA	0
Chrysene	1.0E-05	NA	1.0E-05	22
Indeno(1,2,3-cd)pyrene	3.2E-06	NA	3.2E-06	7
Pentachlorophenol	2.6E-07	2.2E-08	2.8E-07	1
TOTAL	4E-05	6E-06	5E-05	100

NOTE: NA = Not applicable.

[a] From Appendix I.
[b] Sum of risks for ingestion and dermal.

Table 4-8

Statistical Summary of Total Metals in Groundwater — August 1992 Through August 1993, Shallow Perimeter Wells

Element	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Shallow Perimeter Wells								
Arsenic	40	40	0.0182	17.0	2.90	12.0	—	—
Chromium	27	40	0.0014	0.461	0.0327	0.095	0.0024	0.0221
Copper	24	40	0.0012	0.0308	0.0068	0.0107	0.00068	0.0167
Lead	16	40	0.0007	0.0092	0.0017	0.0022	0.0009	0.0031
Mercury	0	16	—	—	—	—	0.0001	0.0004

NOTE: — = Indicates no relevant value.

Table 4-9

Statistical Summary of Total Petroleum Hydrocarbons in Groundwater — August 1992 Through August 1993, Shallow Perimeter Wells

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Shallow Perimeter Wells								
Gasoline	20	40	0.05	23	2.67	*	0.05	0.25
Diesel	26	40	0.23	21	2.77	*	0.13	0.25
Heavy Oil	10	40	0.50	13	1.06	*	0.2	2.5
Total (G, D, and Oil)	31	40	0.08	43	6.06	*	0.2	0.5

NOTE: * = Default to maximum value per statistical guidance.

Table 4-10

Statistical Summary of Volatile Organic Compounds in Groundwater — August 1992 Through August 1993, Shallow Perimeter Wells

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L) Low	Detection Limits (mg/L) High
Shallow Perimeter Wells								
Benzene	18	40	0.001	3.20	0.407	*	0.010	0.010
Toluene	17	40	0.002	5.20	0.549	*	0.010	0.010
Ethylbenzene	17	40	0.002	0.240	0.037	*	0.010	0.010
Xylenes	20	40	0.002	1.20	0.154	*	0.010	0.010

NOTE: * = Default to maximum value per statistical guidance.

Table 4-11

Statistical Summary of Semivolatile Organic Compounds in Groundwater — August 1992 Through August 1993, Shallow Perimeter Wells

Page 1 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Shallow Perimeter Wells								
Phenol	14	39	0.002	0.230	0.041	*	0.010	0.400
bis(2chloroethyl)Ether	0	39	—	—	—	—	0.010	1.10
2-Chlorophenol	0	39	—	—	—	—	0.010	1.10
1,3-Dichlorobenzene	0	39	—	—	—	—	0.010	1.10
1,4-Dichlorobenzene	0	39	—	—	—	—	0.010	1.10
1,2-Dichlorobenzene	0	39	—	—	—	—	0.010	1.10
2-Methylphenol	11	39	0.001	0.228	0.052	*	0.010	1.10
2,2-oxybis(1-Chloropropane)	0	39	—	—	—	—	0.010	1.10
4-Methylphenol	16	39	0.003	0.920	0.093	*	0.010	0.020
N-nitroso-Di-n-Propylamine	0	39	—	—	—	—	0.010	1.10
Hexachloroethane	0	39	—	—	—	—	0.010	1.10
Nitrobenzene	0	39	—	—	—	—	0.010	1.10
Isophorone	0	39	—	—	—	—	0.010	1.10
2-Nitrophenol	0	39	—	—	—	—	0.010	1.10
2,4-Dimethylphenol	14	39	0.004	0.226	0.047	*	0.010	1.10
bis(2-Chloroethoxy)Methane	0	39	—	—	—	—	0.010	1.10
2,4-Dichlorophenol	12	39	0.003	0.226	0.058	*	0.010	1.10
1,2,4-Trichlorobenzene	0	39	—	—	—	—	0.010	1.10
Naphthalene	20	39	0.010	8.60	1.08	*	0.010	0.040
4-Chloroaniline	0	39	—	—	—	—	0.010	1.10
Hexachlorobutadiene	0	39	—	—	—	—	0.010	1.10
4-Chloro-3-Methylphenol	0	39	—	—	—	—	0.010	1.10
2-Methylnaphthalene	15	39	0.002	0.860	0.113	*	0.010	0.400
Hexachlorocyclopentadiene	0	39	—	—	—	—	0.010	1.10
2,4,6-Trichlorophenol	1	39	0.140	—	—	—	0.010	1.10
2,4,5-Trichlorophenol	20	39	0.003	0.165	0.039	*	0.025	0.050
2-Chloronaphthalene	0	39	—	—	—	—	0.010	1.10
2-Nitroaniline	0	39	—	—	—	—	0.025	2.70
Dimethyl phthalate	0	39	—	—	—	—	0.010	1.10
Acenaphthylene	0	39	—	—	—	—	0.010	1.10
2,6-Dinitrotoluene	0	39	—	—	—	—	0.010	1.10
3-Nitroaniline	0	39	—	—	—	—	0.025	2.70

Table 4-11

Statistical Summary of Semivolatile Organic Compounds in Groundwater — August 1992 Through August 1993, Shallow Perimeter Wells

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Acenaphthene	11	39	0.013	0.224	0.048	*	0.010	1.10
2,4-Dinitrophenol	0	39	—	—	—	—	0.025	2.70
4-Nitrophenol	0	39	—	—	—	—	0.025	2.70
Dibenzofuran	7	39	0.003	0.063	0.053	*	0.010	1.10
2,4-Dinitrotoluene	0	39	—	—	—	—	0.010	1.10
Diethylphthalate	0	39	—	—	—	—	0.010	1.10
4-Chlorophenyl-phenylether	0	39	—	—	—	—	0.010	1.10
Fluorene	7	39	0.001	0.065	0.053	*	0.010	1.10
4-Nitroaniline	0	39	—	—	—	—	0.025	2.70
4,6-Dinitro-2-Methylphenol	0	39	—	—	—	—	0.025	2.70
N-Nitrosodiphenylamine	0	39	—	—	—	—	0.010	1.10
4-Bromophenyl-phenylether	0	39	—	—	—	—	0.010	1.10
Hexachlorobenzene	0	39	—	—	—	—	0.010	1.10
Pentachlorophenol	19	39	0.005	7.50	1.07	*	0.025	0.260
Phenanthrene	6	39	0.001	0.043	0.055	*	0.010	1.10
Anthracene	0	39	—	—	—	—	0.010	1.10
Carbazole	8	39	0.010	0.160	0.045	*	0.010	1.10
Di-n-Butylphthalate	0	39	—	—	—	—	0.010	1.10
Fluoranthene	0	39	—	—	—	—	0.010	1.10
Pyrene	0	39	—	—	—	—	0.010	1.10
Butylbenzylphthalate	0	39	—	—	—	—	0.010	1.10
3,3'-Dichlorobenzidine	0	39	—	—	—	—	0.010	1.10
Benzo(a)anthracene	0	39	—	—	—	—	0.010	1.10
Chrysene	0	39	—	—	—	—	0.010	1.10
bis(2-Ethylhexyl)phthalate	3	39	0.002	0.026	0.054	*	0.010	1.10
Di-n-Octyl Phthalate	0	39	—	—	—	—	0.010	1.10
Benzo(b)Fluoranthene	0	39	—	—	—	—	0.010	1.10
Benzo(k)Fluoranthene	0	39	—	—	—	—	0.010	1.10
Benzo(a)Pyrene	0	39	—	—	—	—	0.010	1.10
Indeno(1,2,3-cd)Pyrene	0	39	—	—	—	—	0.010	1.10
Dibenz(a,h)Anthracene	0	39	—	—	—	—	0.010	1.10
Benzo(g,h,i)Perylene	0	39	—	—	—	—	0.010	1.10

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 4-12

Statistical Summary of Total Metals in Groundwater — August 1992 Through August 1993, Deep Perimeter Wells

Element	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Deep Perimeter Wells								
Arsenic	23	23	0.0030	0.174	0.0213	0.0339	—	—
Chromium	14	23	0.0024	0.0132	0.0057	0.0084	0.0029	0.0123
Copper	6	23	0.0017	0.0139	0.0026	0.0026	0.00068	0.0064
Lead	4	23	0.0009	0.0013	0.0007	*	0.0005	0.0022
Mercury	0	10	—	—	—	—	0.0001	0.0004

NOTE: — = Indicates no relevant value.
• = Default to maximum value per statistical guidance.

Table 4-13

Statistical Summary of Total Petroleum Hydrocarbons in Groundwater — August 1992 Through August 1993, Deep Perimeter Wells

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Deep Perimeter Wells								
Gasoline	13	23	0.05	7	1.56	*	0.05	0.08
Diesel	11	23	0.17	3	0.96	*	0.13	0.25
Heavy Oil	2	23	0.1	0.44	—	—	0.2	0.5
Total (G, D, and Oil)	14	23	0.05	8	4.09	*	0.2	0.5

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 4-14

Statistical Summary of Volatile Organic Compounds in Groundwater — August 1992 Through August 1993, Deep Perimeter Wells

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Deep Perimeter Wells								
Benzene	12	23	0.0008	0.355	0.060	*	0.010	0.010
Toluene	10	23	0.0005	0.012	0.006	*	0.010	0.010
Ethylbenzene	12	23	0.001	0.140	0.037	*	0.010	0.010
Xylenes	12	23	0.001	0.040	0.014	*	0.010	0.010

NOTE: * = Default to maximum value per statistical guidance.

Table 4-15

Statistical Summary of Semivolatile Organic Compounds in Groundwater — August 1992 Through August 1993, Deep Perimeter Wells

Page 1 of 2

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Deep Perimeter Wells								
Phenol	5	23	0.001	0.006	0.023	*	0.010	0.310
bis(2chloroethyl)Ether	0	23	—	—	—	—	0.010	0.310
2-Chlorophenol	0	23	—	—	—	—	0.010	0.310
1,3-Dichlorobenzene	0	23	—	—	—	—	0.010	0.310
1,4-Dichlorobenzene	0	23	—	—	—	—	0.010	0.310
1,2-Dichlorobenzene	0	23	—	—	—	—	0.010	0.310
2-Methylphenol	0	23	—	—	—	—	0.010	0.310
2,2-oxybis(1-Chloropropane)	0	23	—	—	—	—	0.010	0.310
4-Methylphenol	0	23	—	—	—	—	0.010	0.310
N-nitroso-Di-n-Propylamine	0	23	—	—	—	—	0.010	0.310
Hexachloroethane	0	23	—	—	—	—	0.010	0.310
Nitrobenzene	0	23	—	—	—	—	0.010	0.310
Isophorone	0	23	—	—	—	—	0.010	0.310
2-Nitrophenol	0	23	—	—	—	—	0.010	0.310
2,4-Dimethylphenol	2	23	0.005	0.016	—	—	0.010	0.310
bis(2-Chloroethoxy)Methane	0	23	—	—	—	—	0.010	0.310
2,4-Dichlorophenol	0	23	—	—	—	—	0.010	0.310
1,2,4-Trichlorobenzene	0	23	—	—	—	—	0.010	0.310
Naphthalene	13	23	0.001	6.40	0.702	*	0.010	0.025
4-Chloroaniline	0	23	—	—	—	—	0.010	0.310
Hexachlorobutadiene	0	23	—	—	—	—	0.010	0.310
4-Chloro-3-Methylphenol	0	23	—	—	—	—	0.010	0.310
2-Methylnaphthalene	15	23	0.002	0.670	0.150	*	0.010	0.025
Hexachlorocyclopentadiene	0	23	—	—	—	—	0.010	0.310
2,4,6-Trichlorophenol	0	23	—	—	—	—	0.010	0.310
2,4,5-Trichlorophenol	0	23	—	—	—	—	0.025	0.780
2-Chloronaphthalene	0	23	—	—	—	—	0.010	0.310
2-Nitroaniline	0	23	—	—	—	—	0.025	0.780
Dimethyl phthalate	0	23	—	—	—	—	0.010	0.310
Acenaphthylene	1	23	0.002	—	—	—	0.010	0.310
2,6-Dinitrotoluene	0	23	—	—	—	—	0.010	0.310
3-Nitroaniline	0	23	—	—	—	—	0.025	0.780
Acenaphthene	11	23	0.002	0.170	0.036	*	0.010	0.080
2,4-Dinitrophenol	0	23	—	—	—	—	0.025	0.780
4-Nitrophenol	0	23	—	—	—	—	0.025	0.780

Table 4-15

Statistical Summary of Semivolatile Organic Compounds in Groundwater — August 1992 Through August 1993, Deep Perimeter Wells

Compound	Number Detected	Number Analyzed	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	95% Upper Confidence Limit (mg/L)	Detection Limits (mg/L)	
							Low	High
Dibenzofuran	9	23	0.003	0.136	0.020	*	0.010	0.310
2,4-Dinitrotoluene	0	23	—	—	—	—	0.010	0.310
Diethylphthalate	0	23	—	—	—	—	0.010	0.310
4-Chlorophenyl-phenylether	0	23	—	—	—	—	0.010	0.310
Fluorene	9	23	0.006	0.034	0.016	*	0.010	0.310
4-Nitroaniline	0	23	—	—	—	—	0.025	0.780
4,6-Dinitro-2-Methylphenol	0	23	—	—	—	—	0.025	0.780
N-Nitrosodiphenylamine	0	23	—	—	—	—	0.010	0.310
4-Bromophenyl-phenylether	0	23	—	—	—	—	0.010	0.310
Hexachlorobenzene	0	23	—	—	—	—	0.010	0.310
Pentachlorophenol	0	23	—	—	—	—	0.025	0.780
Phenanthrene	4	23	0.001	0.016	0.023	*	0.010	0.310
Anthracene	0	23	—	—	—	—	0.010	0.310
Carbazole	9	23	0.020	0.105	0.021	*	0.010	0.025
Di-n-Butylphthalate	0	23	—	—	—	—	0.010	0.310
Fluoranthene	0	23	—	—	—	—	0.010	0.310
Pyrene	0	23	—	—	—	—	0.010	0.310
Butylbenzylphthalate	0	23	—	—	—	—	0.010	0.310
3,3'-Dichlorobenzidine	0	23	—	—	—	—	0.010	0.310
Benzo(a)anthracene	0	23	—	—	—	—	0.010	0.310
Chrysene	0	23	—	—	—	—	0.010	0.310
bis(2-Ethylhexyl)phthalate	0	23	—	—	—	—	0.010	0.310
Di-n-Octyl Phthalate	0	23	—	—	—	—	0.010	0.310
Benzo(b)Fluoranthene	0	23	—	—	—	—	0.010	0.310
Benzo(k)Fluoranthene	0	23	—	—	—	—	0.010	0.310
Benzo(a)Pyrene	0	23	—	—	—	—	0.010	0.310
Indeno(1,2,3-cd)Pyrene	0	23	—	—	—	—	0.010	0.310
Dibenz(a,h)Anthracene	0	23	—	—	—	—	0.010	0.310
Benzo(g,h,i)Perylene	0	23	—	—	—	—	0.010	0.310

NOTE: — = Indicates no relevant value.
* = Default to maximum value per statistical guidance.

Table 4-16

Water Quality Criteria for Detected Compounds (mg/L)

Compound	Federal				State			
	Freshwater		Marine		Freshwater		Marine	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Acenaphthene	—	—	0.970	0.710	—[a]	—	—	—
Arsenic	0.360[b]	0.190[b]	0.069[b]	0.036[b]	0.360[b]	0.190[b]	0.069[b]	0.036[b]
Benzene	—	—	—	—	—	—	—	—
Bis(2-ethylhexyl)phthalate	—	—	—	—	—	—	—	—
Carbazole	—	—	—	—	—	—	—	—
Chromium (Hex)	0.016	0.011	1.10	0.050	0.016	0.011	1.10	0.050
Chromium (Tri)[d]	1.70[c]	0.210[c]	10.3	—	1.736[c]	0.207[c]	—	—
Copper	0.018[c]	0.012[c]	0.0029	0.0029	0.0153[c]	0.0102[c]	0.0025	—
2,4-Dichlorophenol	—	—	—	—	—	—	—	—
2,4-Dimethylphenol	—	—	—	—	—	—	—	—
Dibenzofuran	—	—	—	—	—	—	—	—
Ethylbenzene	—	—	—	—	—	—	—	—
Fluorene	—	—	—	—	—	—	—	—
Lead	0.082[c]	0.0032[c]	0.140	0.0056	0.0561[c]	0.0022[c]	0.1511	0.0058
Naphthalene	—	—	—	—	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—	—	—	—
2-Methylphenol	—	—	—	—	—	—	—	—
4-Methylphenol	—	—	—	—	—	—	—	—
Pentachlorophenol	0.020[e]	0.013[e]	0.013	—	0.015[f]	0.0095[f]	0.013	0.0079
Phenanthrene	—	—	—	—	—	—	—	—
Phenol	—	—	—	—	—	—	—	—
Toluene	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—
2,4,5 Trichlorophenol	—	—	—	—	—	—	—	—
Xylenes	—	—	—	—	—	—	—	—

[a] — means no criterion.
[b] Values based on total recoverable fraction of the metal.
[c] Hardness dependent criteria (100 µm/L used).
[d] Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by the total-recoverable chromium.
[e] pH dependent criteria (7.8 pH used).
[f] pH dependent criteria (7.5 pH used).

Table 5-1

Apparent Source Areas and Associated Constituents

Apparent Source Area	Associated Constituents of Concern
Blow pit area	As, Cr, TPH, CPAHs, PCP, Dioxins/Furans
Former wood treatment/maintenance building[a]	As, Cr, TPH, CPAHs, PCP
Rail lines	As, Cr, TPH, CPAHs, PCP
Former Mill E	TPH
Off site	As

[a] The building includes the former aboveground wood treatment chemical storage tanks, and former and existing underground pipelines, and former petroleum storage tanks.

LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

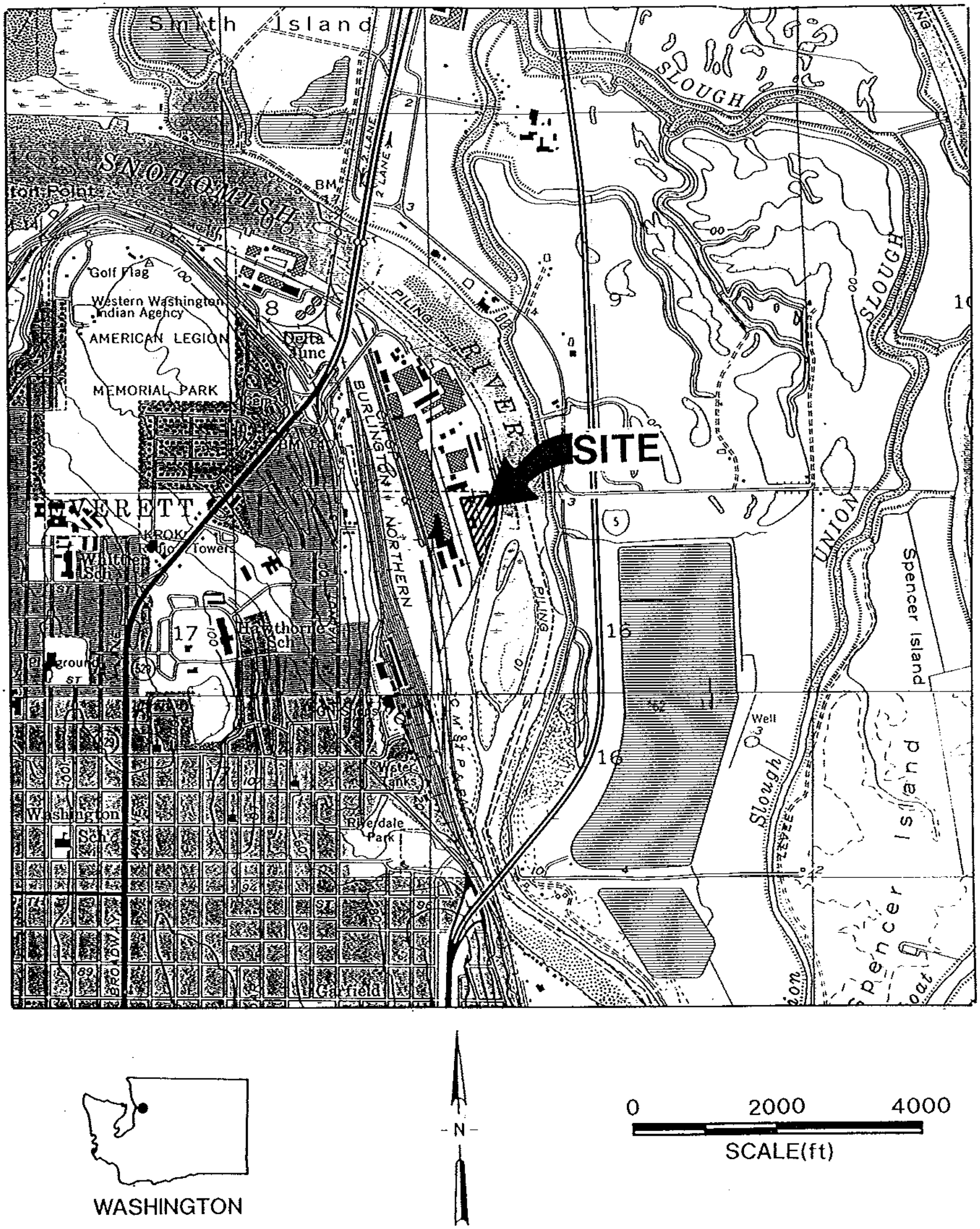
Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, nor the use of segregated portions of this report.

The purpose of an environmental assessment is to reasonably evaluate the potential for or actual impact of past practices on a given site area. In performing an environmental assessment, it is understood that a balance must be struck between a reasonable inquiry into the environmental issues and an exhaustive analysis of each conceivable issue of potential concern. The following paragraphs discuss the assumptions and parameters under which such an opinion is rendered.

No investigation is thorough enough to exclude the presence of hazardous materials at a given site. If hazardous conditions have not been identified during the assessment, such a finding should not therefore be construed as a guarantee of the absence of such materials on the site, but rather as the result of the services performed within the scope, limitations, and cost of the work performed.

Environmental conditions may exist at the site that cannot be identified by visual observation. Where subsurface work was performed, our professional opinions are based in part on interpretation of data from discrete sampling locations that may not represent actual conditions at unsampled locations.

Except where there is express concern of our client, or where specific environmental contaminants have been previously reported by others, naturally occurring toxic substances, potential environmental contaminants inside buildings, or contaminant concentrations that are not of current environmental concern may not be reflected in this document.

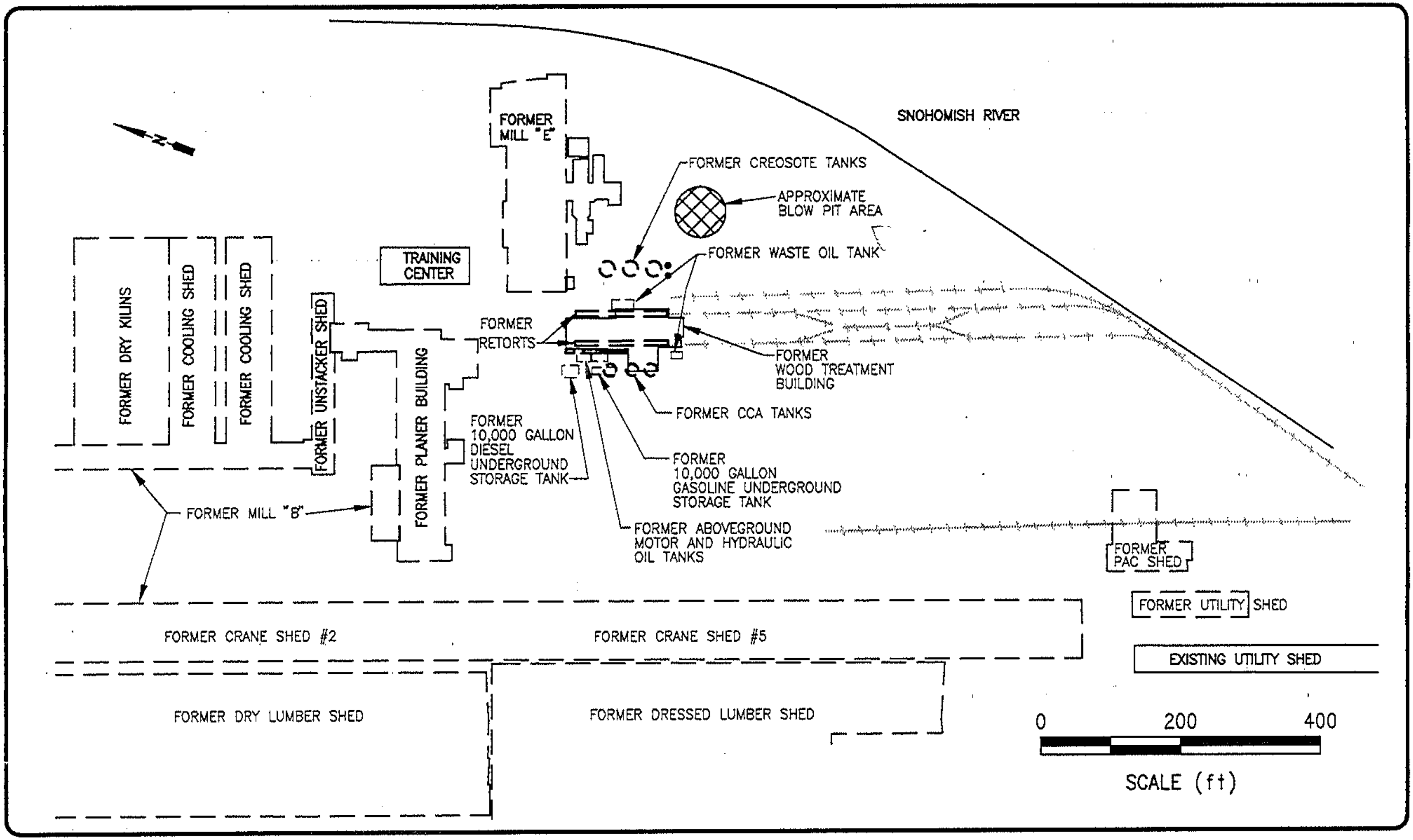


EMCON
Northwest, Inc.

DATE 6/92
DWN. JA
APPR.
REVIS.
PROJECT NO.

Figure 1-1
WEYERHAEUSER COMPANY
FORMER MILL E / KOPPERS FACILITY
EVERETT, WASHINGTON

SITE LOCATION MAP



EMCON
Northwest, Inc.

DATE 5-94
DWN. MLP
REV.
APPR.
PROJECT NO.
0141-037.17

Figure 1-2
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

HISTORICAL AND EXISTING STRUCTURES

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Table 4-17

Sediment Samples With Detected Contaminant Concentrations Greater Than Sediment Management Standards Chemical Criteria

Compound:	Arsenic	Copper	Mercury	Acenaphthene	bis(2-ethylhexyl) phthalate	Dibenzofuran	Fluorene	2-Methylnaphthalene	Naphthalene	Pentachlorophenol	Phenanthrene	Sum LPAH[a]
Criteria[b] (SQS/CSL):	57/93	390/390	0.41/0.59	16/57	47/78	15/58	23/79	38/64	99/170	360/690	100/480	370/780
Units[c]:	mg/kg	mg/kg	mg/kg	mg/kg TOC	mg/kg TOC	mg/kg TOC	mg/kg TOC	mg/kg TOC	mg/kg TOC	μg/kg	mg/kg TOC	mg/kg TOC
Sample Number												
SR-01-01	103	—	—	—	—	—	—	—	—	—	—	—
SR-02-01	67.8	—	—	—	—	—	—	—	—	—	—	—
SR-05-01	253	—	—	—	—	—	—	—	—	—	—	—
SR-05-02	484[d,e]	—	—	—	—	—	—	—	—	—	—	—
SR-05-03	254[d]	—	—	—	—	—	—	—	—	—	—	—
SR-12-03	—	503	—	—	—	—	—	—	—	—	—	—
SR-22-03	—	—	0.51	—	—	—	—	—	—	—	—	—
SR-07-01	—	—	—	64	—	30	27	—	218	—	—	434 (348)[f]
SR-07-02	—	—	—	59	—	34	30	—	144	—	—	—
SR-07-03	—	—	—	26	—	—	—	—	—	—	—	—
SR-10-17S	—	—	—	83	—	47	67	47	111	—	228	(528)[f]
SR-11-02	—	—	—	30	—	—	—	—	—	—	—	565 (30)[f]
SR-11-03	—	—	—	—	—	29	93	—	—	—	—	—
SR-13-02	—	—	—	25	—	—	—	52	217	—	—	389 (322)[f]
SR-18-02	—	—	—	—	72	—	—	—	—	—	—	—
SR-18-03	—	—	—	—	—	—	—	—	—	570	—	—
SR-33-03	—	—	—	—	—	—	—	—	—	610	—	—

[a] Sum LPAH = The sum of the low molecular weight polycyclic aromatic hydrocarbons: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. The value shown is calculated by adding detected values plus detection limits for non-detected LPAH per chapter 173-204 WAC.

[b] Criteria — SQS = Table I Marine Sediment Quality Standards — Chemical Criteria. Chapter 173-204-320 WAC.
CSL = Table III Puget Sound Marine Sediment Cleanup Screening Levels and Minimum Cleanup Levels. Chapter 173-204-520 WAC.

[c] mg/kg = milligrams per kilogram dry-weight; mg/kg TOC = milligrams per kilogram dry-weight normalized to total organic carbon; μg/kg = micrograms per kilogram dry-weight.

[d] Average concentration of field duplicate samples.

[e] Value includes maximum detected sediment concentration for analyte shown in Table 3-23.

[f] Concentrations in parentheses are the sum of detected LPAH, only. For some samples, the detected concentration of LPAH was less than chemical criteria.

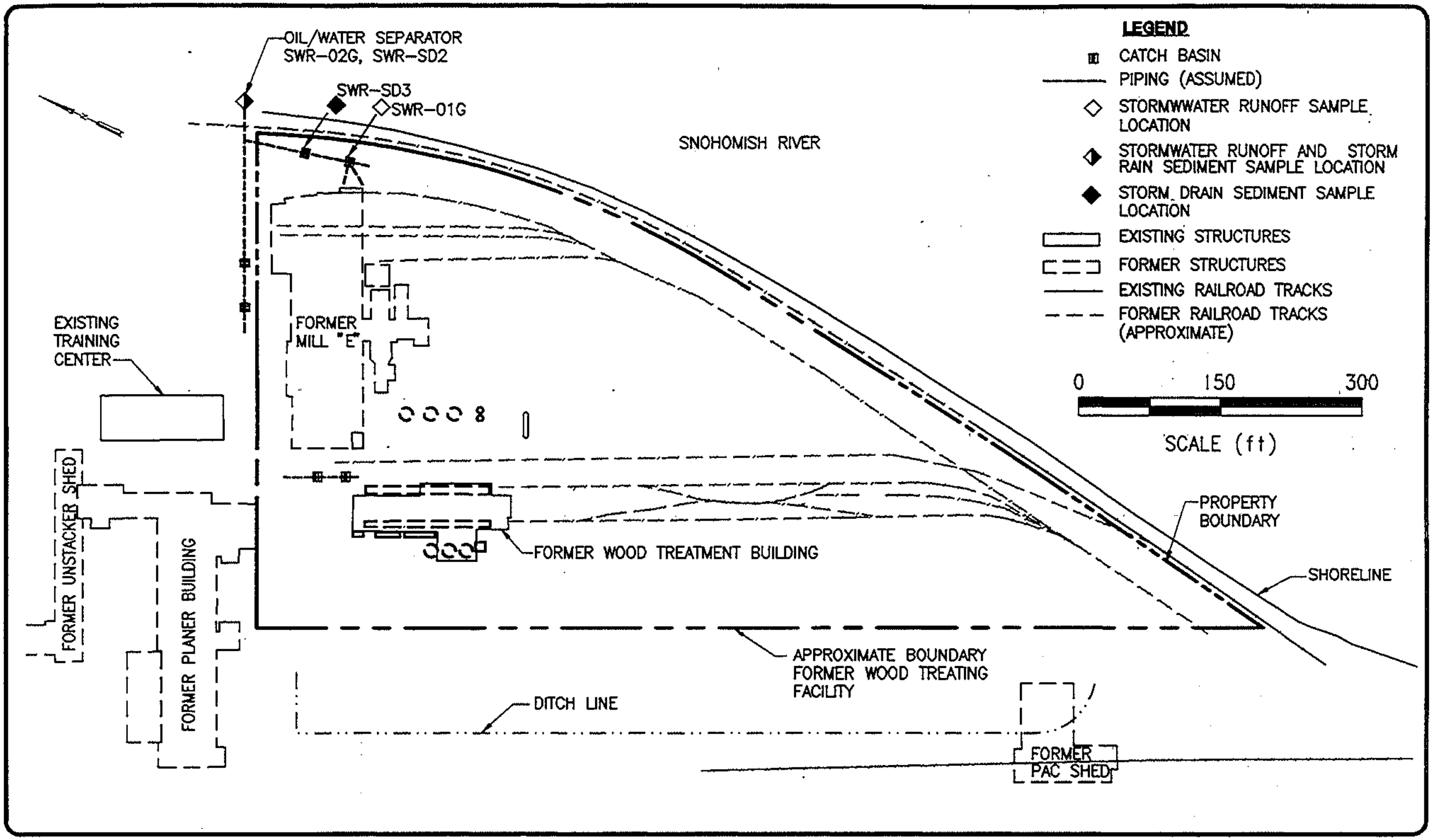

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Figure 2-1
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

STORMWATER CONVEYANCE STRUCTURES AND SAMPLING LOCATIONS

1= 150 05-19-94 G:\DWG\0141\037\17BLC50

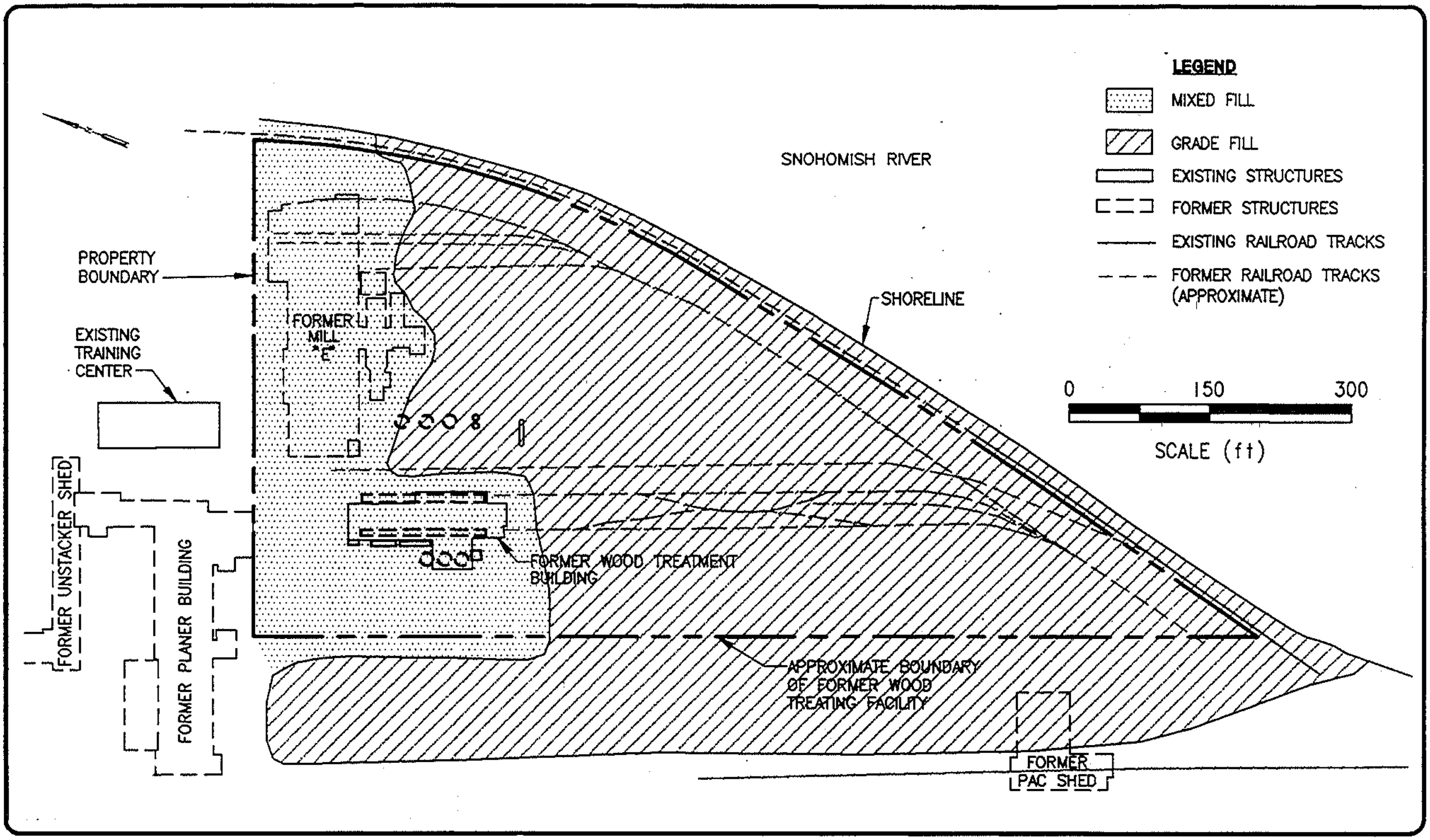

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Figure 2-2
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

EXTENT OF GRADE FILL AND MIXED FILL

1= 150 05-17-94 G:\DWG\0141\037\17BLC46

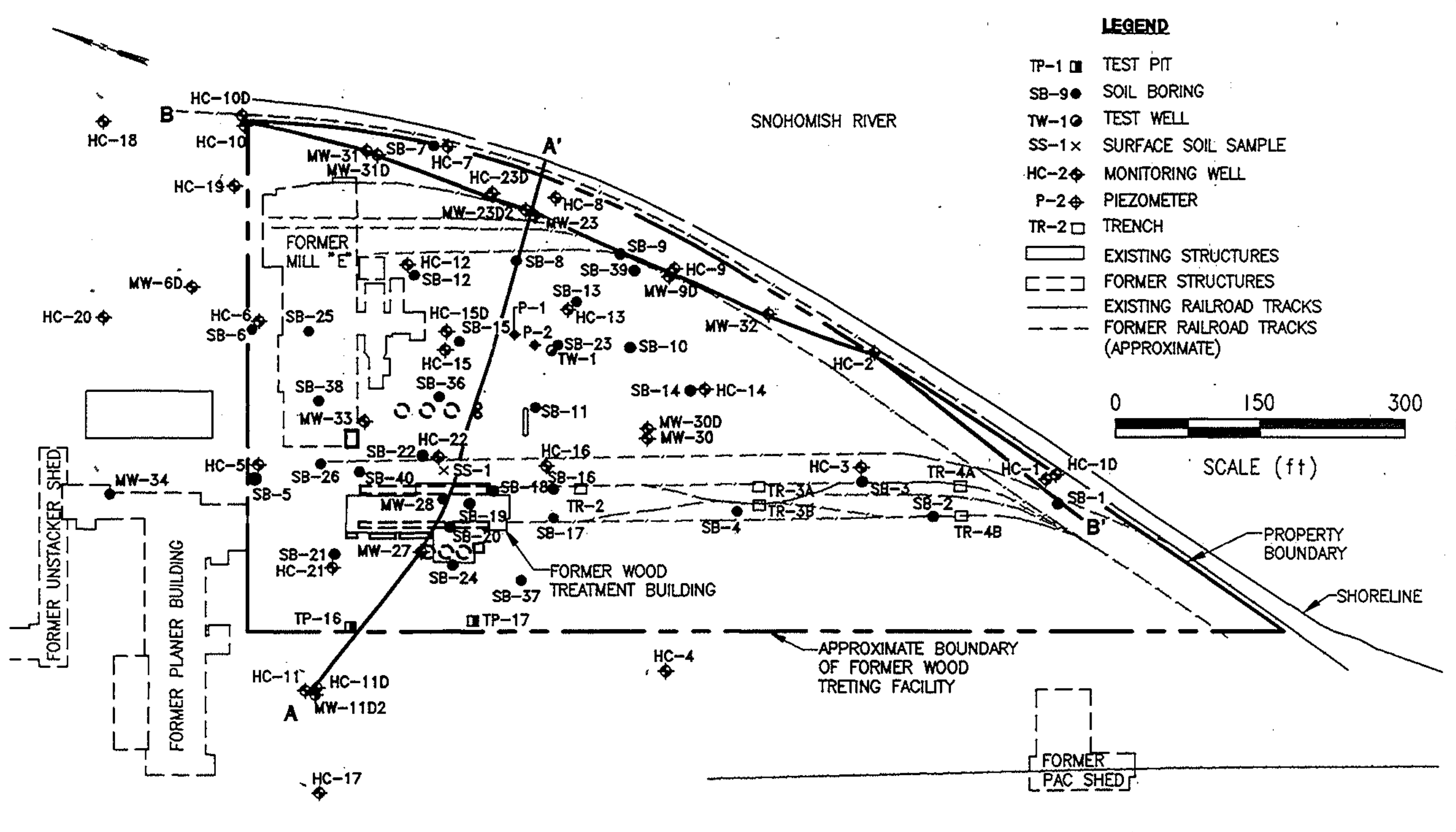

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Figure 2-3
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

CROSS SECTION LOCATION MAP

1= 150 05-17-94 G:\DWG\0141\037\17BLC47

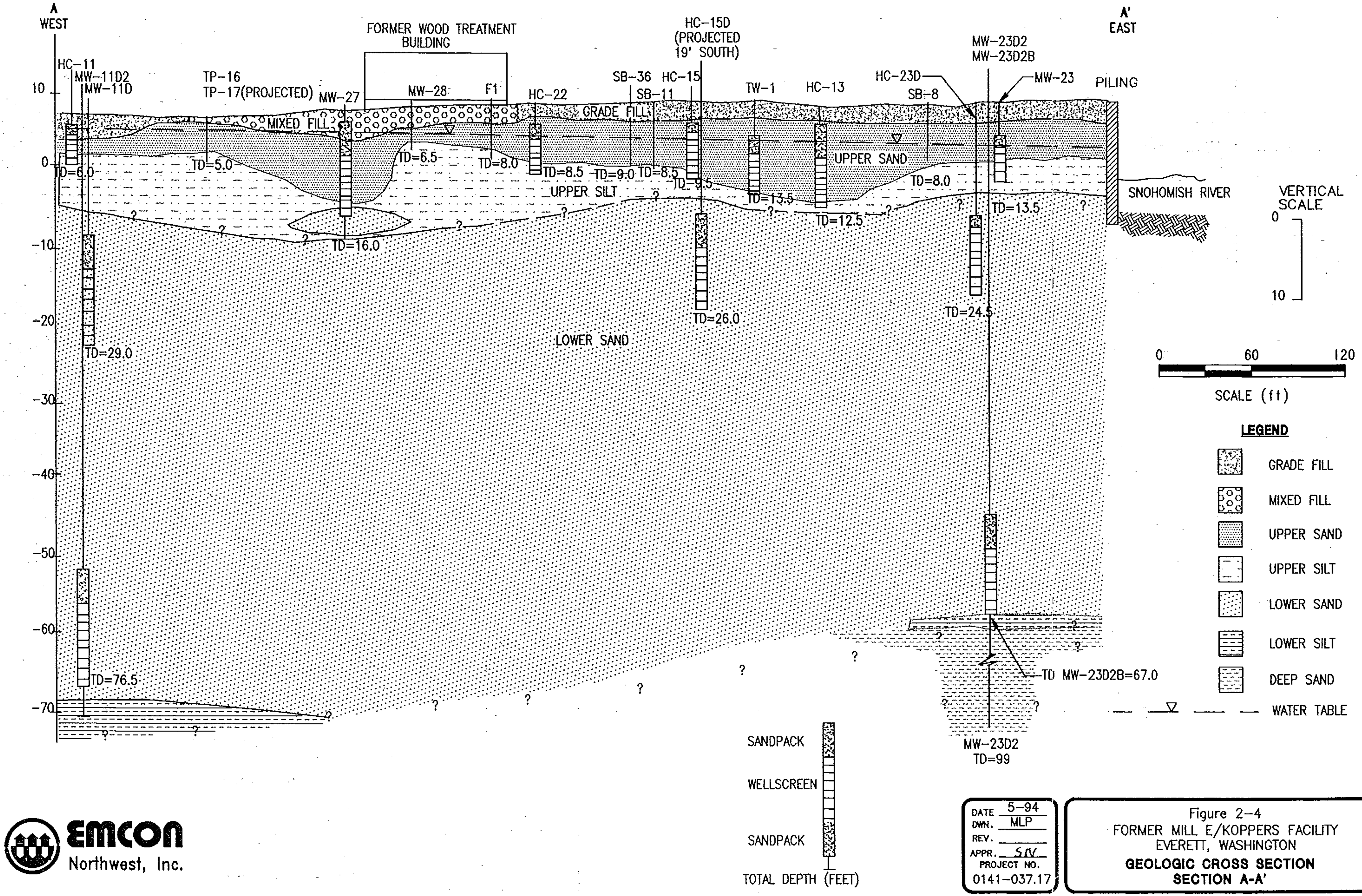

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Figure 2-4
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

GEOLOGIC CROSS SECTION
SECTION A-A'

1= 60 5-17-94 0141\037\17C30A

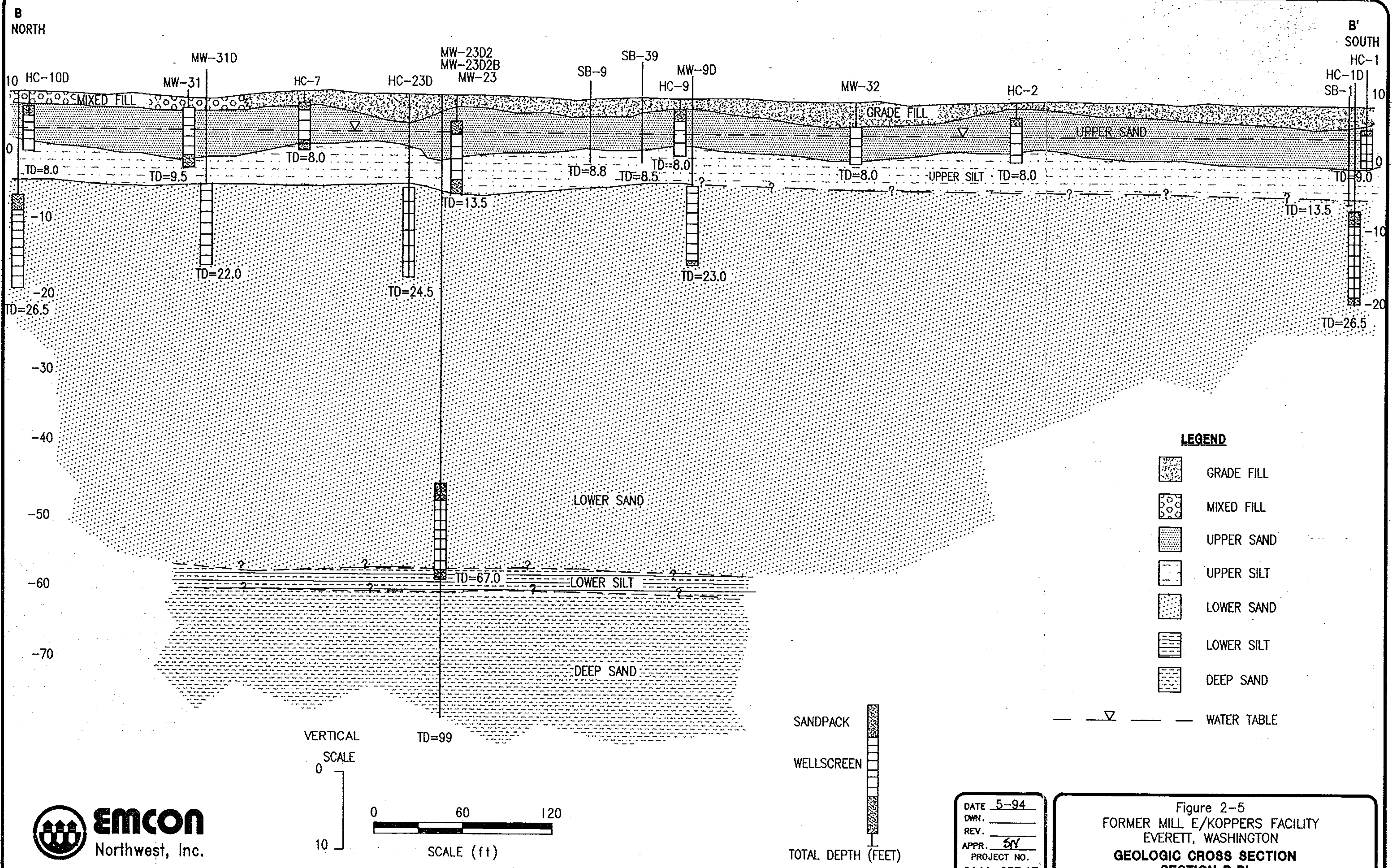

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Figure 2-5
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
GEOLOGIC CROSS SECTION
SECTION B-B'

1= 60   5-17-94   0141\037\17C31A

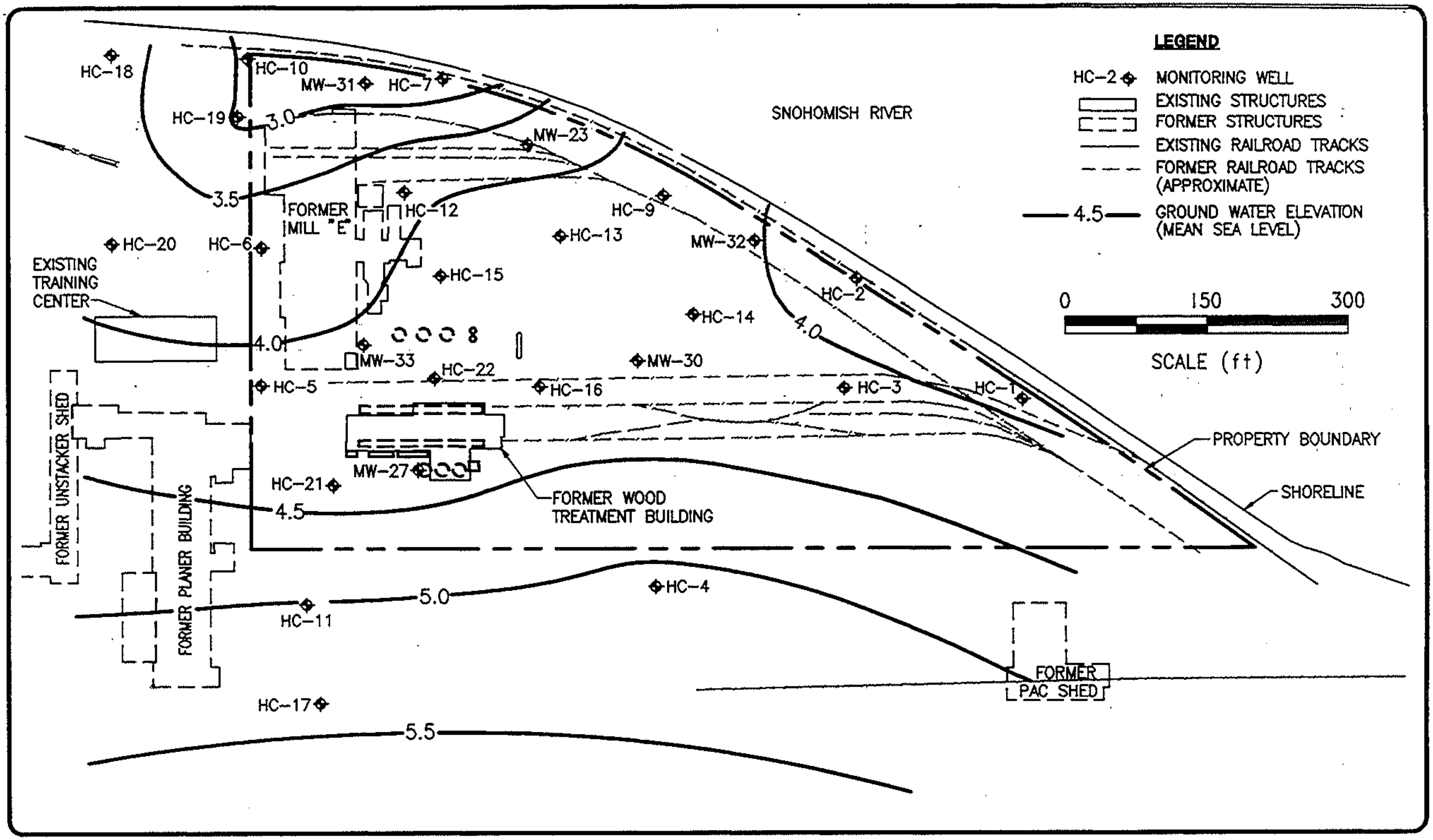

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Figure 2-6
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

GROUNDWATER ELEVATIONS
UPPER SAND AQUIFER - JULY 1992

1= 150 05-19-94 G: \DWG\0141\037\17BLC49

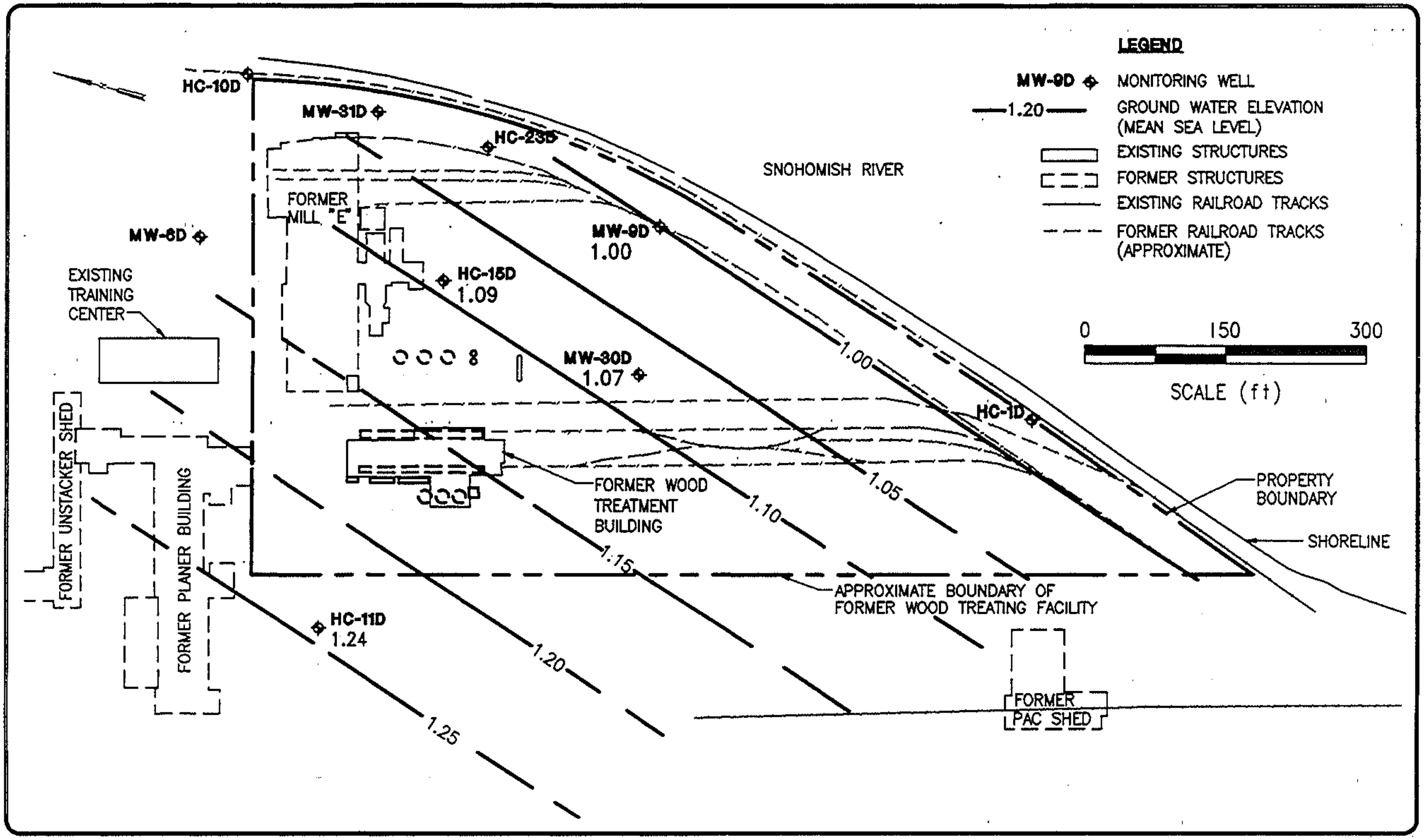

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Figure 2-7
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
GROUNDWATER ELEVATIONS-LOWER SAND AQUIFER
NOVEMBER 1992
NET ELEVATIONS CORRECTED FOR TIDAL INFLUENCE

1= 150 05-17-94 G:\DWG\0141\037\17BLC48

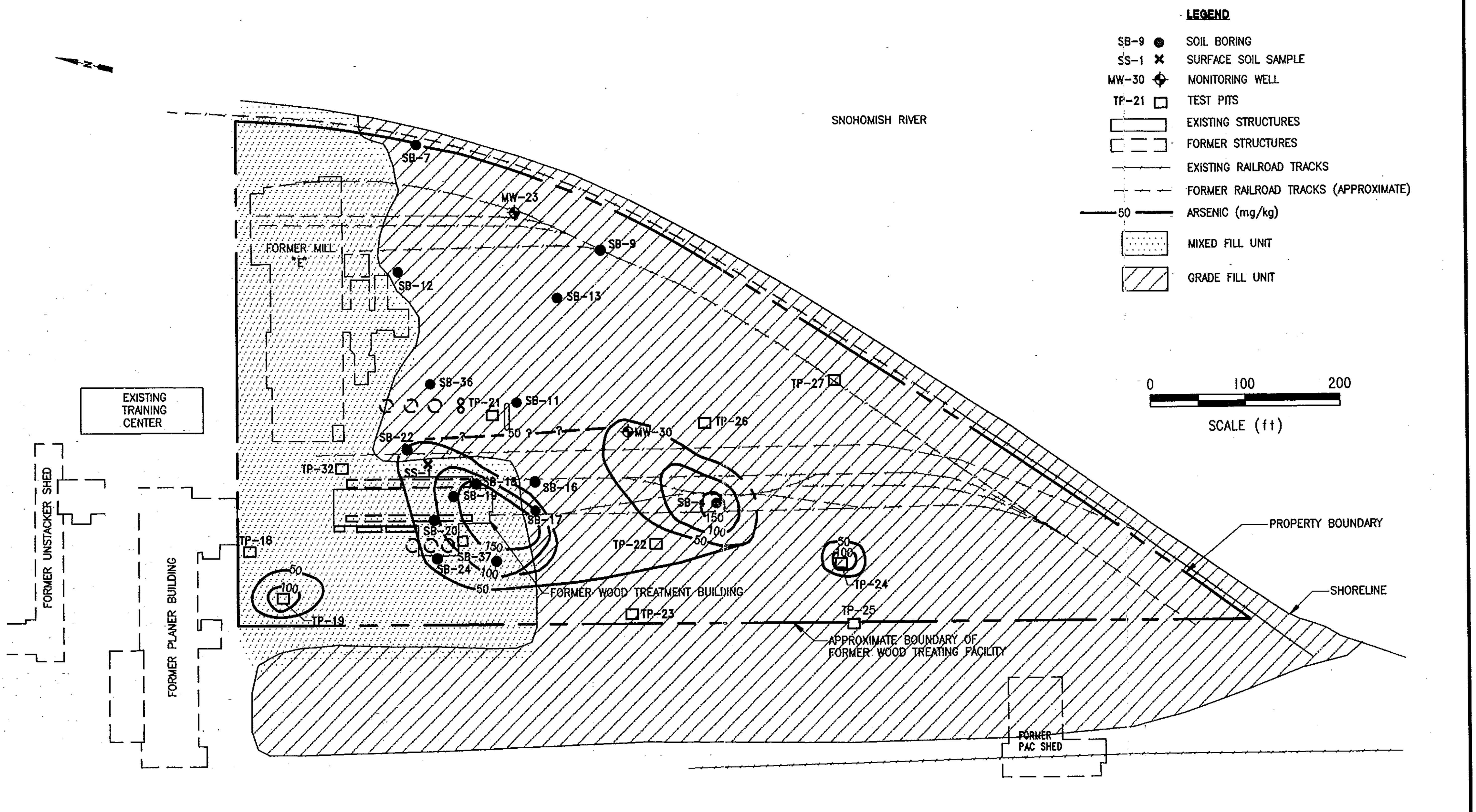

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Figure 3-1
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
ARSENIC IN SOIL
GRADE FILL AND MIXED FILL UNITS

1= 100 5-25-94 0141\037\17BLC58

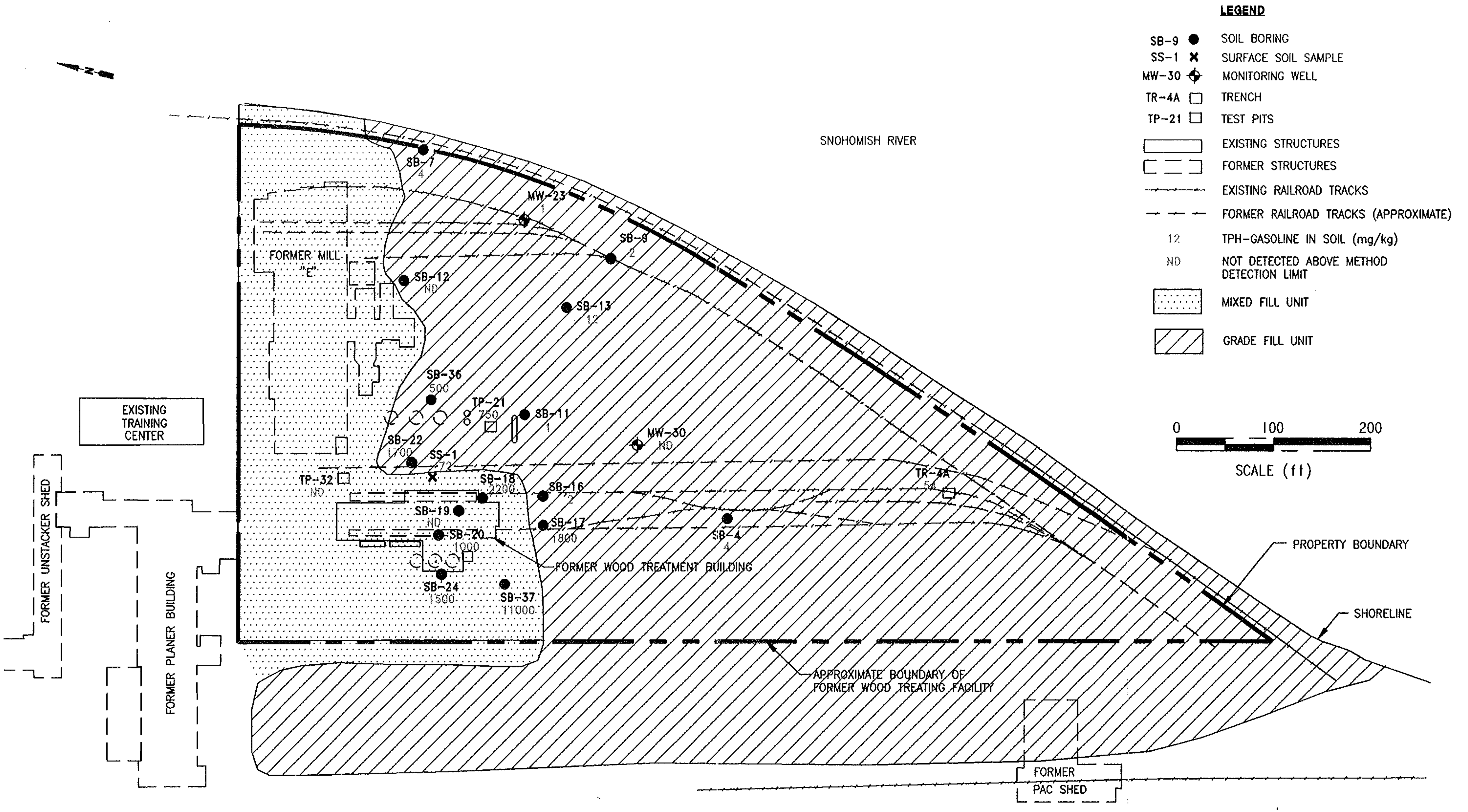

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Figure 3-2
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TPH-GASOLINE IN SOIL
GRADE FILL AND MIXED FILL UNITS

1= 100 5-25-94 0141\037\17BLC676

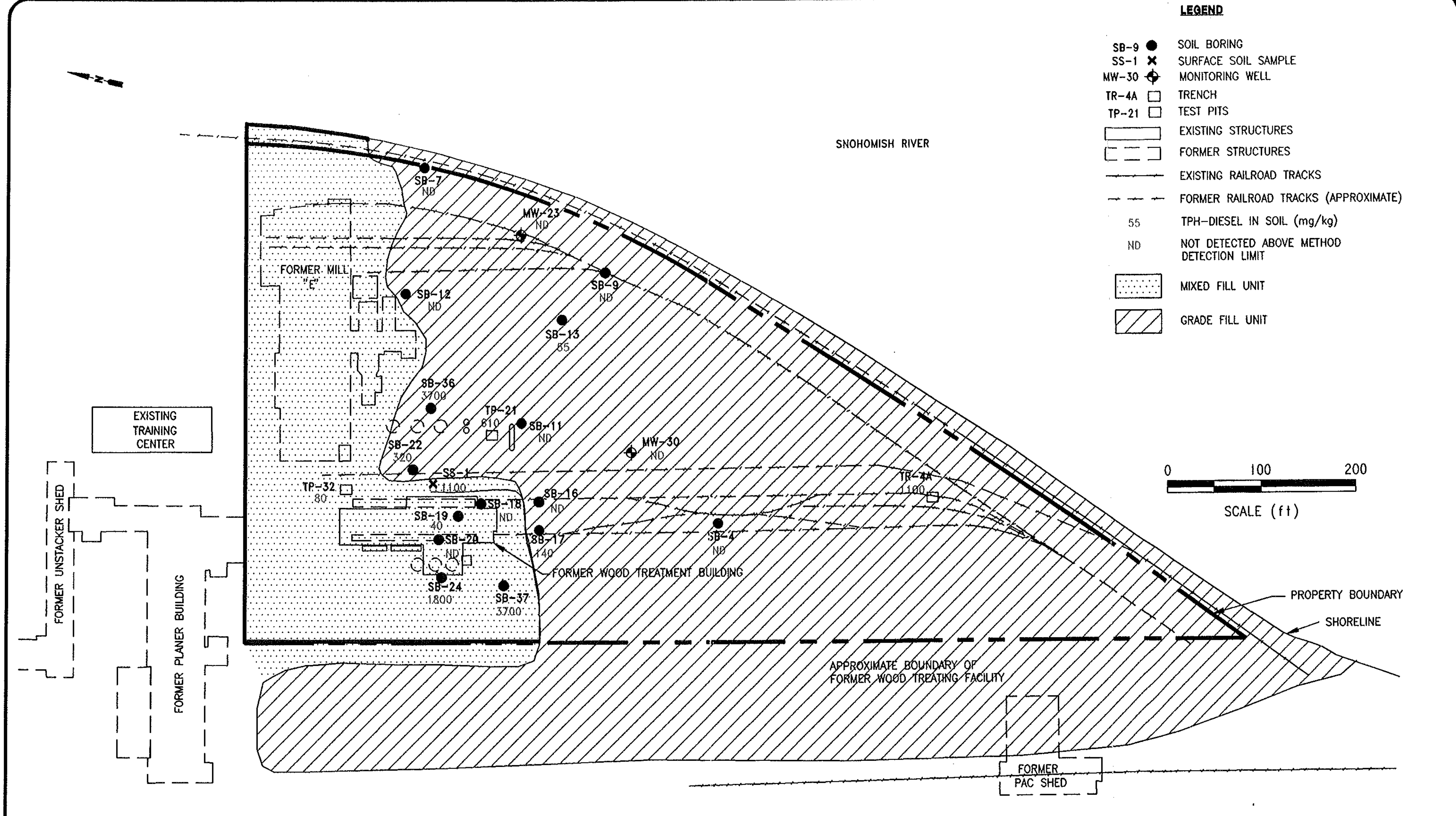

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Figure 3-3
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TPH-DIESEL IN SOIL
GRADE FILL AND MIXED FILL UNITS

1= 100 5-25-94 0141\037\17BLC68

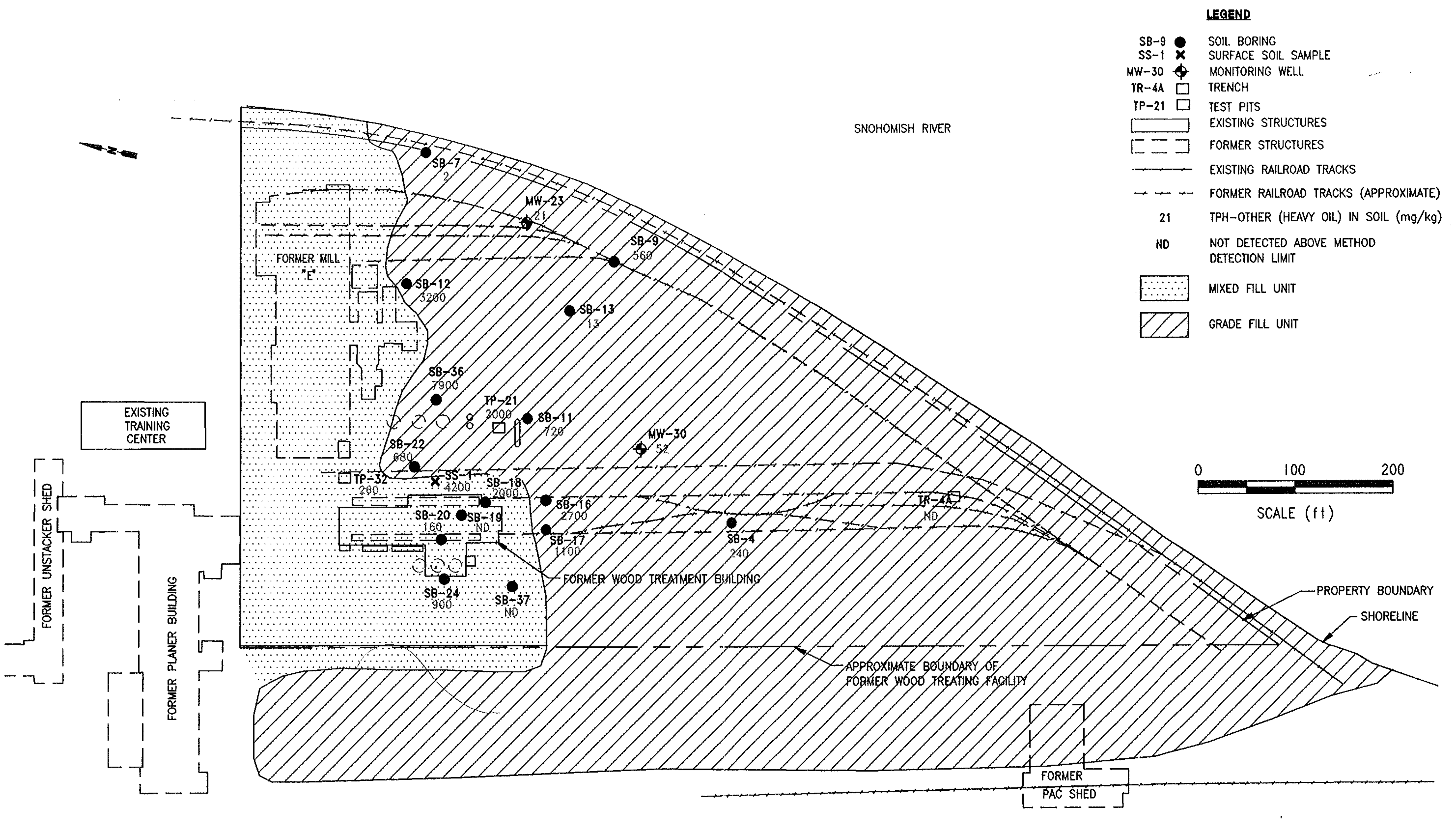

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Figure 3-4
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TPH-OTHER (HEAVY OIL) IN SOIL GRADE FILL AND MIXED FILL UNITS

1= 100 5-25-94 0141\037\17BLC69

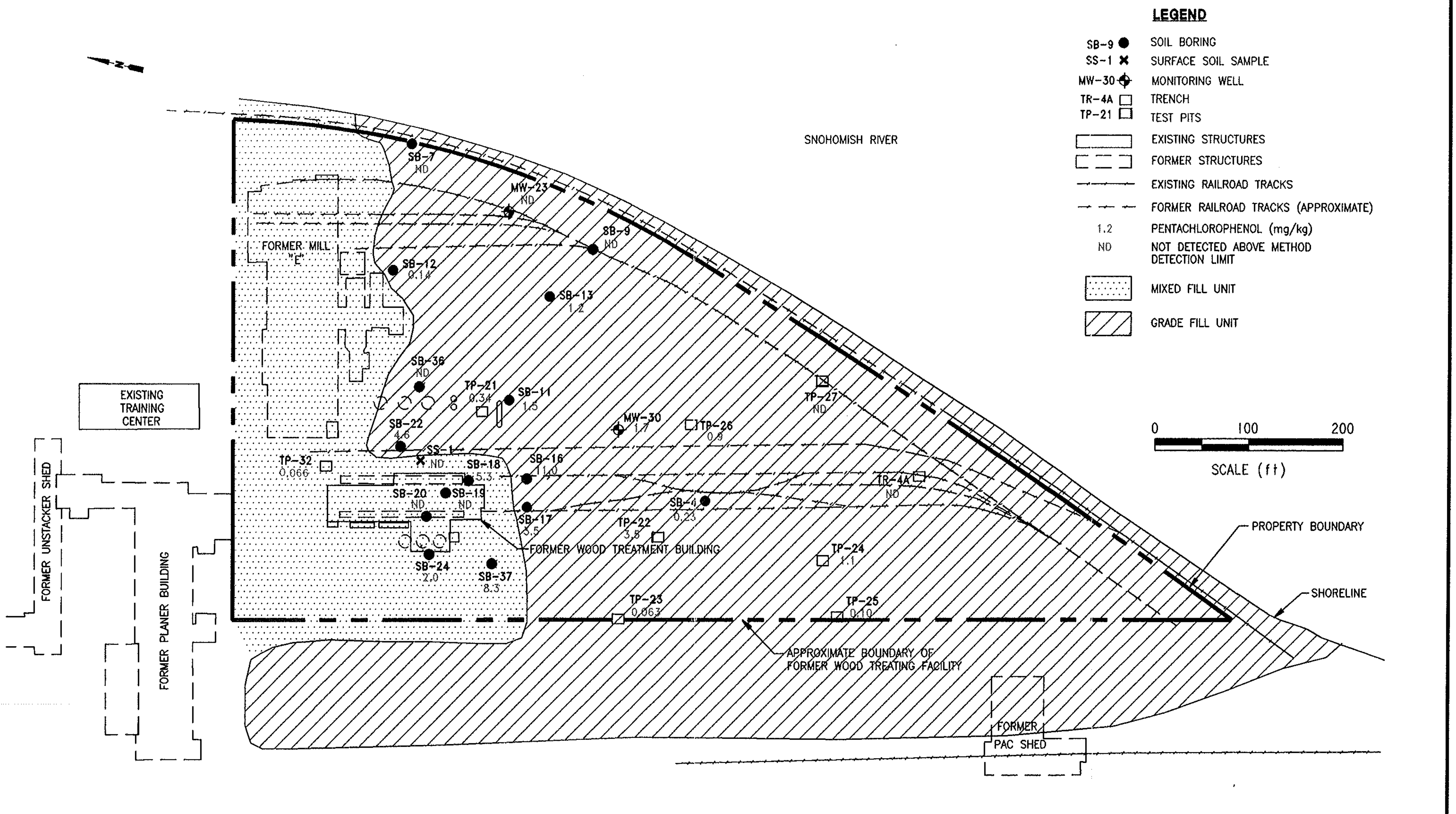

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Figure 3-5
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
PENTACHLOROPHENOL IN SOIL
GRADE FILL AND MIXED FILL UNITS

1= 100 5-25-94 0141\037\17BLC63

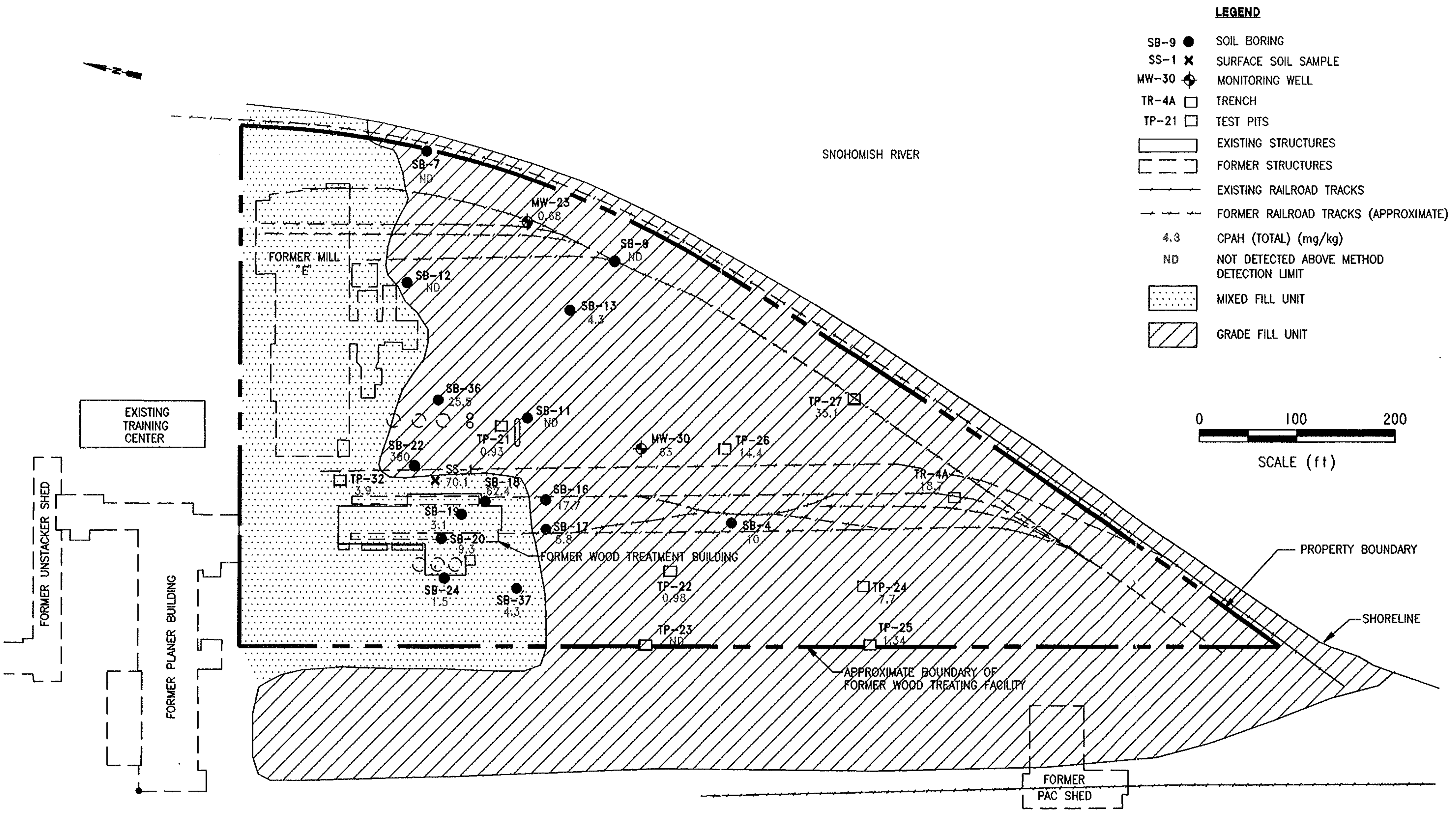

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Figure 3-6
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
CARCINOGENIC PAHs (TOTAL) IN SOIL
GRADE FILL AND MIXED FILL UNITS

1= 100 5-25-94 0141\037\17BLC62

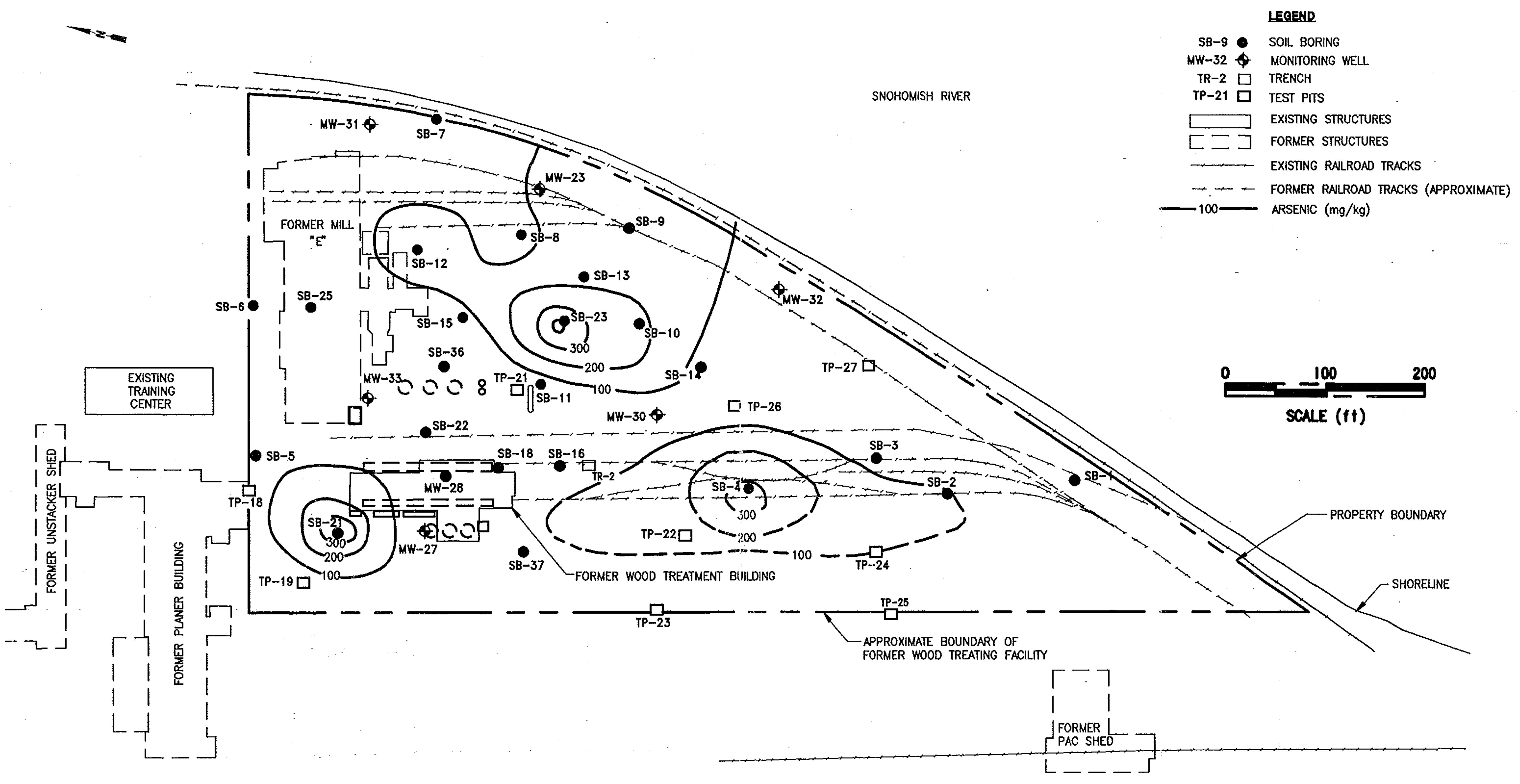

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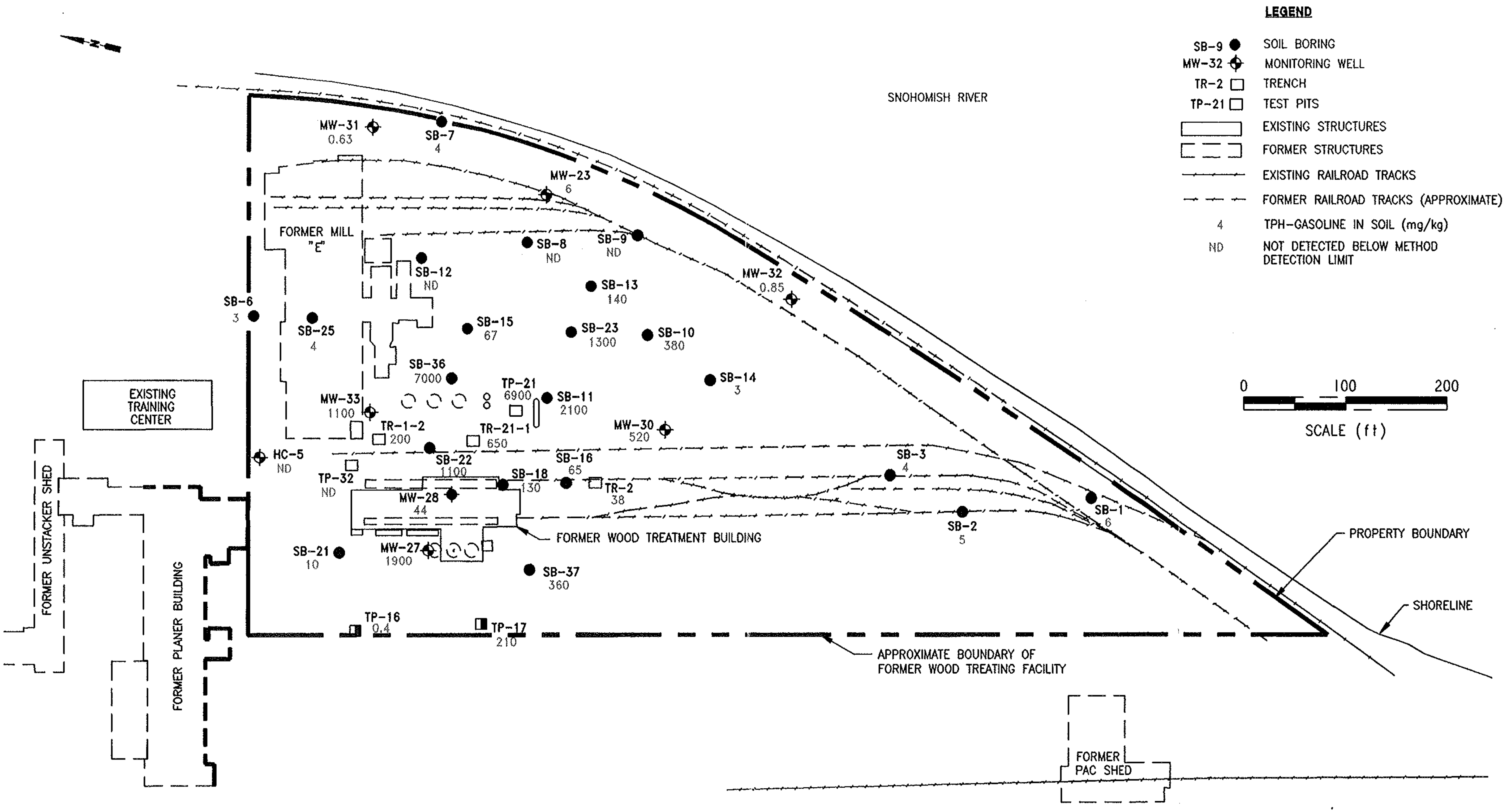
Figure 3-7
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
ARSENIC IN SOIL - UPPER SAND UNIT

1= 100 5-25-94 0141\037\17BLC59



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PROJECT NO.
0141-037.17

Figure 3-8
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TPH-GASOLINE IN SOIL
UPPER SAND UNIT

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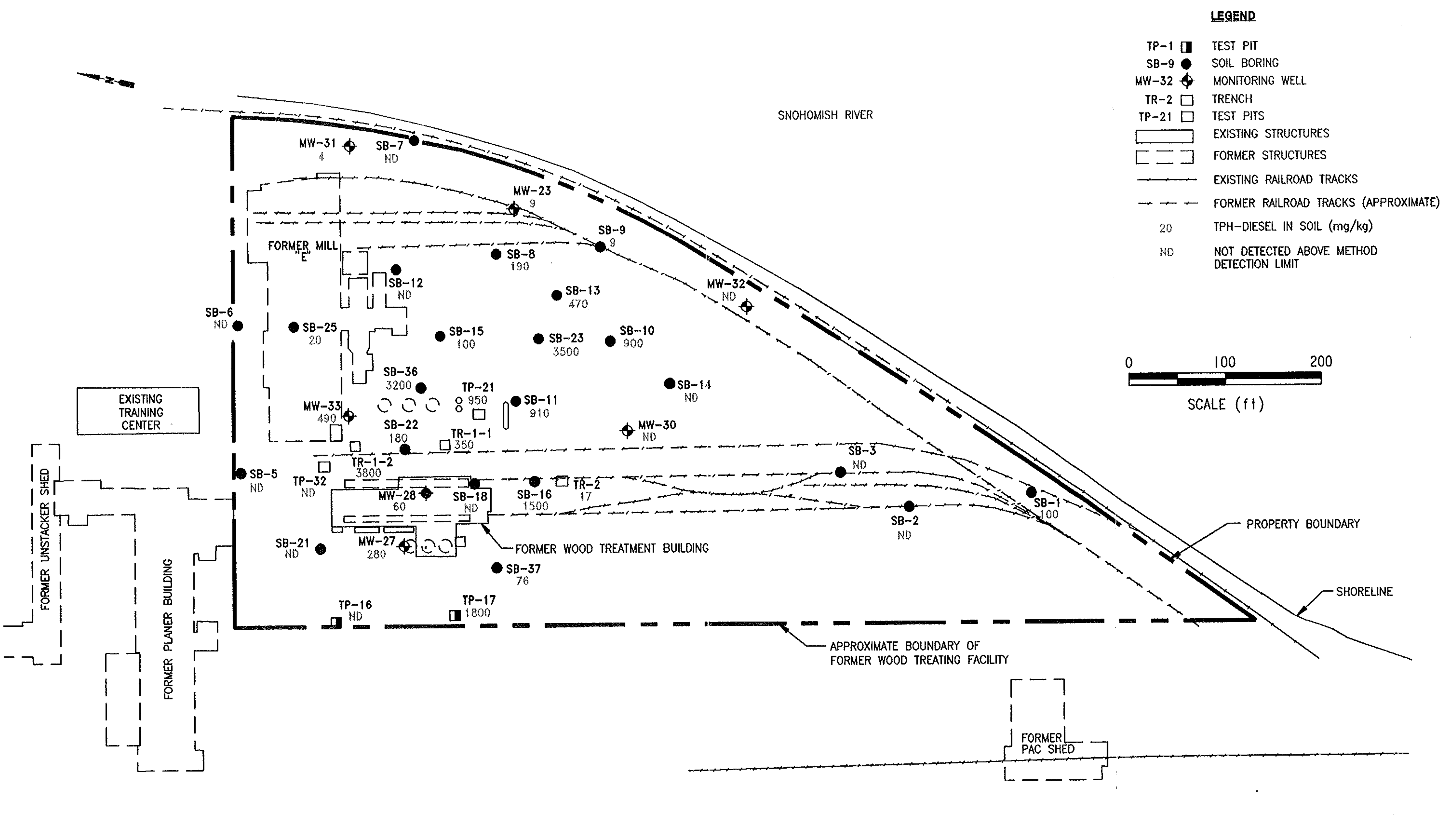
1= 100 5-25-94 0141\037\17BLC66



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0141-037.17

Figure 3-9
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TPH-DIESEL FUEL IN SOIL
UPPER SAND UNIT

1= 100 5-25-94 0141\037\17BLC65

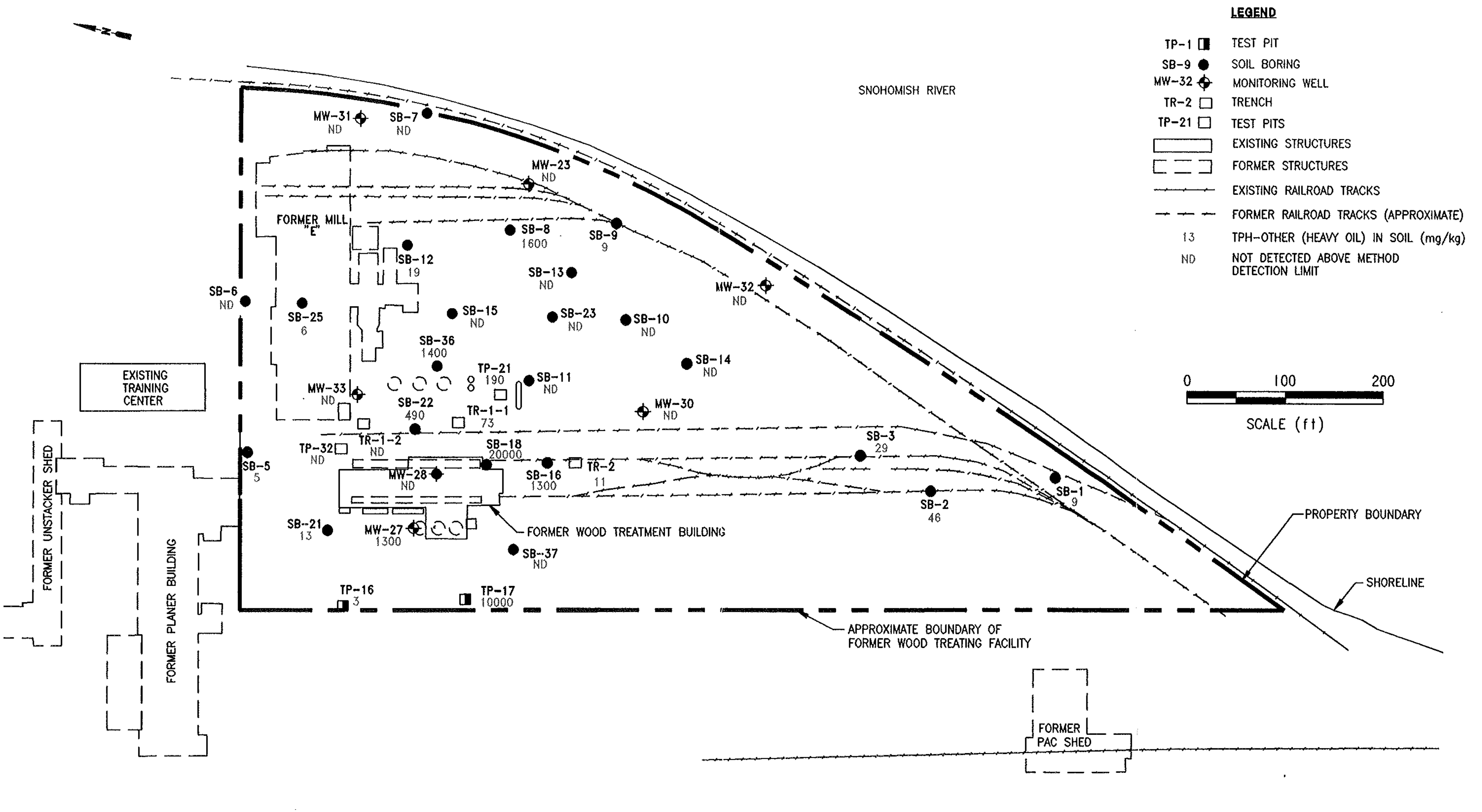

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Figure 3-10
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TPH-OTHER (HEAVY OIL) IN SOIL
UPPER SAND UNIT

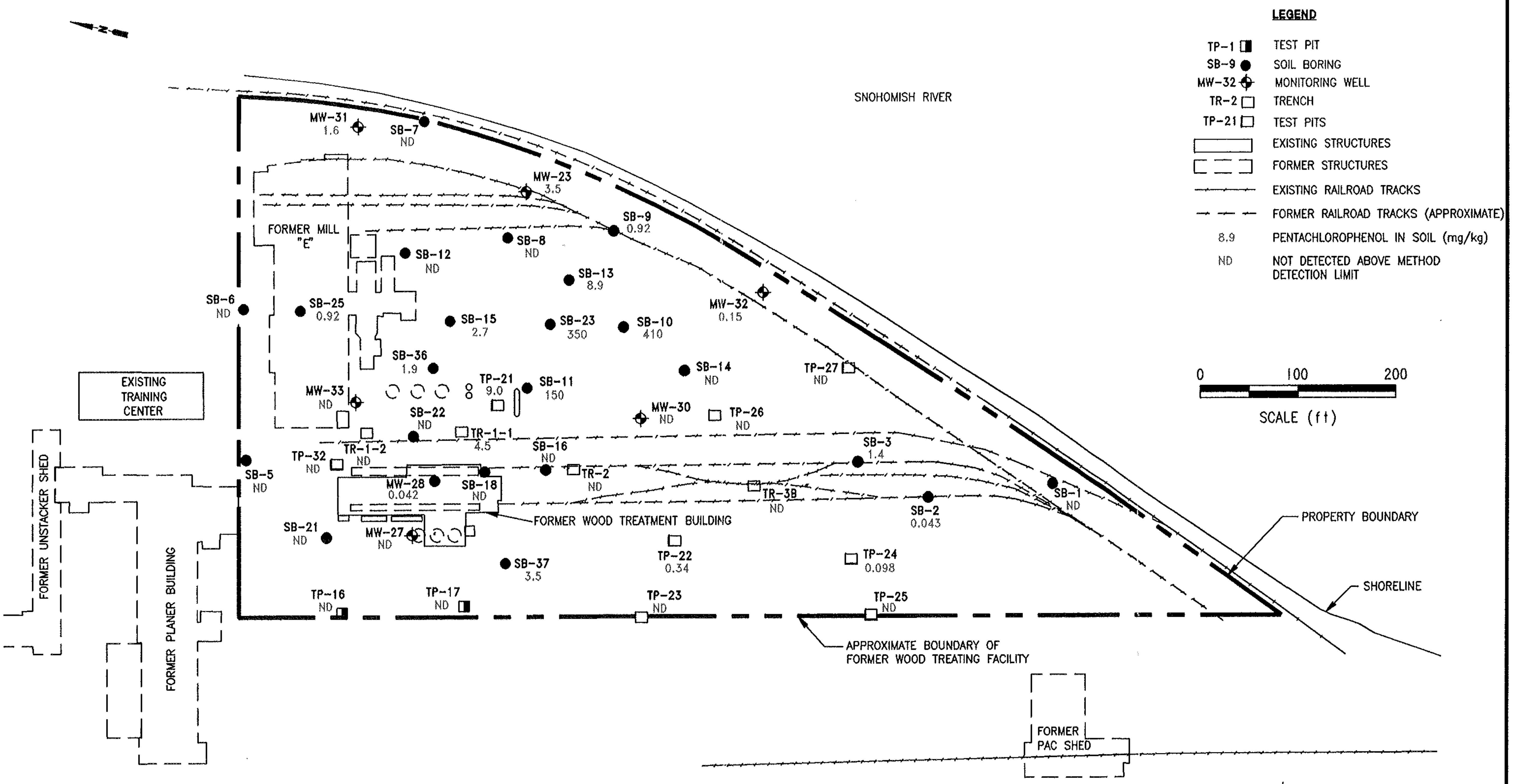

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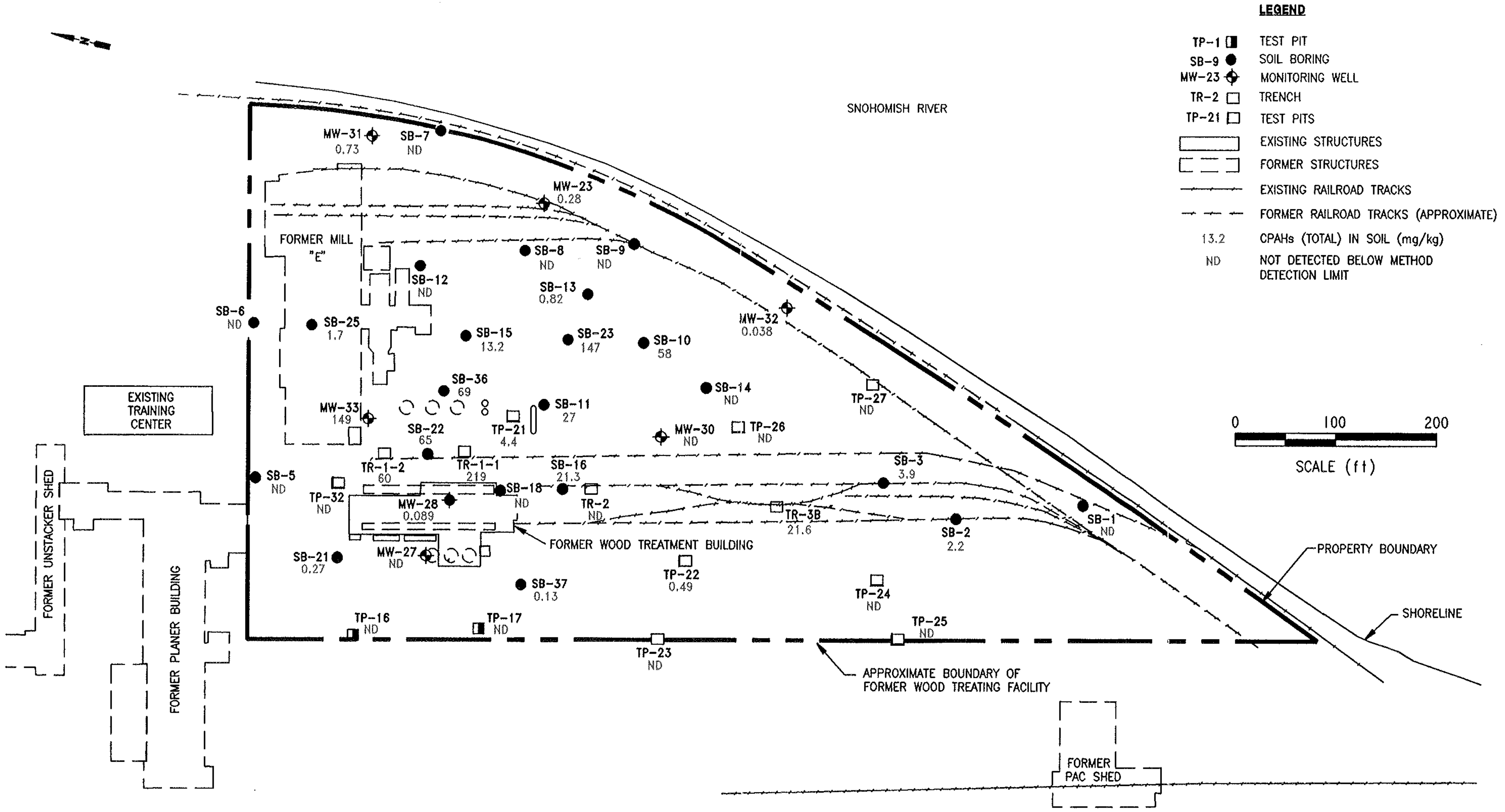
Figure 3-11
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
PENTACHLOROPHENOL IN SOIL
UPPER SAND UNIT

1= 100 5-25-94 0141\037\17BLC61



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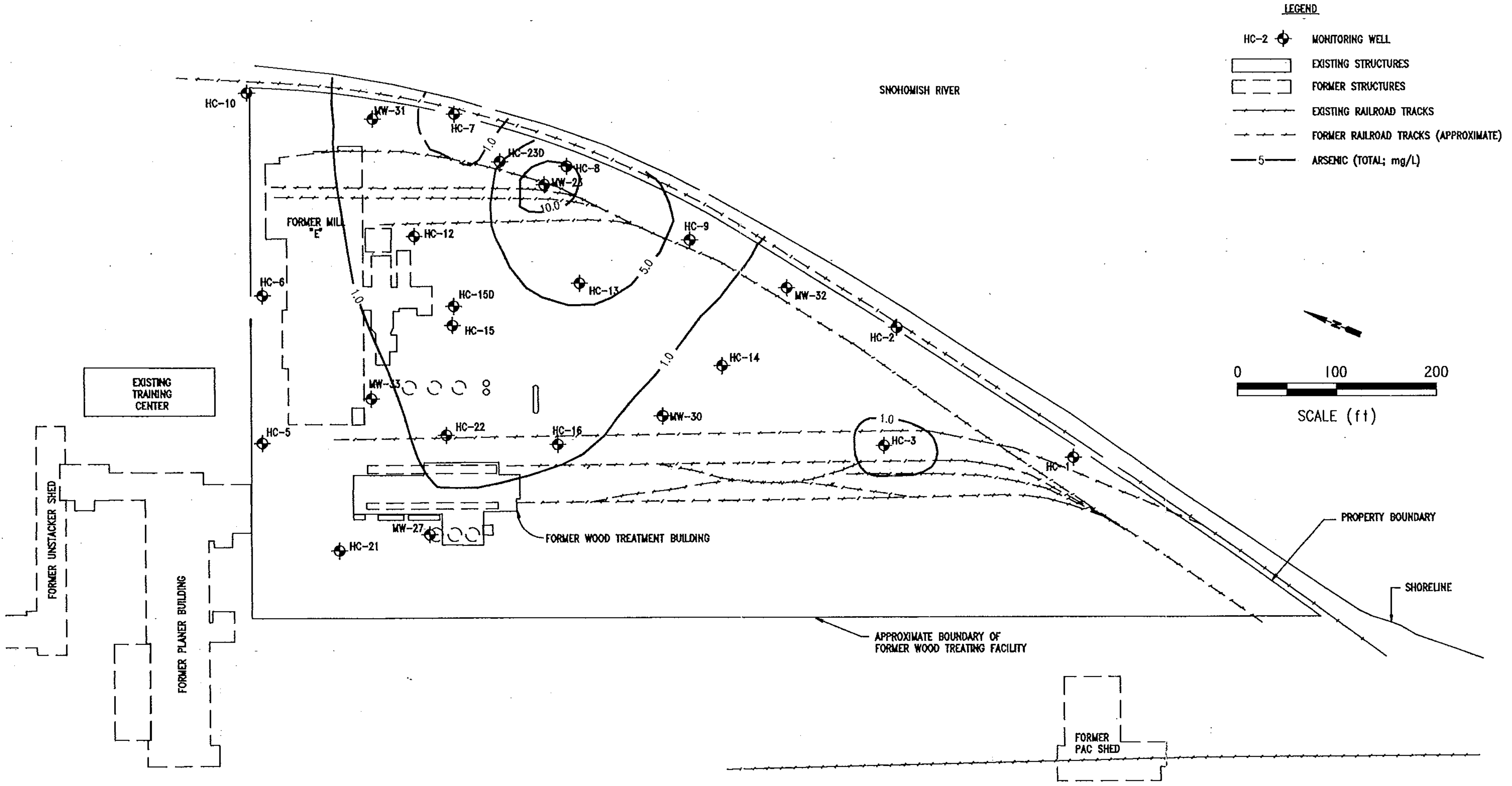
REV.
APPR. SN
PROJECT NO. 0141-037.17

Figure 3-12
WEYERHAEUSER COMPANY
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
CARCINOGENIC PAHs (TOTAL) IN SOIL
UPPER SAND UNIT

1= 100 4-25-94 0141\037\17BLC60



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APPR.
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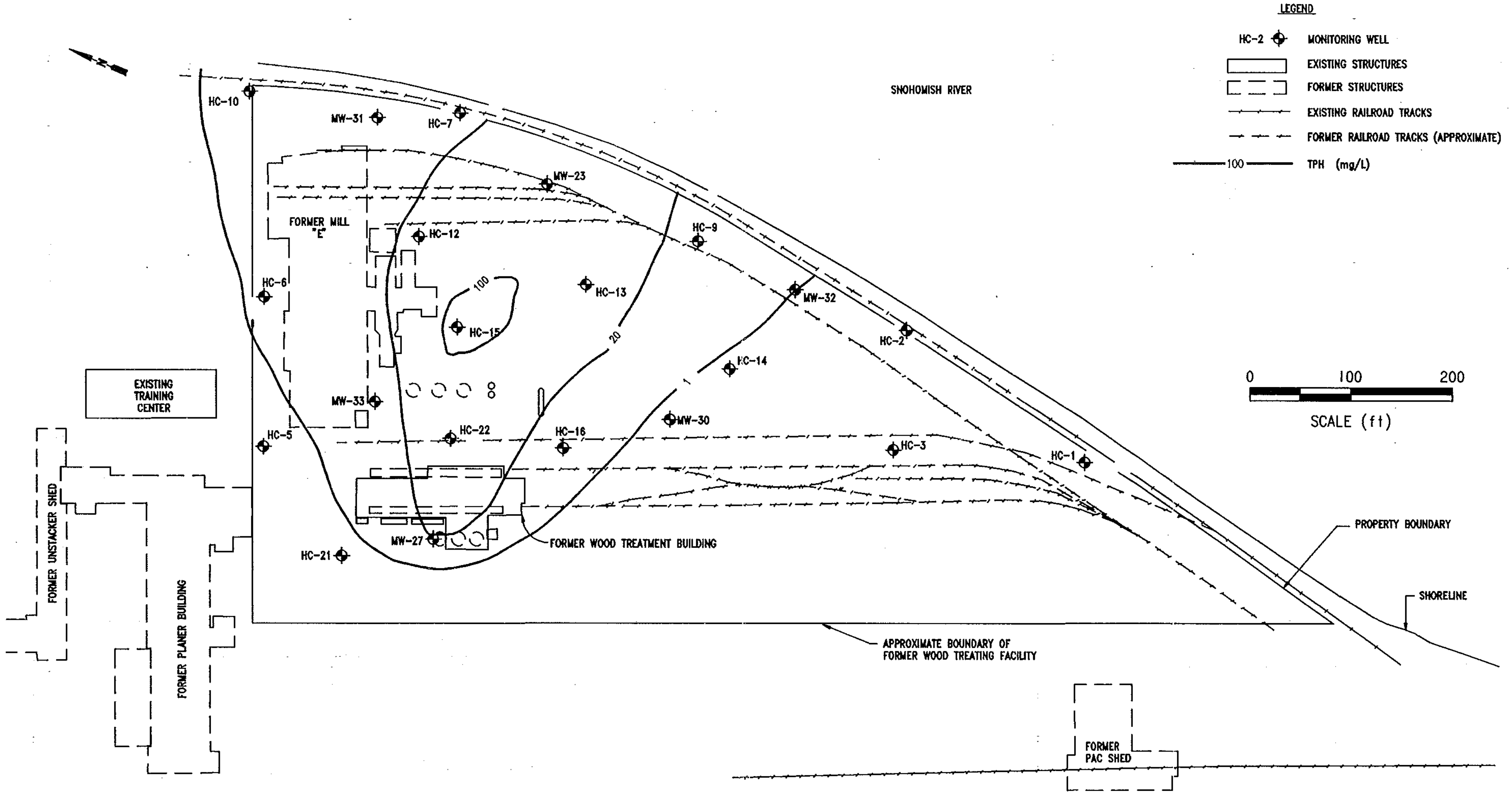
0141-037.17

Figure 3-13
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
ARSENIC IN GROUND WATER
UPPER SAND AQUIFER

1= 100 9-19-94 G:\DWG\0141\037\17BLC70



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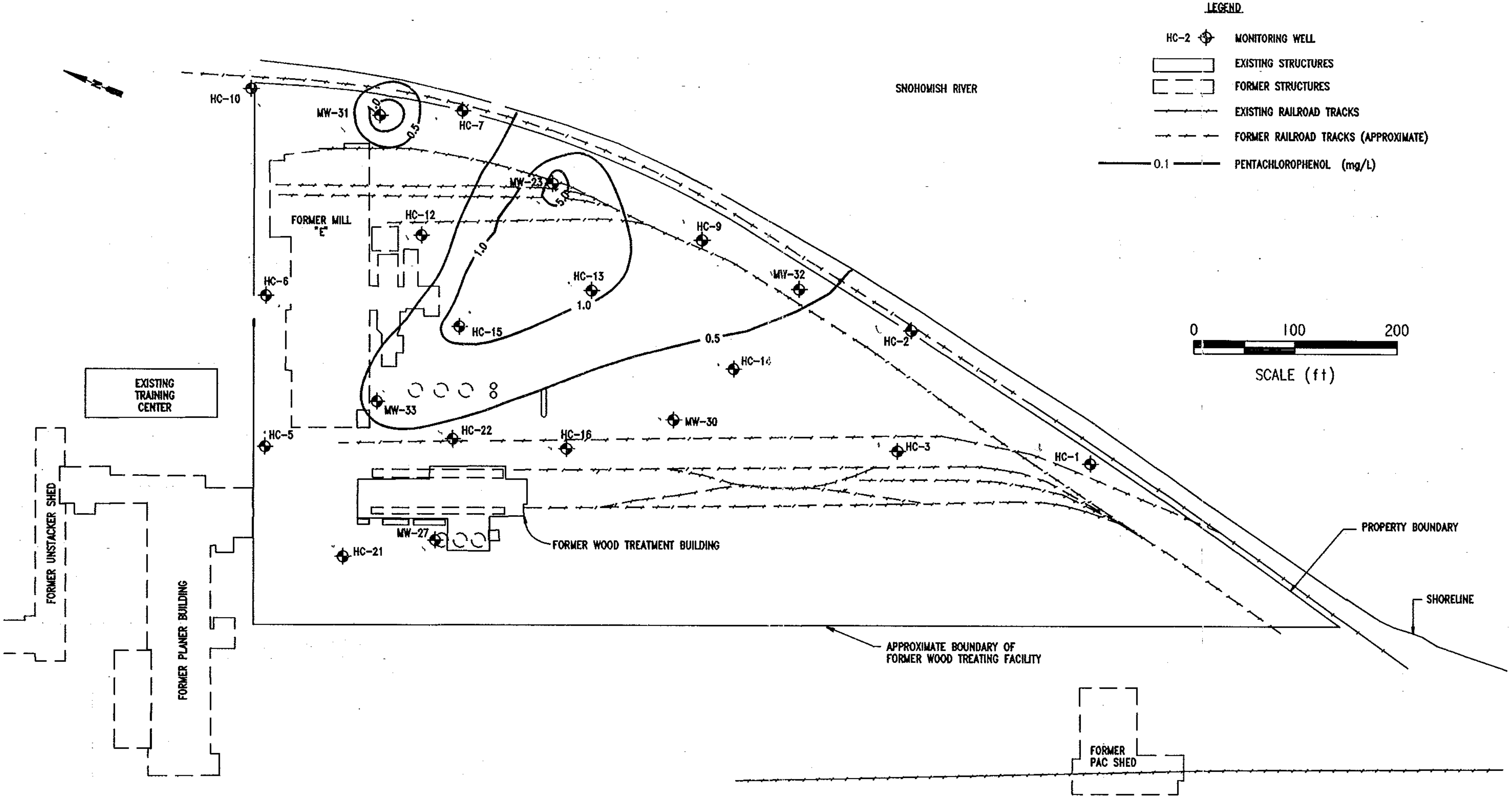
0141-037.17

Figure 3-14
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
TOTAL PETROLEUM HYDROCARBONS
IN GROUND WATER
UPPER SAND AQUIFER

1= 100 5-31-94 0141\037\17BLC71



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APPR. SDJ
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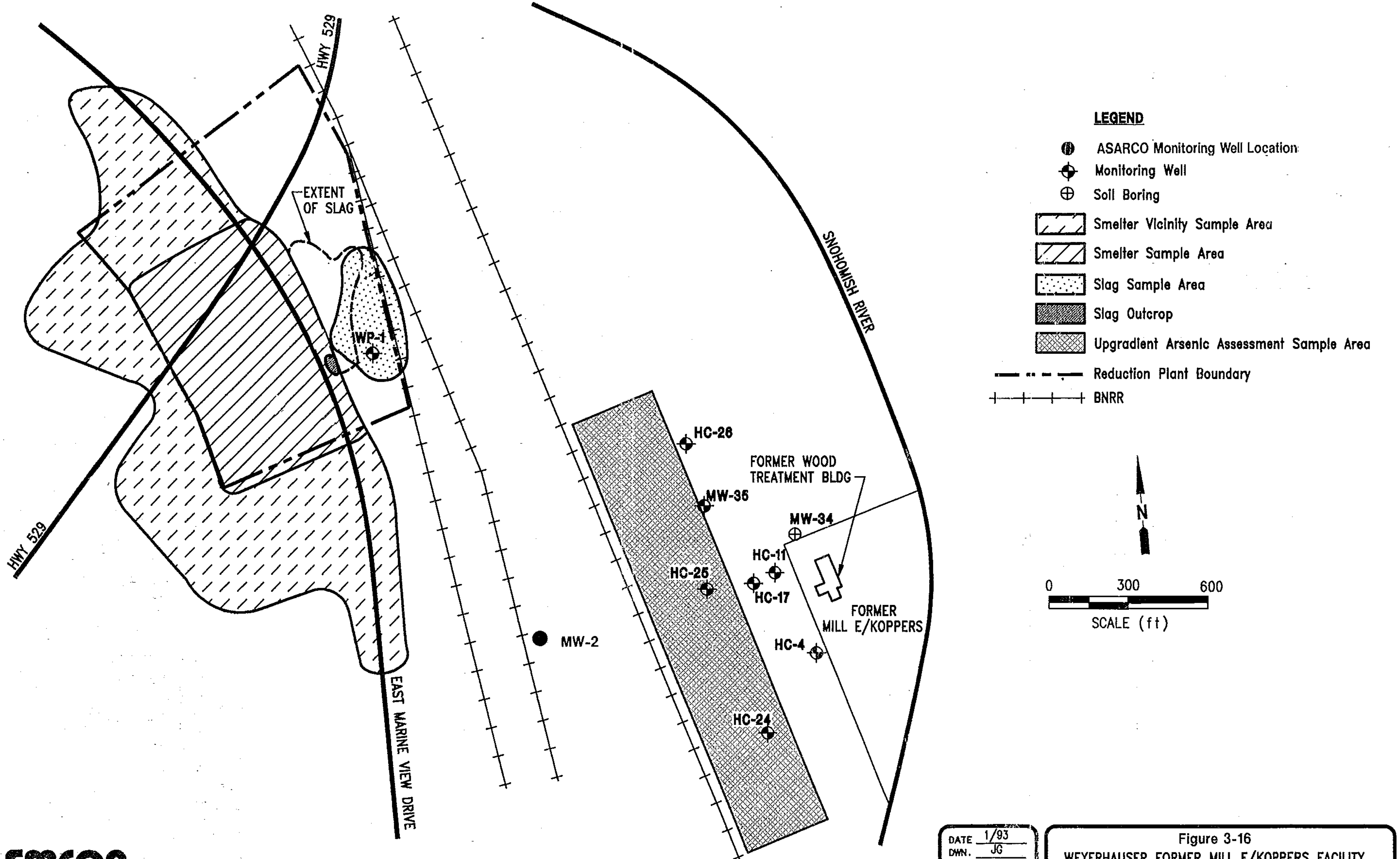
0141-037.17

Figure 3-15
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON
PENTACHLOROPHENOL IN GROUND WATER UPPER SAND AQUIFER

1= 100 5-31-94 0141\037\17BLC72



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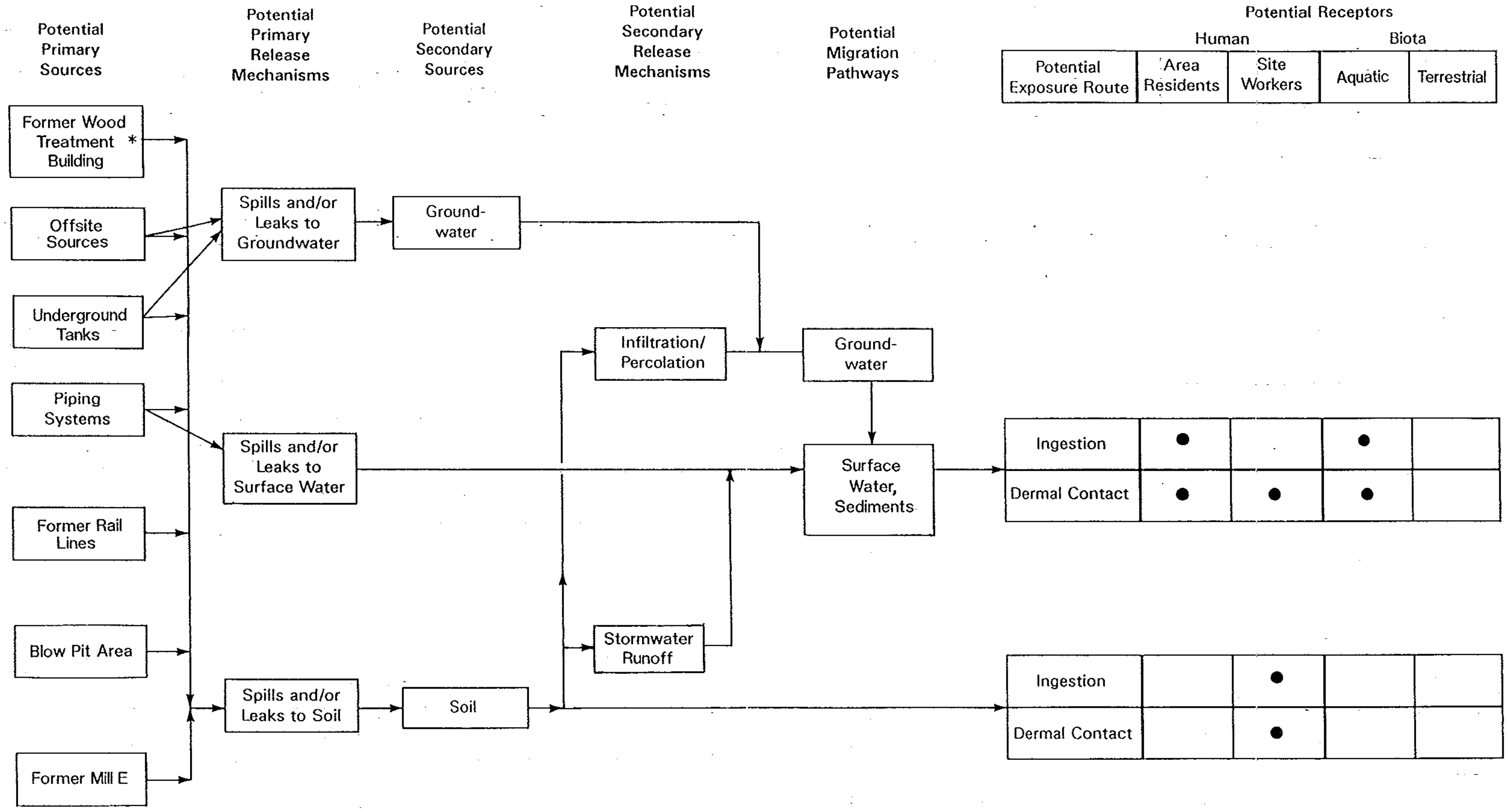
0141037.15

Figure 3-16
WEYERHAUSER FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

ARSENIC SAMPLING AREAS

1= 1 06-24-93 J:\DATA\DWG\0141\037\



Potential Exposure Route	Area Residents	Site Workers	Aquatic	Terrestrial
Ingestion	●		●	
Dermal Contact	●	●	●	

Potential Exposure Route	Area Residents	Site Workers	Aquatic	Terrestrial
Ingestion		●		
Dermal Contact		●		

* Includes Retorts and Aboveground Tanks

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Figure 5-1
FORMER MILL E/KOPPERS FACILITY
EVERETT, WASHINGTON

CONCEPTUAL SITE MODEL