PB96-964606
EPA/ROD/R10-96/138
July 1996

EPA Superfund Record of Decision:

Union Pacific Railroad Tie Treatment, The Dalles, OR 3/27/1996

EPA/ROD/R10-96/138
1996

EPA Superfund
Record of Decision:

UNION PACIFIC RAILROAD CO. TIE-TREATING PLANT
EPA ID: ORD009049412
OU 01
THE DALLES, OR
03/27/1996

RECORD OF DECISION

SELECTED REMEDIAL ACTION

for

THE UNION PACIFIC RAILROAD SITE

The Dalles, Oregon

MARCH 1996

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RECORD OF DECISION

SELECTED REMEDIAL ACTION

FOR THE UNION PACIFIC RAILROAD SITE

THE DALLES, OREGON

1.0 Introduction and Purpose

This document presents the selected remedial action for contaminated soil, groundwater, surface water and sediments, at the Union Pacific Railroad (UPRR) Tie-Treating Plant site in The Dalles, Oregon. The selected remedial action was developed In accordance with Oregon Revised Statutes (ORS) 465.200 through 465.380, and Oregon Administrative Rules (OAR) 340-122-010 through 340-122-110. Also, to the extent practicable, the selected remedial action is consistent with the National Contingency Plan (NCP), 40 CFR Part 300. The UPRR site is on the National Priorities List (NPL or federal "Superfund" site list). The Oregon Department of Environmental Quality (DEQ) is the lead regulatory agency overseeing the investigation and cleanup of the site.

The selected remedial action is based upon the Administrative Record for the site. A copy of the Administrative Record Index is attached as Appendix A. This staff report summarizes the more-detailed information contained in the Administrative Record, particularly in the Final Remedial Investigation Report, dated July 1993, and in the Final Feasibility Study, dated September 1995, for the Union Pacific Railroad Tie Treating Plant in The Dalles, Oregon.

2.0 Summary of Selected remedial action

The selected remedial action for groundwater at the UPRR site consists of the following elements: 1) recovery of wood-treatment oil from the groundwater, and recycling or reuse if possible; 2) hydraulic containment of the groundwater contaminant plume in the shallow, unconfined aquifer, and in the uppermost confined aquifer at the plant site; 3) extraction",of contaminated groundwater from these two aquifers extraction wells; 4) above-ground physical/c he mica I treatment of the extracted groundwater; 5) reinjection or reinfiltration of the water back into the aquifer(s); 6) disposal of. excess extracted water by land application, discharge to surface waters, or discharge to the City of The Dalles' sanitary sewer system; 7) restrictions on the use of groundwater at the site, including at nearby Riverfront Park; and 8) on-going groundwater monitoring.

The selected remedial action for surface water and sediments is no further action, other than on-going monitoring and maintenance of an existing multi-layer cap that covers approximately one-acre of contaminated sediments in a side channel of the Columbia River, offshore of the undeveloped portion of Riverfront Park. The cap was constructed during February and March 1995, as an Interim Remedial Action (IRA).

The selected remedial action for soils at the site consists of the following elements: 1) Institutional controls at the plant site (e.g., site access controls, land use restrictions, worker health and safety requirements, spill control plan, etc.); 2) deferred investigation and, as appropriate, cleanup of surface and subsurface soils that are currently inaccessible (e.g., beneath product storage tanks and treated wood storage areas); 3) phased in-situ Bioremediation of accessible subsurface soils, to the extent feasible; and, 4) no further action for an area in the undeveloped section of Riverfront Park from which contaminated soils were removed in September 1992, as an IRA.

A detailed description of the selected remedial action alternatives can be found in Section 9.

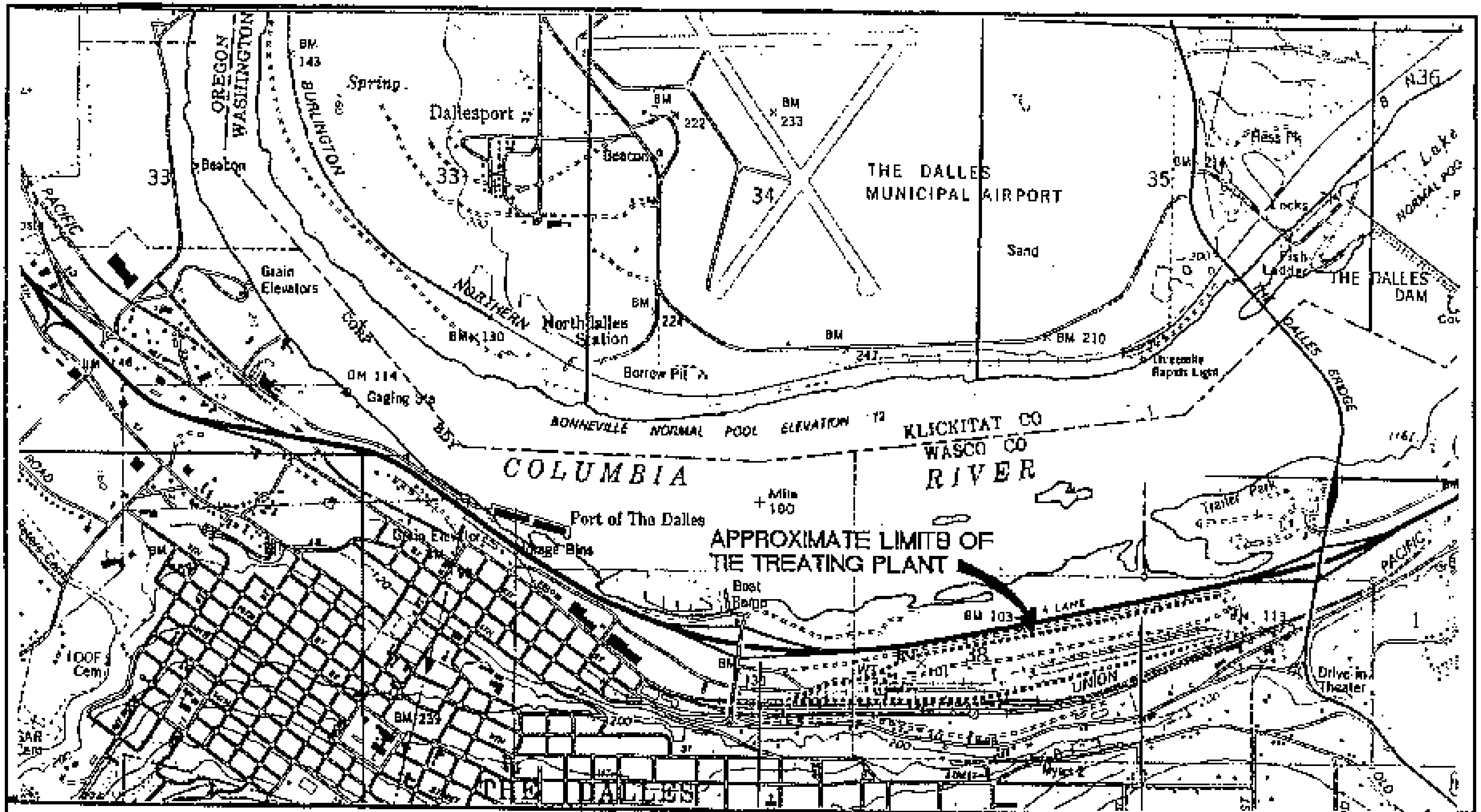
3.0 Site Description

The Union Pacific Railroad (UPRR) site consists of an active wood-treating facility (currently operated by Kerr-McGee Chemical Corporation), the undeveloped portion of Riverfront Park, and a small area of Columbia River sediments adjacent to the undeveloped portion of Riverfront Park, in The Dalles, Oregon.

The tie-treating plant is located on Tie Plant Road in The Dalles. It encompasses approximately 83 acres within Sections 1 and 2, Township 1 North, Range 13 East, Willamette Baseline and Meridian, in Wasco County, Oregon. As indicated in Figure 1., the plant site is located approximately 500 feet south of the Columbia River on an east-west trending alluvial terrace. Riverfront Park, The Dalles levee, and Interstate Highway 84 (1-84) are situated between the plant and the river, to the north. The plant is bordered by the UPRR railyard to the south, Threemile Creek and undeveloped land to the east, and by a residence and an access road to the west.

The plant's main office and all wood-treating facilities are located near the western end of the plant site. The eastern half of the plant has been used for storage of treated and untreated wood railroad cross ties. The site has been divided into separate study areas, based on historical operations, as indicated In Figure 2.

The plant site Is generally flat and slopes gently northward. The plant topography has been modified over the years by placement of sandy and gravelly fill material in various locations by plant operators. Fill material was placed to develop flat, uniform work areas. The current operator continues to place fill material at the plant site on an on-going basis.



NORTH

0 1000 2000 FEET

SCALE

LEGEND

- - - - - - - - Approximate Limits/Boundary

SOURCE:
USGS Base Map, 1977, The Dalles South, 7.5 Quadrangle

OREGON

MAP LOCATION

Figure 1
SITE LOCATION
UNION PACIFIC RAILROAD COMPANY
TIE-TREATING PLANT – THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

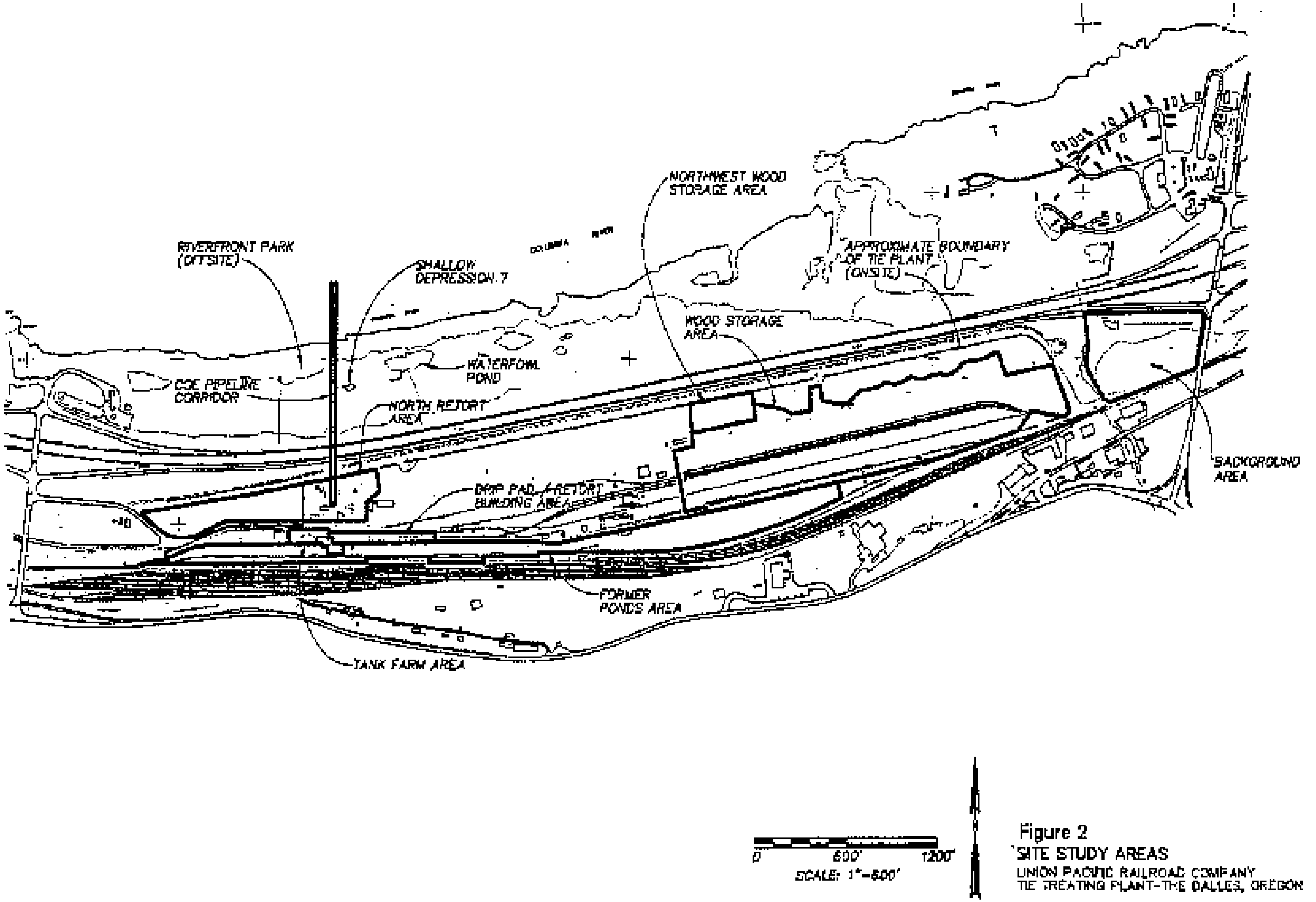


Figure 2
SITE STUDY AREAS
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

The climate at The Dalles is semi-arid. The region is characterized by cold, wet winters and warm, dry summers. The average temperature in 1989 was 54.70EF and the total precipitation was 10.08 inches. The -average annual precipitation during the period from 1931 to 1965 was 11.83 inches. Approximately 25 percent of the annual precipitation occurs as snowfall, with most of the remainder occurring as rainfall during the winter months.

Riverfront Park is divided into two sections: an undeveloped portion and a developed portion. The developed portion, at the western end, includes a swimming area, parking lot, picnic grounds, and recreational space. It is open to the public each year from Memorial Day weekend through October 31. The eastern two-thirds of the park, consisting of an undeveloped wildlife area, is open to the public from June 16 through October 31 each year. The wildlife area is a seasonal wetland that is used by migratory waterfowl during the winter. The area includes a nature trail that parallels the Columbia River, and an unpaved service road paralleling 1-84.

The soils beneath the UPRR site consist of unconsolidated sands, slits, and occasional gravels up to a depth of about 35 feet. Beneath these unconsolidated deposits is a sequence of basalt flows of the Columbia River Basalt Group, totaling more than 2,000 feet in thickness. The Columbia River Basalt Group flows, and their water-bearing zones, dip very gently to the northwest beneath the site.

Groundwater exists in both the unconsolidated alluvial deposits and in the underlying basalt. The water-bearing zones, in order of descending depth, are as follows (see Figure 3):

! The uppermost (unconfined) water-bearing zone consists of the unconsolidated alluvial deposits and the weathered upper surface of the Basalt of Sentinel Gap. This uppermost water-bearing zone is about 35 feet thick. The unconfined groundwater table is encountered at a depth of approximately 10 to 15 feet below ground surface (bgs).

! The Sand Hollow I confined aquifer consists of the interflow zone between the Basalt of Sentinel Gap flow base and the Basalt of Sand Hollow I flow top. It is encountered at a depth of approximately 80 feet bgs.

! The Sand Hollow II confined water-bearing zone consists of the interflow zone between the Basalt of Sand Hollow I flow base and the Basalt of Sand Hollow II flow top. It is encountered at a depth of about 160 feet bgs.

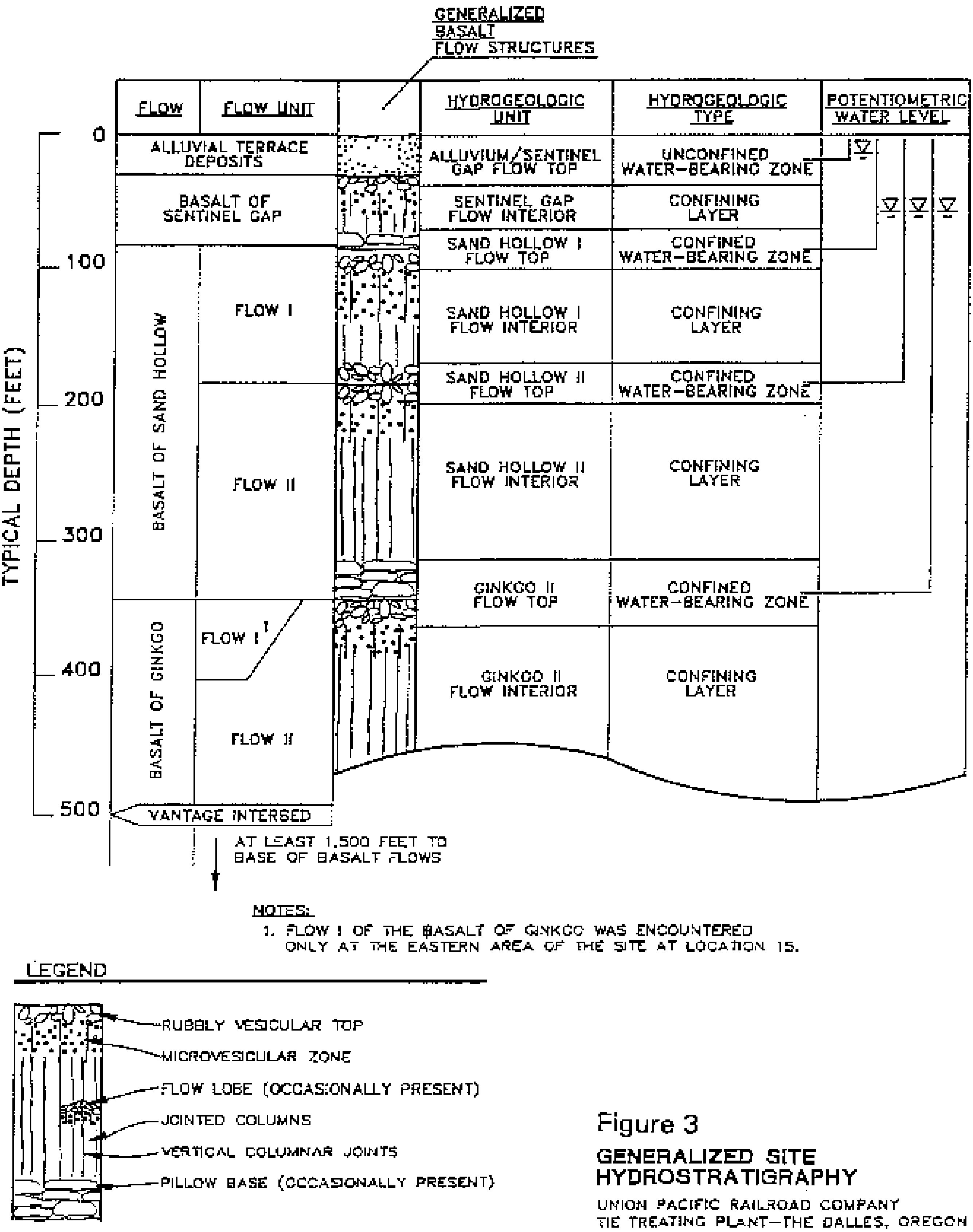


Figure 3

GENERALIZED SITE HYDROSTRATIGRAPHY

UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT—THE DALLES, OREGON

Source: Final Feasibility Study Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, Sept. 1995

- The Ginko II confined aquifer consists of the interflow zone between the Sand Hollow II flow base and the Basalt of Ginko Flow II flow top (except in the eastern part of the site where the Ginko II underlies the Ginko 1). It is encountered at a depth of about 330 feet bgs.

The confined basalt aquifers supply the majority of the groundwater needs in the area. Those zones that underlie The Dalles are designated by the Oregon Water Resources Department (OWRD) as The Dalles Groundwater Reservoir (DGWR) or, informally, as "The Dalles pool." In 1959, the Oregon State Engineer designated The Dalles area as a "Critical Groundwater Area," in recognition of declining water levels in the DGWR over a period of years. Because the DGWR is a critical groundwater area, OWRD closely monitors groundwater withdrawal, and restricts the installation of new wells, with a goal of no net additional groundwater withdrawal.

As part of the Remedial Investigation at the UPRR site, a well use survey was conducted in the area surrounding the tie treating plant. No wells were found which use water from the unconfined water-bearing zone, probably because of low yields from this zone. The closest active well to the site is the City of The Dalles' Lone Pine Well. It is located approximately 6,400 feet east-northeast of the retort building area at the plant site. The results of the well use survey are presented in Section 5.2.

4.0 Site History

4.1 Site Activities

The plant has been used for tie-treating operations since 1923. UPRR's corporate predecessor, the Oregon-Washington Railroad and Navigation Company, owned and operated the plant from 1923 to 1921. During the next 23 years (1927-50), UPRR contracted plant operations to Nebraska Bridge and Timber Supply Company (later known as Forest Products Company). From 1950 to 1987, UPRR contracted with J.H. Baxter and Company to operate the plant. In November 1987, the facility equipment and above-grade structures were purchased from UPRR by Kerr-McGee Chemical Corporation (KMCC). However, UPRR has retained property ownership and responsibility for any environmental concerns that occurred prior to KMCC's purchase.

The plant has operated exclusively as7a wood-treatment facility since its inception. Prior to the 1950's, the plant treated virtually all wood products with coal tar creosote. From 1950 to 1987, creosote and creosote-fuel oil mixture accounted for more than 85% of the total volume of treating chemicals used at the site. Otherwood preserVatives used during this period included ammoniacal copper arsenate (ACA), pentachlorophenol (PCP), and Arban (an organophosphate fire retardant). ACA represented about 5 to 10 percent of the volume of treatment chemicals used at the plant. PCP and Arban use by volume was about 1 percent and less than 1 percent respectively. Since December 1987, creosote and creosote-fuel oil mixtures have been the primary wood preservatives used at the site. KMCC used copper naphthanate to treat wood on a limited basis in 1993 and 1994, but is no longer using this material.

Wood treatment operations at the site are conducted in five pressurized retorts. Wastes associated with this process include steam condensate, boiler blowdown, water and oil containing wood preservatives, and residues resulting from the cleanout of retorts, oil/water separators, and wastewater treatment systems. During early years of operation, until about 1980, process wastewaters were disposed of onsite in four former ponds (see Figure 2). Also, although early waste management records are not available, sludges associated with cleaning out the retorts may have been disposed of in the ponds. The ponds were abandoned by UPRR in 1980. In addition, there is evidence of historic leaks or spills around the product storage and treatment facilities and, in the past, treated wood was allowed to drip dry on unpaved soils at the site. In 1987, a concrete drip-containment pad was constructed in front (east) of the retort building, to catch and contain drippings of wood-treatment chemicals from wood emerging from the treatment retorts.

4.2 Previous Site Investigations

Initial environmental Investigations at the site began in 1985, under authority of DEQ's water quality program. UPRR conducted a four-phase groundwater monitoring program, as part of the renewal requirements for a Water Pollution Control Facility Permit. In 1988, Ecology and Environment, Inc., a contractor for the U.S. Environmental Protection Agency (EPA), conducted a brief investigation ("site inspection") of the site. These early studies confirmed the presence of wood-treating chemical wastes in on-site soils, and in groundwater beneath the site.

In 1988, an on-site well identified as well 2F(1) was properly abandoned. The initial hydrogeologic investigations at the site had identified the well as a possible conduit for contaminant migration into water-bearing zones.

In 1989, when the initial hydrogeologic investigations and EPA's inspection were completed, DEQ and UPRR entered into a Consent Order which required that UPRR conduct a Remedial Investigation (RI) and Feasibility Study (FS) at the site. In addition, EPA proposed that the site be added to its National Priorities List (NPL or "Superfund Site List"). The site was formally added to the NPL in 1990. Since DEQ had already initiated site investigations, and had entered into a Consent Order with UPRR, EPA agreed to allow DEQ to remain as the lead regulatory agency under the Superfund program.

The RI began in 1990, and the FS began in 1991. The Remedial Investigation was completed with the approval of the RI Report in August 1993. The Feasibility Study was completed with the approval of the FS Report in October 1995. The results of the RI are presented in Section 5. The results of the FS are presented in Sections 6 and 7.

4.3 Interim Remedial Measures

As noted in Section 2.0, several interim remedial actions (IRAs) have been completed at the site, under the 1989 DEQ/UPRR Consent Order, to address the most serious and time-critical threats to public health, safety and welfare, and the environment.

In September and October of 1992, approximately 2,450 cubic yards of contaminated soil were excavated from the undeveloped portion of Riverfront Park and properly disposed off-site in a licensed hazardous waste landfill. The excavations were backfilled with clean soil and re-vegetated with native plants. Public notice and a 30-day public comment period were provided, prior to, initiating this IRA.

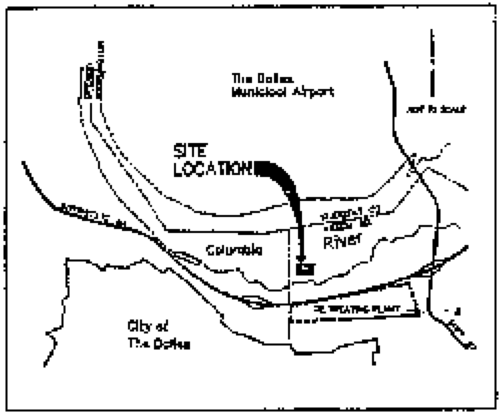
During the excavation activities in the undeveloped portion of Riverfront Park, a former pipeline constructed by the U.S. Army Corps of Engineers (COE) in 1937 was discovered. The pipeline is believed to have been the source of the soil contamination in the park. The pipeline was originally constructed to carry stormwater runoff from the plant site to the Columbia River. At times, the runoff apparently was contaminated with wood-treatment chemicals. The pipeline had two discharge points, a high water discharge point in the park, and a low water discharge point on the Columbia River shoreline. The pipeline was properly abandoned in 1992, by cutting it and filling it with concrete at six locations in the park. The soil removal and pipeline abandonment are more fully described in the May 1993 *Closure Report, Interim Remedial Action at Riverfront Park, The Dalles, Oregon.*

In February 1994, Kerr-McGee Chemical Corporation (KMCC), the tie-treating plant operator, had an accidental release of approximately 125 gallons of creosote/fuel oil mixture. In response to this release, and under DEQ's direction, KMCC removed and replaced approximately 61 cubic yards of surface soil and gravel fill at the plant site. The removal area included the location of surface soil sample number SS-22 (see Figure 10). This sample location had shown the highest concentration of arsenic contamination on the plant site, during the Remedial Investigation. Accordingly, as a result of this removal action, threats to site workers from exposure to surface soils in this area have been reduced.

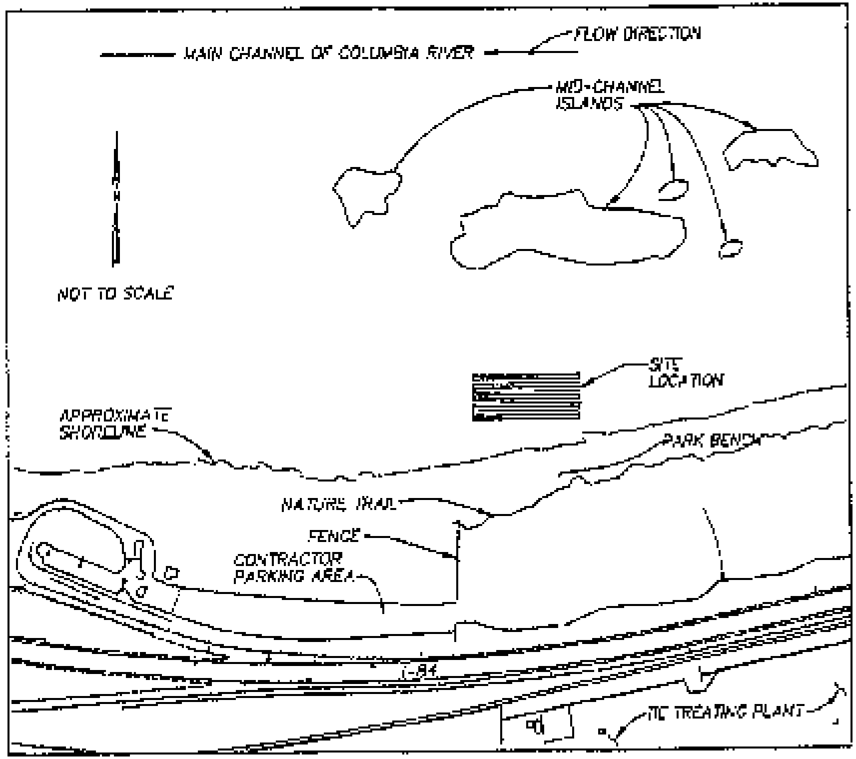
In February and March 1995, a second IRA associated with the former COE pipeline was conducted, also following a public comment period. An area of contaminated sediments in a side channel of the Columbia River were covered with a multi-layer cap. The contaminated sediments in this area are associated with the "low water" discharge point of the former pipeline, as described above. The cap consists of an initial layer of polyester fabric, an intermediate layer of gravel, and an upper layer of rock rip-rap. The location of the cap is marked with buoys, to alert boaters. Figure

4 shows the location of the capped area. Construction of the cap Is more fully described in the July 1995 *Final Closure Report, Union Pacific Railroad Columbia River Operable Unit Cap Construction.*

UNION PACIFIC RAILROAD COMPANY
COLUMBIA RIVER OPERABLE UNIT CAP



VICINITY MAP



SITE MAP

NO. DATE	REVISION	BY	APPD

UNION PACIFIC RAILROAD COMPANY
COLUMBIA RIVER OPERABLE UNIT CAP
THE DALLES, OREGON

Figure 4
Sediment Cap Location

SHEET 1/4
DWG NO. CAP-1
DATE 10/12/94

5.0 Results of Recent Investigation

As described In Section 4.2, DEQ determined in 1989 that detailed investigations were needed at the UPRR site. The results of the Remedial Investigation (RI) define the nature and extent of contamination in the soil, groundwater, surface water and stream sediments at and near the site, sufficiently for the development of remedial action alternatives. The principal contaminants are constituents of the wood-treating chemicals used at the site, including the following:

- **Carcinogenic polycyclic aromatic hydrocarbons (CPAHs)** are constituents of creosote, which is still being used at the site. Of the 16 PAHs detected at the site, 7 are classified as carcinogens (i.e., cancer-causing). The seven CPAHS are benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and benzo(a)pyrene.

- **Pentachlorophenol (PCP)** was used a wood-treating constituent at the site from the 1950s through November 1987. PCP is a known carcinogen.

- **Naphthalene** is a major constituent of creosote. Although naphthalene is not carcinogenic, it Is the most prevalent PAH in creosote and is one of the most mobile creosote constituents in the environment.

- **Arsenic** was used as a wood-treating constituent from the 1950s through 1987. It is a known carcinogen.

- **Benzene** is a constituent of the fuel oils used as part of the wood-treating process. It is a known carcinogen.

Contaminants from historical wood-treating practices are found primarily In the groundwater, surface soils, subsurface soils, and Columbia River sediments. Contaminants were infrequently detected in surface water, in sediments other than in the Columbia River, and in the air. The results of the RI with respect to these various media are discussed below.

As noted in Section 4.0, separate, focused investigations were conducted in the undeveloped portion of Riverfront Park, and along the Columbia River Shoreline, in order to facilitate the quickest possible cleanup of those areas. The results of those investigations are presented in the May 1992 *Interim Remedial Action Plan for Riverfront Park Cleanup, The Dalles, Oregon* and the October 1994 *Remedial Investigation Report, Columbia River ShorelinelAbandoned COE Pipeline Operable Unit.*

The Feasibility Study for the UPRR site evaluated cleanup alternatives for contaminated groundwater and on-site soils. Specifically, the FS addressed EPA's requirements under the National Contingency Plan (40 CFR Part 300), which are the federal "Superfund" regulations, as well as DEQ's requirement for cleanup to background levels or to the lowest concentration levels protective and feasible (OAR 340-122-090). Cleanup options for Riverfront Park soil and sediments, including Columbia River sediments, were evaluated in the May 1992 IRA plan referenced above and in the October 1994 *Interim Remedial Action Plan, Columbia River Shoreline/Abandoned COE Pipeline Operable Unit.*

5.1 Nature and Extent of Groundwater Contamination

As part of the groundwater investigation at the UPRR site, a total of 56 monitoring wells and piezometers (well-like devices in which water level measurements are taken) were installed at and near the site, including in the undeveloped portion of Riverfront Park. The locations of the wells and piezometers are shown on Figure 5.

Groundwater contamination at the UPRR site is caused by deposits of dense, oily, wood-treating chemicals (dense, non-aqueous phase liquids or DNAPL), which dissipate to dissolved constituents with increasing distance from the areas of past releases at the site (e.g., the former ponds, retort building area, treated wood storage area, etc.). DNAPLs at the site consist primarily of creosote and fuel oil mixture containing PAH constituents. Measurable amounts of other constituents, including PCP and arsenic, are also present in the DNAPL. The DNAPL has a specific gravity about 1.04, and a viscosity about 50 times that of water. Accordingly, it tends to move slowly downward in the subsurface, due to gravity, and tends to accumulate in pools at the bottom of the water-bearing zones. The mobile DNAPL pools, and residual immobile DNAPL zones left behind from downward-migrating DNAPL, will serve as continuing, long-term sources of dissolved-phase groundwater contamination.

Mobile-phase DNAPL (in deposits up to ten feet thick) has been found in the unconfined water-bearing zone and in a portion of the confined Sand Hollow II water-bearing zone, near now sealed Well 2F(1). Figure 6 shows the areal extent of DNAPL in the unconfined aquifer. Residual, immobile DNAPL is suspected of occurring in the Sand Hollow I and Sand Hollow II flow tops. A minor film of floating oil (light, nonaqueous phase liquid or LNAPL) is also found in the unconfined aquifer.

Dissolved contaminants are found in the unconfined water-bearing zone, and in the confined Sand Hollow I and II water-bearing zones. The plume of dissolved contamination in the unconfined water-bearing zone extends to the Columbia River (see Figure 7). Also, dissolved contaminants are believed to be migrating downward from the unconfined to the Sand Hollow I water-bearing zone. Figure 8 shows the extent of the dissolved contaminant plume in the Sand Hollow I water-bearing zone. No contamination has been detected in the confined Ginko II water-bearing zone.

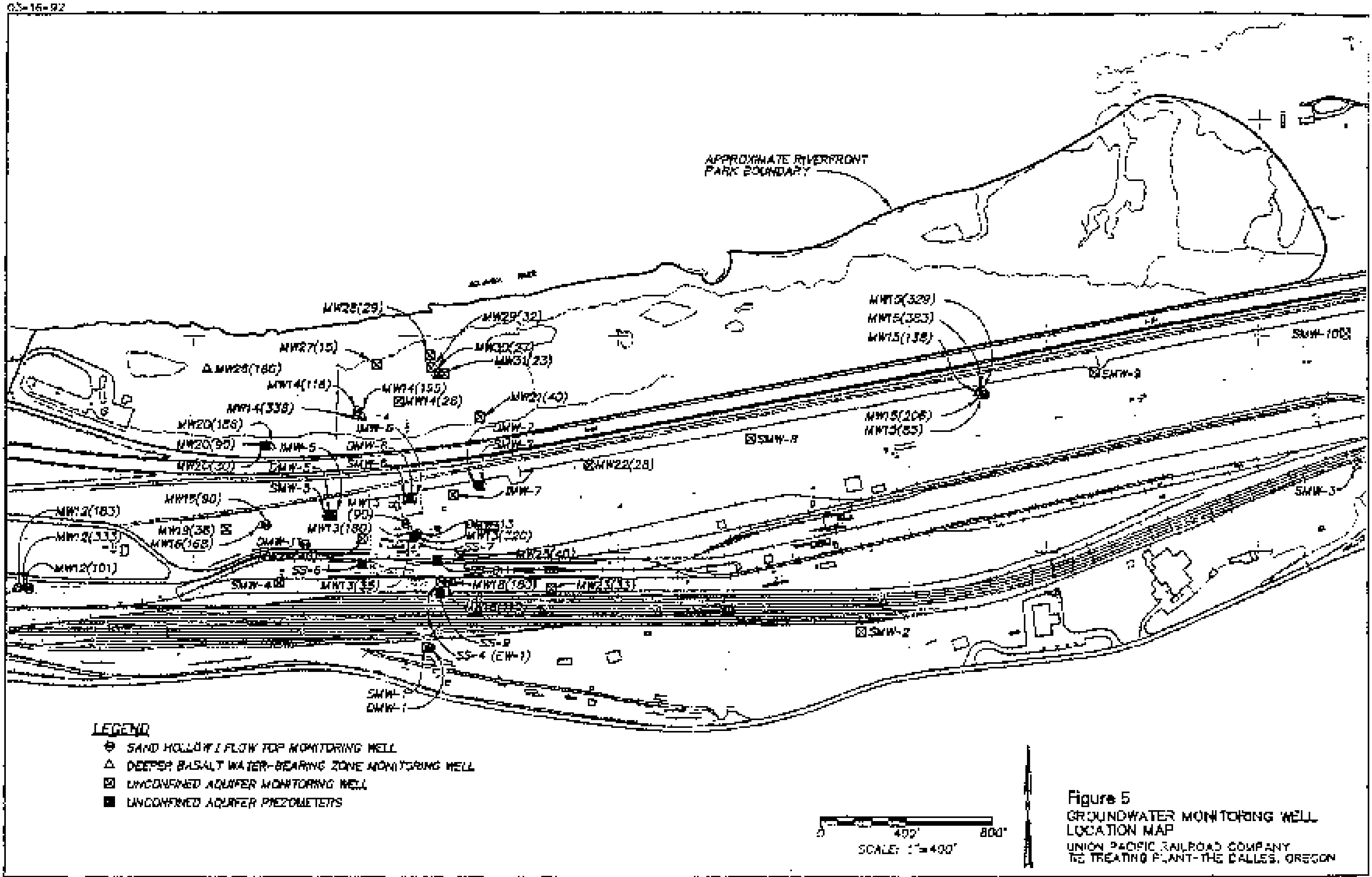


Figure 5
GROUNDWATER MONITORING WELL LOCATION MAP
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: First Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

11-30-95 C84A.DWG

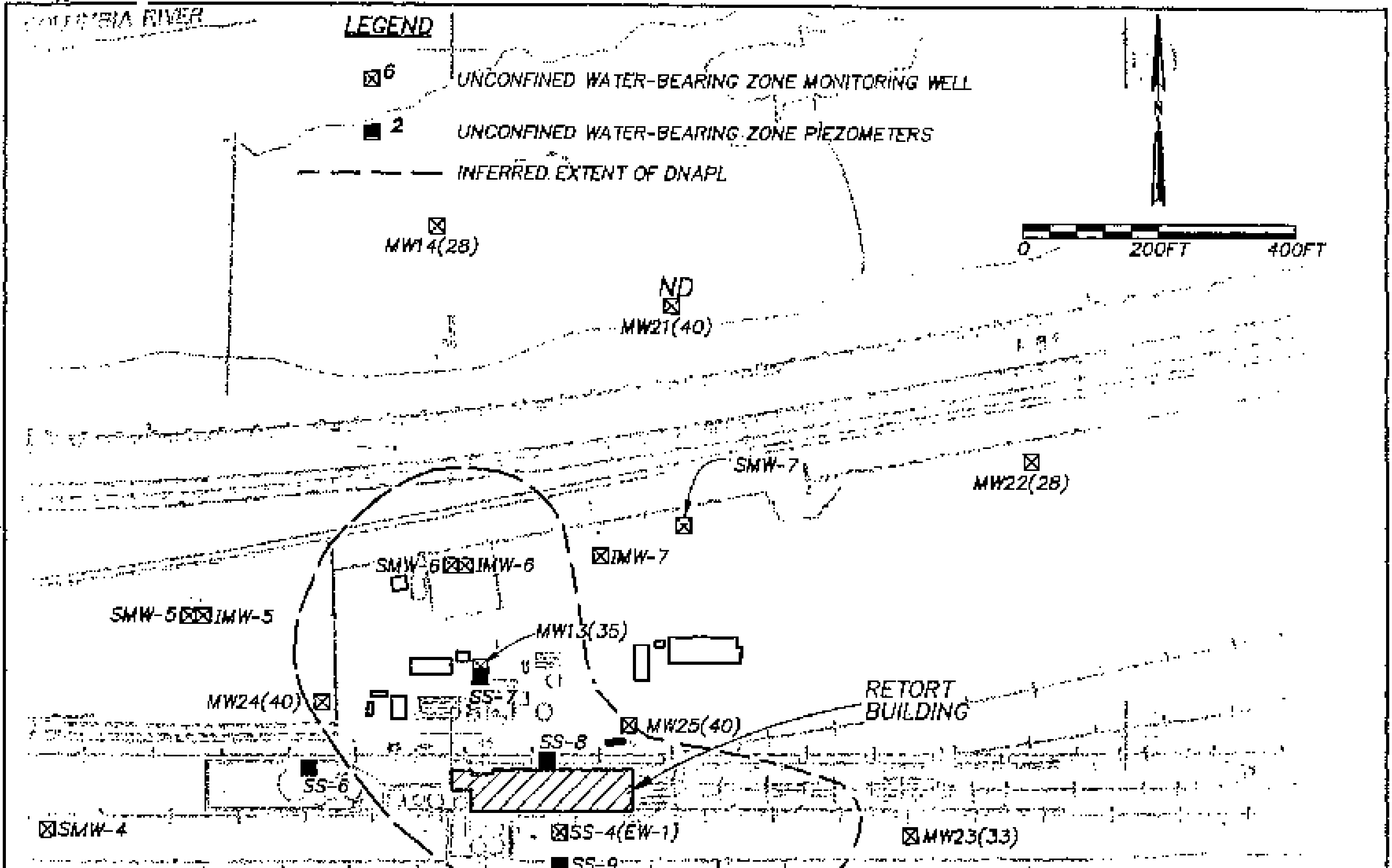


Figure 6
DNAPL EXTENT FOR UNCONFINED AQUIFER
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: CH2M Hill, November 1995

03-21-91

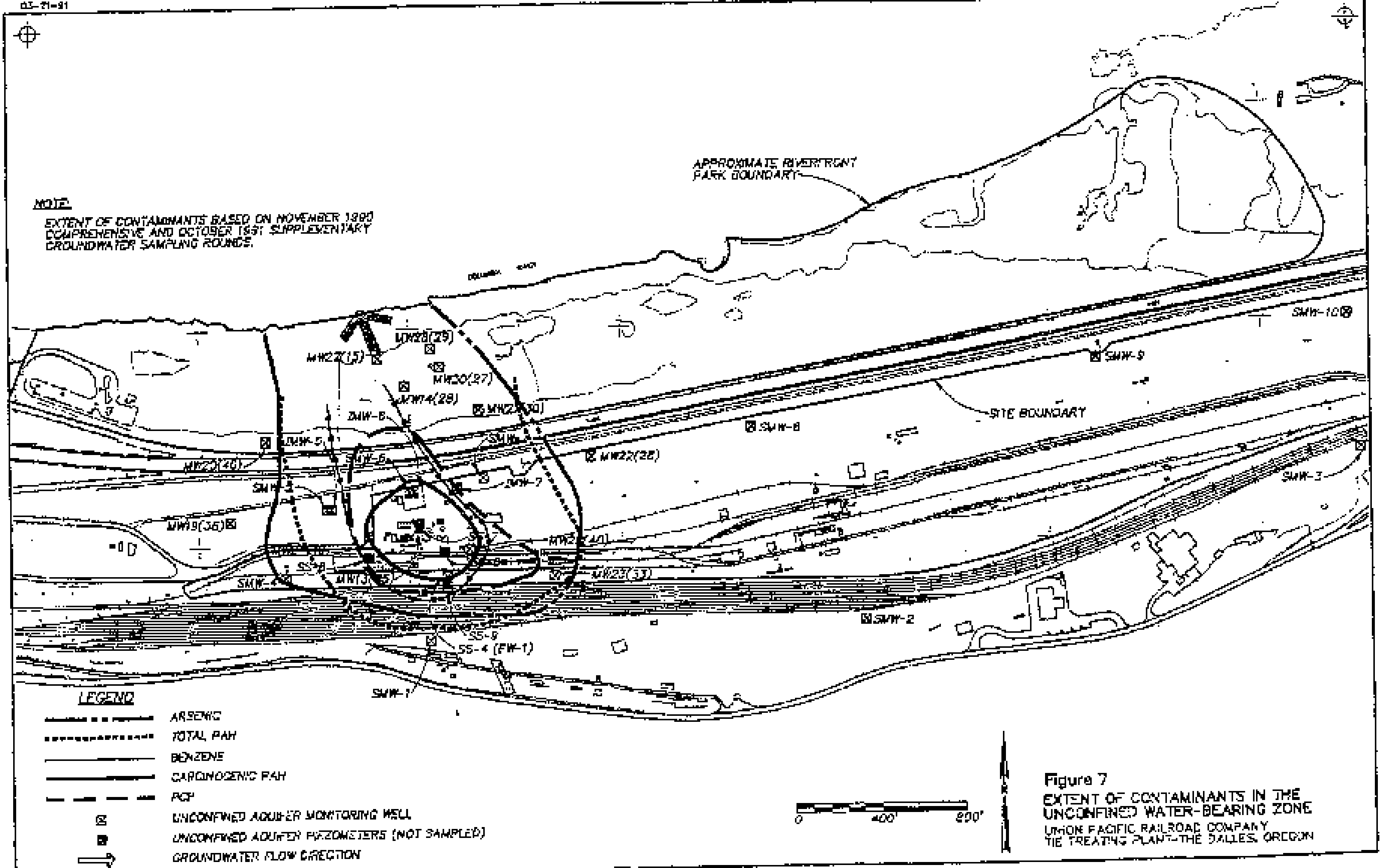


Figure 7
EXTENT OF CONTAMINANTS IN THE UNCONFINED WATER-BEARING ZONE
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT–THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

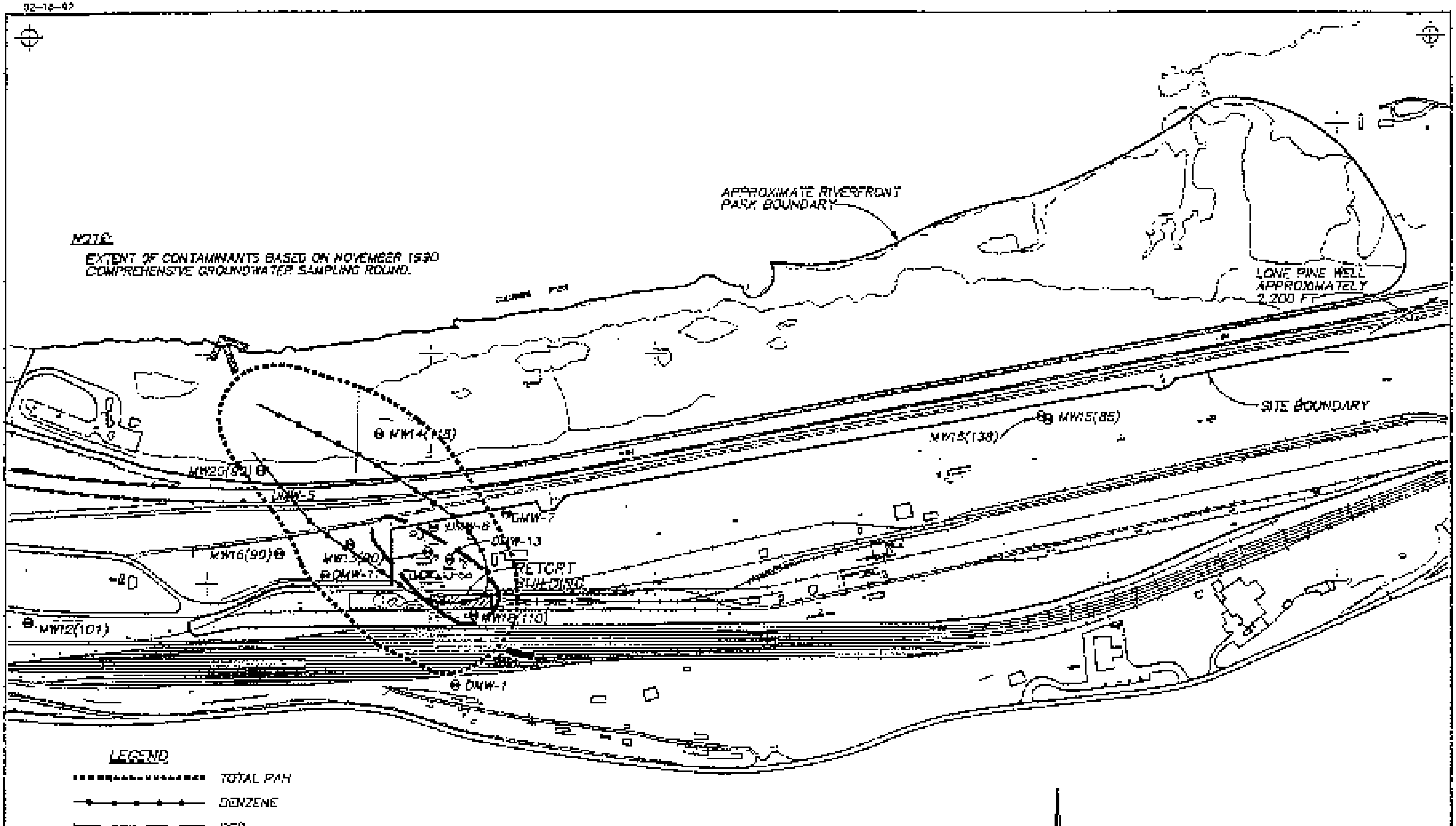


Figure 8
EXTENT OF CONTAMINANTS IN THE SAND HOLLOW I WATER-BEARING ZONE
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

Table 1 presents a summary of pertinent data from November 1990 sampling at the site, for some representative groundwater contaminants. As indicated, several contaminants (arsenic, benzene, pentachlorophenol, and benzo(a)pyrene) were detected at concentrations that exceed federal drinking water standards or "Maximum Contaminant Levels" (MCLs), established under the Safe Drinking Water Act. Several other contaminants were detected at concentrations that exceed proposed MCLs.

Table 1

Summary of Selected Groundwater Contamination Data
November 1990 Sampling

Constituent	No. of Samples	No. of Detections	Concentration Range mg/L	Drinking Water MCL(1) mg/L
Inorganics				
Arsenic, total	51	14	0.009 - 1.210	0.05
Volatile Organics				
Benzene	51	11	0.003 - 0.120	0.005
Ethylbenzene	51	16	0.002 - 0.170	0.7
Toluene	51	15	0.001 - 0.270	1
Semi-Volatile Organics				
Pentachlorophenol	51	7	0.006J - 0.900	0.001
Naphthalene	51	16	0.003J - 18.00	--
Benzo(a)anthracene	51	2	0.028 - 1.50	0.0001a
Benzo(b&k)fluoranthene	51	2	0.010 - 0.860	0.0002a
Acenaphthene	51	30	0.003J - 6.50	0.0004a
Phenanthracene	51	13	0.005 - 14.00	0.0003a
Chrysene	51	2	0.008 - 1.90	0.0002a
Benzo(a)pyrene	51	2	0.002J - 0.72	0.0002

Notes:

(1) Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act
a - Proposed MCL
J - Estimated value

5.2 Private Well Investigation

As part of the Remedial Investigation, a survey was conducted to identify private and municipal water supply wells near the UPRR site. Information on well locations was provided by the Oregon Water Resources Department. Six wells (one active and five inactive) were identified. The locations of these wells are shown on Figure 9. Each well was sampled at least once, for volatile and semi-volatile organic compounds. No hazardous constituents were detected in any of the wells.

A description of the wells, and the number of times each well was sampled, is provided in Table 2 below.

Table 2
Summary of Investigation of Offsite Wells

Current Owner	Date Installed	Total Depth (feet)	Remarks	Sampling Events
City of The Dalles	1979	385	Lone Pine Well (Active)	13
Threemile Irrigation Coop.	1945	335	(Inactive)	1
Wasco County	1977	421	Formerly East Side Well or Greenline Well owned by City of The Dalles (Inactive)	1
Wasco County	1962	161	Formerly Seufert Electro-metallurgical Co. Well (Inactive)	1
Oregon Cherry Growers	1954	114	(Inactive)	2
City of The Dalles	1923	200.5	City Hall Well (Inactive)	1

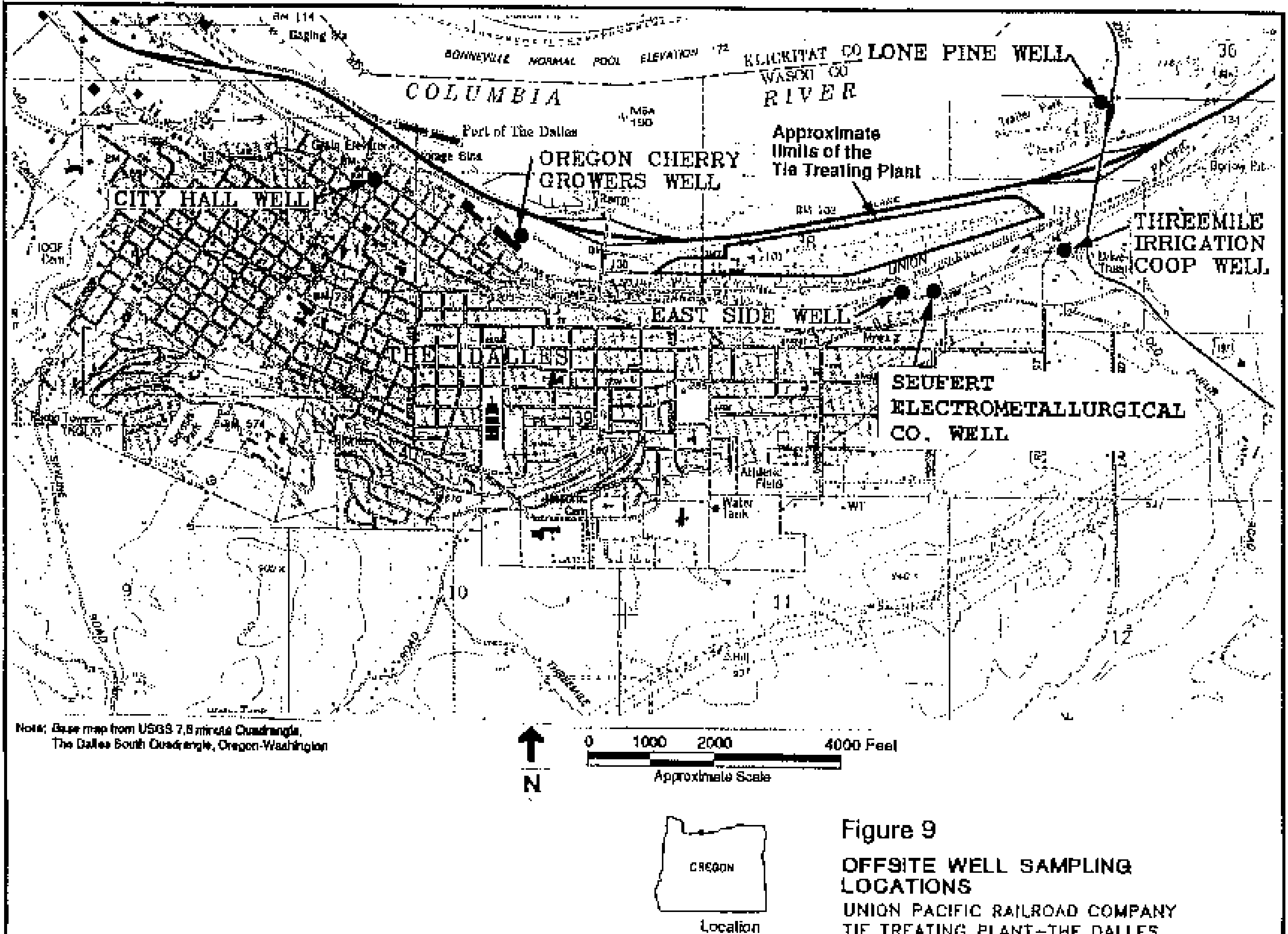


Figure 9

OFFSITE WELL SAMPLING LOCATIONS

UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT–THE DALLES,

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

5.3 Nature and Extent of Surface Water Contamination

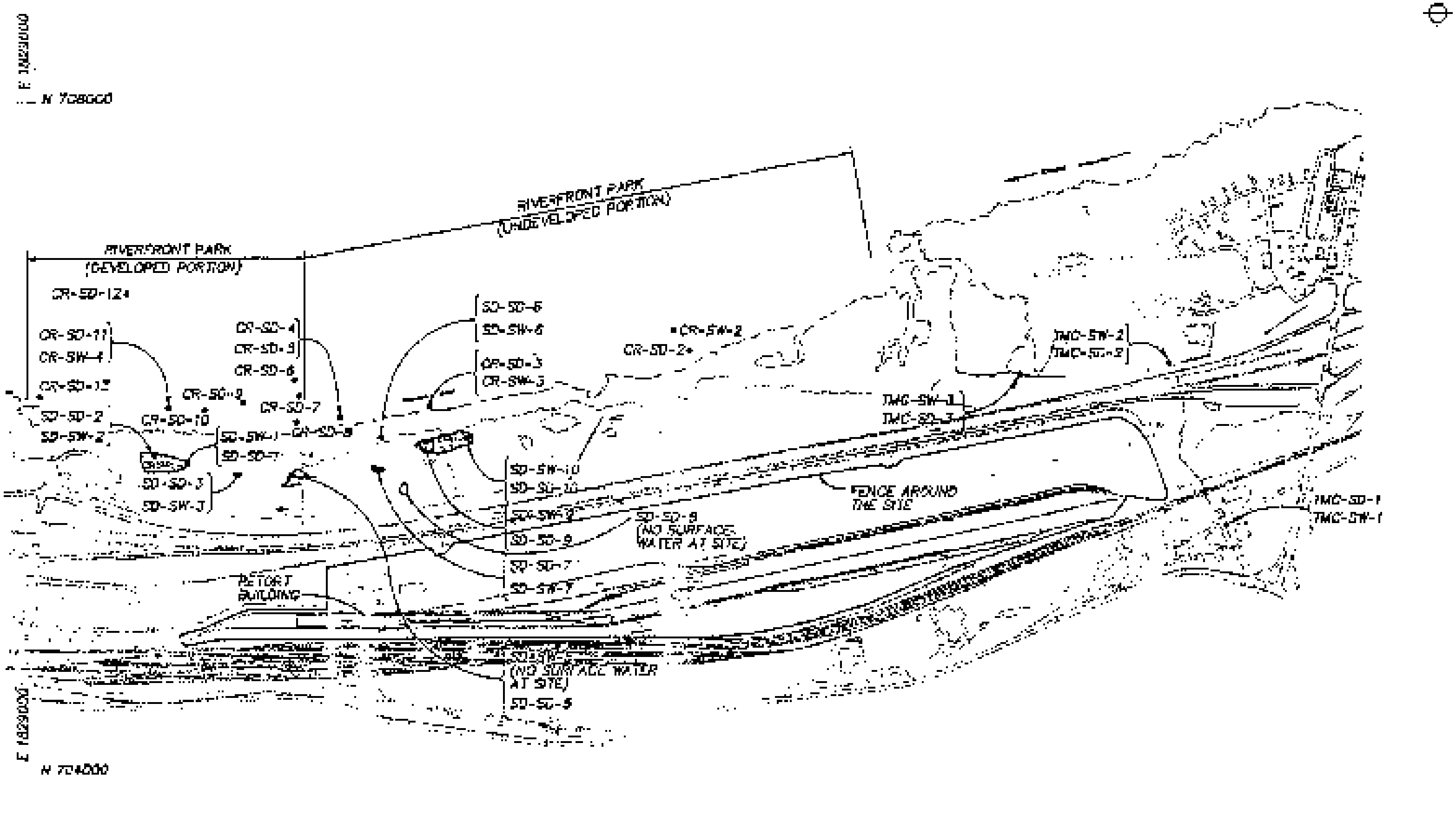
Surface water samples were collected from the Columbia River, Threemile Creek, the waterfowl pond in the undeveloped portion of Riverfront Park, from seeps along the Columbia River shoreline adjacent to Riverfront Park, and from seasonal shallow depressions in Riverfront Park. Figure 10 shows the location of samples collected in 1990. Additional sampling was conducted on several other occasions. The distribution of contaminants of concern in surface water samples was limited to several sporadic detections of CPAHs, PCP and arsenic.

No contaminants of concern were detected in water samples from Threemile creek. In addition, no contaminants of concern were detected in the Columbia River, except for one water sample collected in what appeared to be a groundwater seep on the Columbia River shoreline adjacent to the undeveloped portion of Riverfront Park. PCP was detected at 0.059 milligrams per liter (mg/L), and benzo(a)pyrene at 0.016 mg/L, in that sample. The PCP concentration exceeded DEQ criteria for protection of aquatic organisms (0.013 mg/L). However, the seep appears to have been transitory, as it was not visible during subsequent sampling events.

Arsenic was detected in several samples from the seasonal shallow depressions, and in one sample from the waterfowl pond, in the undeveloped portion of Riverfront Park. The concentration detected in the waterfowl pond (0.016 mg/L) is well below the DEQ criteria for protection of aquatic organisms (0.048 mg/L). The maximum arsenic concentration in a seasonal shallow depression in the undeveloped portion of the park was 0.159 mg/L. This concentration exceeds the criteria for protection of aquatic life. However, this surface water contamination was likely caused by underlying contaminated soils which were removed from this portion of the park in 1992 (see Section 4.3).

5.4 Nature and Extent of Sediment Contamination

Sediment samples were collected on a number of occasions from the waterfowl pond in Riverfront Park, along the Columbia River shoreline adjacent to the park, and in Threemile Creek. Figure 10 shows 1990 sampling locations. With the exception of the area associated with the former COE pipeline, sediment along the Columbia River shoreline and in the waterfowl pond exhibited generally low concentrations of CPAHs, naphthalene, PCP and arsenic. Contaminants of concern in Threemile Creek sediments were also detected only at very low concentrations.



LEGEND

- • — ACTUAL SAMPLING LOCATION
- (shape) — CLOSED SHALLOW TOPOGRAPHIC DEPRESSION
- CR — COLUMBIA RIVER
- TMC — THREEMILE CREEK
- SD — SHALLOW DEPRESSION
- SD-SD — SEDIMENT
- SW — SURFACE WATER

NOTE:
SD-SD-4 AND SD-SW-4 WERE NOT COLLECTED BECAUSE SITE HAS BEEN PAVED. CR-SD-1 WAS NOT COLLECTED BECAUSE SEDIMENT WAS NOT PRESENT AT THE TIME OF SAMPLING. SD-SW-5 AND SD-SW-8 WERE NOT COLLECTED BECAUSE, SD-SW-8, SURFACE WATER WAS NOT PRESENT AT THE TIME OF SAMPLING.

Figure 10
1990 SURFACE WATER AND SEDIMENT SAMPLING PLAN FOR THREEMILE CREEK, COLUMBIA RIVER, AND SHALLOW DEPRESSIONS
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

In the waterfowl pond, the maximum concentrations of representative contaminants detected are as follows:

Constituent	Maximum Conc. (mg/kg)
arsenic	151
PCP	6.6
naphthalene	1.0
chrysene	1.9

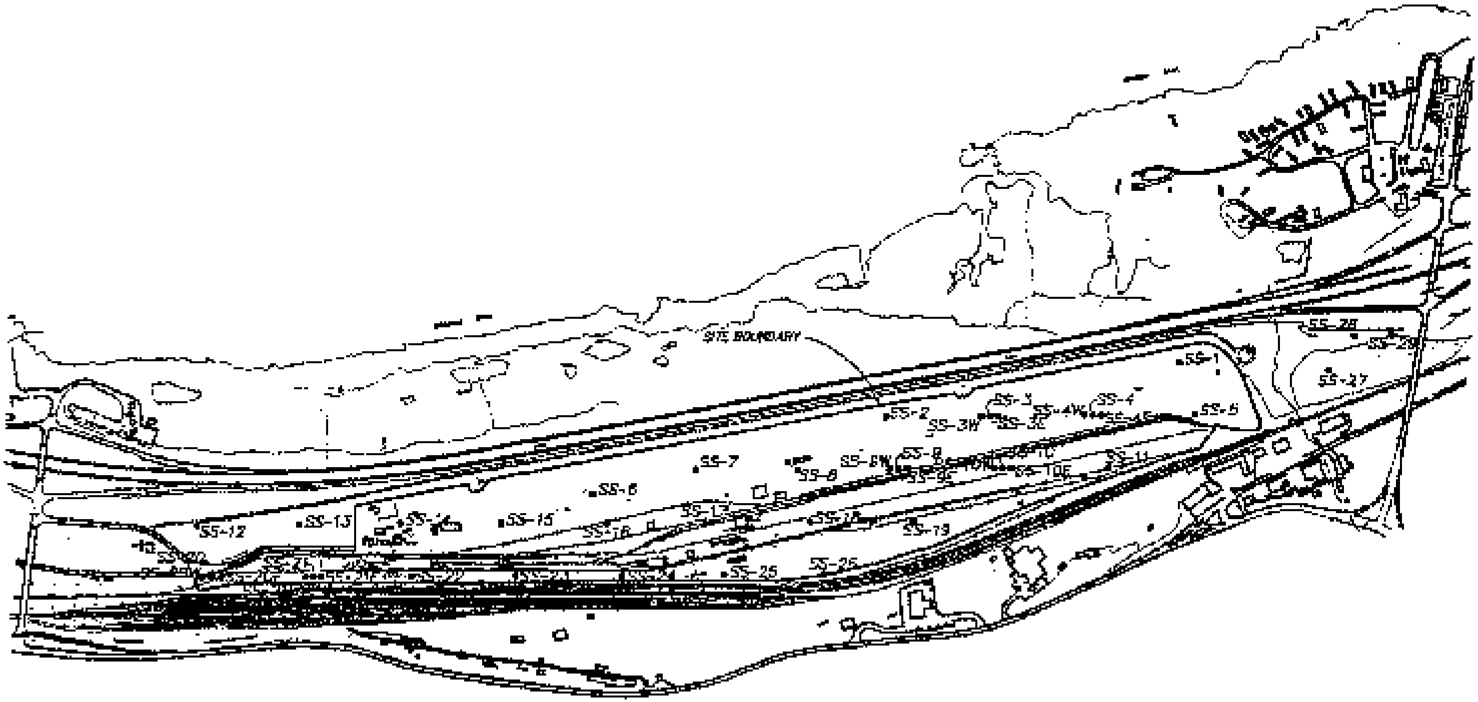
There are no promulgated federal or state of Oregon sediment quality standards. During the 1992 Interim Remedial Action in Riverfront Park, DEQ approved leaving this pond sediment in place, because fish tissue and aquatic organism bioassay data indicated that little, if any, adverse impact was occurring. Also, contaminant distribution within the pond appeared to be random. DEQ believed that attempting to excavate the contaminated sediments would cause greater ecological damage than leaving it in place.

As described in Section 4.3, an area of sediment contamination associated with the former Corps of Engineers pipeline was found in a side channel of the Columbia River, adjacent to the undeveloped portion of Riverfront Park. The contaminated area covers approximately one acre. Prior to the placement of a protective cap in early 1995, contaminant concentrations within this one-acre area were as high as 4,611 mg/kg for total PAHs, 99.5 mg/kg for pentachlorophenol (PCP), and 822 mg/kg for arsenic. Contamination was generally found at a depth of about four feet below the surface of the sediment, and extended to a depth of about eight feet. The protective, multi-layer cap covers all areas where surface (0 to 12 inches deep) sediment concentrations exceeded 4 mg/kg for total PAHs and/or 39 mg/kg of arsenic. The upper 12 inches of the sediment is the biologically active zone in which most aquatic life is found. A “protective concentration" for PCP could not be determined at this site. However, PCP was not detected in any location where total PAH concentrations exceeded 4 mg/kg. Therefore, the protective level for PAHs is also assumed to be protective for PCP.

Underlying sediment contamination does exist above these "protective" levels, in some areas not covered by the cap. However, these areas are already covered by at least 12" of clean sediment, and sedimentation analyses indicate that there is a low potential for sediment erosion from these areas.

5.5 Nature and Extent of Surface Soil Contamination

Samples were collected from surface soils (0-4 inches below ground surface) at the tie-treating plant site, in the undeveloped portion of Riverfront Park, and in a background area east of the plant site. On-site and-background sample locations are shown on Figure 11. Table 3 summarizes the results of the investigation. The



LEGEND

▪ SURFACE SOIL SAMPLING LOCATION

0 600 FT 1200 FT

N

Figure 11
ONSITE AND BACKGROUND
SURFACE SOIL SAMPLING LOCATIONS
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

analytical results indicate a sporadic occurrence of contaminants in surface soils at the plant site. This may be due, at least in part, to the fact that the material at the surface is primarily fill, consisting of gravel and sand (see Section 3.0). Very little native soil is present at the surface. However, all of the surface soil samples at the plant site contained at least one of the contaminants of concern. The highest concentrations occurred in the wood-storage area, the former ponds area, and the north retort area (see Figure 2).

The distribution of contaminants of concern In the surface soil samples collected in Riverfront Park was primarily limited to the Immediate vicinity of Shallow Depression 7, the low area east of Shallow Depression 7, and the two shallow depressions south of the waterfowl pond (Figure 12). As previously mentioned (Section 4.3), an Interim Remedial Action was accomplished in Riverfront Park in 1992 that resulted in the removal of approximately 2,450 cubic yards of contaminated soil. This removal action included the sampled areas in Shallow Depression 7 and the two shallow depressions south of the waterfowl pond.

Table 3
Summary of Occurrence of Contaminants of Concern
in Surface Soil Samples
(0-4 inches below ground surface)

Analytical Parameter	No. of Detections (% of samples)	Range of Detected Values (mg/kg)	Mean of Detected Values (mg/kg)
Onsite Samples	38 samples		
CPAHs	27 (71)	0.057-105	12
Naphthalene	12 (32)	0.075-5.4	0.9
Pentachlorophenol	17 (45)	0.14-7.9	2.5
Benzene	0 (0)	NA	NA
Arsenic	24 (92)	0.92-139[1]	16
Riverfront Park Samples[2]	21 samples		
CPAHs	11 (52)	1.3-1,096	257
Naphthalene	1 (6)	NA	1,990
Pentachlorophenol	11 (52)	4-621	125.7
Benzene	0 (0)	NA	NA
Arsenic	0 (0)	NA	NA
Background Area Samples	3 samples		
CPAHs	1 (33)	NA	0.3
Naphthalene	0 (0)	NA	NA
Pentachlorophenol	0 (0)	NA	NA
Benzene	0 (0)	NA	NA
Arsenic	3 (100)	2.5-7.1	4.1

NA = Not applicable; detection limits are specified in Appendix J of the RI Report.

[1]The sample that contained 139 mg/kg arsenic was probably removed during 1994 Interim Remedial Action taken by KMCC; see Section 4.3.
[2]Riverfront park samples taken prior to 1992 Interim Remedial Action.

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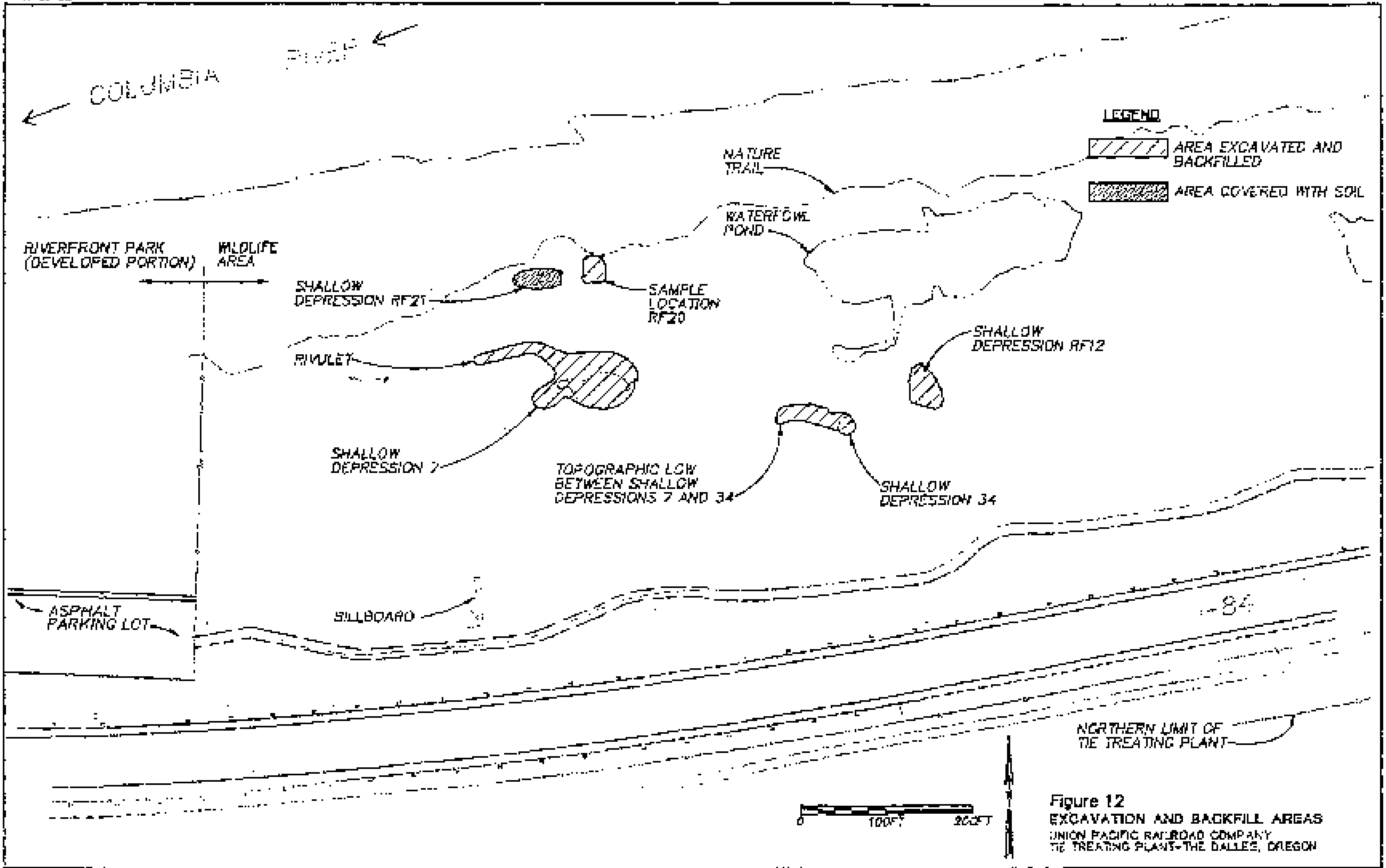

Figure 12
EXCAVATION AND BACKFILL AREAS
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT–THE DALLES, OREGON

Source: Closure Report, Interim Remedial Action at Riverfront Park, The Dalles, Oregon. Prepared by CH2M Hill, May 1993

5.6 Nature and Extent of Subsurface Soil Contamination

Subsurface soil samples (0-15 feet below ground surface) were also collected at the plant site, in the undeveloped portion of Riverfront Park, and in the background area east of the plant site (see Figure 13). The primary contaminants in subsurface soils were CPAHs and naphthalene; arsenic distribution was irregular. A summary of the analytical results for CPAHs in subsurface soil samples is presented in Table 4.

The contaminants of concern were detected near both existing and former facilities located in the western half of the plant site, and at only a few locations in the eastern half. Subsurface contaminant distribution during the Remedial Investigation (RI) was evaluated at both the 0 to 5-foot (shallow) and 5 to 15-foot depth intervals. The data indicate that both shallow and deep soil contamination is sporadically distributed; it principally occurs around buildings, in the central portion of the former ponds area, the tank farm area, the retort building area, and the eastern portion of the north retort building area (see Figure 2). The highest contaminant concentrations in the 5 to 15-foot depth zone were typically in samples obtained nearest the water table.

Most of the subsurface soil samples from Riverfront Park were collected from above the water table, in order to assess the most likely threats to park users (i.e., it is unlikely that park users would be exposed to soil below the water table). The distribution of subsurface soil contamination was observed to be limited to the immediate vicinity of Shallow Depression 7 (see Figure 12). As previously described, the contaminated subsurface soils (to a depth of 5 feet below ground surface) in this area were excavated and disposed of offsite, as part of the 1992 IRA.

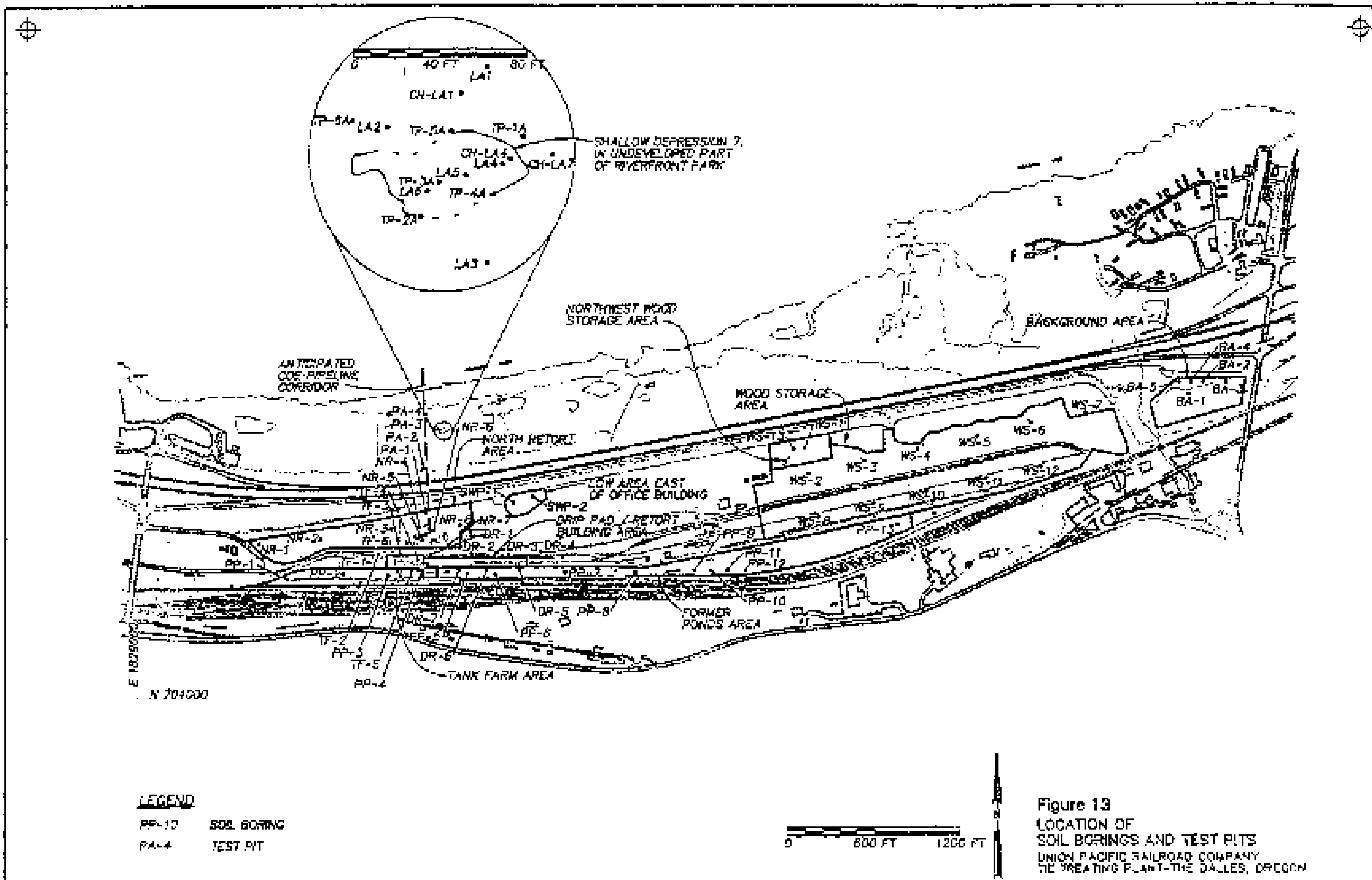

Figure 13
LOCATION OF
SOIL BORINGS AND TEST PITS
UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT-THE DALLES, OREGON

Source: Final Remedial Investigation Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, July 1993

Table 4 **Summary of Analytical Result for CPAHs** **in Subsurface Soil Samples** **(0-15 feet below ground surface)**			
Sampling Location	**No. of Detections (% of samples)**	**Range of Detected Values (mg/kg)**	**Mean of Detected Values (mg/kg)**
Plant Site			
Tank Farm	14 (50)	5.6 - 1,366	175
Former Ponds	29 (50)	1 - 2,953	328
Drip Pad/Retort Bldg.	19 (44)	1.1 - 697	172
North Retort	24 (53)	5.4 - 2,348	334
Wood Storage	2 (3)	1 - 1.5	1.3
(NW Portion)	3 (21)	1.3 - 29	19
Riverfront Park[1]			
Shallow Depression 7	10 (31)	23 - 1,064	409
Rivulet NW of Shallow Depression 7	7 (100)	10 - 3,106	848
Waterfowl Pond	6 (24)	1.6 - 30	11
Low Area between Shallow Depression 7 and Waterfowl Pond	2 (6)	1.3 - 26	14
Other Parts of Park	12 (10)	1.9 - 599	75
Background Area	0(0)	NA	NA

Note: Detection limits are specified in Appendix J of the RI Report.

NA = Not applicable.

[1] Sample results prior to 1992 Interim Remedial Action.

5.7 Endangerment Assessment

As part of the Rl, a baseline (i.e., existing conditions) endangerment assessment was conducted to evaluate potential risks to public health and to the environment if no cleanup activities were conducted at the site. Potential risks to both humans and to aquatic organisms, associated with exposure to the contaminated soils, groundwater, surface water and sediments were studied. The results of those assessments are presented in the following subsections. More detailed information on the Endangerment Assessment can be found in Chapters 7 and 8 of the 1993 RI Report.

Human health risks are expressed in terms of both the potential carcinogenic (i.e., cancer causing) and non-carcinogenic risks. The carcinogenic risk is expressed as the increased chance or "excess risk" that an individual will develop cancer over the course of a lifetime, as a result of exposure to contamination at a site. The "background" lifetime cancer risk for all individuals in this country is about one in four. The added risk, from exposure to site contaminants, is expressed as a probability, such as $1x10^{-6}$ (one in a million). DEQ rules, OAR 340-122-040 and 090, require that remedial actions be protective of human health, but the term "protective" is not defined. EPA has identified an acceptable range for excess lifetime cancer risk of $1x10^{-6}$ to $1x10^{-4}$ or one additional chance in 1,000,000 to one additional chance in 10,000.

Risk estimates are based on the "reasonable maximum exposure" (RME) expected to occur under both current and future land-use conditions. The RME is defined as the highest exposure that is reasonably expected to occur at the site. The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures.

Total non-carcinogenic health risks are expressed in terms of a Hazard Index (HI). In general, an HI of 1.0 or less indicates that even the most sensitive individual is not likely to experience adverse health effects. If the HI is greater than 1.0, there may be a concern for adverse health affects to the general population. The higher the HI value above 1.0, the greater the potential risk. EPA has Identified a Hazard Index of 1.0 as an acceptable risk level for non-carcinogens.

Recent amendments to Oregon's Environmental Cleanup Law, in House Bill 3352 (1995 Legislative Session), define exposure to contaminants posing an excess lifetime cancer risk of $1x10^{-6}$ for Individual carcinogens, and a Hazard Index of 1.0 for noncarcinogens, to be acceptable and protective of human health.

5.7.1 Groundwater Assessment

The groundwater assessment for the UPRR Site evaluated the potential health risks to site workers and to hypothetical future residents at the site. Although residential use of the site is unlikely, consideration of potential residential use provides the most conservative risk assessment scenario. The assessment considered the concentrations of contaminants identified in the groundwater, the toxicity of those contaminants, and the potential ways In which individuals could be exposed to those contaminants in the groundwater (i.e., exposure pathways).

As described In Section 5.1, the RI identified a number of contaminants In the groundwater that pose potential risks to public health, including arsenic, benzene, PCP, and several PAH compounds. Of these contaminants, the PAHs were found to present both the greatest potential carcinogenic and non-carcinogenic risks. Table 5 presents a summary of the estimated excess lifetime cancer risks and non-cancer hazard indices associated with potential Ingestion of contaminated groundwater at the site.

Table 5 Summary of Risk Estimates for Groundwater			
Water-Bearing Zone	**Exposure Setting**	**Non-cancer Hazard Index[1]**	**Excess Lifetime Cancer Risk[2]**
Unconfined	Worker	17.6	$3x10^{-2}$
	Resident	49.3	$1x10^{-1}$
Sand Hollow I	Worker	1.2	$6x10^{-4}$
	Resident	3.5	$2x10^{-3}$

[1] Non-cancer Hazard Index assumes Reasonable Maximum Exposure scenario.
[2] Excess Lifetime Cancer Risk assumes Reasonable Maximum Exposure scenario, and assumes that all CPAHs are equal in potency to benzo(a)pyrene.

In summary, the calculated risks for both carcinogenic and non-carcinogenic effects from potential ingestion of groundwater at the UPRR Site, by both site workers or assumed future residents, are in excess of EPA's recommended acceptable range and are not considered "protective" under Oregon Law or DEQ's rules. Accordingly, a remedial action is needed to address the groundwater contamination at the site, in at least the unconfined and Sand Hollow I water-bearing zones.

5.7.2 Soils Assessment

The soils assessment evaluated the potential risks to site workers from exposure to contaminated surface and subsurface soils. In addition, prior to the 1992 IRA in Riverfront Park, potential risks from exposure to contaminated soil in the undeveloped portion of the park were evaluated. Tables 6 and 7 provide a summary of the estimated excess lifetime cancer risks and non-cancer hazard indices associated with potential ingestion of contaminated soils at the site.

Surface soils in the retort building area and wood storage area both pose an estimated excess lifetime cancer risk to site workers of $3x10^{-5}$, under an RME, site worker exposure scenario. CPAHs contribute more than 80 percent of the total risk for the wood storage area, but only 40 percent of the risk in the retort building area. Arsenic contributes the remainder of the risk in these areas. Arsenic contributes 100 percent of the total risk in the background area ($2x10^{-6}$).

The subsurface soils in the retort building area pose an estimated excess lifetime cancer risk to site workers of $1x10^{-4}$. CPAHs contribute more than 95 percent of the total risk.

Table 6 Summary of Risk Estimates for Surface Soil			
Source Area of Concern	**Exposure Setting**	**Non-cancer Hazard Index[1]**	**Excess Lifetime Cancer Risk[2]**
Retort Bldg. Area	Worker	0.08	$3x10^{-5}$
Wood Storage Area	Worker	0.03	$3x10^{-5}$
Background Area	Worker	0.02	$2x10^{-8}$

[1] Non-cancer Hazard Index assumes Reasonable Maximum Exposure scenario.
[2] Excess Lifetime Cancer Risk assumes Reasonable Maximum Exposure scenario, and assumes that all CPAHs are equal in potency to benzo(a)pyrene.

Table 7 Summary of Risk Estimates for Subsurface Soil			
Source Area of Concern	**Exposure Setting**	**Non-cancer Hazard Index[1]**	**Excess Lifetime Cancer Risk[2]**
Retort Bldg. Area	Worker	0.13	$1x10^{-4}$
Wood Storage Area	Worker	Not Evaluated[3]	$4x10^{-7}$
Background Area	Worker	<0.01	$2x10^{-7}$

[1] Non-cancer Hazard Index assumes Reasonable Maximum Exposure scenario.
[2] Excess Lifetime Cancer Risk assumes Reasonable Maximum Exposure scenario, and assumes that all CPAHs are equal in potency to benzo(a)pyrene.
[3] All non-carcinogens were eliminated by risk-based screening.

Prior to the 1992 Interim Remedial Action, contaminated soil in the undeveloped portion of Riverfront Park posed an estimated excess lifetime cancer risk of 1×10^{-5} to a child and $5x10^{-6}$ to an adult recreational user of the park. PAHs contributed 95 percent of the total risk. The current estimated excess lifetime cancer risk, following the 1992 IRA, is 2.5×10^{-6} for a child. This estimate is based upon the conservative assumption that a child would visit the undeveloped portion of Riverfront Park one day a week, 26 weeks a year, for 5 years, and would Ingest 200 milligrams of contaminated soil on each visit. Risks to infrequent visitors of the undeveloped portion of the park would be substantially less.

5.7.3 Surface Water and Sediment Assessment

The surface water and sediment assessments evaluated potential risks to adult and child recreational users of the Columbia River and Threemile Creek, and to aquatic organisms which reside in the Columbia River, Threemile Creek, and in the waterfowl pond in Riverfront Park.

The assessment of potential risks to humans considered the effects of possible incidental ingestion of contaminated surface water and sediments, dermal contact with contaminated sediment, and the ingestion of fish caught in potentially contaminated waters. The results indicate that such potential exposures would not pose unacceptable levels of risk. The potential risks to children were greater than the potential risks to adults in all cases, and the potential ingestion of sediments posed slightly greater risk than dermal contact with contaminated sediment or the potential ingestion of water in all cases.

The greatest potential risk to children is associated with potential ingestion of Columbia River sediment near the former COE pipeline outfall, adjacent to the undeveloped portion of Riverfront Park (not in the developed swimming area in Riverfront Park). Such exposure resulted in an estimated excess lifetime cancer risk of $8x10^{-7}$ and a non-cancer Hazard Index of less than 0.01. The estimated risks to children from dermal exposure to these same contaminated Columbia River sediments are an excess lifetime cancer risk of $9x10^{-8}$ and a Hazard Index of less than 0.01. These values are orders of magnitude lower than the risk levels considered protective by EPA and DEQ.

The greatest potential risk to children from ingestion of surface water is also associated with the former COE pipeline area off-shore from the undeveloped portion of Riverfront Park (not in the developed swimming area). Incidental ingestion during swimming resulted in an estimated excess lifetime cancer risk of $4x10^{-7}$ (i. e., well below the level considered protective by EPA and DEQ). Non-cancer risks were eliminated by risk-based screening.

The estimated risks from fish ingestion were the same in upstream, background areas as in near-site areas $7x10^{-6}$). The risk is due primarily to the presence of arsenic in the water.

All of the estimated potential risks to children and adults associated with exposure to contaminated sediment and surface water, and with the ingestion of fish, are within the range considered acceptable by EPA. In addition, it must be emphasized that the risk estimates presented above are based on conservative RME conditions (see Section 5.6). For example, the estimated risks from incidental ingestion of sediment are based on the assumption that a child ingests 100 milligrams of contaminated sediment per day, one day per week, 26 weeks a year, for 5 years. It must also be emphasized that these risk are based on conditions that existed before a protective cap was placed over contaminated Columbia River sediments in February and March 1995 (see Section 4.3). Accordingly, current risks should be significantly less.

The assessment of potential risks to aquatic organisms was conducted in two phases. During the Remedial Investigation, protective concentrations for wood-treating chemicals in sediment were calculated based on the potential partitioning of chemicals from the sediment to surface water. Calculated concentrations In water were then compared to federal surface water ambient water quality criteria (AWQC), and “protective" concentrations In sediment were derived. These calculated sediment values were then compared to sediment sampling results. No samples from Threemile Creek exceeded the criteria. The maximum PAH concentration detected in sediment from the waterfowl pond In the undeveloped portion of Riverfront Park (30.2 mg/kg) exceeds the calculated standard of 20.9 mg/kg. However, bioassay tests were conducted on pond sediment using the water fleas. (*Daphnia magna*), and there was no mortality to the test organisms. In addition, tissue analysis conducted on fish and macro-invertebrates collected in the waterfowl pond, Columbia River and Threemile creek showed, no elevated concentrations compared to species collected in background areas (upper Threemile Creek and Spearfish Lake).

The second phase of assessments was associated with the Investigation of the former COE pipeline area on the Columbia River shoreline adjacent to the undeveloped portion of Riverfront Park (see report titled *Interim Remedial Investigation at the Columbia River Shoreline/Abandoned COE Pipeline Outfall Operable Unit,* October 1994). This study included three separate elements. First, benthic communities upstream and downstream of the contaminated sediment area were compared. The results of this comparison showed no impairment or only slight Impairment of downstream communities compared to upstream (background) communities. The slight impairment could be due to sediment contamination or may simply be the result of subtle differences in physical habitat, food sources, or human activity at the nearby park or boat launch facilities. Second, tissue samples from fresh water clams (*Corbicula*) collected upstream, downstream and within the contaminated sediment area were analyzed for accumulations of wood-treating chemicals. In addition, two samples of semi-resident fish (sculpin), collected upstream and downstream from the site, were analyzed. The results indicated uniformly low levels of non-carcinogenic PAHs in all of the clams collected (i.e., concentrations in clams collected on-site and downstream from the site did not exceed concentrations in clams collected upstream from the site). No PAHs were detected In either of the two fish. Third, sediment toxicity tests were conducted using the amphipod *Hyalella azteca* and the water flea *Daphnia magna*. The results of these tests were used to calculate protective contaminant concentration levels in the sediment.

As described in Section 4.3, Columbia River sediment with contaminant concentrations exceeding the calculated protective levels have been covered with a multi-layered cap. A few isolated areas of sediment contamination above protective levels exist in the waterfowl pond in the undeveloped portion of Riverfront Park. However, 21 of 25 samples from the pond had no detectable PCP contamination and 19 of 25 samples had no detectable CPAH contamination.

In summary, these assessments indicate that surface water and sediments currently do not pose an unacceptable risk to either human health and safety, nor to the environment. Accordingly, DEQ believes that no further action for surface water and sediments is needed, other than continued monitoring and maintenance of the sediment cap.

6.0 Description of Remedial Action Alternatives

In the Feasibility Study (FS), remedial action alternatives were developed for groundwater beneath the UPRR site, and for surface and subsurface soils at the site. These alternatives are described separately in the following subsections. In addition, an alternative for surface water and sediment remediation is briefly discussed below.

Remedial action alternatives for soils in the undeveloped portion of Riverfront Park were developed prior to the 1992 Interim Remedial Action. Contaminated soils were then removed to the extent feasible and residual risks are now within the range considered protective by EPA and DEQ (see Section 5.6.2). Accordingly, additional soil removal in this area is not being considered by DEQ.

6.1 Groundwater Alternatives

Four groundwater alternatives (GW-1 through GW-4) were developed during the FS, to address groundwater remediation for the three affected water-bearing zones (unconfined, Sand Hollow I and Sand Hollow II) and recovery of DNAPL from the Sand Hollow If basalt flow interior. GW-1 is the no action alternative; GW-2 relies on institutional controls; and GW-3 and GW-4 rely on DNAPL recovery and groundwater removal and treatment. The four groundwater alternatives are described in greater detail below:

! **Alternative GW-11 -** No Action. DEQ rules, OAR 340-122-080(3), and the National Contingency Plan, 40 CFR 300.430, require consideration of a no-action alternative. Under this alternative, no remedial measures would be taken to improve groundwater quality. Rather, this alternative relies on natural attenuation of the contaminants over time. At the UPRR site, hundreds of years may be required before the groundwater is restored to acceptable levels, due to the presence of DNAPL (see Section

5.1). The cost of this alternative, for legal and environmental consulting, is estimated to be approximately $100,000;

! **Alternative GW-2 -** Institutional Controls. This alternative requires placing restrictions that limit potential human exposure to the groundwater contaminants and monitoring the effectivenessof these controls. The institutional controls placed on the unconfined water-bearing zone would differ from those placed on the Sand Hollow I and Sand Hollow II zones. For the unconfined water-bearing zone, restrictions would be placed on the western end of the tie-treating plant, and on Riverfront Park, to prohibit future withdrawal and use of the unconfined groundwater in those areas.

There are currently legal restrictions on the withdrawal of groundwater from the Sand Hollow I and Sand Hollow II zones (see Section 3.0). Additional appropriations are possible only by the City of The Dalles. Accordingly, the 1959 State Engineer's order for The Dalles Critical Groundwater Area would be monitored, to ensure that there continues to be no future private appropriation of groundwater from Sand Hollow I and II water-bearing zones within a 1-mile radius from the retort building at the plant site. Alternative GW-2 also includes on-going monitoring of groundwater and the Columbia River. The estimated cost of Alternative GW-2, Including monitoring for 30 years, is approximately $2,210,000;

! **Alternative GW-3 -** Groundwater Containment, Removal and Treatment Option Number 1. This alternative provides groundwater extraction to achieve hydraulic containment of the on-site portion of the unconfined water-bearing zone and the Sand Hollow I water-bearing zone; above ground physical/chemical treatment of the extracted water; reinjection or reinfiltration of extracted water with discharge of any excess water to surface water or the city's sanitary sewer system, or by land application, in accordance with DEG requirements; recovery of free phase DNAPL, including the use of "water flooding" to enhance DNAPL recovery, and recycling or reuse of the recovered product if possible; restrictions on the use of groundwater, as In Alternative GW-2; and periodic monitoring. Groundwater extraction from the Sand Hollow If flow top is included as a contingency measure for this alternative. The estimated cost of this alternative, assuming 30 years of operation, is approximately $13,840,000;

- **Alternative GW-4 -** Groundwater Containment, Extraction and Treatment Option Number 2. This alternative is identical to Alternative GW-3, except that the area of hydraulic containment for the unconfined water-bearing zone is expanded to include the undeveloped portion of Riverfront Park. The estimated cost of this alternative, assuming 30 years of operation, is approximately $14,160,000.

6.2 Surface and Subsurface Soil Alternatives

As described in Sections 4.3 and 6.0, contaminated soil was removed from the undeveloped portion of Riverfront Park during a 1992 IRA. In the 1995 Feasibility Study, the following alternatives were developed to address contaminated soil at the tie-treating plant site. These alternatives combine remedies for surface and subsurface soils, and are based on remedial action levels that achieve 10^{-5} cumulative excess lifetime cancer risk for site workers, based on RME exposure conditions (see Section 5.6).

- **Alternative S-1:** No Action. As with groundwater Alternative GW-1, no action would be taken to reduce existing threats at the site. Instead, this alternative would rely on natural attenuation of contaminants over an extended period of time. The cost of this alternative, for legal and environmental consulting, is estimated to be approximately $100,000;

- **Alternative S-2:** Institutional Controls. This alternative consists of site access controls, expanded worker health and safety requirements, a drip/spill management plan, a soil excavation management plan, and a deed restriction to warn potential future users of the site of the hazards present from potential exposure to contaminated surface and subsurface soils. The estimated cost of this alternative, for legal and environmental consulting, is approximately $100,000;

- **Alternative S-3:** Institutional Controls, Deferred Investigation and Cleanup of Inaccessible Areas, and Phased In-situ Bioremediation. This alternative includes institational controls as described in Alternative S-2; and deferred investigation, and cleanup as appropriate, of surface and subsurface soils that are currently inaccessible, due to the active operation of the tie-treating plant; and, to the extent feasible, phased, in-situ bioremediation (bioventing) of subsurface soil. The estimated cost of this alternative is approximately $2,149,000;

- **Alternative S-4:** Capping, Institutional Controls, and Phased In-situ Bloremediation. This alternative consists of placement of a gravel cap over surface soil with contaminant concentrations above the 10-' risk level; combined with institutional controls and phased In-situ bloremediation of subsurface soil, as described in Alternative S-3. The estimated cost of this alternative is approximately $7,772,000;

- **Alternative S-5:** Surface Soil Removal, Institutional Controls, and Phased Subsurface Bioremediation Option Number 1. This alternative is similar to Alternative S-4, except surface soil with contaminant concentrations above the 10^{-5} risk level would be excavated and disposed of offsIte, rather than left in place and capped with gravel. Institutional controls, combined with phased In-situ bioremediation of accessible subsurface soil would also be provided. The estimated cost of this alternative is approximately $16,412,000; and

- **Alternative S-6:** Surface Soil Removal, Institutional Controls, and Phased Subsurface Bioremediation Option Number 2. This alternative is identical to Alternative S-5, except excavated surface soil would be subjected to thermal treatment and soil washing, prior to disposal. The estimated cost of this alternative is approximately $25,280,000.

6.3 Surface Water and Sediment Alternative

As described in Section 5.2, the Remedial Investigation (RI conducted at the UPRR site indicated that surface water quality in The Columbia River, Threemile Creek and In the waterfowl pond in Riverfront Park has not been adversely affected by past practices at the UPRR site, and does not currently pose a significant risk to public health, safety, welfare or the environment. The RI did indicate that sediments In the waterfowl pond in Riverfront Park have been adversely affected. However, contamination was found to be sporadic, and there were no wood-treating chemicals detected in fish collected from the pond. DEQ believes that any attempt to excavate sediment from the pond would cause significant harm to the pond and surrounding parkland.

As described in Section 4.3, a multi-layer cap has recently been constructed over an area of contaminated sediments in the Columbia River adjacent to the undeveloped portion of Riverfront Park. The cap was constructed as an Interim Remedial Action (IRA) In February and March 1995. As part of the approved IRA Plan, UPRR has already agreed to a program of monitoring and maintenance of the cap for a period of 20 years.

In accordance with the above, DEQ is recommending no further action for surface water and sediments at the UPRR site, other than the previously approved program for on-going monitoring and maintenance of the sediment cap.

The estimated cost of a No Further Action alternative, for on-going monitoring and maintenance of the cap, over a period of 20 years, is approximately $61,000.

7.0 Evaluation of Remedial Action Alternatives

The alternatives described in Section 6, for the remediation of groundwater, and soils were evaluated during the FS in terms of the remedy selection criteria specified in Oregon Administrative Rules (OAR) 340-122-090, and in EPA's National Contingency Plan (NCP), 40 CFR 300.430. The results of those evaluations are presented in sections 7.1 and 7.2.

An evaluation of the selected surface water/sediment alternative is presented in Section 7.3.

7.1 Evaluation of Groundwater Alternatives

7.1.1 Overall Protection of Human Health and the Environment

OAR 340-122-090(5) states that only background concentrations are presumed to be protective. However, DEQ's Director may find concentration levels greater than background to be protective, based upon the results of the site characterization and endangerment assessment, or in consideration of other relevant cleanup or health standards, criteria or guidance. Due to the presence of wood-treating chemicals in the form of DNAPL (see Section 5.1), cleanup of the groundwater to background conditions is not considered technically feasible. Groundwater treatment technologies can clean up dissolved constituents, but there is currently no effective technology for completely remediating deposits of DNAPL.

Alternative GW-1 provides no active intervention to improve groundwater quality. Instead, it relies on natural attenuation of the contaminants over a very long period of time (perhaps hundreds of years). Based upon the exposure assessment, allowing contamination to remain unabated for that period of time poses unacceptable potential risks to public health. Accordingly, this alternative is not protective.

Alternative GW-2 may be considered protective of public health, since it restricts potential human consumption of the contaminated groundwater. However, like

Alternative GW-1, it also relies solely on natural attenuation to reduce contaminant concentrations.

Both Alternatives GW-3 and GW-4 are protective of human health and the environment. Under both alternatives, groundwater with contaminant concentrations exceeding the 10^{-6} excess lifetime cancer risk levels in the Sand Hollow I waterbearing zone (and in the Sand Hollow II, if monitoring results so warrant) would be captured and treated. Also, both alternatives would contain onsite DNAPL and on-site groundwater in the unconfined water-bearing zone. However, under alternative GW-3, the unconfined aquifer beneath Riverfront Park would not be captured. Instead, Alternative GW-3 would rely on natural attenuation and flushing to achieve protective levels in the park. Alternative GW-4 provides an expanded network of extraction wells which would capture contaminated groundwater in the unconfined water-bearing zone beneath the undeveloped portion of Riverfront Park, and return It to the plant site for treatment.

7.1.2 Use of Permanent Solutions and Alternative or Resource Recovery Technologies

Both Alternatives GW-3 and GW-4 use permanent solutions and alternative technologies. DNAPL recovery and reuse is a permanent solution to reducing the single largest contaminant mass at the plant. DNAPL recovery is also considered an alternative technology. Both Alternatives GW-3 and GW-4 have groundwater treatment options that result in the permanent destruction of dissolved contaminants. Physical/chemical treatment removes more than 99 percent of dissolved organics with activated carbon. When saturated, the carbon Is regenerated by heating In a furnace. The regeneration process destroys the organic contaminants adsorbed to the carbon. Also, approximately 95-99 percent of the- dissolved arsenic In the extracted groundwater will be removed by a precipitation process for off-site disposal in a hazardous waste landfill.

7.1.3 Cost-Effectiveness

Alternative GW-1 is the least costly alternative (estimated present worth cost of $ 100,000). However, it does not achieve any contaminant mass reduction, except for that provided by natural attenuatiorn over an extended period of time. Therefore, Alternative GW-1 is not cost-effective.

Alternative GW-2 has an estimated present worth cost of $2.2 million. No reduction in contaminant mass is achieved, but a reduction in risk is provided through restrictions on the use of groundwater. The increased cost of Alternative GW-2 compared to GW-1 is therefore generally proportional to the increased benefit.

Alternative GW-2 provides a moderate amount of risk reduction at a moderate cost, and is considered cost-effective.

Alternative GW-3 has the most benefit per unit cost. This alternative has an estimated present worth cost of $13,838,000 and achieves the removal of approximately 548,000 kilograms of contaminant mass (i.e., a cost of approximately $25 per kilogram removed). Compared to Alternative GW-2, this is an incremental cost per incremental increase in mass reduction of approximately $21 per kilogram (i.e., $11.6 million increase in cost, divided by 548,000 increase in kilograms of mass removed, equals about $21 additional cost per each additional kilogram of mass removed, compared to Alternative GW-2).

Alternative GW-4 provides a small amount of additional mass removal over Alternative GW-3 (an estimated additional 250 kilograms), at an estimated present worth cost of $14,156,000 (i.e., an incremental cost increase of about $318,000 compared to Alternative GW-3). Overall, Alternative GW-4 has an incremental cost per incremental increase in mass reduction of approximately $1,270 per kilogram, compared to Alternative GW-3 (i.e., $318,000 ÷ 250 kg = $1,272/kg). This incremental cost increase is considered excessive, and Alternative GW-4 is not considered cost-effective.

7.1.4 Effectiveness

7.1.4.1 Reduction of Toxicity, Mobility and Volume

Alternatives GW-3 and GW-4 are the most effective options, since they both provide a significant reduction in contaminant toxicity, mobility and volume, within a reasonable time frame. Contaminant volume reduction is accomplished primarily by DNAPL removal. Contaminant toxicity reduction is afforded by the treatment processes, which permanently destroy the organic contaminants. DNAPL mobility is reduced by DNAPL extraction, enhanced by the water flooding technique, to reduce DNAPL concentrations to levels of residual concentration. At this point, DNAPL is no longer mobile or its mobility has been significantly reduced. However, residual immobile DNAPL would still act as Er long-term source of dissolved groundwater contamination. The mobility of the dissolved groundwater contaminant plume is hydraulically controlled by the extraction wells, to the extent practicable. Alternative GW-4 provides a greater degree of dissolved contaminant removal and containment than does alternative GW-3, but at significantly greater cost.

Alternatives GW-1 and GW-2, which rely on natural attenuation, provide no active treatment or containment of contaminants.

7.1.4.2 Short-term Risks During Implementation

Plantsite activities during the Implementation of Alternatives GW-3 and GW-4 are expected to pose minimal threats to the community. Restricted plant access Is currently In place (the site is fenced and there is a security guard at the entrance) to protect the community from exposures to contaminated soil materials that might be generated during installation of the extraction and additional treatment system. There were no exposures to contaminated materials during the 1994-1995 construction of the groundwater extraction and reinjection/reinfiltration system.

Remediation activities in the undeveloped portion of Riverfront Park associated with Alternative GW-4 would probably require limiting community access to this area during construction activities, so that visitors would not be exposed to contaminated soils or construction hazards.

Plantsite remediation activities during the implementation of Alternatives GW-3 and GW-4 are expected to pose minimal threats to plant workers. KMCC's existing health and safety procedures, plus the additional institutional controls included in soil remedies S-2 through S-6, provide methods to mitigate or eliminate worker exposure. Remediation workers would follow appropriate OSHA health and safety procedures for working at hazardous waste sites.

There would be no short-term risks during implementation of Alternatives GW-1 (no action) or GW-2 (institutional controls).

7.1.4.3 Length of Time Until Remedial Objectives Are Achieved

MCLs and risk-based drinking water standards may ultimately be achieved downgradient of the hydraulic capture zone in the unconfined and Sand Hollow I water-bearing zones, under Alternatives GW-3 and GW-4, but the time required to meet this objective is not known. Similarly, the time to cleanup groundwater by natural attenuation, under Alternatives GW-1 and GW-2, is also unknown. Clearly, however, Alternatives GW-3 and GW-4, which include active containment and DNAPL removal, would be more effective than Alternatives GW-1 or GW-2.

Hydraulic containment would be achieved for Alternatives GW-3 and GW-4 within 1 month of implementation. DNAPL removal, if shown to be effective, would achieve source reduction immediately upon implementation but would take an unknown period of time to be completed. DNAPL removal is already underway, as a pilot project.

7.1.4.4 Magnitude of Residual Risks

Alternatives GW-3 and GW-4 contain areas in both the unconfined water-bearing zone and Sand Hollow I water-bearing zone that have residual DNAPL. There are no proven technologies to restore DNAPL zones in aquifers to drinking water standards. Thus, the residual risk is controlled through containment and institutional controls.

Alternatives GW-3 and GW-4 also both contain groundwater in the Sand Hollow I water-bearing zone that exceeds the 10^{-6} excess lifetime cancer risk level. Groundwater contaminants downgradient of the Sand Hollow I capture zone are non-carcinogenic and would be allowed to naturally attenuate. These downgradient contaminants already are below the protective level (i.e., Hazard Index is less than 1.0).

Alternative GW-3 contains groundwater exceeding the 10^{-6} risk level in the unconfined water-bearing zone; the capture zone extends slightly beyond the northern tie plant boundary. Alternative GW-3 uses natural attenuation and institutional controls to control residual risk outside the capture zone, in the undeveloped portion of Riverfront Park. This approach provides reasonable management of downgradient residual risk, because there is currently no use of groundwater in this area and the groundwater quality is at non-detectable levels prior to its discharge to the Columbia River. Institutional controls would be used to prevent potential future use of groundwater from the unconfined aquifer in Riverfront Park.

Alternative GW-4 provides active management of downgradient residual risk in Riverfront Park through additional hydraulic containment. Extraction wells would be installed in the park and extracted water pumped back to the plant site for treatment.

Alternative GW-2 (placing restrictions on future use of affected groundwater on the unconfined water-bearing zone onsite and at Riverfront Park) would mitigate the potential for exposure to contaminated groundwater, but would not decrease the groundwater concentrations. Accordingly, there would be a 3×10^{-2} excess lifetime cancer risk to site workers and a 1×10^{-1} risk to future residents for the unconfined water-bearing zone and a 6×10^{-4} excess lifetime cancer risk for the Sand Hollow I water-bearing zone to site workers, if long-term exposure were to occur.

7.1.4.5 Long-term Reliability of Controls

Hydraulic containment of groundwater (Alternatives GW-3 and GW-4) is a proven, reliable technology. Groundwater monitoring would confirm the long-term reliability of the hydraulic capture zones in preventing the downgradient migration of contaminants. Institutional controls included in Alternatives GW-2, GW-3, and GW-4 can mitigate or prevent potential exposure to contaminants in the unconfined water-bearing zone.

GW-1, the No Action Alternative, is not reliable for controlling the potential risk associated with contaminated groundwater at the site.

7.1.5 Implementability

7.1.5.1 Technical and Administrative Feasibility

Each of the alternatives is considered to be Implementable from an administrative standpoint. UPRR has already initiated negotiations with the Port of The Dalles, regarding use restrictions on groundwater beneath Riverfront Park. Under recent amendments to Oregon's Environmental Cleanup Law, on-site (including Riverfront Park) remedial actions are exempt from state and local permits. However, the remedy must comply with the substantive requirements of state and local laws and regulations.

From a technical standpoint, UPRR has already constructed and successfully operated the water treatment facility included in alternatives GW-3 and GW-4. Treated water was discharged to the City of The Dalles' sanitary sewer system, under a temporary permit from the city.

Implementation of alternative GW-4 would be the most difficult, because it would require the placement of piping beneath I-84 and the levee. Also, there would be both short-term and long-term environmental impacts to Riverfront Park, from construction and operation of the groundwater extraction well system.

7.1.5.2 Availability of Services and Materials

Well drillers and remediation contractors, for installation of extraction wells and reinjection/reinfiltration systems, are readily available. Local contractors may be able to provide basic services such as mechanical or electrical contracting support. The water treatment facility has already been constructed.

7.1.6 Compliance with Other Regulations

The contaminants in groundwater at the UPRR site are designated as "Hazardous Wastes," under the federal Resource Conservation and Recovery Act (RCRA). There are requirements under RCRA for persons who "generate" hazardous wastes (e.g., by extracting the contaminated groundwater), and for the management (i.e., storage, treatment and disposal) of such wastes. Each of the alternatives can be designed and implemented to comply with RCRA requirements. As noted in Section 7.1.5.1, on-site remedial actions are exempt from RCRA permitting requirements.

There are also federal and state standards for drinking water (maximum contaminant levels or MCLs) which are applicable to groundwater at the UPRR site. Due to the presence of contamination in the form of DNAPL, it is unlikely that any of the alternatives can completely restore the groundwater at this site to a level of full compliance with the drinking water standards (see Section 5.1).

The proposed extraction and reinjection of groundwater in Alternatives GW-3 and GW-4 requires approval from the Oregon Water Resources Department. The proposed discharge of excess extracted groundwater to the land (land application) or to the City of The Dalles' sanitary sewer system (Alternatives GW-3 and GW-4) would also be regulated. Surface water discharge and/or land application of excess water is subject to regulation by DEQ. The proposed discharge of excess water to the sanitary sewer system would require approval by the City of The Dalles. It is believed that the requirements for either type of discharge can be readily met. For example, approval to discharge to the city's sanitary sewer system was obtained during initial operation of UPRR's new water treatment system. Under recent amendments to Oregon law, on-site cleanup actions are exempt from state and local permitting requirements, but the substantive requirements of applicable state and local regulations must be met.

7.1.7 Supplementary Measures

Since restoration of the groundwater to drinking water quality is unlikely (see Section 7.1.4), DEQ believes that other measures will be necessary to ensure protection of public health. Specifically, DEQ believes that some form of administrative restrictions on the potential use of contaminated groundwater, such as deed restrictions, are needed. OAR 340-122-090(3) provides authority for the Director to require such supplementary measures. Each of the alternatives, except Alternative GW-1 (No Action), includes provisions for deed restrictions.

7.2 Evaluation of Soil Alternatives

7.2.1 Overall Protection of Human Health and the Environment

OAR 340-122-090(5) states that background levels are the only concentration levels presumed to be protective for all contaminants in -all media. However, there is no feasible remedial action that can attain background levels at the tie-treating plant for surface and subsurface soils. The current excess lifetime cancer risk to workers at the site Is 3 x 10^{-5} for surface soil and 1 X 10^{-4} for subsurface soil. These levels are within the range of 1 X 10^{-4} to 1 x 10^{-6} considered protective of human health by EPA. Therefore, all of the alternatives, including alternative S-1, the no-action alternative, could be considered protective.

Alternative S-2, Institutional Controls, provides additional protection for site workers and potential future residents, by establishing deed restrictions and expanded worker safety requirements. However, no efforts would be made to reduce contaminant concentrations. Alternative S-3 (institutional Controls, Phased Subsurface Bioremediation, and Deferred Investigation and Cleanup of Inaccessible Areas) provides further protection, because contaminant concentrations In subsurface soils are reduced, and areas currently inaccessible would be Investigated and cleaned up as appropriate, when they do become accessible. Alternative S-4 (Capping and Phased Subsurface Bioremediation) is somewhat more protective than alternative S-3 in the short-term, because capping immediately reduces the possibility of exposure to contaminated surface soil. Alternatives S-5 and S-6 (Surface Soil Removal and Phased Subsurface Bioremediation) are the most protective, because steps are immediately taken to reduce contaminant concentrations in surface soil, and concentrations in subsurface soil would also be reduced, over time, to the extent practicable.

7.2.2 Use of Permanent Solutions and Alternative or Recovery Technologies

Alternatives S-3, S-4, S-5, and S-6 all employ phased, in-situ bioremediation (bioventing), an alternative treatment technology, to permanently destroy subsurface CPAHs. Additional pilot testing would be required to determine the actual effectiveness of CPAH destruction. Based on existing pilot studies and published data, a 50 percent reduction in the concentration of CPAHs is assumed. Alternative S-6 also includes low-temperature thermal treatment and soil washing for excavated surface soil. Low-temperature thermal treatment permanently destroys PAHs, and soil washing is an alternative technology for arsenic removal.

Neither Alternative S-1 or S-2 involve permanent solutions or alternative treatment technologies.

7.2.3 Cost-Effectiveness

Alternative S-1 is one of the least costly alternatives (estimated present worth cost of $100,000). However, it does not achieve any contaminant mass reduction, except for that provided by natural attenuation over an extended period of time. Therefore, Alternative S-1 is not cost-effective.

Alternative S-2 also has an estimated present worth cost of $100,000. Again, no reduction in contaminant mass is achieved, but a reduction in risk is provided through increased worker protection requirements, deed restrictions, etc. In general, Alternative S-2 provides a moderate amount of risk reduction at a moderate cost, and is considered cost-effective.

Alternative S-3 provides a moderate incremental reduction in residual risk for subsurface soils at a moderate cost. This alternative has an estimated present worth cost of $2,149,000 and treats an estimated 4,600 kilograms of CPAHs (an estimated total cost of about $470 per kilogram). Compared to Alternative S-2, this is an Incremental cost per incremental increase in mass reduction of approximately $450/kg (i.e., $2,049,000 increase in cost ÷ 4,600 kg increased contaminant mass removed = $450/kg). This cost/benefit relationship is acceptable and Alternative S-3 is considered to be cost-effective.

Alternative S-4 has an estimated present worth cost of $7,772,000, an increase of $5,623,000 over Alternative S-3. This alternative provides a cap over contaminated surface soils, but results in no additional reduction in contaminant mass, nor measurable risk reduction, compared to Alternative S-3. Accordingly, the derived benefits are not proportional to the costs, and Alternative S-4 is not considered cost-effective.

Alternatives S-5 and S-6 have estimated present worth costs of $16,412,000 and $25,280,000 respectively. These alternatives do provide approximately 1,230 kg of additional contaminant mass removal compared to Alternative S-3, because some contaminated surface soils would be removed. However, the resulting reduction in residual risk is relatively small (from $3x10^{-5}$ to $8x10^{-6}$ for the retort area and from $3x10^{-5}$ to $2x10^{-5}$ for the wood storage area). The incremental cost increases, compared to Alternative S-3, are substantial ($14,263,000 for Alternative S-5 and $23,131,000 for Alternative S-6). Accordingly, Alternatives S-5 and S-6 are not cost-effective, since the incremental cost increases are not proportional to the incremental risk reduction achieved.

7.2.4 Effectiveness

Alternatives S-5 and S-6 would be the most effective, because contaminant concentrations in both surface and subsurface soils would be permanently reduced.

Alternative S-4 would be somewhat less effective. Exposure to surface soils would be prevented by a cap, but contaminant concentrations would not be reduced.

Alternative S-2, Institutional controls, would be reasonably effective in preventing exposure to contaminated soils, but it provides no reduction in contaminant concentrations. Alternative S-3 would be more effective, since it includes treatment of subsurface soils and deferred investigation and cleanup of both surface and subsurface soils that are currently inaccessible. Alternative S-1 is the least effective alternative, since no actions would be taken to reduce existing risks at the site.

7.2.4.1 Reduction of Toxicity. Mobility and Volume

Alternatives S-1 and S-2 would not result in any reduction in the toxicity or mobility of contaminants, nor in the volume of contaminant mass

Alternatives S-3, S-4, S-5 and S-6 use subsurface bioremediation to destroy PAH compounds. However, the amount of contaminant volume reduction that would be obtained is not yet known. The in-situ bioremediation will be most effective on those PAH compounds which have the greatest mobility in the subsurface. Thus, contaminant mobility will also be reduced.

Alternative S-4 would prevent direct contact with surface soils, but would not reduce potential contaminant mobility to groundwater, nor reduce contaminant toxicity or volume.

Alternatives S-5 and S-6 would reduce the volume and mobility of contaminants by excavation and off-site disposal of approximately 13,800 cubic yards of surface soil. An estimated 509 kilograms of arsenic and 726 kilograms of CPAHs would be removed from the site. In addition, Alternative S-6 includes treatment of the excavated soil, to reduce contaminant toxicity.

7.2.4.2 Short-term Risks During Implementation

Site activities during the implementation of all alternatives, except no action, are expected to pose minimal threats to plant workers or the community. Workers have a personal protection program for their activities and the public is not allowed access to the plant because of the existing security system (fences and guards). Remediation workers would follow personal protection protocols during surface and subsurface activities.

Alternatives S-5 and S-6 would have slightly increased potential for exposing the community to site contaminants and offsite transport of surface soil contaminants. Accidents could occur during offsite transport, resulting in the release of contaminated soils into the environment.

7.2.4.3 Length of Time Until Remedial Objectives Are Achieved

Alternative S-2, institutional controls, could be implemented within 3 months. The capping component of Alternative S-3 could be implemented within 12 months. Surface soil removal alternatives could be implemented within 18 months (soil removal should be conducted in the dry summer months). Bioremediation may not reach a point of no further measurable contaminant reduction for 8 to 10 years.

7.2.4.4 Magnitude of Residual Risks

Using this interpretation, Alternatives S-1, S-2, S-3, and S-4 do not reduce site risks for surface soil because there is no reduction in surface soil concentrations with these alternatives. Alternatives S-5 and S-6 do reduce site risks because contaminated surface soil is removed from the site. Residual risks for these alternatives were calculated assuming all sample locations affected by the excavation are reduced to one-half the detection limit for the compound of interest. Using this approach, residual risks from exposure to surface soils in the retort area are reduced from a baseline level of 2.82×10^{-5} to 7.82×10^{-5} following implementation of Alternatives S-5 and S-6. For the wood storage area, baseline risks are reduced from a baseline level of 3.22×10^{-5} to 2.04×10^{-5} following implementation of these alternatives.

For subsurface soil, Alternative S-2 does not reduce residual risks because there is no reduction in subsurface contaminant concentrations. Alternatives S-3, S-4, S-5, and S-6 all use in situ bioventing, which could potentially provide a reduction in residual risk through contaminant biodegradation. However, no pilot studies or full-scale implementation of bioventing on wood preserving sites have been taken to completion. Therefore, considerable uncertainty exists regarding what magnitude of residual risk can be achieved following implementation of these alternatives. It is assumed that long-term subsurface bioventing could-,reduce contaminant concentrations for sample locations above the water table in the protective and feasible remediation target areas by 50 percent. This reduction in concentrations could yield a reduction in excess lifetime cancer risk for subsurface soils from 1.04×10^{-4} to 8.11×10^{-5}.

7.2.4.5 Reliability of Controls

Each alternative, except Alternative S-1 (no action), would reduce the possibility of long-term exposure to contaminated soil, but would rely extensively on institutional controls. Existing site access controls would be continued, existing worker health and safety protocols would be expanded, and a deed restriction, spill management plan and soil excavation plan would be added. Given that the tie-treating plant is an active Industrial facility, these controls are a reliable means of protecting plant workers and the outside community from potential exposure to contaminated surface and subsurface soils. The facility is fenced and guarded to control access, and workers currently must comply with existing health and safety protocols to prevent harmful exposure to wood-treating chemicals. UPRR has already modified its contract with the plant operator, Kerr-McGee Chemical Corporation, to address the institutional controls described In Alternative S-2, and also included in Alternatives S-3 through S-6.

Capping (Alternative S-4) is a reliable method of preventing exposure to contaminated soils. The tie-treatment plant is currently "capped" to some extent with gravel, to maintain a uniform working surface (see Section 3.0).

Alternatives S-3 through S-6 would rely on In-situ bioremediation for treatment of subsurface soils. The reliability of this remedy is uncertain, because full-scale implementation of this technology has not yet been completed at a wood-treating site.

7.2.5 Implementability

7.2.5.1 Technical and Administrative Feasibility

Alternative S-1 requires no Implementation. Alternative S-2, and all succeeding alternatives, include institutional controls at the plant site (e.g., site access controls, spill management plan, excavated soil management plan, etc.). Such controls should be readily implementable through UPRR's contract with the plant operator Kerr-McGee Chemical Corporation.

Alternatives S-3, SA S-5, and S-6 rely on subsurface bioremediation to treat CPAHs. The technical feasibility of this emerging technology has not been completely demonstrated at wood-treating sites. Although the pilot testing conducted to date is promising, there is uncertainty regarding the achievement of the levels of mass reduction assumed in the Feasibility Study Report.

Implementation of Alternative S-4 would involve capping of surface soil, and Implementation of Alternatives S-5 and S-6 would involve the excavation of surface soils. While capping and soil excavation are technically feasible, either option would significantly disrupt the operation of the tie-treating facility. Stored raw materials, finished products, and railroad lines would have to be relocated, and plant operations would have to be temporarily reduced or curtailed. In addition, de minimis drippage from treated wood, as well as accidental spills and leaks from the on-going operation, would pose a continuing threat of re-contamination of the surface soils. For all of these reasons, the technical implementability of Alternatives S-4, S-5, and S-6 would be difficult.

7.2.5.2 Availability of Services and Materials

Services and materials for capping, soil excavation, and off-site treatment and disposal are readily available. In addition, local contractors may be able to install the subsurface bioremediation system.

7.2.6 Compliance with Other Regulations

There are no state or federal regulations which would apply to Alternatives S-1 through S-4, in which contaminated soils would be left in place. Excavation of contaminated soil, under Alternatives S-5 and S-6 would trigger RCRA requirements. However, it is anticipated that both of these alternatives could be conducted in compliance with RCRA requirements.

7.2.7 Supplementary Measures

Oregon's Environmental Cleanup rules, OAR 340-122-090(3), consider institutional controls to be supplements to cleanup measures. Alternatives S-2 through S-6 all rely to some extent upon institutional controls to prevent or minimize potential exposures to contaminated surface and subsurface soils at the tie-treating plant. OAR 340-122-090(3) provides authority for the Director to require such supplementary measures, where necessary to protect public health, safety and welfare and/or the environment.

7.3 Evaluation of Sediment Alternatives

As stated in Section 5.0, cleanup alternatives for sediments were not evaluated in the Feasibility Study. Rather, alternatives for sediment remediation were evaluated in two separate Interim Remedial Action Plans. The alternatives considered in those plans are briefly discussed below.

In the May 1992 *Interim Remedial Action Plan for Riverfront Park Cleanup, The Dalles, Oregon,* the cleanup of contaminated sediments in the waterfowl pond was considered, but rejected. UPRR determined, and DEQ agreed, that the cleanup of the sporadic contamination in this area was not justified., in view of the significant environmental impact that sediment excavation would cause.

The October 1994 *Interim Remedial Action Plan for the Columbia River Shoreline/Abandoned COE Pipeline Outfall Operable Unit, The Dalles, Oregon* considered several cleanup options for contaminated Columbia River sediments adjacent to Riverfront Park. Alternatives included no action, monitoring, capping, and sediment excavation. Following public notice and a 30-day public comment period, DEQ selected Alternative 3B, a multi-layer cap covering an area of approximately one acre. DEQ rejected sediment excavation, due to the threat of significant environmental impact during implementation, and because of other implementation problems. Similarly, DEQ rejected the option of extending the cap to background concentration levels, because of significant cost and implementation concerns. DEQ believes that the existing one-acre cap will be provide an effective long-term remedy, with proper monitoring and maintenance. The Interim Remedial Action Plan previously approved by DEQ requires monitoring and maintenance of the cap for a period of 20 years. Accordingly, DEQ believes no further action Is needed, other than this continued monitoring and maintenance. A No Further Action Alternative is evaluated below.

7.3.1 Overall Protection of Human Health and the Environment

An alternative limited to continued monitoring and maintenance is protective of human health, because the excess lifetime cancer risk prior to capping was less than 1×10^{-6}. The intent of the cap is to protect aquatic organisms from coming into contact with contaminated sediment. The existing cap covers most, but not all of the contaminated sediment. It covers all areas where contaminant concentrations levels were believed to pose a significant threat to aquatic life, based on studies conducted at the site (see Section 5.6.3).

7.3.2 Use of Permanent Solutions and Alternative or Recovery Technologies

Technically, the No Further Action alternative does not provide a permanent solution, as contaminated sediment is merely covered by the existing cap, and contaminant concentrations are not reduced. However, the cap was designed and constructed to last for a very long time. Capping is not considered to be an alternative or resource recovery technology.

7.3.3 Cost-Effectiveness

The No Further Action alternative is considered to be cost-effective, since it is protective and no additional costs are required (approximately $61,000 has already been budgeted by UPRR for on-going monitoring and maintenance of the cap for a 20-year period, in accordance with the previously approved Interim Remedial Action Plan).

7.3.4 Effectiveness

7.3.4.1 Reduction of Toxicity, Mobility and Volume

The mobility of contaminated sediments is controlled by the cap, which is designed to resist erosion by river waters, including 100-year flood events. However, the cap does not reduce the toxicity or volume of contaminants in the sediment.

7.3.4.2 Short-term Risks During Implementation

There will be brief, short-term risks to contractors who will perform the periodic monitoring and, if necessary, maintenance of the cap. The greatest risks may be to divers who will inspect the cap under water. Use of properly trained and experienced contractors, and compliance with all applicable worker safety requirements will serve to minimize such risks.

7.3.4.3 Length of Time Until Remedial Objectives Are Achieved

Remedial action objectives have already been met by construction of the cap. Proper monitoring and maintenance will ensure the continued protectiveness of this remedy.

7.2.4.4 Magnitude of Residual Risks

Based upon toxicity studies conducted on contaminated river sediments, the cap should have reduced risks to aquatic organisms to minimal levels. Risks to humans were less than $1x10^{-6}$ prior to construction of the cap, and have now been further reduced.

7.2.4.5 Long-term Reliability of Controls

The cap was designed to withstand 100-year frequency flood events. It should be a very reliable remedy, with the planned monitoring and maintenance.

7.3.5 Implementability

7.3.5.1 Technical and Administrative Feasibility

Construction of the cap required the approval of a number of state, local and federal agencies, including but not necessarily limited to the U.S. Army Corps of Engineers, the Division of State Lands, the Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, The Columbia Gorge Commission and the City of The Dalles. During construction, a survey of the cap revealed a few low spots where additional rip rap was needed. However, the work could not be completed during the permitted timeframe. New permits were obtained, and work was completed in February 1996. Any future maintenance of the cap would require similar approvals, and would likely be restricted to certain times of the year. However, there is no reason to believe that such approval could not be obtained.

7.2.5.2 Availability of Services and Materials

Rock rip rap, gravel and other cap construction materials potentially needed for cap repair and maintenance are readily available. Contractors capable of performing the required monitoring and maintenance work are also available.

7.3.6 Compliance with Other Regulations

As noted above, the existing cap was constructed in accordance with all applicable regulations. Monitoring and maintenance of the cap would also be conducted in compliance with these regulations.

8.0 Peer Review Summary

A project team, consisting of a Project Manager, a Hydrogeologist, a registered Professional Engineer, and a Toxicologist, has been Involved throughout the course of this project. Team members have reviewed project documents such as work plans, draft and final versions of the RI and k reports, Interim Remedial Action Plans, and DEQ's Staff Report for Recommended Remedial Action, and have submitted written comments to the Project Manager. Team members have also participated in various meetings with UPRR and with CH2M Hill, the environmental consulting firm representing the railroad on this project. Written comments from the project team to the Project Manager are maintained in a separate "Peer Review" portion of the project file, and are a part of the Administrative Record for the site. The project team unanimously supports the selected remedial actions described in Section 9.

9.0 The Selected Remedial Action

The selected remedial action is Alternative GW-3 for groundwater, Alternative S-3 for soils, and No Further Action for surface water and sediment, other than continued monitoring and maintenance of the Columbia River sediment cap, as required under a previously approved Interim Remedial Action Plan. The effectiveness of the selected remedy will be reviewed by DEQ at least each five years, and the remedy may be adjusted as appropriate. The selected remedial action is described in greater detail, in separate sections below.

9.1 Remedial Action Objectives and Cleanup Standards

Remedial action objectives (RAOs) for this site are expressed as narrative goals and/or numerical cleanup levels for specific contaminants in specific media. RAOs are derived from the conceptual goals in Oregon's Environmental Cleanup Rules, OAR 340-122-040. This rule requires that remedial actions attain "a degree of cleanup of hazardous substances that assures protection of present and future public health, safety, and welfare and the environment." Specific RAOs for this site are described in the following sections.

9.1.1 Groundwater Remediation Objectives

The remedial action objectives for groundwater at this site are:

- Protect industrial workers at the site and reasonably likely future users of groundwater downgradient of the site from exposure to unconfined water-bearing zone, Sand Hollow I flow top, or Sand Hollow II flow top groundwater contamination that exceeds protective levels (10^{-6} excess lifetime cancer risk levels or MCLs or proposed MCLs) for CPAHs, pentachlorophenol, and arsenic. A potential reasonable exposure route is ingestion by humans of contaminated groundwater;

- Prevent degradation of the existing water quality in the Ginkgo flow top;

- Prevent discharges of contaminated groundwater to the Columbia River, and/or to the waterfowl pond in Riverfront Park, at concentrations which exceed DEQ Surface Water Quality Criteria (see Section 9.1.3);

- Prevent further migration of DNAPL in the unconfined water-bearing zone and Sand Hollow II flow interior;

- Restore water quality In the water-bearing zones currently contaminated with DNAPL, to the extent feasible; and

- Remove DNAPL to the extent practicable, to prevent continued vertical or horizontal migration to the uncontaminated portions of the aquifer.

The selected groundwater remedy is premised on a potential drinking water scenario for the Sand Hollow I and Sand Hollow II water-bearing zones, since these aquifers are currently used as a source of drinking water in The Dalles area and are hydraulically connected to the unconfined aquifer. The remedy recognizes that the unconfined water bearing zone is currently not used for drinking water, but institutional controls (deed restrictions) will be provided, to ensure no future use of this aquifer on-site and in Riverfront Park as a drinking water source.

Relevant federal drinking water Maximum Contaminant Levels (MCLs) are selected as specific groundwater cleanup goals for the Sand Hollow I, Sand Hollow II, and unconfined water-bearing zones. For those contaminants that do not have promulgated or proposed MCLs, calculated health-based standards are selected as the cleanup goals. The health-based standards represent an excess lifetime cancer risk of $1x10^{-6}$ or a non-cancer hazard index of 1, based on a residential exposure scenario. The selected groundwater cleanup goals are:

- 0.05 mg/L for arsenic (MCL);

- 0.10 mg/L for chromium (MCL);

- 1.3 mg/L for copper (proposed MCL);

- 0.001 mg/L for pentachlorophenol (MCL);

- 0.0001 mg/L for benzo(a)anthracene (proposed MCL);

- 0.0002 mg/L for chrysene (proposed MCL);

- 0.0002 mg/L for benzo(a)pyrene (proposed MCL);

- 0.0002 mg/L for benzo(b, and k)fluoranthene (proposed MCL);

- 0.0003 mg/L for dibenzo(a,h)anthracene (proposed MCL);

- 0.0004 mg/L for indeno(123-cd)pyrene (proposed MCL); and,

- 0. 15 mg/L for naphthalene (non-cancer risk)

DEQ recognizes that the unconfined water bearing zone is not currently used as a drinking water source. However, DEQ is concerned that downward leakage of contaminants from the unconfined zone could impact the Sand Hollow I aquifer and has therefore identified MCLs as a cleanup goal for the unconfined zone. If UPRR can demonstrate to DEQ that downward leakage does is not occurring, or that leakage will not affect attainment of MCLs in the Sand Hollow I aquifer, and that future use of unconfined zone as a drinking water source is unlikely, then achievement of MCLs will not be retained as a cleanup goal for the unconfined zone.

The above list does not include all organic contaminants of concern, but it is representative and includes those compounds posing the greatest risks. Attainment of these cleanup levels should result in adequate cleanup of all contaminants of concern.

However, based on information obtained during the remedial investigation, DEQ believes that the selected remedy may not be able to achieve the concentration levels presented above, in the unconfined water-bearing zone, nor in a portion of the Sand Hollow I aquifer. Groundwater contamination may be especially persistent in the immediate vicinity of the contaminant source areas (former ponds, retort area, etc.) where concentrations are relatively high and DNAPL is present (see Figure 6). DNAPL recovery is the highest priority remedial action for this site, as it provides significant permanent reduction of highly concentrated contaminants (primarily creosote), and prevents the vertical or horizontal migration of the NAPL. Water flooding and other innovative techniques will be used to optimize DNAPL recovery, to the extent they are feasible. However, following the removal of mobile DNAPL, significant amounts of residual immobile DNAPL will remain within soil pore spaces. This residual contamination presents a long-term source (i.e., decades) for dissolved phase contamination of the groundwater. EPA has concluded that it is generally not feasible to restore contaminated groundwater in direct contact with mobile or residual DNAPL to drinking water quality. The water-bearing zones currently contaminated with DNAPL will be given a preference for treatment. The selected remedy will remove as much NAPL from the aquifer as is practicable, and will prohibit the use of the unconfined aquifer.

The ability to achieve cleanup goals at till points throughout the area of contamination, or contaminant plume, cannot be determined until the extraction system has been implemented, modified as necessary, and plume response monitored over time. If the selected remedy cannot meet the specified remediation goals, at any or all of the monitoring points during implementation, modifications to the selected remedy and goals may replace the selected remedy and goals for these portions of the plume. Such modifications will, at a minimum, prevent further migration of the plume and include a combination of containment technologies (typically continued groundwater extraction), institutional controls (e.g., restrictions on groundwater use), and continued monitoring of groundwater quality. These controls are considered to be the most protective of human health and the environment, under the circumstances.

The selected remedy will include groundwater extraction for an estimated period of 30 years, during which time the system's performance will be carefully monitored on a regular basis and adjusted as warranted by the performance data collected during operation. Modifications may include any or all of the following:

a) At individual wells where cleanup goals have been attained, pumping may be discontinued, although periodic monitoring of the well would be conducted;

b) Alternating pumping at wells to eliminate stagnation points;

c) Pulse pumping to allow aquifer equilibration and encourage adsorbed contaminants to partition into a dissolved phase in groundwater; and,

d) Installation of additional extraction wells, interceptor trenches or other DNAPL recovery systems, to facilitate or accelerate cleanup of the contaminant plume and/or DNAPL recovery or hydraulic containment.

The decision to invoke any or all of these measures may be made during a periodic reevaluation of the remedial action by DEQ, which will occur at least every five years.

9.1.2 Soil Remediation Objectives

The remedial action objectives for soil at the UPRR site are:

! Prevent human exposure through direct contact (ingestion, inhalation or dermal contact) to surface and subsurface soils with contamination that exceeds protective levels;

! Minimize further contaminant migration from soil to groundwater, as appropriate (data gathered during the RI indicate that potential contaminant migration from soil to groundwater, under existing conditions, is insignificant compared to the contribution from residual DNAPL).

9.1.3 Surface Water and Sediment Remediation Objectives

The remedial action objectives for surface water and sediments are:

- Protect existing water quality in the Columbia River and in the waterfowl pond in the undeveloped portion of Riverfront Park; and
- Prevent exposure of aquatic organisms to surface sediments with contaminant concentrations shown to be toxic to aquatic life.

Based upon the results of the limited sediment toxicity testing conducted during the RI (see Section 5.6.2), the following cleanup levels were developed for the design of the Columbia River sediment cap:

- 69 mg/kg for arsenic;
- 4 mg/kg for total PAHs.

DEQ has adopted Water Quality Criteria for the protection of aquatic life in surface water (OAR 340-41, Table 20). The following criteria are selected as appropriate cleanup levels for protection of existing water quality in the Columbia River, and in the Riverfront Park waterfowl pond, for the UPRR site:

- 0.048 mg/L for arsenic;
- 0.011 mg/L for chromium;
- 0.012 mg/L for copper;
- 0.013 mg/L for pentachlorophenol;
- 0.62 mg/L for naphthalene; and,
- 0.52 mg/L for acenaphthene.

As noted in Section 5.3, during the RI only one Columbia River water sample exceeded any one of these standards. That sample was collected along the shoreline near the former COE pipeline in what was probably a transitory groundwater seep. The seep could not be seen during subsequent investigations.

9.2 Description of the Selected Remedy

9.2.1 Groundwater Remedy

For groundwater, the selected remedial action requires:

! Recovery of creosote oil (DNAPL) to the extent feasible from the unconfined water-bearing zone and the Sand Hollow II intraflow zone, with extraction wells, and recycling or re-use of the recovered material, if possible. DNAPL recovery in the unconfined water-bearing zone will be implemented in a phased approach, including recovery using single wells and "water flooding" to push DNAPL toward the recovery wells, if possible;

! Hydraulic containment of the DNAPL source areas in the unconfined and Sand Hollow I water-bearing zones, and monitoring of the dissolved groundwater contaminant plumes to determine if additional hydraulic containment is needed;

! Monitoring of the Sand Hollow II water-bearing zone, to determine if protective levels are exceeded and cleanup of this zone necessary. If groundwater remediation is warranted, hydraulic containment will be implemented;

! Above-ground physical/chemical treatment of the extracted water from all affected water-bearing zones, to the extent practicable;

! Reinjection or reinfiltration of the extracted water back into the appropriate aquifers (reinjection of extracted groundwater Into the Sand Hollow I and Sand Hollow II aquifers Is required, under the 1959 Order for The Dalles Critical Groundwater Area);

! Disposal of any excess extracted water by either discharge to the City of The Dalles sanitary sewer system, discharge to surface water (Threemile Creek or the Columbia River), or land application of the treated water, in accordance with DEQ requirements;

! Institutional controls, such as deed restrictions, to prohibit the use of shallow groundwater at the site and in Riverfront Park; and

! Long-term monitoring, including a reassessment of the remedy each five years, to assure the effectiveness of the remedy.

9.2.2 Soil Remedy

For surface and subsurface soils, the selected remedial action includes:

! No further action for the area in the undeveloped portion of Riverfront Park from which contaminated soils were removed as an Interim Remedial Action in 1992;

! Phased, in-situ bioremediation ("bioventing" - see Figure 14) of protective and feasible areas of subsurface contamination at the tie-treating plant. Bioventing involves the injection of air into subsurface soils, to stimulate the growth and activity of indigenous microorganisms capable of breaking down PAH compounds. The decision. regarding the extent to which bioventing will be implemented will made under the remedy selection protocols in place at the time when the full-scale bloventing system is implemented;

! Institutional controls at the tie-treating plant, including site access controls, deed restrictions, expanded worker safety requirements, a drip/spill management plan, and a soil excavation management plan; and

! Deferred investigation, and cleanup as appropriate, of surface and subsurface soils at the tie-treating plant that are currently inaccessible. Decisions regarding the deferred investigations and evaluation of potential cleanup actions will be conducted using the DEQ risk assessment protocol and remedy selection criteria In place at the time the investigations occur. Situations that will trigger the deferred investigations are listed below. The appropriateness of this list will be re-evaluated during periodic reviews of the remedy, at least each five years.

    1. Removal and/or replacement of a tank from the tank farm area;

    2. Demolition and/or replacement of the retort building or drip pad, or any other existing structure in the North Retort Area;

    3. A permanent reduction in inventory levels in the wood storage yard, exposing an additional 50 percent of surface soils in that area; and/or

    4. Groundwater or NAPL monitoring data which indicates that there is a significant undiscovered source of groundwater contamination at the plant site.

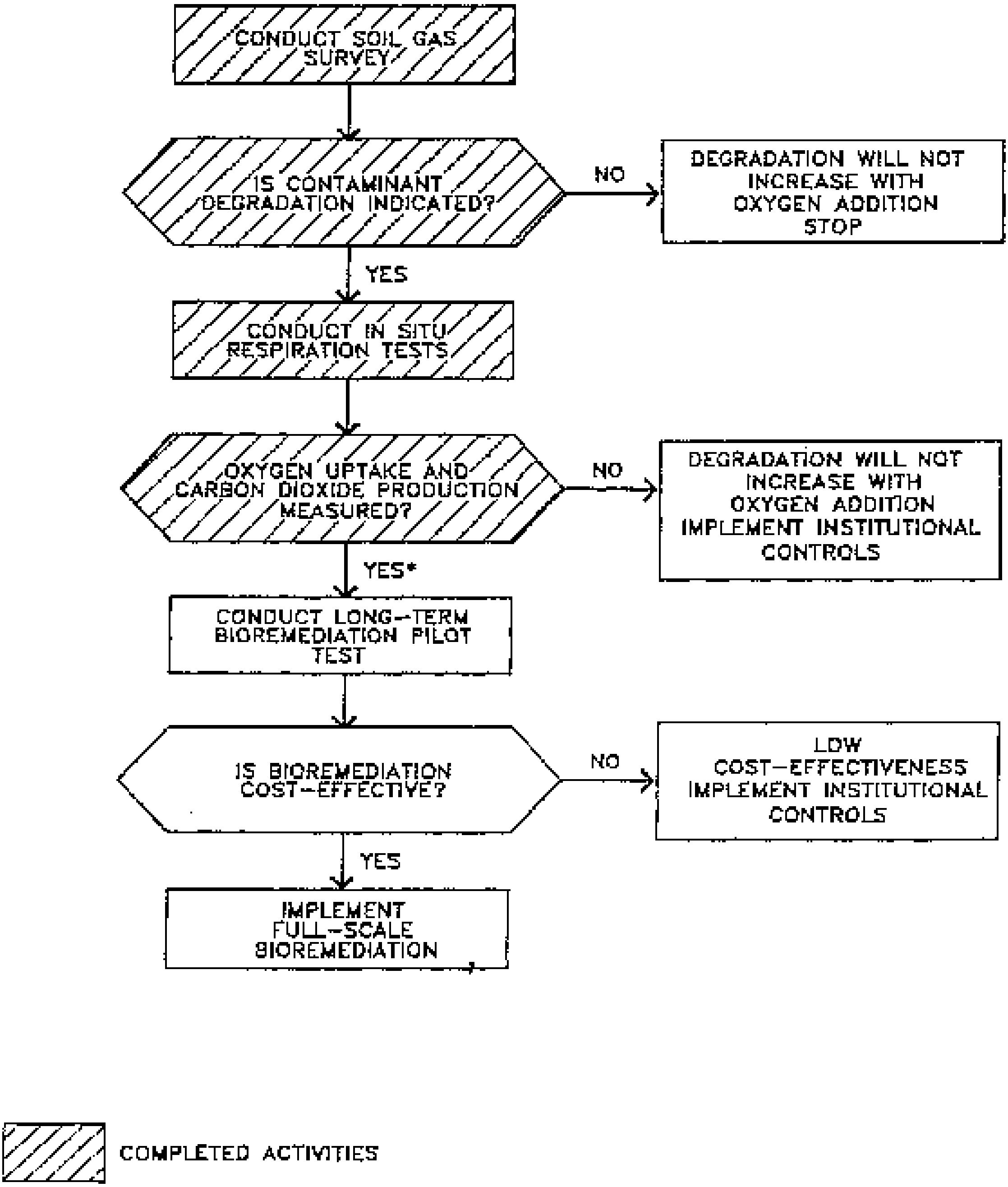

Figure 14

PHASED APPROACH FOR BIOREMEDIATION FOR SURFACE SOILS

UNION PACIFIC RAILROAD COMPANY
TIE TREATING PLANT—THE DALLES, OREGON

Source: Final Feasibility Study Report, Tie Treating Plant, The Dalles, Oregon. Prepared by CH2M Hill, Sept. 1995

The investigations shall include soil sampling and an evaluation of the risks to humans from exposure to the soil, and an evaluation of the likely effects of any soil contamination on the performance of the groundwater remedy (i.e., could the detected soil contamination serve as a significant source, of on-going groundwater contamination?). The investigations will be conducted and results reported to DEQ in accordance with a protocol and schedule approved by DEQ.

9.2.3 Surface Water and Sediment Remedy

For surface water and sediments, the selected remedial action is No Further Action, other than the continued monitoring and maintenance currently required under a previously approved Interim Remedial Action Plan. The approved monitoring and maintenance plan includes the following:

! The cap will be monitored for a period of 20 years, at intervals of 1, 3, 5, 10, 15, and 20 years. An underwater diver inspection of the cap will extend 30 feet beyond the cap footprint, to monitor for scouring of native sediment around the cap;

! Near-shore sediment monitoring will be conducted annually for a period of 5 years after cap construction and every 5 years thereafter for a total of 20 years. A grid system will be established and used for all monitoring. Permanent survey control points will be established onshore to facilitate this surveying;

! The cap and near-shore sediments will also be monitored after each 100-year flood event (the ability to withstand a 100-year flood event was a design criterion for cap construction);

! Temporary survey transects will be established to control diver location during cap and near-shore sediment monitoring activities. The diver will be equipped with an audio link to support personnel, and an underwater video camera. The diver will videotape each survey transect and provide audio commentary of visual observations. A copy of the tape with audio overlay and a written summary report will be submitted to DEQ; and

! Corrective action to maintain the cap and near-shore sediments will be instituted as appropriate. For example, a survey was conducted during cap construction to determine final cap elevations. The survey revealed some low spots in the rip rap layer of the cap. However, the subcontractor did not make the results available until after the Corps of Engineers and Oregon Division of

State Lands permit had expired. Therefore, additional rip rap was placed in these areas, and cap construction completed, in February 1996.

No further action is selected for surface water and sediment, for the following reasons:

! The results of the Remedial Investigation indicate that the levels of contamination in the waters of the Columbia River, Threemile Creek, and the waterfowl pond In Riverfront Park do not pose a significant risk to public health and safety, nor to potential environmental receptors;

! A multi-layer cap has been placed over contaminated sediment in the Columbia River adjacent to the undeveloped portion of Riverfront Park. Contamination of sediment in the waterfowl pond in the undeveloped portion of Riverfront Park is sporadic and excavation of the sediments would result in significant short-term damage to the pond and nearby portions of the park. In addition, the pond is too shallow to permit capping of the sediment; and

! The results of the Remedial Investigation indicate that sediment in Threemile Creek does not pose a significant risk to human health and safety, nor to environmental receptors.

9.3 Evaluation of the Selected Remedial Action

The selected remedial action meets the requirements of ORS 465.315, and OAR 340-122-090, as described in the following sections:

9.3.1 Protectiveness

Cleanup of groundwater to background or protective levels is not believed to be technically feasible, due to the presence of DNAPL. The selected remedy therefore relies on source (DNAPL) reduction, containment of the contaminant plume, and restrictions on groundwater use, to provide protection of public health.

The estimated excess lifetime cancer risk to site workers, from exposure to surface and subsurface soils is currently $3x10^{-5}$ and $1x10^{-4}$ respectively. These risk levels are within the range EPA considers to be protective of human health. Implementation of increased worker protection requirements, a drip/spill management plan, a soil excavation plan, deed restrictions, phased in-situ bioremediation and deferred investigation and cleanup provide significantly greater protection to site workers and potential future residents at the site. In addition, it is anticipated that the plant operator will continue to place crushed rock in operational areas, which will help reduce potential exposure to contaminated surface soils. Since this is an active facility, more aggressive cleanup measures are not cost-effective and would be difficult to implement. Also, there is the likelihood that de minimis drippage from treated wood, and accidental spills and leaks could re-contaminate soils at the site. Only the provision for deferred investigation and cleanup in the selected soil Alternative S-3 addresses this concern.

Existing conditions in surface water at and near the site do not pose a significant risk to public health, safety and/or the environment. Contaminated sediment in the Columbia River adjacent to the undeveloped portion of Riverfront Park has been covered with a protective cap. No further action, other than continued monitoring and maintenance of the cap, is needed to protect public health and aquatic life. The cap has reduced site risks to the lowest levels that are both protective and feasible.

9.3.2 Use of Permanent Solutions and Alternative or Resource Recovery Technologies

The selected remedial action provides, to the maximum extent practicable, a permanent solution. DNAPL recovery and reuse is a permanent solution to the single largest contaminant mass at the site. Water flood technology is an emerging technology for DNAPL recovery. Extracted groundwater will be subjected to physical/chemical treatment to permanently destroy most of the organic contaminants, and permanently remove most of the inorganic contaminants from the water. In-situ biological treatment of the subsurface soil also provides permanent destruction of organic contaminants, although the level of contaminant reduction that can be achieved is currently unknown. Physical/chemical treatment of the groundwater and in-situ biological treatment of the soil are both considered alternative treatment technologies. Extracted creosote (DNAPL) will, be reused or recycled, to the extent practicable.

9.3.3 Cost-Effectiveness

The selected remedial action, while more costly than some other alternatives, attains a high level of permanent risk reduction. Accordingly, DEQ believes that the total costs are proportional to the effectiveness of the remedy, and that the selected remedial action is cost-effective, in accordance with OAR 340-122-090(7). The estimated cost of implementing the selected remedial action is approximately $16,000,000 ($13,840,000 for groundwater, $2,150,000 for soils, and $61,000 for monitoring and maintenance of the Columbia River sediment cap). The costs for deferred investigation and cleanup of soils at the plant site cannot be estimated.

It should be noted that an additional $2,474,000 has already been spent by UPRR for Interim Remedial Actions ($1,630,000 for removal of contaminated soil from Riverfront Park, and $844,000 for construction of the Columbia River sediment cap). Also, the projected costs for Implementing the selected remedial action are based on an assumed 30 years of operation and maintenance. However, the remedy will be reevaluated by DEQ at least each five years, and the remedy may be adjusted as appropriate.

9.3.4 Effectiveness

Overall, the selected remedial action Is believed to be very effective. There will be a significant reduction of contaminant mobility through the removal of mobile DNAPL, containment of portions of the groundwater plume, and containment of contaminated Columbia River sediments. There will be a significant reduction in contaminant mass through DNAPL recovery, physical/chemical treatment of extracted groundwater and, possibly, by in-situ biological treatment of subsurface soil.

DEQ recognizes, however, that the numerical groundwater cleanup goals (Section 9.2) will likely not be achievable at this site. DEQ expects that high concentrations of contaminants will be removed initially, but this contaminant reduction is expected to decrease with time and will level out at some point. The concentrations at which this leveling occurs may be well above the numerical cleanup goals. Therefore, a risk management strategy including long-term monitoring, groundwater use restrictions, and periodic reviews to evaluate the effectiveness of the remedy is provided. The effectiveness of the selected remedy is discussed further in sections below.

9.3.4.1 Reduction in Toxicity, Mobility and Volume

Groundwater contamination that exceeds the cleanup levels in the Sand Hollow I aquifer will be hydraulically contained. Also, groundwater contamination in the unconfined aquifer will be contained to the extent practicable (the contaminant plume extends beneath highway I-84 and Riverfront Park, and full containment is not practicable). Containment of mobile DNAPL In the unconfined, and in the Sand Hollow II intraflow zone will be provided. Containment of contaminated Columbia River sediments is provided by the sediment cap.

DNAPL recovery, and groundwater removal and treatment could reduce the volume of contaminant mass in affected aquifers by approximately 548,800 kilograms. In-situ bioremediation of subsurface soils could reduce contaminant mass by approximately 4,600 kilograms. Reduction of contaminant toxicity is afforded by the water and soil treatment process, which permanently destroy organic contaminants.

9.3.4.2 Short-term Risks During Implementation

Remediation activities are expected to pose minimal-risks to plant workers and the nearby community. The most significant threats may be associated with the underwater monitoring of the Columbia River sediment cap. In all cases, plant and remediation workers will be protected by appropriate health and safety protocols.

9.3.4.3 Length of Time Until Remedial Objectives Are Achieved

Hydraulic containment of mobile DNAPL and the dissolved groundwater contaminant plumes could be achieved within one month of start-up. DNAPL removal and in-situ bioremediation of subsurface soils have already begun. However, the time to attain remedial action objectives is unknown. It is estimated that in-situ bioremediation may take 8 to 10 years to achieve the point where no further contaminant reduction is occurring. Remedial action objectives for surface water and sediment have already been achieved, and must only be maintained.

9.3.4.4 Magnitude of Residual Risks

The selected remedial action will reduce risks from potential exposure to contaminated groundwater by DNAPL removal, hydraulic containment and restrictions on the groundwater use. However, there are no known technologies for restoring DNAPL contaminated aquifers to drinking water standards. Accordingly, the degree of residual risk reduction cannot be accurately predicted.

There is also uncertainty regarding the effectiveness of in-situ bioremediation of subsurface soils. It is estimated that this technology may be able to reduce current risks from approximately $1x10^{-1}$ to $8x10^{-5}$.

Risks from exposure to surface soils by plant workers will be reduced through institutional controls, including expanded worker health and safety requirements, a spill control plan, soil excavation management plan. The community will be protected by existing site access controls and a deed restriction. There may be additional risk reduction as a result of the on-going placement of crushed rock at the site by the site operator.

There may be additional reductions in risks to both surface and subsurface soils, as a result of the deferred investigations and cleanup required by the selected remedy. However, the magnitude of such potential reductions cannot be predicted at this time.

Based upon toxicity studies conducted on contaminated river sediments, the cap should have reduced risks to aquatic organisms to minimal levels. Risks to humans were less than $1x10^{-6}$ prior to construction of the cap, and have now been further reduced.

9.3.4.5 Long-term Reliability of Controls

Hydraulic containment and physical/chemical treatment of groundwater are reliable technologies. The reliability of institutional controls, for restriction of groundwater use and for protection of plant workers, should also be very effective. The Columbia River sediment cap should be a very reliable remedy, with proper monitoring and maintenance. The reliability of DNAPL recovery and in-situ bioremediation is uncertain, as these are innovative, developing technologies. Pilot testing is currently underway to determine the effectiveness of these technologies at the UPRR site.

Groundwater monitoring will be performed on a frequent basis to evaluate the performance of the remedial action. Data will be collected from both within and outside the contaminant plume, to monitor changes in contaminant concentration and in the size and shape of the plume. Changes in the design of the remedy may be made, as necessary to maximize DNAPL recovery, and groundwater contamination containment and cleanup.

9.3.5 Implementability

9.3.5.1 Technical and Administrative Feasibility

The selected remedial action is believed to be implementable. Granular activated carbon (GAC) treatment, and iron co-precipitation are well developed water-treatment technologies, and a water-treatment facility has already been constructed at the tie-treating plant site. Similarly, DNAPL recovery and in-situ biological treatment of subsurface soils use readily available construction equipment. However, additional pilot testing will be required to refine these systems. Institutional controls should also be readily implementable. UPRR has already initiated negotiations with the Port of The Dalles and with the plant operator Kerr-McGee Chemical Corp.

Under recent amendments to Oregon's Environmental Cleanup Law, on-site remedial actions, including actions in Riverfront Park, are exempt from state and local permits. However, the remedy must comply with the substantive requirements of state and local laws and regulations.

9.3.5.2 Availability of Services and Materials

Well drillers and remediation contractors, for installation of groundwater extraction wells and reinjection/reinfiltration systems, and for the in-situ bioremediation system, are readily available. Also, local contractors may be able to provide basic services such as mechanical and electrical contracting support.

Materials for maintenance of the sediment cap (rock rip rap, gravel, etc.) are also readily available. Contractors capable of performing the cap monitoring and maintenance work are also available.

9.3.6 Compliance with Other Laws

It is believed that the selected remedial action can comply with most applicable federal, state and local standards, except for the attainment of drinking water standards for groundwater.

9.3.7 Compliance with House Bill 3352

House Bill 3352 (1995 Legislative Session) amended Oregon's environmental cleanup law (ORS 465.315 and 465.325). Certain provisions became effective July 18, 1995. Other provisions will not become legally operative until rulemaking by DEQ is completed. DEQ is nonetheless required to select remedial actions consistent with the purpose and intent of HB 3352, to the maximum extent practicable within the bounds of existing cleanup rules (OAR 340, Chapter 122). This section evaluates consistency of the selected remedial action with HB 3352.

9.3.7.1 Protectiveness

Under HB 3352, the protectiveness of a remedial action is determined by application both of acceptable risk levels prescribed by the statute and a risk assessment undertaken for the site in question. This provision will not be fully operative until rulemaking is completed. The selected remedial action for the UPRR site is nonetheless consistent with this provision of HB 3352 and current rules.

The acceptable risk levels prescribed by HB 3352 for human health are $1x10^{-6}$ for individual carcinogens and a Hazard Index of 1 for non-carcinogens; acceptable cumulative risk for a site will be addressed in future rulemaking. The selected remedial action for groundwater at the Union Pacific Railroad facility establishes cleanup goals for the unconfined, the Sand Hollow I, and possibly the Sand Hollow II aquifers equal to federal drinking water standards, or for contaminants for which there is no drinking water standard, to levels resulting in an excess lifetime cancer risk of $1x10^{-6}$ for Individual carcinogens and a non-cancer Hazard Index of 1. However, DEQ believes attainment of such goals may not be technically feasible. Accordingly, the remedy relies on source reduction (DNAPL removal) and containment, to reduce contaminant concentration and mobility. Potential human exposure to groundwater under the Tie-Treating Plant and Riverfront Park will be reduced or prevented through institutional controls.

For sediments and surface waters, the human health risks existing before an Interim Remedial Action was undertaken (sediment cap constructed) were within the acceptable risk levels prescribed by HB 3352. One possible exception was the estimated risk of 7×10^{-6} associated with the ingestion of fish. However, this risk level was also found in background areas. DEQ's existing cleanup rules do not require remediation below background levels. Moreover, risks associated with sediments and surface waters have been decreased by the placement of a protective cap over contaminated sediments as an Interim Remedial Action. The selected remedial action is therefore consistent with HB 3352's provisions and application of current rules, including the requirement to prevent significant adverse affects to ecological receptors.

For soils, the selected remedial action will result in a reduction of risks from the current maximum levels of $3x10^{-5}$ for surface soils and $1x10^{-4}$ for subsurface soils. The amount of reduction from treatment alone is unknown, since the investigation and cleanup of areas currently inaccessible will be deferred, and because the effectiveness of in-situ bioremediation has not yet been determined. However, the combination of treatment and institutional controls will result in a level of protection consistent with HB 3352 and current rules.

9.3.7.2 Treatment

Once the amendments in HB 3352 become fully operative, the treatment of hot spots of contamination will be required. The selected remedial action for the Union Pacific Railroad site is consistent with this provision, in that it requires treatment of the most highly contaminated soils and groundwater. The selected remedy is also consistent with HB 3352, in that the required treatment is limited to that which is feasible within a reasonable time frame.

9.3.7.3 Remedial Methods

HB 3352 provides that remedial actions may achieve protection of human health and the environment through a variety of potential methods, ranging from treatment to institutional controls, from removal of contaminants to cutting off potential exposure pathways. The method or methods used at a particular site will be determined by application of other provisions of HB 3352.

The selected remedial action is consistent with the remedial methods described in HB 3352, by including a combination of containment, removal, treatment, institutional controls, and other measures such as monitoring and maintenance.

9.3.7.4 Balancing Factors

Under HB 3352, remedial actions selected by DEQ will balance effectiveness, implementability, long-term reliability, short-term risk, and reasonableness of cost. Similar factors applicable under DEQ's existing cleanup rules have been evaluated above for the selected remedial action. Further, long-term reliability of the remedy is evaluated in connection with "permanent solutions," and is ensured by requirements for monitoring, maintenance, and periodic review. Reasonableness of cost, evaluated in connection with "cost-effectiveness," is supported by DEQ's determination that the cost of the selected remedial action are proportional to the effectiveness of the remedy.

9.3.7.5 Land Use

HB 3352 requires DEQ, when selecting a remedial action, to consider current and reasonably-anticipated future land uses at the facility and surrounding properties. As discussed above, DEQ considered present and potential future exposure scenarios in selecting the remedial action for the site (e.g., the likely continued industrial use of the Tie-Treating Plant property or the likely future use of Riverfront Park for recreational purposes only.

The selected groundwater remedy is premised on a potential drinking water scenario for the Sand Hollow I and Sand Hollow II water-bearing zones, since these aquifers are currently used as a source of drinking water in The Dalles area and are hydraulically connected to the unconfined aquifer. The remedy recognizes that the unconfined water bearing zone is currently not used for drinking water, but institutional controls (deed restrictions) will be provided, to ensure no future use of this aquifer on-site and in Riverfront Park as a drinking water source.

10.0 Public Notice and Comments

DEQ's notice of the proposed remedial action was published In the Secretary of State's Bulletin, and in The Dallas Chronicle, on February 1, 1996. In addition, copies of the notice were mailed to 45 individuals who had previously requested to be on DEQ's mailing list for The Dalles area. Copies of the RI and FS Reports, DEQs Staff Report for Recommended Remedial Action and other pertinent project documents were made available for public review at The Dalles/Wasco County Public Library, in The Dalles, and at DEQ headquarters in Portland.

A 30-day public comment period began on February 1 and ended on March 1, 1996. Only one party, Union Pacific Railroad (UPRR) submitted comments in response to DEQ's notification. UPRR's comments were submitted by their environmental consultant CH2M Hill of Portland, Oregon. UPRR's comments were considered by DEQ in preparing this Record of Decision.

11.0 Consideration of Public Comments

As described In Section 10, written comments were received from CH2M Hill, on behalf of Union Pacific Railroad (UPRR). UPRR owns the tie-treating plant property and will be responsible for implementing the selected remedial action for the site. Staff from CH2M Hill, UPRR's environmental consultant, met with DEQ staff on February 28, 1996 to discuss UPRR's concerns, and written comments were submitted on March 1, 1996. The majority of UPRR's comments were simply editorial and do not affect the selected remedy. Only two of UPRR's comments request changes in the text which would affect the selected remedial action. These two comments, and DEQ's responses, are presented below.

Comment 1: In Section 9.2.2 of the Staff Report, DEQ presented four examples of situations that would trigger the deferred soil Investigations. UPRR requests that this list be the identified triggers, rather than just examples.

Response 1: DEQ agrees that the four situations presented in the Staff Report should be identified as triggers, and the requested change in the text has been made. However, there may be additional situations that should also be triggers. Accordingly, the appropriateness of this list will be re-evaluated during periodic reviews of the remedy, at least each five years. In addition, DEQ has added text to clarify that the deferred investigations will include soil sampling and an assessment of risks associated with any identified soil contamination.

Comment 2: DEQ's proposed plan included a requirement for periodic monitoring of surface water quality in the waterfowl pond in the undeveloped portion of Riverfront Park. DEQ's rationale is that the contaminated unconfined aquifer maybe discharging to this pond. Although water quality in the pond is currently acceptable, there was concern that continued discharges could adversely affect water quality in the pond over time. UPRR reports that the waterfowl pond dries up in the summer and floods in the winter. Accordingly, UPRR believes that monitoring of water quality in the pond is not warranted.

Response 2: In light of this new information, DEQ agrees to delete this requirement from the Record of Decision. Details of the required groundwater and/or surface water monitoring program will be determined during remedial design and remedial action.

12.0 Documentation of Significant Change

As noted in Section 11, two changes were made in the selected remedial action, in response to comments received from Union Pacific Railroad. First, four situations are identified which will trigger the deferred investigation portion of the soil remedy. In DEQ's February 1, 1996 recommended remedial action, these four situations were merely presented as examples of such situations. DEQ has also added text to clarify that the deferred investigations will require soil sampling and an assessment of risks associated with any identified soil contamination. Second, the requirement to monitor surface water quality in the waterfowl pond in Riverfront Park has been deleted. Details of the required groundwater and/or surface water monitoring requirements will be determined during remedial design and remedial action.

13.0 Final Decision of The Director

The selected remedial action for the Union Pacific Railroad Tie-Treating Plant site is protective, and to the maximum extent practicable, uses permanent solutions and alternative technologies, is cost-effective, effective and implementable. It therefore satisfies the requirements of ORS 456.315, and OAR 340-122-040 and 340-122-090. The detailed evaluation of how the selected remedial action meets the regulatory requirements is provided in Section 9.3.

14.0 Director's Signature

Langdon Marsh

Langdon Marsh, Director
Department of Environmental Quality

March 27, 1996

Date

ADMINISTRATIVE RECORD INDEX

UNION PACIFIC RAILROAD SITE, THE DALLES

The Administrative Record Index is the list of documents on which the selected remedial action is based. The documents listed below contain the specific data and guidance used in evaluating remedial action alternatives for the Union Pacific Railroad Site at The Dalles.

GENERAL GUIDANCE DOCUMENTS

1. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final.* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01, October 1988.

2. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final.* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, EPA/540/1-89/002, December 1989.

3. *Risk Assessment Guidance for Superfund, Volume II, Environmental Manual, Interim Final.* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, EPA/540/1-89/001, March 1989.

4. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference.* U.S. Environmental Protection Agency, Environmental Research Laboratory, EPA/600/3-89/013, March 1989.

5. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*. OSWER Directive 9285.6-03, March 1991.

6. *Supplemental Guidance for Superfund Risk Assessments in Region 10.* U.S. Environmental Protection Agency, Region 10, August 23, 1991.

7. *Suggested ROD Language for Various Ground Water Remediation Options*. U.S. Environmental Protection Agency, OSWER Directive 9283.1-03, October 1990.

SITE-SPECIFIC DOCUMENTS

8. Order on Consent, DEQ No. ECSR-CR-89-01, between DEQ and UPRR, signed by DEQ's Director May 8, 1989.

9. *Preliminary Health Assessment for Union Pacific Railroad, Kerr McGee Tie Plant, The Dalles, Wasco County, Oregon, CERCLIS No. ORD009049412.* U.S. Dept. of Health and Human Services, Public Health Service, Agency for Toxic

Substances and Disease Registry, December 9, 1991.

10. *Interim Remedial Action Plan for Riverfront Park Cleanup, The Dalles, Oregon*. Prepared for BNRR by CH2M Hill, May 1992.

11. *Closure Report. Interim RemedialAction at Riverfront Park, The Dalles, Oregon.* Prepared for UPRR by CH2M Hill, March 1993.

12. *Final Remedial Investigation Report*. Prepared for UPRR by CH2M Hill, July 1993.

13. *Work Plan for Soil Gas Survey and In Situ Respiration Tests.* Prepared for UPRR by CH2M Hill, September 1993.

14. *Results of the Soil Gas Survey and In Situ Respiration Tests.* Prepared for UPRR by CH2M Hill, May 1994.

15. *Wastewater Treatment System, Design Basis*. Prepared for UPRR by CH2M Hill, May 1994.

16. *Final Work Plan for a Pilot Scale Bioventing Test: Step 2 of the Bioventing Program, Union Pacific Railroad, Tie-Treating Plant - The Dalles, Oregon.* Prepared for Union Pacific Railroad (UPRR) by CH2M Hill, September 1994.

17. *Remedial Investigation Columbia River Shorellne/Abandoned COE Pipeline Outtall Operable Unit.* Prepared for UPRR by CH2M Hill, October 1994.

18. *Interim Remedial Action Plan, Columbia River Shoreline/Abandoned COE Pipeline Outfall Operable Unit.* Prepared for UPRR by CH2M Hill, October 1994.

19. *Union Pacific Railroad, The Dalles Tie-Treating Site, Iron Coprecipitation System, Design Basis.* Prepared for UPRR by CH2M Hill, November 1994.

20. *Volume 1, Operation and Maintenance Manual, Wastewater Treatment System, The Dalles, Oregon.* Prepared for UPRR by CH2M Hill, May 1995.

21. *Revised Pilot DNAPL Recovery Program, Phase 1: Demonstration of DNAPL Recoverability, Tie Treating Plant, The Dalles, Oregon.* Prepared for UPRR by CH2M Hill, May 1995.

22. *Final Closure Report, Union Pacific Railroad Columbia River Operable Unit Cap Construction.* Prepared for UPRR by CH2M Hill, July 1995.

23. *Final Feasibility Study, Tie Treating Plant, The Dalles, Oregon.* Prepared for UPRR by CH2M Hill, September 1995.