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1.0 INTRODUCTION

This report presents the results of Phase I of the Remedial Investigation (RI) for the J.H. Baxter Wood Preserving (JHB) site located in Eugene, Oregon. This report was prepared by Keystone Environmental Resources, Inc. (Keystone) on behalf of J.H. Baxter Wood Preserving. The information contained in this report was prepared pursuant to the Remedial Investigation Work Plan (Phase I) prepared by Keystone Environmental Resources, Inc. in March 1990.

The objectives of the Phase I Remedial Investigation as described in the Work Plan were to:

- o Augment data previously collected at the site,
- o Identify and define the nature and extent of chemical constituents that may have been released to the environment,
- o Identify and characterize migration pathways,
- o Identify the potential environmental impact and risk to human health and the environment, and
- o Gather necessary data to support the evaluation of remedial alternatives and the selection of a remedy.

To achieve the objectives of the RI, an additional ten monitoring wells were installed at the site, two aquifer tests were conducted, and sampling and analyses were performed on:

- o Subsurface soils onsite,
- o Groundwater onsite,
- o Sediment from onsite drainage ditches,
- o Sediment from an onsite surface water retention pond,
- o Surface water from drainage ditches,
- o Surface water from onsite retention pond.

Results of the sampling and analyses have been used to evaluate the nature and extent of onsite contamination and to perform a Public Health and Environmental Assessment (PHEA) of the "no action" alternative at the site. This risk assessment will be refined to incorporate additional data that may be acquired during any subsequent phases of the RI. Residential properties are situated approximately 500 feet from the northern perimeter of the Baxter property. Therefore, updating the risk assessment as data is obtained is recognized as an important aspect of the RI.

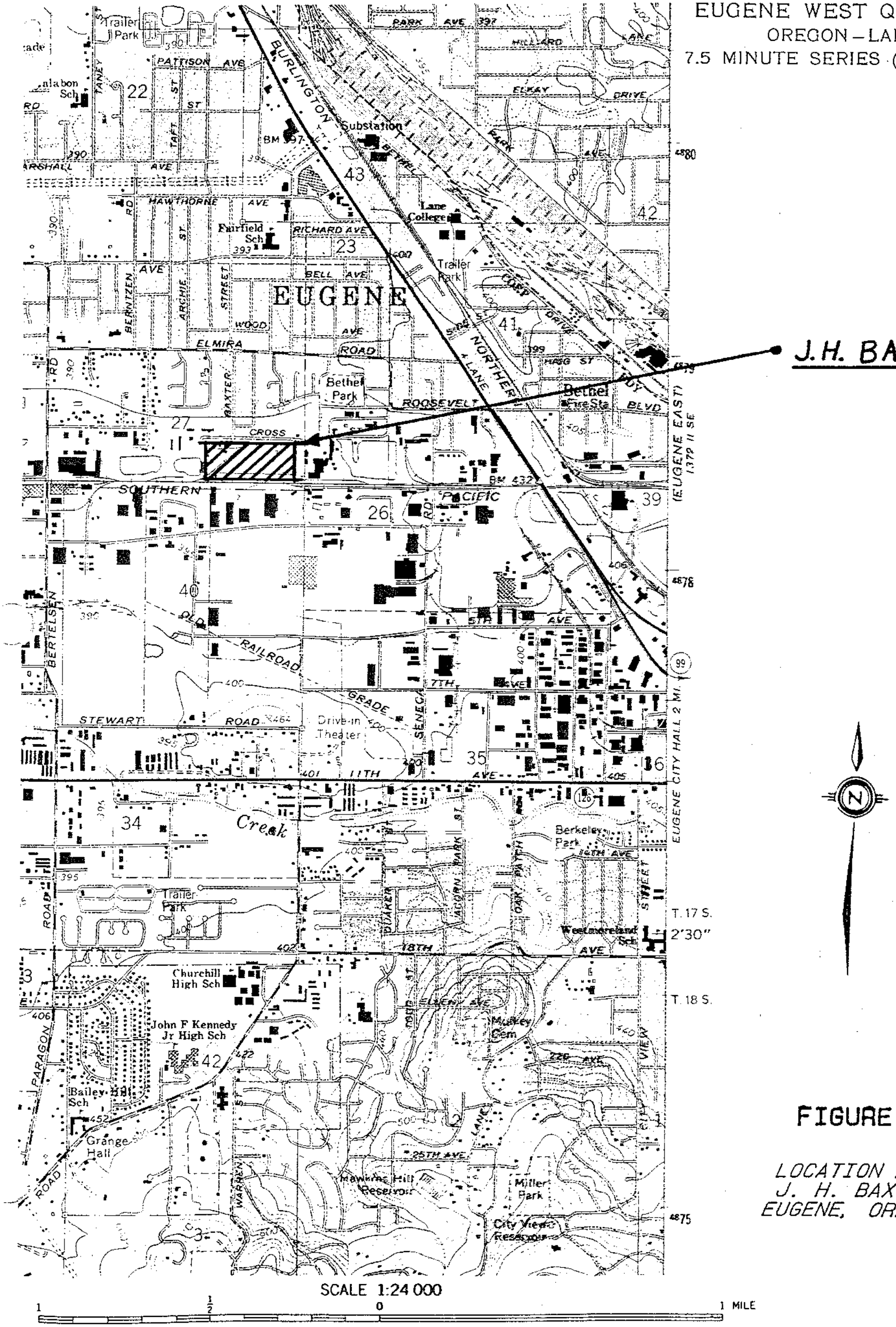
In the Phase I Work Plan it was stated that twelve monitoring wells would be installed for the RI. However, ten wells were installed due to the unanticipated geologic stratigraphy encountered at depth (clay layer at approximately 80 feet below grade) during the RI drilling program. At a meeting held at the site in May 1990, during the RI monitoring well installations, the drilling program was modified with the approval of J.H. Baxter and by personnel from the Oregon Department of Environmental Quality (DEQ). The modification was the elimination of wells W-10D and W-11D from the drilling program.

An Addendum (I) for the Phase I Work Plan was prepared by Keystone proposing that the number of aquifer tests to be performed in the RI be reduced to two from the four outlined in the Work Plan. This addendum to the Work Plan was submitted in October of 1990 and was approved by the DEQ.

1.1 Site Background

The J.H. Baxter Wood Preserving facility consists of approximately 42.45 acres, and is located within the Eugene City limits (Figure 1-1). A residential area is north of the site. The area east and south of the site is occupied by light industry. Businesses located to the east include Alpine Veneer, Oregon Dome (a precut building plant), Perrco-Storrs Co. (a warehouse), Al Larion Trucking, A & H Truck Repair, the American Plywood Association testing laboratory, and an electrical contractor shop and warehouse owned by Phillips Electric Company. The Southern Pacific Railroad borders the site on the south. Businesses south of the site include Hearin Industries dry kiln, a Georgia Pacific building supplies distribution yard, Western Graphics, a building supply wholesaler called Weatherlys, Inc., Oregon Rubber Co., Christopher Hydraulic Services, a metal fabrication shop (Henry Manufacturing Co.), and Hyster forklift sales and service. The property to the west of the site is light industrial and residential. Industries to the west include Zippo Manufacturing, log storage areas, warehouses, Cascade metal plating, and a helicopter repair and modification shop called Heli-Jet.

EUGENE WEST QUADRANGLE
OREGON – LANE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



J.H. BAXTER

SCALE 1:24 000

FIGURE 1-1

LOCATION MAP
J. H. BAXTER
EUGENE, OREGON

The entire site is surrounded by a chain-link fence. The plant office is located along Roosevelt Boulevard at the northern edge of the property.

Five retorts are currently used to pressure treat wood products at the J.H. Baxter plant. The first of these (retort number 85) is located southwest of the office, and is used to treat wood with J.H. Baxter Exterior Fire-Retardant Formulation (JHB EXT FR). JHB EXT FR is a mixture of water, phosphoric acid, dicyandiamide, melamine and formaldehyde. D-Blaze, an interior fire retardant containing boric acid, water and ammonium phosphate, is also used to treat wood in this retort. In addition to the retort, the JHB EXT FR process area consists of several process and storage tanks and a pull track which leads out of the cylinder to the west. The tank farm and the pull track are paved. The retort and tank farm area are displayed in Figure 1-2

The main retort facility is south of the JHB EXT retort. This area consists of four wood treating retorts. The current and historic preservative usage in each of these cylinders is listed on Table 1-1. Several work tanks associated with these processes are also located in this area. This tank farm is paved and diked. The area east of these retorts is paved to contain any drippage that may occur as charges of treated wood are pulled from the retorts. The area beneath all retorts is paved and surrounded by diking. Additional storage and process tanks are south of the main retort facility. This area is also diked and paved. Approximately 165,000 square feet, excluding buildings, is covered by pavement at the site (Figure 1-2). The exact dates and schedules for the paving in the retort and tank farm areas is not available.

A stormwater retention pond, approximately one acre in size, is on the southwest corner of the property. The remainder of the acreage is used to store untreated and treated wood, and for framing and wood processing. Although the site is relatively flat, most surface waters from the treated wood storage areas flow to the southwest corner of the property into a surface water retention pond.

1.2 Site History

J.H. Baxter constructed and began operating its Eugene wood treating plant in 1943 using creosote in what is now retort number 83. In 1945, a second retort (#82) was

TABLE 1-1

EUGENE PRESERVATIVE/FIRE RETARDANT FORMULATIONS AND USAGE OVER TIME

	Start	Finish
Coal Tar Preservatives		
-Coal Tar Creosote	1943	Present
-50/50 ~ 50% Coal Tar Creosote/50% #6 Fuel Oil	1945	Present
-Southern Pacific Blend ~ 50% Coal Tar Creosote/25% #6 Fuel Oil/25% #2 Diesel	1961	1973
Pentachlorophenol		
-Penta A ~ 5-7% Pentachlorophenol/93-95% Aromatic Oil & #2 Diesel	1945	Present
-Penta C ~ 5-7% Pentachlorophenol/93-95% Mineral Spirits	1968	Present
Metallic Oxides		
-Chemonite		
Ammoniacal Copper Arsenate ~ 1-13% Oxides/1.4-22% Ammonia/65-97.6% Water (Oxides ~ 50.2% Arsenic Pentoxide/48.2% Copper II Oxide)	1952	1985
Ammoniacal Copper Zinc Arsenate ~ 1-13% Oxides/1.4-22% Ammonia/.24-3% Ammonia Bicarbonate/62-97.4% Water (Oxides ~ 50% Copper II Oxide/25% Zinc Oxide/25% Arsenic Pentoxide)	1985	Present
-Chromated Zinc Chloride (CZC) ~ 2.5% Solids/ 97.5% Water (Solids ~ 20% Sodium Dichromate as Chromium trioxide/80% Zinc Chloride as Zinc Oxide)	1959	1970
Fire Retardants		
- Protexal ~ 22% Solids/78% Water (Solids ~ 14% Borax/23% Monoammonium Phosphate/63% Ammonium Sulfate)	1955	1961
-Pyresote ~ 13% Solids/87% Water (Solids ~ 25% Boric Acid/5% Sodium Dichromate/35% Zinc Chloride/35% Ammonium Sulfate)	1955	1975
-Flamescape ~ 13% Solids/87% Water (Solids ~ 45% Diammonium Phosphate/39% Ammonium Sulfate/16% Boric Acid)	1975	1985

TABLE 1-1(continued)

EUGENE PRESERVATIVE/FIRE RETARDANT FORMULATIONS AND USAGE OVER TIME

	Start	Finish
-J.H. Baxter Exterior (NCX) ~ 13% Solids/87% Water (Solids ~ 57.2% Polymer/42.8% Phosphoric Acid) (Polymer ~ 57.2% Dicyandiamide/16.4% Melamine/ 26.4% Formaldehyde)	1970	Present
-D-Blaze ~ 2.5-3.0% Solids/97-97.5% Water (Solids ~ Ammonium Phosphate - Boric Acid Type Fire Retardant)	1985	Present

Note: Percentage concentrations are approximates

RETORT TREATMENTS

Number	Currently Used	Formerly Used
81	Penta A	S.P. Tie Mix, ACA, Creosote
82	ACZA, PCP-A, Creosote, 50/50	S.P. Tie Mix, ACA
83	Creosote, 50/50, Penta A	S.P. Tie Mix, ACA, Pyresote, Protexal, CZC, Flamescape
84	Penta C, ACZA	CZC, Pyresote, ACA
85	J.H. Baxter Exterior, D-Blaze	Pyresote, Flamescape

TABLE 1-2
CONTAMINANT CONCENTRATIONS IN SHALLOW GROUNDWATER AQUIFER
J.H. BAXTER WOOD PRESERVING
EUGENE, OR

WELL NO.		W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	MINIMUM DETECTED	MAXIMUM DETECTED
DEPTH OF WELL		28.5	26.0	33.0	22.5	75.5	70.0	20.0	20.0		
CONTAMINANT	PRACTICAL QUANTITATION LIMIT										
ACENAPHTHENE	1.0	1.0	286.8	0.8	0.8	0.8	1.3	78.4	510	0.5	30000
ACENAPHTHYLENE	1.0	0.9	8.6	0.8	0.8	0.8	0.8	3.8	15.2	0.5	1000
ANTHRACENE	1.0	0.9	6.9	0.8	0.8	0.8	1.3	5.0	191.7	0.5	14000
BENZO(A)ANTHRACENE	1.0	0.9	5.0	0.8	0.8	0.8	1.2	2.4	73.6	0.5	4200
BENZO(A)PYRENE	1.0	0.9	3.4	0.8	0.8	0.8	1.1	2.4	37.7	0.5	1000
BENZO(B)FLOURANTHENE	1.0	0.9	3.5	0.8	0.8	0.8	1.1	2.7	54.0	0.5	1000
BENZO(G,H,I)PERYLENE	1.0	0.9	3.1	0.8	0.8	0.8	0.8	2.7	16.6	0.5	1000
BENZO(K)FLOURANTHENE	1.0	0.9	3.5	0.8	0.8	0.8	1.1	2.6	38.0	0.5	1000
CHRYSENE	1.0	0.9	4.9	0.8	0.8	0.8	1.2	2.4	73.2	0.5	4200
FLOURENE	1.0	1.1	134.1	0.8	0.8	0.8	1.3	42.2	513.7	0.5	30000
FLOURANTHENE	1.0	1.1	33.3	0.8	0.8	0.8	1.5	8.9	387.0	0.5	36000
NAPHTHALENE	1.0	1.2	2324	0.8	0.8	0.8	1.7	1091	1950	0.5	79000
PHENANTHRENE	1.0	1.2	240.6	0.8	0.8	1.1	1.5	76.8	990.8	0.5	58000
PYRENE	1.0	1.2	35.7	0.8	0.8	0.8	1.3	7.5	360.1	0.5	23000
PHENOL	1.0	1.0	32.3	1.0	1.0	1.0	1.2	89.5	13.5	0.5	1000
2,4-DIMETHYLPHENOL	1.0	1.0	110.2	1.0	1.0	1.0	1.0	182.3	15.1	0.5	1400
2-NITROPHENOL	1.0	1.0	2.6	1.0	1.0	1.0	1.0	3.9	4.7	0.5	1000
PENTACHLOROPHENOL	1.0	16.4	1746	1.4	2.0	405.6	541.7	2134	97.7	0.5	5600
ARSENIC	2.0	1.1	6.2	1.1	3.5	1.0	1.4	107.7	180.3	0.5	430
CHROMIUM	20.0	15.5	11.6	11.6	14.6	22.2	22.2	22.2	22.2	5	50
COPPER	20.0	12.0	11.6	11.6	10.0	22.1	11.1	14.0	10.4	5	80
ZINC	10.0	15.6	16.3	9.2	13.8	8.4	8.3	13.3	23.9	5	690

Note:

All values (except max. and min.) are geometric means and are in ug/L.

W-1 to W-3 means calculated from samples obtained over the period from 7/86 to 7/90.

W-4 to W-8 means calculated from samples obtained over the period from 12/86 to 7/90.

Not detected constituents were assigned a value equal to 1/2 the quantitation limit for the constituent.

This value for non-detect constituents was used in the calculation of geometric mean values presented above.

Metal concentrations are total concentrations.

PAH concentrations in well W-2S varied considerably between quarterly sampling sessions. For example the naphthalene concentration in well W-2S has ranged from 28 ug/L to 79,000 ug/L. A seasonal pattern is not evident in the data (Table 4, Appendix B). However, since the surface water retention pond is probably the major source for the contamination observed in well W-2S, the fluctuations of contaminant levels in the pond would likely influence the contamination observed in well W-2S.

The arsenic concentrations were also the highest in wells W-2, W-7 and W-8 over the quarterly sampling period (July 1986 to April 1990). The geometric mean concentrations of arsenic in these wells were 6.2 ug/L, 108 ug/L and 180 ug/L, respectively. The geometric mean concentrations for chromium ranged from 11.6 ug/L (wells W-2 and W-3) to 22.2 ug/L (wells W-5 through W-8). Copper had a geometric mean concentration range of 10 ug/L (well W-4) to 22.1 ug/L (well W-5). Zinc had a maximum detected concentration of 690 ug/L in well W-4 and a mean (geometric) concentration range of 8.3 ug/L (W-6) to 23.9 ug/L (W-8). The metal concentrations presented in Table 1-2 are dissolved metal concentrations.

Pentachlorophenol (PCP) was detected at elevated concentrations in several wells. Well W-2 and wells W-5 through W-8 had geometric mean PCP concentrations of 1,746 ug/L, 406 ug/L, 542 ug/L, 2,134 ug/L and 98 ug/L, respectively. The maximum concentration of PCP detected in of the quarterly sampling events was 5,600 ug/L (well W-7) in April of 1990.

Well W-1 exhibited trace concentrations of pentachlorophenol, PAHs and metals. Wells W-3 and W-4 did not display elevated levels of any of the site associated constituents.

Certain compounds not normally analyzed in specified EPA protocols were reported as semi-quantified results in the quarterly monitoring reports submitted by Brown and Caldwell. These compounds are not discussed here since the method of analysis and interpretation used to identify them imply uncertainty. The compounds and their semi-quantified concentrations are provided in Appendix B in the quarterly groundwater monitoring results section.

elevation, stockpile removed material on the western side of the dike between J.H. Baxter and Barker's property, and create a "stilling pond with bottom at elevation of 386.51 feet with side sloped 1 to 1. No outside fill was required, nor was material moved to or from other portions of the plant. The J.H. Baxter work order dated 10/24/75 for the pond project states "project required by DEQ as per plans submitted 10/15/75 to be in operation by 7/1/76."

Bentonite was used to seal the majority of the pond. The bentonite was distributed on top of the water and then sank to form a loose seal. The south and west banks were sealed before moving out toward the middle of the pond and sealing the center of the pond. The amount of bentonite placed in the pond is not known. Therefore, the thickness and continuity of the bentonite layer at the bottom of the pond is not known. However, bentonite was observed in the three sediment samples obtained from the bottom of the pond.

In 1981, the facility constructed a sprayfield immediately west of the pond to facilitate stormwater evaporation. This spray evaporation field covered an area approximately equal to that of the pond, and was operated until 1982. An aerator was added to the pond in 1984 in an attempt to enhance aerobic biodegradation of organic constituents in the pond and increase the rate of evaporation.

From approximately 1945 until 1955, a burn pit was maintained in the southwest portion of the plant under what is now the dry shed, just northeast of the runoff containment pond. The pit was approximately 40 feet square and 4 feet deep. Oil sludges were transferred mainly by 55 gallon drum but a pipe line also ran from the process area to the pit. Apparently, tank bottoms were transferred to the pit via this line although the exact location of the line is unknown, as are the frequency and duration of its use.

In 1955, the dry shed was constructed on top of the old burn pit. Sometime prior to that (6/15/55), the pit was dug out and filled. After an extensive search of company files and discussions with plant personnel, it is still unknown what happened to the excavated material or where the fill came from.

From the late 1970s or early 1980s until present, the plant has disposed of contaminated soils and sludges at the Chem Security Landfill in Arlington, Oregon. This site is a Class added, and the facility began to treat wood with pentachlorophenol (PCP). In 1952 the Eugene plant began treating wood with chemonite. Retort number 84 was added in 1966, retort number 81 was added in 1967 and retort number 85 was added in 1970. The facility began treating wood with fire retardants in 1955. Table 1-1 gives a description of preservative usage over the history of the plant.

The precise historic preservative storage locations are not known. Generally, a review of aerial photographs show that treated material was stored in the northwest portion of the plant just as it is today, although treated wood was periodically stored on other areas of the plant.

No records are available on the total quantity of preservatives used at this site over its history. In order to give a gross estimate of historical preservative utilization, data from J.H. Baxter & Co. treating plants from 1988 were used to estimate the annual amount of preservative typically used by preservative type. It is emphasized that this is the total amount used and does not represent the amount spilled or released to the environment. Today, only trace amounts of preservative escape the process as fugitive air emissions and/or drippage. Even given the fact that past practices were not as environmentally sound as those followed today, the fraction of the total preservative used which was inadvertently released to the environment would be very small.

A creosote retort could use 4,800,000 pounds or 550,000 gallons of creosote treating solution per year. A retort devoted to PCP treatments could use 270,000 pounds of PCP or about 510,000 gallons of treating solution. For arsenical treatments, a devoted retort could use 300,000 pounds of preservative on a metal oxide basis or approximately 1,100,000 gallons of treating solution.

A log pond formerly existed in the southwest corner of the site. This property was not part of the J.H. Baxter plant at the time, but was owned and operated by Cabax Mill (subsequently named Barker-Williamette). Raw logs were stored in this pond to prevent blue stain and to soften the wood prior to milling. In the mid 1970s, this portion of the property was purchased by J.H. Baxter & Co. and the current plant installations were constructed. The filling of the "Barker" log pond and construction of the Baxter runoff pond was done by Wildish Construction Co. (Eugene, Oregon). Wildish was to "remove debris from...log pond and area surrounding same", level adjacent area to 394 foot

I Hazardous waste landfill. The only other landfill referenced in J.H. Baxter files is the Bethel Danebo Landfill. The only reference to this landfill is a hand-written EPA site assessment of the Eugene site from 1984. Only the name of the landfill is known; it is not known how long it was used or what was sent there.

On or about 1982, a hazardous waste storage shed was built for the temporary accumulation (less than 90 days) of site-generated process wastes. Empty drums are accumulated in an area just northwest of the storage shed. Historically, wastes were accumulated in these same areas.

In the current operation of the plant, no onsite waste treatment is done. Wastes generated by the plant in treating operations are all handled as hazardous waste and shipped offsite within 90 days of generation. Three types of waste are produced: (1) Chemonite wastes, EPA Waste Code D004, which are solidified in 55 gallon steel drums and shipped to Chemical Waste Management's Arlington, Oregon Landfill (formerly Chem Security); (2) PCP and creosote process wastes, non-regulated by EPA, are incinerated by either Chemical Waste Management or GSX in a manner equivalent to the handling of EPA Waste Code K001; and (3) PCP and creosote contaminated waste water sludges, EPA Waste Code K001, which are incinerated by Rollins Environmental Services via Chemical Waste Management in accordance with all applicable Federal standards.

All of these wastes are either process sludges or sludges mixed with dirt from process sumps and recycle pads. These sludges are removed from retorts and sumps manually or from process tanks via a filter press or manually by emptying and subsequently entering the process tanks.

A cooling tower which utilizes process water operates on the plant. Because process water is used in the cooling tower, solids that accumulate in the tower due to the evaporation of the process water are classified by the plant as "waste water" sludges and handled as K001 wastes (i.e., EPA Waste Code K001).

The plant operated two butt treating (i.e., thermal treatment of the butt ends of cedar poles) tanks from sometime prior to 1950 to approximately 1961. No butt treating is currently done at the Eugene Plant. At some point prior to 1970, one of the two butt tanks was converted over to a mix tank for penta treating solution, and the other tank was removed.

A well was operated on site sometime prior to 1972. The water tower supplied by the well was located in the general area of the Aqua ammonia mix tanks. The well was located between the ACZA mix tank and the dry chemical storage building. The well was used to supply process water to the plant and was 82 feet below grade in depth. During the RI (May 1990) the well was abandoned using procedures approved of by the Oregon Department of Water Resources.

The Eugene Plant submitted an application for interim status as a TSD facility in 1980 or 1981. This application was made as a precautionary filing due to uncertainties regarding RCRA regulations, and was subsequently withdrawn. No onsite disposal of hazardous wastes has occurred at the site since 1955 when the old burn pit was closed. Wastes are only accumulated temporarily. Today, the site is correctly considered to be a generator only facility.

1.3 Site Features

The J.H. Baxter site is situated in west Eugene which lies in the southern or upper Williamette Valley, between the foothills of the Cascade Range (east), the Calapooya Range (south), and the Coast Range (west). The west Eugene area is at an elevation of approximately 400 feet above mean sea level. The topography of the valley is relatively flat with an overall relief of generally less than 100 feet. Surface water bodies in the vicinity of the site consist of local ditches, drainage canals, Amazon Creek to the west (approximately 2 miles to the west), the Fern Ridge Reservoir (approximately 3 miles to the west), Clear Lake (approximately 4 miles to the northwest) and the Willamette River (approximately 2 miles to the east).

Natural surface water drainage in the Eugene area is to the north-northwest toward the Willamette River. In the vicinity of the site (west Eugene) the surface water drainage has been modified by a system of ditches and canals constructed by the Army Corps of Engineers and the Soil Conservation Service during the 1950's. The drainage system is part of the lower Amazon Creek Watershed which drains west and north through Clear

Lake (situated near the Eugene airport) to the Long Tom River and eventually to the Willamette River at a point approximately 40 miles north of the City.

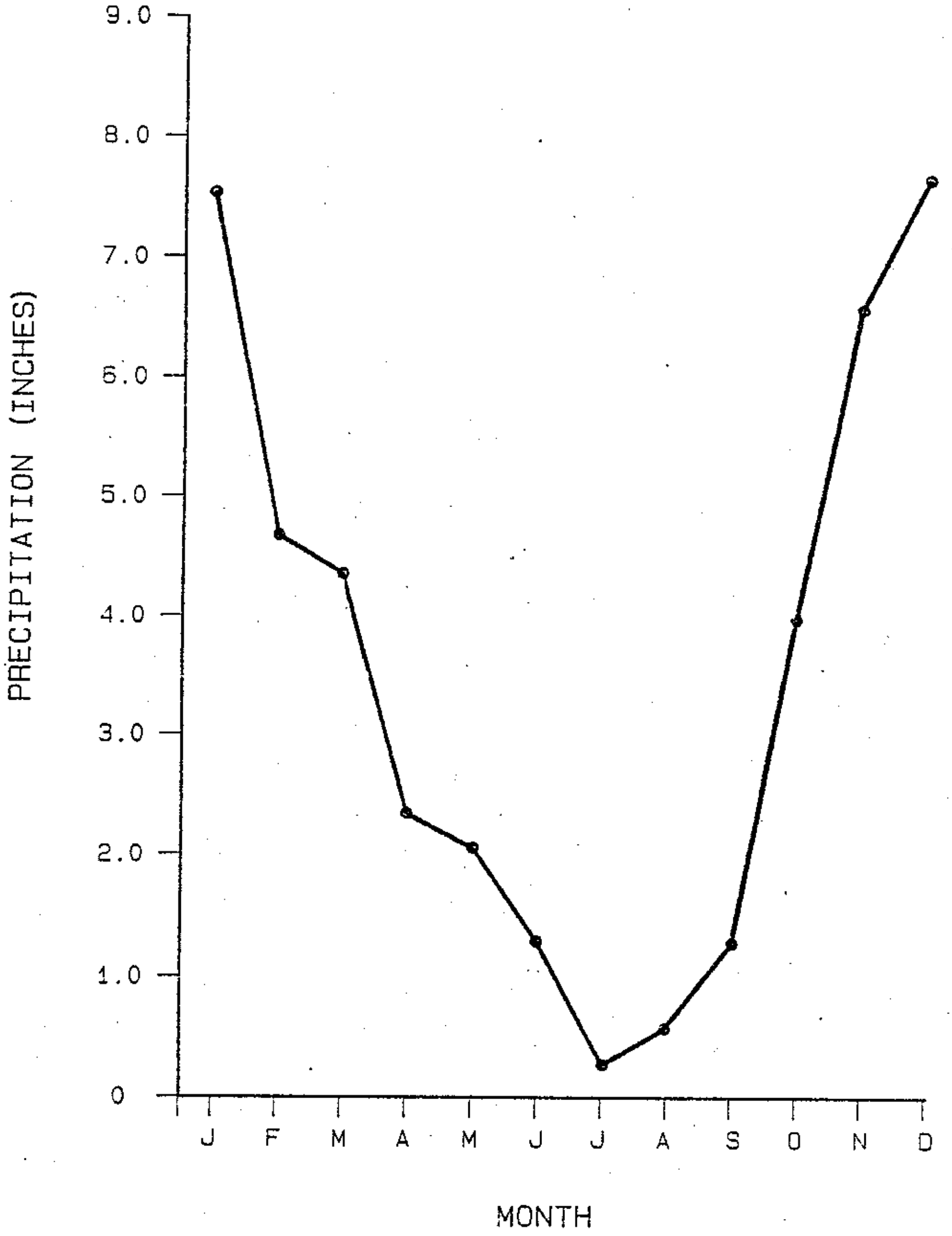
Most of the surface water that falls on the site is collected and transferred to a surface water retention pond in the southwest corner of the property. After experiencing preliminary treatment in the pond consisting of aeration and skimming by absorbent booms, the water is gradually released into a drainage ditch which follows the southern boundary of the Baxter property and exits the site at the southwest corner of the property and proceeds westwards. Just west of the site the ditch is diverted underground and resurfaces immediately west of Bertelsen Road where the ditch connects with the A-3 drainage channel constructed by the Army Corps of Engineers. The A-3 channel is the southernmost man-made channel in the Amazon Creek drainage system which flows to the northwest.

1.3.1 Climate

The climate around the Eugene area is largely controlled by maritime air from the Pacific Ocean. The Cascade Mountains to the east and The Coast Range to the west influence local weather patterns. The Coast Range acts as a barrier to coastal fog, but not to storms crossing the ridges. The Cascade Mountains inhibit most westward flow by continental air masses. Eugene's normal annual rainfall is 46.04 inches. July and August are normally the driest months; rainfall begins to increase during the second or third week of September, and gradually increases until the beginning of January. Rain gradually decreases from January until the latter part of June. Figure 1-3 shows average monthly precipitation for the Eugene area.

Average monthly temperatures range from 82.6^{O}F (July) to 33.8^{O}F (January), with an annual mean of 52.5^{O}F. The lowest temperature recorded was -12^{O}F (December 1972), and the highest recorded temperature was 108^{O}F (August 1981). July is the warmest month while January is the coldest (Figure 1-4).

A wind graph for Eugene is shown in Figure 1-5. The annual mean windspeed is 7.6 miles per hour. In the fall, winter and spring months (September to May) the wind direction is from the southwest. During the summer (June to August), the predominant



KEYSTONE
ENVIRONMENTAL RESOURCES, INC.

FIGURE 1-3

MONTHLY PRECIPITATION AVERAGE
EUGENE, OR

C68061

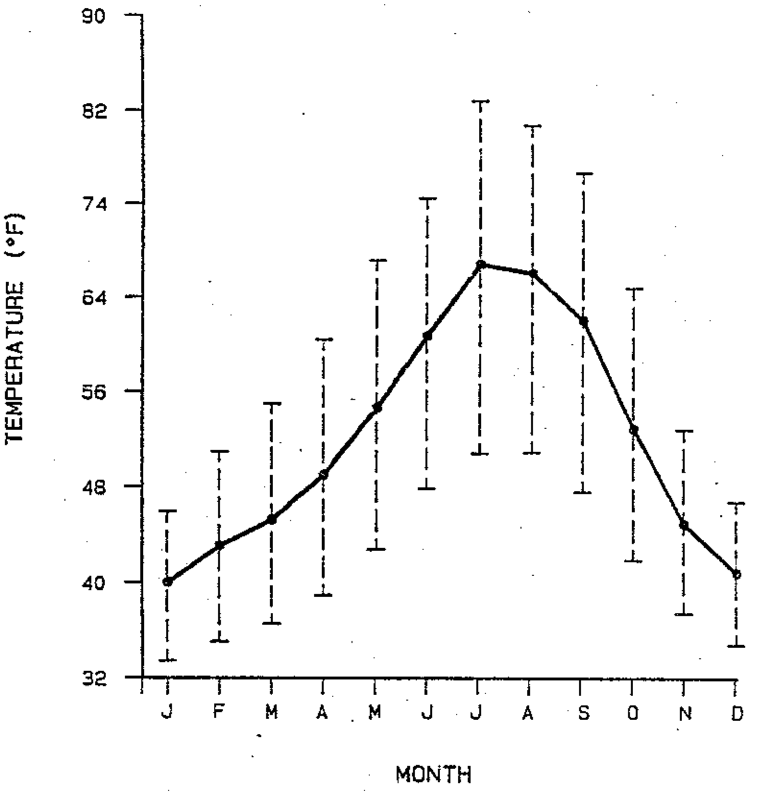


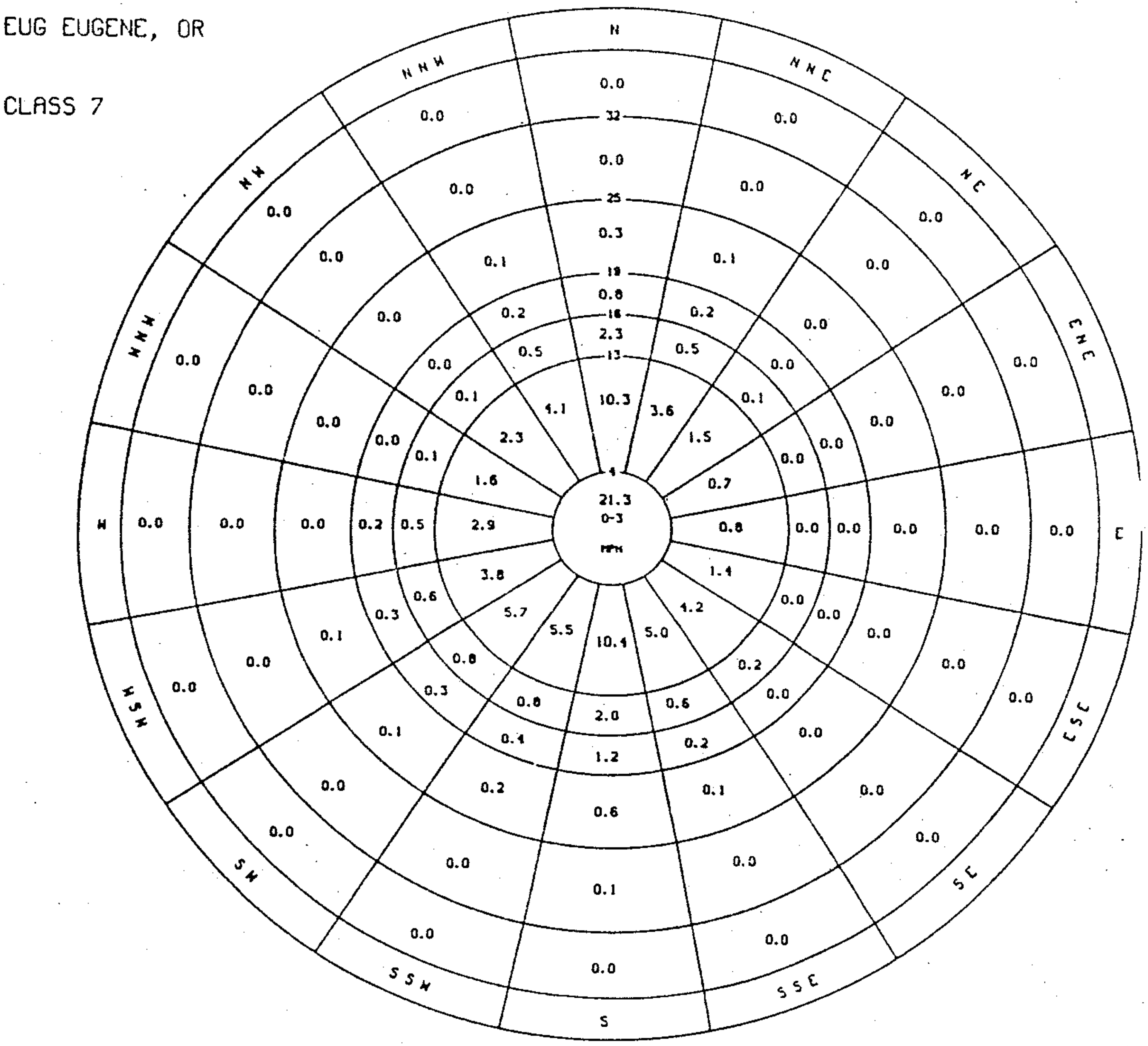
FIGURE 1-4

MONTHLY TEMPERATURE AVERAGE AND RANGE EUGENE, OR

C68062

FIGURE 1-5

Wind Graph
Eugene, OR



wind direction is from the north (seasonal data on wind direction obtained from Weather Bureau in Eugene).

1.3.2 Land Use and Demographics

The total population of Eugene in 1988 was 108,770. Springfield's population was 41,080, and the Lane County population was 273,700. Eugene/Springfield comprises the second largest metropolitan area in Oregon. Eugene/Springfield's primary manufacturing sector is the wood products industry. Service business and retail employ approximately 22 percent of the population, while the government also employs 22 percent of the population.

Residential and retail areas are interspersed throughout the Eugene area. Light to medium industrial sites are concentrated near the western side of Eugene. Heavy industrial sites are located east of the airport, which is northwest of Eugene. The J. H. Baxter site is located within the western industrial area of Eugene.

1.4 History of Past Investigations

Previous investigations have been undertaken at this site. The first surface water samples were obtained in January 1981 as part of the NPDES permit issued in 1980. The water samples were analyzed for oil and grease, phenol, chemical oxygen demand (COD) and pH. In December 1984, samples of process water, runoff, process streams and residuals were collected by an EPA contractor (Radian Corp.). These samples were collected to provide technical background for hazardous waste listings. The results of this sampling are given in a report entitled "Plant Analytical Data Summary J.H. Baxter and Company Eugene, Oregon," December 1985. In May 1984, DEQ collected samples for an NPDES inspection. These samples were collected from a sediment sample in the pond, the pond effluent, and water samples of the drainage ditch above and below the pond outflow.

The NPDES permit issued in 1980 to the facility was revised in 1985. As a condition of the permit, groundwater was monitored quarterly in eight monitoring wells installed by Brown and Caldwell Consulting Engineers (Brown and Caldwell) in 1986. These results were submitted to DEQ quarterly. A surface geophysical survey of the site was performed in 1987. Also in 1987, Brown and Caldwell performed two aquifer tests (pump tests) at the site. The results of the above surveys indicated that chemical constituents associated with some of these treatment processes have been detected in study area groundwaters, surface waters and subsurface soils. The following subsections summarize the available data by medium of interest.

1.4.1 Groundwater Characterization

Groundwater monitoring ensued in 1986. Wood treating related contaminants were detected in both shallow and intermediate depth wells.

Table 1-2 presents the geometric mean and minimum and maximum detected constituent concentrations determined from quarterly monitoring (7/86 through 4/90) of the eight Brown and Caldwell wells (W-1 to W-8) installed in the shallow groundwater aquifer. In situations where a constituent was not detected, half of the quantitation limit for the constituent was used in the calculation of the geometric mean values appearing in Table 1-2. The Brown and Caldwell quarterly sampling results were summarized and presented in groundwater monitoring reports submitted to the DEQ on a quarterly basis. The monitoring well locations are shown on Figure 1-2.

Wells W-2, W-7 and W-8, generally contained the highest amounts of the constituents listed in Table 1-2. Polycyclic aromatic hydrocarbons (PAHs) were at elevated concentrations in these wells. Naphthalene, the PAH compound detected at the highest concentrations, had geometric mean concentrations for wells W-2, W-7 and W-8 of 2,324 ug/L, 1,091 ug/L and 1,950 ug/L, respectively. Phenanthrene's mean concentrations ranged from 77 ug/L (well W-7) to 991 ug/L (W-8). Potentially carcinogenic PAHs including benzo(a)pyrene, benzo(b)fluoranthene and chrysene, were also detected in wells W-2, W-7 and W-8. Benzo(a)pyrene was detected at mean (geometric) concentrations of 3.4 ug/L, 2.4 ug/L and 37.7 ug/L in wells W-2, W-7 and W-8, respectively. The geometric mean concentrations of benzo(b)flouranthene in wells W-2, W-7 and W-8 were 3.5 ug/L, 2.7 ug/L and 54 ug/L, respectively. The respective mean (geometric) concentrations of chrysene over the sampling period in wells W-2, W-7 and W-8 were 4.9 ug/L, 2.4 ug/L and 73.2 ug/L, respectively.

1.4.2 Subsurface Soil Characterization

Subsurface soil borings throughout the study area from 1986 displayed the characteristic chemical constituents associated with the wood treatment process employed at the facility. Samples taken at boring locations W-2, W-7 and W-8 displayed detectable levels of constituents at depths ranging from 5.5 feet (boring W-8) to 21.0 feet (boring W-2). The W-2 soil boring sample (21.0 feet) contained 58.0 mg/kg of pentachlorophenol. Both W-7 and W-8 soil boring samples contained PAHs. The W-8 soil sample contained higher PAH levels than the W-7 soil sample. In the W-8 soil sample acenaphthene, anthracene, and naphthalene were detected at concentrations of 23 mg/kg, 15 mg/kg and 36 mg/kg, respectively.

Pentachlorophenol was detected in soil boring W-8 at 1.2 mg/kg but not in boring W-7. Table 1-3 presents the analytical data for the site's subsurface soil boring samples obtained by Brown and Caldwell in 1986. When a particular constituent which was analyzed for was not detected, then one-half the quantitation limit for the constituent was assigned as the concentration for the constituent and this value was used in the calculation of the geometric mean for the constituent (Table 1-3).

1.4.3 Surface Water Characterization

Onsite surface water samples were collected from the pond outfall. These samples were analyzed for pH, oil & grease, chemical oxygen demand (COD), pentachlorophenol, copper and arsenic. Pentachlorophenol was added to the NPDES list in June of 1984. In December of 1985, phenol was deleted from the NPDES list and copper and arsenic were added. Discharge monitoring reports for 1987 and 1988 showed average pentachlorophenol, copper and arsenic concentrations in the pond discharge water to be 1.94 mg/L, 0.76 mg/L and 2.34 mg/L respectively.

TABLE 1-3
CONTAMINANT CONCENTRATIONS DETECTED IN SUBSURFACE SOIL BORINGS
J.H. BAXTER WOOD PRESERVING
EUGENE, OR

BORING NO. SAMPLE DEPTH		W-1 27.5 to 28.5'	W-2 20-21'	W-3 33.0'	W-4 14-15'	W-5 5.5-6'	W-6 15.5-16'	W-7 6.5-7'	W-8 5.5-6'	GEOMETRIC MEAN
CONTAMINANT	PRACTICAL QUANTITATION LIMIT									
ACENAPHTHENE	100	–	–	–	50	50	50	2800	23000	381.2
ACENAPHTHYLENE	100	–	–	–	50	50	50	50	50	50.0
ANTHRACENE	100	–	–	–	50	50	50	1000	15000	284.8
BENZO(A)ANTHRACENE	100	–	–	–	50	50	50	200	3300	152.5
BENZO(A)PYRENE	100	–	–	–	50	50	50	400	1100	140.6
BENZO(B)FLOURANTHENE	100	–	–	–	50	50	50	100	1100	106.6
BENZO(K)FLOURANTHENE	100	–	–	–	50	50	50	100	1100	106.6
CHRYSENE	100	–	–	–	50	50	50	600	3300	190.0
FLOURENE	100	–	–	–	50	50	50	1900	20000	343.0
FLOURANTHENE	100	–	–	–	50	50	50	3000	50	113.4
NAPHTHALENE	100	–	–	–	50	50	100	400	36000	324.5
PHENANTHRENE	100	–	–	–	50	50	50	6000	15000	407.6
PYRENE	100	–	–	–	50	50	50	1000	13000	276.8
PHENOL	100	–	–	–	50	50	50	50	50	50.0
2,4-DIMETHYLPHENOL	100	–	–	–	50	50	50	50	50	50.0
PENTACHLOROPHENOL	100	50	58000	50	50	50	50	50	1200	110.2
ARSENIC	NA	–	–	2000	–	–	–	–	–	2000
CHROMIUM	NA	–	–	14000	–	–	–	–	–	14000
COPPER	NA	–	–	–	–	–	–	–	–	–
ZINC	NA	–	–	–	–	–	–	–	–	–

Note:

All values in ug/kg.

NA = not available

"-"= not analyzed

W-1 to W-3 samples obtained in 7/86. W-4 to W-8 samples obtained in 12/86.

Not detected constituents were assigned a value equal to 1/2 the quantitation limit for the constituent.

value for not detected constituents was used in the calculation of ge tric mean values presented above.

2.0 FIELD INVESTIGATION RESULTS

This section interprets and discusses the regional and site-specific geology and hydrogeology. Included is a summary of the findings of two aquifer tests conducted by Keystone in November, 1990. The field methods employed to install monitoring wells, perform the aquifer tests and acquire samples for analysis are also summarized in a following subsection.

Additionally, the analytical results of soil, groundwater, sediment, surface water and offsite well samples obtained by Keystone for the RI are presented and discussed in this section.

2.1 Investigative Methods

Specific procedures used in the investigation to sample soils and groundwater, decontaminate equipment and record observations are detailed in the Phase I Work Plan document developed by Keystone in December 1989 and revised in March 1990. Some of the procedures outlined in the Work Plan are repeated in this section and any deviations in specific procedures from the Work Plan are noted and discussed.

The chronology of field activities comprising Phase I of the RI are summarized below.

Activity	Start Date	Finish Date
Well Installation	5/8/90	6/11/90
Soil Sampling	5/8/90	6/11/90
Groundwater Sampling	7/19/90	8/3/90
Well Installation (W-15S)	11/1/90	11/1/90
Aquifer Tests (W-12I & W-13S)	11/2/90	11/10/90
Sediment Sampling	11/5/90	11/6/90
Surface Water Sampling	11/5/90	11/6/90
Offsite Well Sampling	11/16/90	12/7/90

Monitoring Well Installation

Monitoring wells were installed to delineate the extent of contamination at the site and to further determine site geology and aquifer characteristics. A total of ten additional wells were installed at five locations in 1990 (Figure 1-2). A summary of the pre-RI and RI monitoring wells installed on the site is provided below.

Pre RI wells					
	W-1S	W-2S	W-3S	W-4S	W-5I
	W-6I	W-7S	W-8S		
Phase I wells					
	W-9S	W-9I	W-11S	W-11I	W-12I
	W-12D	W-13S	W-13I	W-13D	W-14I

While installing wells during the remedial investigation, close scrutiny was given to water production, physical indications of site constituents and the nature of geologic materials penetrated. Continuous soil samples were obtained down to the water table and at 5 foot intervals thereafter. The continuous samples were collected by a steel shelby tube type device hydraulically driven into the soil. The soil samples collected at 5 foot intervals were obtained from the "blouie tube" (ie. discharge tube for cuttings attached to casing hammer on air rig) using a sieve (No. 60, 0.25 mm) to catch the soil cuttings. Both the continuous and discrete soil samples were screened with the photoionization device (HNu meter) and then placed in clean glass jars. Samples not chosen for chemical analysis are stored at the plant site.

Phase I wells were installed as listed below:

- Well W-12D was advanced to a depth of approximately 135 feet below grade. This depth was below the base of a clay confining layer.

- A second well, W-12I, of intermediate depth (80 feet) was installed adjacent to existing well W-3S.

- A nest of three wells was installed along the property line northwest of the JHB EXT FR treating area. These wells were set at approximately

28 feet (W-13S), 70 feet (W-13I), and 135 feet (W-13D). These wells were used to verify inferences about site geology and contaminant transport made in a geophysical survey of the site.

- An intermediate well (W-14I; 78 feet) was installed adjacent to existing well W-1S.
- An intermediate (68 feet) well (W-9I) and a shallow well (W-9S) were installed upgradient of any potential known sources of contamination; existing data indicated that the south-central property line was a suitable location.
- A shallow well (W-11S; 25 feet) and an intermediate (W-11I; 83 feet) were installed west of existing well W-4S, approximately 150 feet east of the property line.
- A shallow well (W-15S) was installed approximately 60 feet west of the W-13 well nest (observation well for aquifer tests)

Monitoring Well Construction

Wells installed at the J.H. Baxter site, for the purposes of the RI, were installed in accordance with Guidelines for Monitoring Well Design, Installation, Testing, Decommissioning and Record Keeping (State of Oregon, Department of Environmental Quality, Solid Waste Section). A summary of well installation and construction methods are provided below.

Monitoring wells were installed by using air rotary techniques in all cases except for well W-15S which was installed by using the hollow-stem auger drilling method. Well W-15S was installed in November, 1990 as an observation well for pump tests being performed in November, 1990. The materials used for the well, filter pack, seal, grout and protective casing are the same as those described below for the other shallow wells installed earlier in 1990. A detailed well log for W-15S is provided in Appendix A.

A section of 6-inch, 8-inch or 10-inch diameter surface casing was installed at each location. The purpose of the surface casing is to keep the unconsolidated deposits from falling into the well during subsequent drilling. This casing also prevented erosion under the drilling equipment and helped to prevent surface contaminants from entering the well. The casing was set at depths varying from approximately 8 to 35 feet below grade. Each of the shallow and intermediate wells were completed using schedule 40 4-inch diameter PVC screen and schedule 40 4-inch diameter PVC riser pipe. Wells deeper than 100 feet were constructed using schedule 80 4-inch diameter PVC screen and riser.

Shallow wells were set to approximately 25 feet through a 6-inch diameter steel casing. These wells were screened from approximately 15 to 25 feet below grade.

Intermediate depth wells were installed to depths ranging from 67 to 83 feet below grade. Intermediate well screens were set from 57 to 83 feet below grade. Because these wells were close to shallow wells, a steel casing was installed and extended below the screened interval of the shallow wells. This casing was 8 inches in diameter and was used to isolate the upper saturated monitoring zone from deeper zones thereby preventing cross-contamination from occurring. Six-inch diameter casing was driven using a casing hammer to the total depth of the intermediate well. Then 4-inch diameter PVC screen and riser were installed. Sand pack, bentonite, and grout were added incrementally as the 6-inch casing was retrieved.

Deep well construction occurred in a similar fashion as described for the intermediate depth wells. The first casing string (10-inch diameter) was installed to a depth below the level where the shallow wells were set (approximately 35 feet below grade). Then 8-inch diameter steel casing was driven to approximately 75 feet to isolate the deeper well construction from the intermediate well. A 6-inch diameter casing was then driven to the depth of the well below the clay layer. Four-inch diameter PVC screen and riser were installed as in the intermediate and shallow wells except below 100 feet where 4-inch diameter schedule 80 PVC screens and riser pipe were used. The 6-inch diameter casing was retrieved as filter sand and bentonite was added incrementally. The 6-inch casing was grouted in at the deep wells at about 110 feet below grade (in clay layer). The 8-inch diameter casing was removed completely from the boring. The deep well screens were set at approximately 125 to 135 feet below grade.

Table 2-1 summarizes the construction details of all the wells installed on the site, including the wells installed by Brown and Caldwell in 1986.

At each well nest, the shallower wells were drilled first to identify, if present, contaminated intervals which would require isolation. This was very important in maintaining the integrity of deeper well construction.

Close attention was given to drill cutting samples and character of the unconsolidated deposits to select intervals for monitoring. Cuttings samples were collected at 5-foot intervals. Screened intervals for sampling were adjacent to water bearing material near the target depth. All well screens were 10 feet in length and had slot openings of 0.01 inches (#10 slot). The #10 slot screens were chosen based on well logs constructed by Brown and Caldwell from previous drilling programs at the site which indicated the presence of fine sediments such as silt in the shallow geology. The sand pack was a clean, graded, silica sand, sized to prevent entrance through the well screen (#10 slot), and was added as the 6-inch casing was retreated to expose the formation. The sand pack was installed to at least 2 feet above the upper-most slots of the screen. Approximately 2 feet of pelletized bentonite was added above the sand to isolate the sand pack and grout. Grout was then added by tremie tube methods, from the bottom of the annulus, as the casing strings were withdrawn. Grout was approximately a 5 to 1 cement bentonite slurry mixture which sealed potential avenues of migration created by casing removal and shallower water bearing zones.

At all wells, a 6-inch, 8-inch or 10-inch diameter steel protective casing (approximately 2 to 3 feet above grade) was left in place and fitted with a lockable cap. Additional protection for the wells was provided by constructing steel bannisters and cementing them into the ground at each well nest location except the nest situated on the front lawn of the plant office. The well construction details can be seen on the well logs provided in Appendix A.

TABLE 2-1
SUMMARY OF WELL CONSTRUCTION DATA
J.H. BAXTER WOOD PRESERVING
EUGENE, OREGON

Well No.	Construction Date	Top of Casing Elevation (msl)	Well Depth (fbg)	Well Casing Material	Well Diameter (inches)	Well Screen Slot Width (inches)	Screened Interval (fbg)	Sand Pack Interval (fbg)
W-1S	7/2/86	395.71	22	PVC	4"	0.02	12-22	10-22.5
W-2S	7/3/86	393.16	23	PVC	4"	0.02	13-23	11-26
W-3S	7/7/86	395.01	28	PVC	4"	0.02	18-28	14-33
W-4S	12/20/86	396.56	19	SS	4"	0.02	9-19	8-22.3
W-5I	12/16/86	396.71	73	SS	4"	0.02	63-73	59.3-75.5
W-6I	12/21/86	397.77	67	SS	4"	0.02	57-67	53-71
W-7S	12/24/86	397.66	17	SS	4"	0.02	7-17	5.7-20
W-8S	12/15/86	395.9	17.5	SS	4"	0.02	7-17	5.8-20
W-9S	5/10/90	396.46	25	PVC	4"	0.01	15-25	13-25
W-9I	6/11/90	396.19	67	PVC	4"	0.01	57-67	56-57
W-11S	5/11/90	394.17	25	PVC	4"	0.01	15-25	13-25
W-11I	6/8/90	394.17	94	PVC	4"	0.01	73-83	71-94
W-12I	5/30/90	395.62	78.5	PVC	4"	0.01	69-79	68-79
W-12D	5/24/90	395.54	134	PVC**	4"	0.01	123-133	116-134
W-13S	5/11/90	396.71	28	PVC	4"	0.01	18-28	15-28
W-13I	5/20/90	396.14	70	PVC	4"	0.01	60-70	58-70
W-13D	5/25/90	396.4	133	PVC**	4"	0.01	123-133	116-133
W-14I	6/1/90	395.6	77.5	PVC	4"	0.01	67-77	65-77
W-15S	11/1/90	396.62	28	PVC	4"	0.01	18-28	16-28

fbg - feet below grade
msl - feet above mean sea level
SS - stainless steel (grade 304)
PVC - polyvinyl chloride schedule 40
PVC** schedule 40 to 100', then schedule 80 to bottom of well

Drill equipment and casings were decontaminated before each well was drilled by steam cleaning. Additionally, the drill rig and associated equipment were decontaminated before moving to a new well nest location.

Well locations were selected based on previously generated data, taking into consideration the direction of groundwater flow and existing wells where site constituents have been detected. All but two wells (W-9S and W-9I) were placed in areas downgradient of suspected source areas, or at the downgradient edge of the suspected area affected by site-related constituents. Deeper wells gathered information regarding the quality of the groundwater in a deep confined aquifer encountered at the site during the RI drilling program.

All drill cuttings were containerized and stored in an approved storage area. All containers were labelled to identify the well, the date, and the approximate interval from the well from which the cuttings originated. Decontamination occurred at a decon area in the vicinity of the machine and mechanics shops. The decon water collected on the ground surface which was contoured such that the water moved to a surface drain which was connected to the plants surface runoff drainage system. The water entering the drain would eventually discharge into the surface water retention pond in the southwest corner of the site where the water is aerated and the surface skimmed by adsorbent booms before entering ditches which connect to the City of Eugene storm sewer system.

Well Development

Upon completion, each of the wells were developed by using compressed air supplied by the air rotary drill rig. An air line (1-inch plastic pipe) was lowered into each of the newly installed Keystone wells to a point immediately above the well screens in the intermediate and deep wells, to avoid the possibility of damaging the sand pack, and near the top of the screen in the shallow wells. A new section of air line was used at each well location. At least three casing volumes of water were removed from each well and until turbid free water was observed. This resulted in a minimum of approximately 45 gallons of water being removed from the shallow wells, 150 gallons from the intermediate wells and approximately 300 gallons from the two deep wells. Because of the large volumes of water purged from the wells the purged water was first pumped into a 45 gallon drum, to monitor the volume purged, and then subsequently pumped into a portable 500 gallon tank supplied by the plant. The water was then discharged directly from the tank into the process stream for plant wastewaters.

Aquifer Tests

The two locations chosen for the aquifer tests (pump tests) were wells W-12I and W-13S. These wells were installed by Christensen Well Drilling Co. in May/June of 1990 under the supervision of Keystone personnel. Well W-12I is situated immediately south of the westernmost kiln and well W-13S is located along the northern property boundary approximately 500 feet west of the plant office. These two wells were selected as pump test locations for the following reasons:

1) A shallow well (W-13S) and an intermediate depth well (W-12I) were necessary to evaluate the hydraulic properties of the shallow and deeper zones of the aquifer.

2) W-13S was selected for the shallow zone test location because the groundwater is contaminated in the well and the probability of exacerbating the contaminant situation at this location was less than at other shallow well locations. W-12I was chosen for the intermediate test well because the shallow zone at this location had lower levels of constituents of concern than the intermediate zone. Therefore pumping W-12I would be less likely to draw contaminated groundwater into deeper zones of the aquifer.

3) Due to their location relative to the site boundaries, wells W-13S and W-12I could be used for pumping as part of a future remedial program (if necessary).

The presence of pentachlorophenol (PCP) in the groundwater at both pump test locations necessitated the development of a strategy to manage the groundwater removed during the pump tests. The City of Eugene imposed discharge limits of 60 grams per day of pentachlorophenol to the sewer system and that the maximum groundwater discharge rate be 20 gallons per minute (gpm). To ensure these requirements would be satisfied, two 20,000 gallon tanks were used for temporary storage if it was determined that the 60 gram/day limit would be exceeded by directly discharging the pumped groundwater into the sewer system. The stored groundwater could subsequently be discharged at a controlled rate compatible with the PCP mass discharge rate imposed by the City. The City of Eugene also required that the pump discharge water be sampled daily and analyzed for pentachlorophenol. Details on the method of sampling is presented in the next section (Groundwater Sampling). The analytical results of the tests are provided in Appendix B.

Prior to the initiation of either the step tests or constant rate tests, the water levels in each, pumping and observation well used for the test, were monitored over a 24 hour period to ascertain the normal diurnal fluctuations of the water table. Water levels in the wells were monitored using an electronic water level meter.

Each pump test was preceded by a step test to determine an optimum pumping rate for the constant rate portion of the tests. The step tests consisted of pumping each well (W-12I and W-13S) at several different flow rates for one to two hours. The pumping rate during the step tests and subsequent constant rate tests were measured by using a calibrated bucket and stop watch. The drawdown in the pumping well and a nearby observation well during the step tests and constant rate pumping tests were measured using pressure transducers connected to a data logger. Unfortunately, due to a computer disk error the step test data recorded by the data logger was unrecoverable and thus a quantitative evaluation of the step test data was not possible. However, the primary goal of determining a sustainable pumping rate, with sufficient drawdown in the pumping well, for the constant rate pumping tests, was achieved.

The data logger used for the pump tests was the Hermit model 1000B manufactured by In-Situ Inc. of Laramie, Wyoming. Two 15 psi pressure transducers, with a range of 0-35 feet (range of change in water level measurable not range of depths below water transducer can be used) and an accuracy of 0.1% of the range, were connected to the Hermit data logger. The pressure transducers were secured in the pumping wells by taping them to the pump discharge pipe approximately 5 to 10 feet above the 4-inch grundfos submersible pump (1/2 horsepower, rated at 13 gpm against 111 feet of head and 26 gpm at 65 feet of head). For the W-12I pump test the pump was set approximately 45 feet below grade and the pressure transducer in well W-12I was positioned at approximately 35 feet below grade. The pump was set at the bottom of the well for the W-13S pump test which is approximately 28 feet below grade. The pressure transducer in well W-13S was situated approximately 23 feet below grade. In the observation wells the pressure transducers were suspended in the center of the wells (W-15S for the W-13S pump test and W-3S for the W-12I pump test) approximately 20 feet below grade.

The step test performed on well W-12I revealed that this well could be pumped at a rate exceeding 15 gpm. However, because of the discharge restrictions on the pump test, a pumping rate of 15 gpm was chosen for well W-12I. This pumping rate combined with a PCP concentration of 0.5 milligrams per liter (mg/L) (analytical data available for W-12I) would produce a loading of 41 grams per day of pentachlorophenol. Since this loading is less than the maximum allowable loading of 60 grams per day into the POTW, the groundwater pumped during the W-12I test was directly discharged to the sewer without temporary storage.

The step test for well W-13S showed that the optimum pump test rate was 7.5 gpm. The analytical data for W-13S indicated that the PCP concentration in the groundwater at this location was 2.06 mg/L. This concentration at a discharge rate of 5 gpm to the POTW would satisfy the City's requirement that no more than 60 grams/day of PCP would be discharged. This meant that for the duration of the W-13S pump test, 2.5 gpm of the total flow rate, was diverted to the 20,000 gallon storage tanks. This resulted in a total groundwater storage of approximately 8500 gallons for the W-13S pump test. The stored water was released subsequent to the termination of the W-13S pump test at a rate not exceeding 5 gpm.

An additional well was installed at the site on November 1st 1990 (W-15S) prior to the initiation of the pump tests. This well was used as an observation well for the W-13S and W-12I pump tests. It was situated 68 feet west of well W-13S. The well log for W-15S showing construction details is provided in Appendix A. Other wells used as observation wells for the W-13S pump test included W-13I, W-3S, W-7S and W-1S. The observation wells for the W-12I pump test included W-3S, W-15S, W-13I, W-5I and W-11I. These wells were chosen as observation wells for the pump tests because they collectively provide observation points enabling a three dimensional sampling of the hydraulic characteristics of the aquifer.

The W-12I constant rate pump test began at 1:30 P.M. on November 3rd and was terminated at 5:00 P.M. on November 5th 1990. A rate of 15 gpm was pumped from the aquifer for the duration of the pump test. Pressure transducers connected to a data logger were used to measure the change in water level in the pumping well and observation well W-3S during the test. The recording interval of the data logger, for each test (pumping and recovery), was set on a logarithmic scale which produced initial recording intervals of 0.2 seconds and a maximum recording interval of 10 minutes, starting at 100 minutes into the test and continuing until the termination of the test. Manual measurements of the water levels in these two wells and the remaining observation wells for the pump test were measured at intervals of approximately 1 hour until the termination of the pump test. An electronic water level probe (audible indicator) accurate to 1/8-inch was used to obtain the manual water depth measurements.

The W-12I pump test was terminated earlier than originally anticipated because it was evident that the water levels had stabilized and even began to rise after approximately 1 day of pumping. The likely cause of the water level stabilization and rise was precipitation (rain) which fell steadily during the W-12I test (accurate data for amount of rainfall that fell at site during test is not available).

Water level measurements continued to be recorded by the transducer data logger assembly after the pump was turned off. This data constituted the recovery data for the test which continued to be recorded for 870 minutes in wells W-12I and W-3S. The recovery data was recorded with the same frequency as the drawdown data.

The W-13S constant rate pump test began on November 7th at 8:15 A.M. and terminated on November 9th at 4:00 P.M. The well was pumped at a rate of 7.5 gpm for the duration of the test. The water level monitoring procedures for this pump test were analogous to the procedures outlined above for the W-12I pumping and recovery time periods.

The W-13S pump test was terminated after approximately 2 days of pumping because the water level measurements indicated that the pump test had reached equilibrium conditions.

Groundwater Sampling

Monitoring wells were allowed to equilibrate for several weeks before being sampled. One round of samples was collected from all onsite monitoring wells by Brown and Caldwell personnel in July/August 1990 (18 wells). Water levels were obtained from all wells before groundwater samples were collected. Wells were checked for specific conductance, temperature, and pH prior to purging. Each well was checked for floating products and dense nonaqueous phase liquids (DNAPLs) prior to purging. Purging was continued until specific conductance, temperature and pH had stabilized, then sampling occurred. Purging was conducted by a combination of dedicated pumps, for wells W-1S to W-8S, and portable pumps which were appropriately decontaminated according to Keystone's standard operating procedures detailed in the Phase I RI Work Plan. A table summarizing purged well volumes, pH, temperature, specific conductance and samplers observations is included in Appendix B in the groundwater analytical results July/August 1990 section. Sample container preparation, including preservatives used, and QA/QC samples collected (eg. trip blanks, field blanks, duplicates) during the sampling procedure are discussed and detailed in the Phase I Work Plan.

At that time, all wells were sampled and analyzed for the constituents of concern related to the wood treating activities at the site including PAHs, volatile organic compounds (VOCs), phenols, arsenic, chromium, copper and zinc. Additional parameters analyzed were iron, manganese, total organic carbon (TOC), total dissolved solids (TDS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), phosphate, ammonia, and nitrate.

The groundwater samples were packaged in coolers with ice and sealed for transportation to Keystone's lab in Monroeville, PA.

Sample results were used to characterize the constituents in the aquifer, and to characterize the groundwater to allow an evaluation of a feasible interim measure or remedial alternative.

Additional groundwater samples were obtained during the two pump tests performed in November 1990 by Keystone. Two grab samples were taken after approximately 24 hours and 48 hours had transpired in each pump test. The samples were obtained from a T-valve on the pump discharge line used to periodically measure the pump discharge flow rate. The sampler wore latex gloves and used clean laboratory supplied glass bottles to collect the water sample directly from the discharge valve. The pump discharge flow rate was not appreciably effected during this sampling procedure. The samples were analyzed for pentachlorophenol by Keystone's laboratory in Monroeville, Pennsylvania. Proper shipping and chain of custody procedures were followed.

Subsurface Soil Investigation

Soils investigation took place only at the locations of the monitoring wells. The soil investigation assisted in the description of the subsurface materials as well as in the definition of the vertical extent of site related constituents. All soil sampling was performed under the supervision of a Keystone hydrogeologist. Soil samples down to the water table were collected using a thick-walled steel tube attached to the bottom of the drill rods (similar to shelby tube). The tube was hydraulically driven into the surface soils. Soil samples collected from below the water table were obtained using a sieve to catch soil cuttings being returned to the surface by the air rotary drilling progression. Undisturbed soil samples from below the water table were not collected because the loose sands and gravels would not be recoverable using split-spoons or shelby tube sampling methods. All soil cuttings brought to the surface during the investigation were placed in 55 gallon steel or 45 gallon plastic drums for storage onsite until the final disposition of the material can be determined.

Soil samples were field classified according to the Unified Soil Classification System (ASTM D2488-84) and any visible or odorous evidence of contamination was recorded. Samples were placed in new glass jars for storage, shipment, and analyses. Soil samples were collected continuously to the water table and at discrete 5-foot intervals thereafter. Most soil samples were screened using the HNu organic detection device. Due to very humid conditions near the end of the drilling program soil samples obtained from boring W-9I could not be screened with the HNu. The HNu device does not operate reliably under humid weather conditions. Only the soil sample, of the soil samples obtained above the water table, with the highest HNu reading from each well boring nest location (except at W-9S and W-9I where one sample from each boring was retained for analysis) was submitted for analysis. This resulted in a total of 6 soil samples retained for analysis. HNu readings were recorded in the field logbook adjacent to the soil sample description and depth interval. If all the samples from an individual borehole appeared to be uncontaminated (based on HNu readings), the surface sample was submitted for analysis.

The soil samples were analyzed for PAHs, phenols, volatile aromatics, arsenic, chromium, copper, zinc, iron, manganese, and TOC.

The steel tube samplers were decontaminated between each use. The decontamination procedure consisted of washing the tube in a laboratory grade detergent solution followed by a distilled water rinse, acetone rinse, air drying, and a final distilled water rinse. All decontamination solutions and rinses were collected and disposed of in plant process waters. All downhole drilling and sampling equipment was steam-cleaned before moving to the next boring location.

Surface Water Characterization

Surface waters were investigated to determine potential contamination of surface water runoff at the site. Surface water samples from the drainage ditch and the surface water retention pond were sampled by Keystone personnel in November 1990 in accordance with Keystone SOP 206, Surface-Water Sampling Techniques. Chain of custody procedures were followed from initial collection through laboratory analysis. The drainage ditch surface water samples were collected as grab samples. The surface water samples obtained from the retention pond were collected from approximately 2 feet below the surface of the water using a masterflex pump. Tygon tubing was used with the masterflex pump to obtain the samples. Tygon is compatible with the contaminants at the site given the short exposure time involved in the sampling procedure and the concentrations of the contaminants in the water. A new piece of tygon tubing was used at each sampling location.

Following collection, samples were labelled and appropriately preserved. The samples were packaged in coolers with ice and sealed for transportation back to Keystone's Analytical Division Laboratory located in Monroeville, Pennsylvania.

A total of four (4) samples were be collected at various locations (Figure 1-2). An upstream sample was obtained from the drainage ditch at the southeast end of the site to represent a reference sample. Another sample was collected in the ditch just upstream of the point where the surface water retention pond drains into a ditch. The third sample was obtained from the ditch draining the surface water retention pond. The fourth sample was obtained from the drainage ditch near the southwest property line of the site.

Three near surface water samples were obtained from the surface water retention pond along the east-west centerline of the pond (Figure 1-2). The samples were obtained from a depth of approximately two feet below the surface of the pond.

The samples were analyzed for the same parameters as the groundwater samples.

Sediment Characterization

A sediment investigation was performed by Keystone to determine the potential contamination of sediments in the surface drainage ditches and the surface water retention pond. Samples were collected at the same locations as surface water samples. Sediment sampling from both the surface water retention pond and the drainage ditch were performed in accordance with Keystone SOP 202, Lake and Stream Bottom Sediment Sampling. All sediment samples were collected as grab samples. The samples were packaged and kept on ice during transportation back to Keystone's Analytical Division Laboratory located in Monroeville, Pennsylvania.

The drainage ditch sediment samples were obtained to a depth of approximately 4 inches and consisted of surface and subsurface sediment. The samples were collected using a 2-inch diameter core sampler and stainless-steel trowels. Any sediment sampling equipment which was used to collect samples from different locations were thoroughly cleaned between samples using a brush and water, acetone rinse, and distilled water rinse. Detailed decontamination procedures for the sampling equipment is provided in the Phase I Work Plan (Appendix B).

One sample was obtained from the drainage ditch at the southeast end of the site to represent a reference sample. Another sample was collected in the ditch just upstream of where the surface water retention pond drains into the ditch. The third sample was obtained from the ditch draining the surface water retention pond. The fourth sample was obtained from the drainage ditch near the southwest property line of the site.

A total of three (3) sediment samples were collected from the surface water retention pond. The samples were collected along the center line of the pond, at the west end, the middle and the east end of the pond. Samples were collected to a depth of approximately 4 inches using a "ponar" sediment sampling device. Each sample was analyzed separately.

The sediment samples were analyzed for the same parameters as the soil samples.

Offsite Water Well Sampling

As part of the RI, Brown and Caldwell performed a survey of the water wells in the vicinity of the J.H. Baxter plant. A total of 102 wells were identified during the survey in the vicinity of the plant. A listing of these wells, including residence addresses and owners is presented in Appendix B in the offsite analytical results section. Also included in this section of Appendix B is an outline of the offsite well sampling and decontamination procedures. The approximate radial distance from the north central boundary (ie. near W-13 well nest) of the site to the nearest residence is approximately 500 feet and to the nearest residence with a water well used for drinking purposes is approximately 1000 feet.

Of the 102 wells, approximately one-half were active, only three were being used as sources of drinking water, and one well was used for drinking water but the residence has been condemned by the City and is currently vacant. A total of nineteen offsite wells were sampled and tested for pentachlorophenol. The sampled wells included the three wells used for drinking water and the well on the property which has been condemned by the City of Eugene. The samples were sent to Water Analysis & Consulting, Inc. in Eugene.

Monitoring Well Elevation and Horizontal Coordinate Survey

The monitoring wells were surveyed by Roberts Surveying Inc. in December 1990 at the request of Keystone. The well survey consisted of obtaining the elevation of well W-15S (installed in November 1990) and the horizontal coordinates for all the wells on the site. The well coordinates were surveyed to the nearest tenth of a foot and the elevation for W-15S was surveyed to the nearest hundredth of a foot. A plan map with well location coordinates was prepared by Roberts Surveying at a scale of 1-inch to a 100-feet.

2.2 Geology

2.2.1 Regional Geology

Eugene is located immediately west of the Cascade mountain range in western Oregon, and is located within the Pacific Border (Puget Trough section) physiographic province. The Puget Trough section is characterized by diverse lowlands. The J. H. Baxter site lies in the southern or upper Willamette Valley, between the foothills of the Cascade Range (east), the Calapooya Range (south), and the Coast Range (west).

The general geology of the Eugene area has been discussed by Dickenson (1972), Frank (1973), Wells and Peck (1961), and Vokes et.al. (1951). The following paragraphs summarize the geology of the area as reported by the above references.

The Eugene area is dominated by unconsolidated, alluvial deposits which are Quaternary in age. The alluvial deposits are divided into older alluvium and younger alluvial deposits. Some tertiary-age volcanic and intrusive rocks are also present in the area. Both alluvial units are composed primarily of sand and gravel lenses, with varying degrees of silt and clay materials intermixed. These sediments were deposited chiefly by the Willamette River and its major tributaries.

The more recent alluvial deposits are distinguished from the older alluvium by the relatively minor amounts of fine grained material, greater permeability, and less weathering. These younger deposits generally extend to a maximum depth of 30 to 40 feet below ground surface. The younger alluvium exists within the active floodplain of the Willamette River and its major tributaries and comprises the most permeable aquifer in the upper valley.

The older alluvium, on which the Baxter site is located, is the most extensive aquifer in the area. These alluvial deposits vary in thickness and are estimated to be approximately 150 to 200 feet thick beneath the site. Alluvial deposits to a depth of approximately 100 feet below the surface consist of interconnected lenses of coarse volcanic sand and gravel interspersed with fine silt and sand. These deposits are capable of yielding large quantities of groundwater. Below a depth of approximately 100 feet, the coarser alluvial deposits grade into and interfinger with lenses of sand, silt, clay, and pebbles.

2.2.2 Site Geology

Geologic information for the site was obtained through observations made during the monitoring well installations performed by Keystone in May/June of 1990 (wells W-9S, W-9I, W-11S, W-11I, W-12I, W-12D, W-13S, W-13I, W-13D and W-14I) and through the review of drilling logs for the monitoring wells installed by Brown and Caldwell in July and December of 1986 (wells W-1S, W-2S, W-3S, W-4S, W-5I, W-6I, W-7S and W-8S).

An additional well was installed by Keystone in November of 1990 (well W-15S) to provide a water level observation well for the aquifer tests conducted in November 1990. The geologic and hydrogeologic information obtained from this well is included in the findings.

Figure 2-1 indicates the locations of three geologic cross-sections (A-B, A-C and B-D) prepared from well log information to assist in the visualization of the site geology. The three geologic cross-sections A-B, A-C and A-D are presented in Figures 2-2, 2-3 and 2-4, respectively.

The shallow geology of the site consists of quaternary age alluvial deposits. These deposits are composed of sand and gravel, with lesser amounts of silt and clay. The sand and gravel deposits overly a clay unit which is encountered at depths ranging from approximately 81 feet below grade at well location W-9I to approximately 93 feet below grade at well location W-13D. Beneath the clay layer in the northwest portion of the Baxter property are deposits of medium to coarse sand and gravel. The monitoring well drilling logs for all the wells installed at the site are provided in Appendix A.

Based on the drilling programs, the uppermost unconsolidated deposits which are comprised of clay and gravel vary gradationally over the site. These deposits are relatively uniform in thickness over the site (approximately 10 to 15 feet thick).

Beneath these uppermost deposits are sediments which are dominated by gravels mixed with varying types and amounts of finer materials such as sand, silt and clay. These sediments are shown on cross-sections A-B, A-C and A-D and are described as either clayey gravels, silty gravels, sandy gravels or gravels depending on the type and amount of finer materials present. The deeper gravels in these sediments generally tend to have lower proportions of fine materials such as silt and clay than the shallower portion of the gravel sediment sequence. However, in the southern part of the site where well W-9I is situated the gravel sediments contain a larger proportion of fines throughout the gravel sequence than observed at the other well locations on the site.

Although gravel dominates this geologic sequence there are sand and clay lenses within the gravels as shown on the geologic cross-sections (Figures 2-2, 2-3 and 2-4). The gravel sequence of sediments is approximately 60 to 70 feet thick beneath the western half of the Baxter property.

Underlying the gravel sediment sequence is a clay layer comprised of two distinct clay units. The shallower clay unit can be described as a brown to gray, plastic, moist clay which can be designated as "CH" according to the unified soil classification system.

Immediately beneath the brown to gray clay is a blue or blue to gray clay unit which can be described as lean and of low to medium plasticity ("CL" classification according to the unified soil classification system). The contact between these two clay units is sharp.

Based on the drilling program it is evident that the brown to gray clay ranges in thickness from approximately 20 feet at well location W-9I to approximately 3 feet at location W-11I.

Figure 2-5 is the structural contour map for the top of the brown to gray clay unit. From this figure it is observed that the top of the clay dips to the northwest beneath the Baxter property. The magnitude of the dip was calculated to be approximately 0.72 degrees from horizontal (determined from Figure 2-5).

The blue to gray clay was encountered at four drilling locations (W-9I, W-11I, W-12D and W-13D) and was fully penetrated at two drilling locations (W-12D and W-13D). The thickness of the blue clay at boring locations W-12D and W-13D was approximately 18 feet. Therefore, the total combined thickness of the clay layer (brown to gray and blue to gray clay), at locations W-12D and W-13D, is approximately 35 feet and 26 feet, respectively.

Medium to coarse sands and gravels with minimal amounts of finer materials were discovered beneath the blue clay at well borings W-12D and W-13D. Significant quantities of water under pressure were flowing into the boring during drilling. This geologic unit represents a confined artesian aquifer.

2.3 Hydrogeology

The principal sources of groundwater in the Eugene area are the alluvial valley deposits. Zones of gravel and coarse sand in these units yield moderate to large quantities of water to wells installed in them. The alluvium is considered the only source of groundwater in the area suitable for large-scale development. Consolidated tertiary rocks in the area yield only small quantities of water. The general groundwater flow direction is to the northwest down valley towards the Willamette River. Seasonal variations in the direction of groundwater movement can occur due to non-uniform infiltration during the rainy season resulting in groundwater ridges and troughs forming. The ridges block the flow of groundwater toward the rivers resulting in groundwater movement downstream sub-parallel to the rivers. Precipitation is the primary source of recharge for groundwater in the Eugene area.

The hydrogeology for the site was evaluated using a variety of information that was obtained by Brown and Caldwell and Keystone.

Included as sources of hydrogeologic information for the site are the data and results from two aquifer (pump) tests performed by Brown and Caldwell in December of 1987 and two additional pump tests conducted by Keystone as part of the RI in November of 1990 (summarized below). Water level data was examined and used to determine the vertical and horizontal groundwater movement beneath the site.

The information gathered during the drilling programs indicated that two separate aquifers are present beneath the site. A shallow aquifer consisting of silty, sandy, clayey gravels (approximately 15 to 90 feet below grade) and a deeper aquifer (approximately 110 feet below grade) confined by a thick clay layer (described above) and consisting of medium to coarse sand and gravel. The aquifer tests conducted at the site have concentrated on examining the hydraulic properties of the shallow aquifer where constituents of concern have been detected.

2.3.1 Aquifer Tests

Introduction

Keystone performed two aquifer tests (pump tests) at the J.H. Baxter wood treating facility in November 1990. The purpose of the tests was to determine the hydraulic properties (transmissivity, hydraulic conductivity and storativity) for the shallow alluvial aquifer at the Baxter site. The hydraulic properties of the aquifer will be used to determine the groundwater flow rates and aquifer characteristics necessary to design interim remedial alternatives (if necessary) for the site .

Transmissivity is defined as the rate of groundwater flow per unit width through the entire saturated thickness of an aquifer per unit hydraulic gradient. The hydraulic conductivity, which can be calculated by dividing the transmissivity by the saturated thickness of the aquifer, describes the rate at which groundwater will flow through a porous medium. The hydraulic conductivity is a function of the physical characteristics of both the porous medium and the fluid (usually water) flowing through the porous medium.

Storativity is defined as the volume of water released from or taken into storage in an aquifer per unit horizontal area per unit decline or rise in the peizometric head. For a confined aquifer the storativity value is generally within the range of 5 x 10^{-3} to 5 x 10^{-5} (Freeze and Cherry, 1979). In an unconfined aquifer, the storativity is referred to as the specific yield and is usually in the range of 0.01 to 0.3 (Freeze and Cherry, 1979).

The hydraulic properties discussed above can be used to provide important information regarding the movement of groundwater within the aquifer under natural hydrogeologic conditions or hydrogeologic conditions induced by man-made activities such as pumping from wells.

Brown and Caldwell conducted two pump tests, each approximately 24 hours in duration, in December, 1987. These tests produced valuable information regarding the characteristics of the shallow aquifer. However, it was decided that longer term tests (approximately 72 hours) would be desirable given the nature of the shallow aquifer, which was assumed to be unconfined based on the conclusions of the Brown and Caldwell report dated May 1988.

Brown and Caldwell concluded that the shallow alluvial aquifer at the Baxter site is unconfined and has an average transmissivity of 6,500 gallons per day per foot (gpd/ft) and an average hydraulic conductivity of 9.8 x 10^{-5} ft/sec (8.5 ft/day). Brown and Caldwell was unable to determine the storativity, or specific yield in the case of an unconfined or water table aquifer, and concluded that the 24 hour test duration was not long enough to establish the characteristic inflection in the drawdown-time curve of an unconfined aquifers response to pumping. However, a specific yield value of 0.2 to 0.35 was estimated by Brown and Caldwell for the aquifer based on the aquifer geology and published values for specific yield (Fetter, 1980).

Data Analysis

The pump test data from the W-13S and W-12I pump tests were analyzed using standard graphical techniques. The curve matching method developed by Theis in 1935 was employed to analyze the data as well as the semilog straight-line method (Cooper-Jacob, 1946). Each method (Cooper-Jacob and Theis) has its advantages and each method can be used to verify the findings of the other.

Inherent in both of the analytical methods are a common set of assumptions:

- The aquifer is infinite in areal extent,
- the aquifer is homogeneous, isotropic, and uniform in thickness over the area of influence of the pumping test,
- prior to pumping, the potentiometric surface is (nearly) horizontal over the area influenced by the pumping test,
- the aquifer is pumped at a constant discharge rate,
- the well fully penetrates the aquifer and therefore, receives water from the entire thickness of the aquifer, and
- all the water removed from the well comes from aquifer storage.

In the natural geologic environment at a test well site the above assumptions are never fully satisfied. However, the effects of deviation from these ideal conditions can be recognized and compensated for by either applying a correction factor or not using the effected portion of the data in the interpretation procedure.

W-12I Pump Test

The W-12I pump test consisted of pumping well W-12I at a constant rate of 15 gpm for 3,030 minutes (50.5 hours). At the termination of the pump test, water level recovery data was recorded for a period of 870 minutes (14.5 hours). The water level data recorded during the test for well W-12I and the observation wells (W-3S, W-15S, W-13I, W-5I and W-11I) are provided in Appendix C.

Observation wells W-13I, W-5I and W-11I are screened over approximately the same interval as W-12I (68 to 78 feet below grade). The remaining two observations wells, W-3S and W-15S, are screened over a much shallower interval in the aquifer (18 to 28 feet below grade).

The water level data was converted to drawdown data (ie. net decline of water level due to pumping) and plotted against time (minutes) on semilog axes (Jacob method) and log-log axes (Theis method) for the pumping well and all the observation wells. The data was then interpreted to determine the hydraulic properties of the aquifer.

Jacob Method

For the semilog plots a straight line was fit to the portion of the data which displayed a linear trend. Using the slope of the straight-line and the pumping rate the transmissivity was calculated using Equation 2.1. The intercept of the straight-line on the time axis was determined and used to calculate the storage coefficient (storativity) using Equation 2.2.

$$T = 264 \times Q / s \qquad (2.1)$$

where $T =$ transmissivity, in gpd/ft

$Q =$ pumping rate, in gpm

$s =$ change in drawdown between any two times whose ratio is 10 (over one log cycle), in feet

$$S = (0.3 \times T \times t_o) / r^2 \qquad (2.2)$$

where $S =$ storativity, dimensionless

$T =$ transmissivity, in gpd/ft

$t_o =$ intercept of straight-line at zero drawdown, in days

$r =$ distance, in feet, from the pumped well to the observation well where the drawdown measurements were made

The Jacob method was used to analyze the pumping drawdown data for all the test wells and the recovery data for the pumping well, W-12I, and the nearest observation well, W-3S.

Figure 2-6a is a semilog plot of the pump test data for the pumping well W-12I. Certain characteristics of the data are immediately apparent. Two linear trends are discernible in the data. The early time data, up to approximately 1 minute, displays a linear trend and the later data between the times of approximately 10 minutes and 1,000 minutes displays another linear trend. Figure 2-6b is the same as Figure 2-6a except the data has been interpreted and the interpretation is shown on the Figure. It is evident that the line drawn through the early data has a slope greater than the slope of the line drawn through the later time data. The transmissivities calculated for the early and later time data are 720 gpd/ft and 11,310 gpd/ft, respectively.

The relatively low value for the transmissivity for the early time data (720 gpd/ft) can be attributed to the storage of water in the well casing and sand pack prior to the start of the pump test. One of the assumptions stated earlier for the Jacob method of analysis is that all the water being pumped from the well comes from aquifer storage. However, during the initial stages of a the pump test the water present in the well before the test begins, is removed before water moves from the aquifer. This is a commonly observed feature in drawdown data for the pumping well and its observed effect increases with increases in the storage capacity of the pumping well. The estimated volume of storage for the casing and sand pack in well W-12I is 50 gallons. At a pumping rate of 15 gpm it would take approximately 3 minutes to remove the stored water from the well. This time frame agrees with the duration of the effect observed on Figures 2-6a and 2-6b.

Therefore, the transmissivity value of 11,310 gpd/ft calculated from the line drawn through the later time values on Figure 2-6b, represents the transmissivity determined from the drawdown data obtained from well W-12I.

As Figure 2-6b shows, the drawdown periodically levels off or rises. This anomalous feature can probably attributed to a recharge effect likely caused by a rainfall event described earlier. The portion of the data beyond approximately 1,000 minutes was not used in the determination of the aquifer hydraulic properties for the W-12I pump

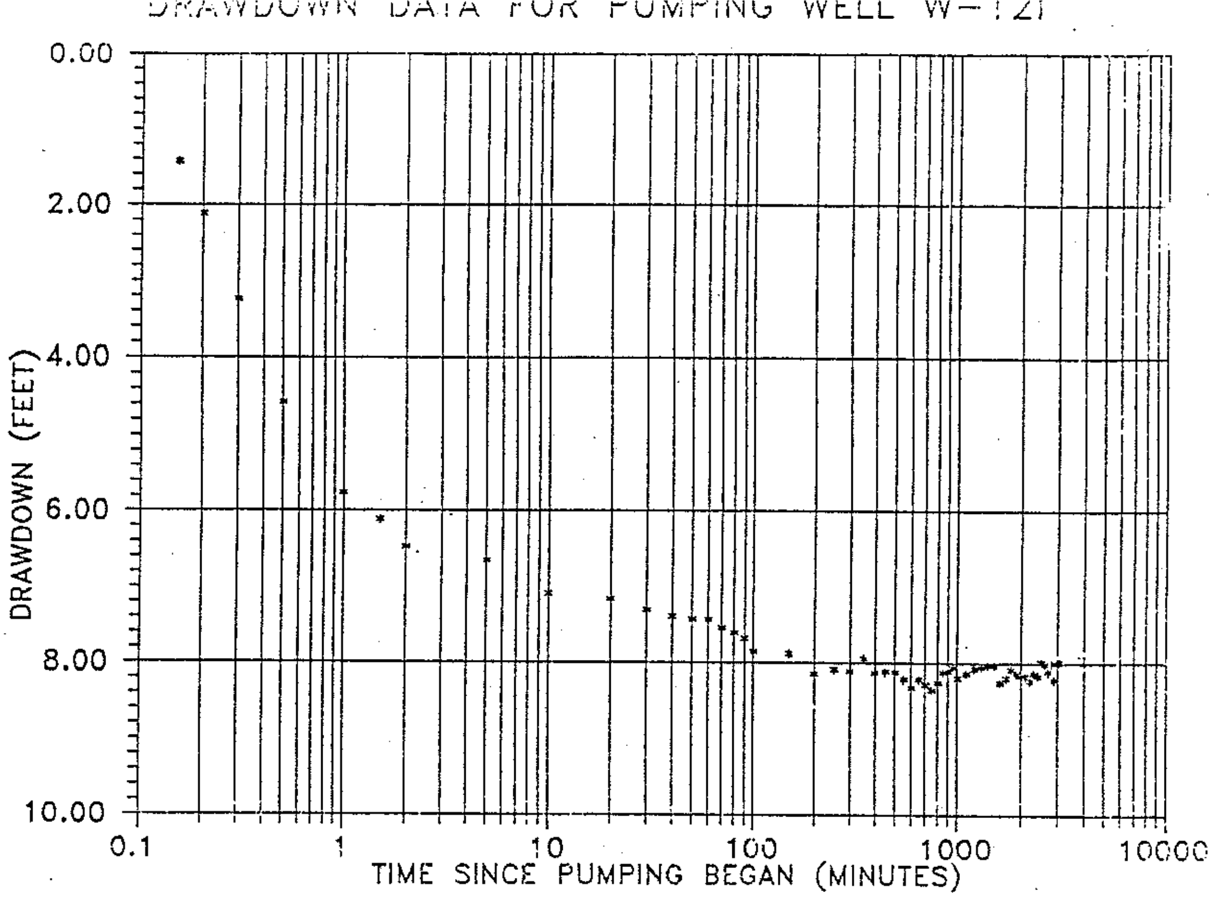


FIGURE 2-6a

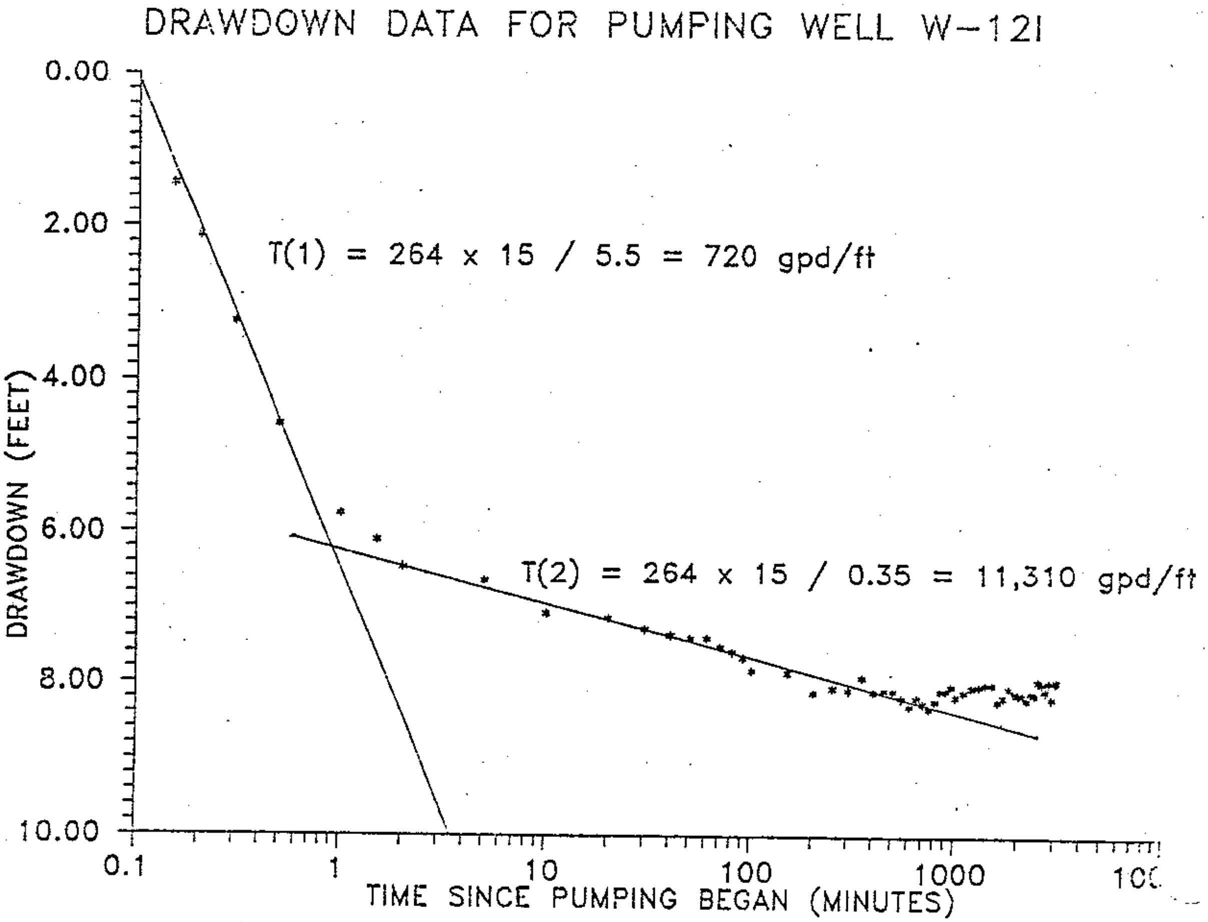


FIGURE 2-6b

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test. Pumping level fluctuations become evident on the semilog plots for all of the observation wells beginning at approximately the same time (1,000 minutes).

Recovery data acquired for well W-12I was also analyzed to determine the transmissivity in the vicinity of well W-12I. Figure 2-7a is the uninterpreted semilog plot of calculated recovery versus time for W-12I and Figure 2-7b is the interpreted version of the same graph. Recovery data is independent of drawdown data and therefore the values for aquifer hydraulic properties determined from recovery data are independent of the values determined from drawdown data. This provides two independent methods for evaluating the hydraulic properties of an aquifer. Recovery data was also obtained and analyzed for the nearest observation well, W-3S. Recovery data was not obtained for the remaining observation wells.

Recovery data is useful in determining the transmissivity for the pumping well, such as well W-12I. Drawdown data is not as reliable in the pumping well due to fluctuations in the water level that can occur as a result of changes in the pump output rate or turbulence created by the pumping action in the well. Figure 2-7b displays two linear portions of the data similar to that observed on the drawdown graphs for well W-12I (Figure 2-6b). The transmissivities determined for each of the lines shown on Figure 2-7b are 780 gpd/ft and 8,800 gpd/ft, respectively.

The smaller of the two transmissivity values possibly represents the effect of pumped water, which remained in the discharge pipe, draining back into the well after the pump was turned off.

The storativity cannot be determined using drawdown or recovery data from well W-12I (ie. the pumping well) because one of the parameters used to calculate the storativity in Equation 2.2 is "r", which is zero for W-12I. Recall that "r" was previously defined as the distance from the pumping well to the observation well.

Figures 2-8a and 2-8b are the drawdown graphs for observation well W-13I. From Figure 2-8b a value of 11,310 gpd/ft was determined for the transmissivity and a value of 3.8×10^{-4} was determined for the storativity.

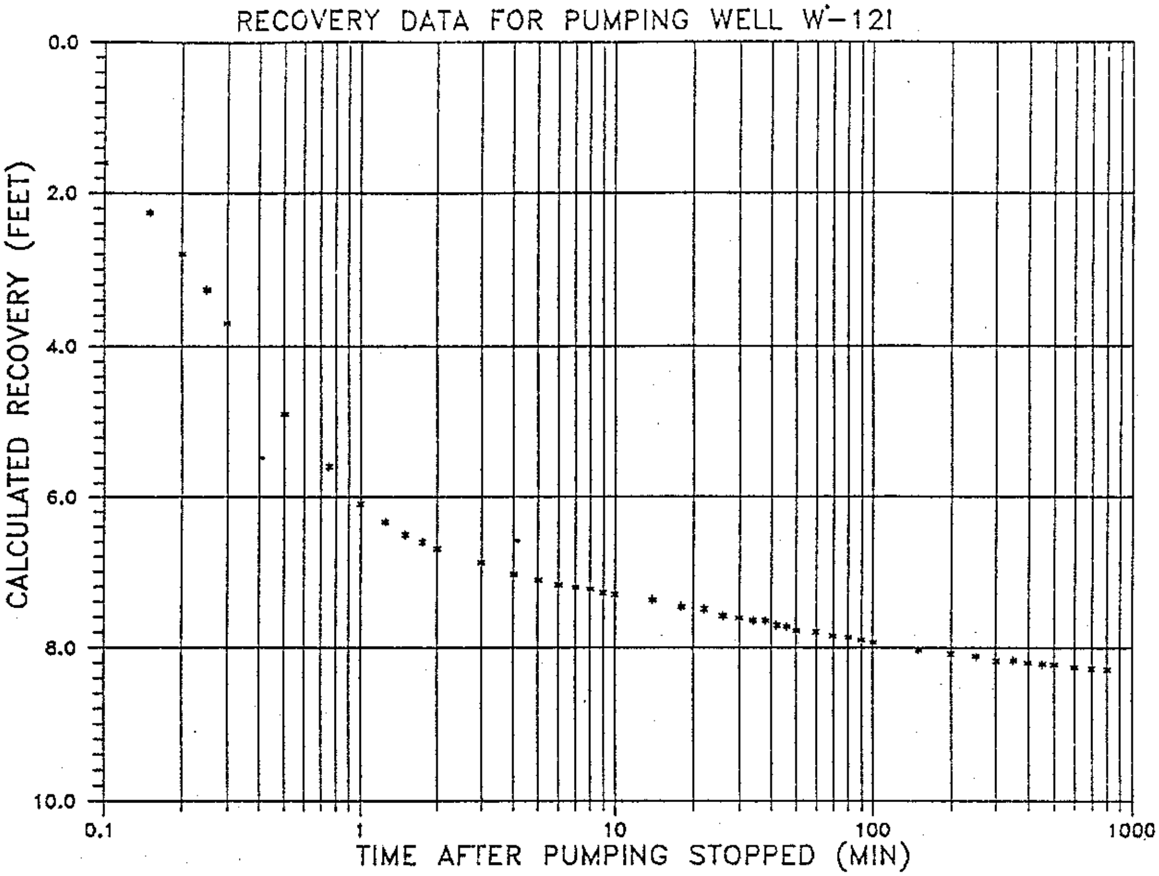

FIGURE 2-7a

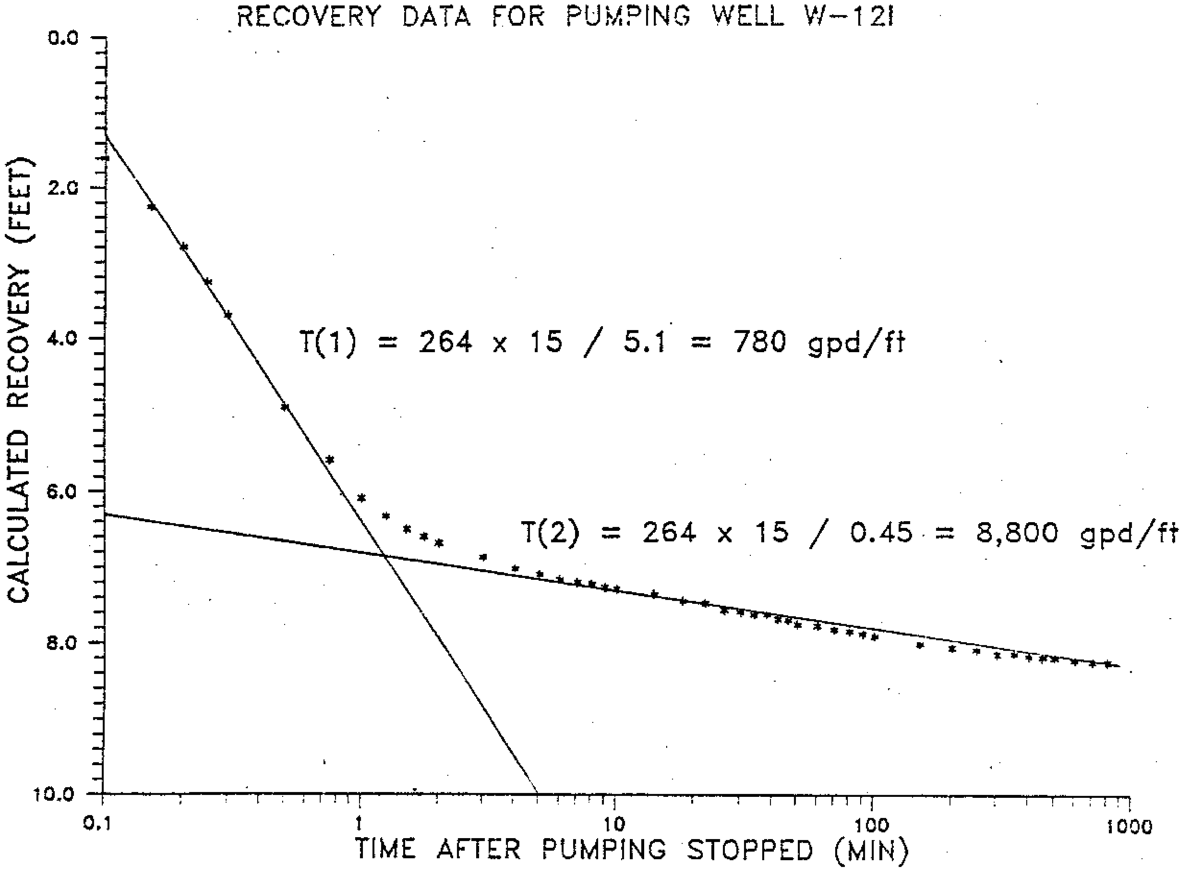

FIGURE 2-7b

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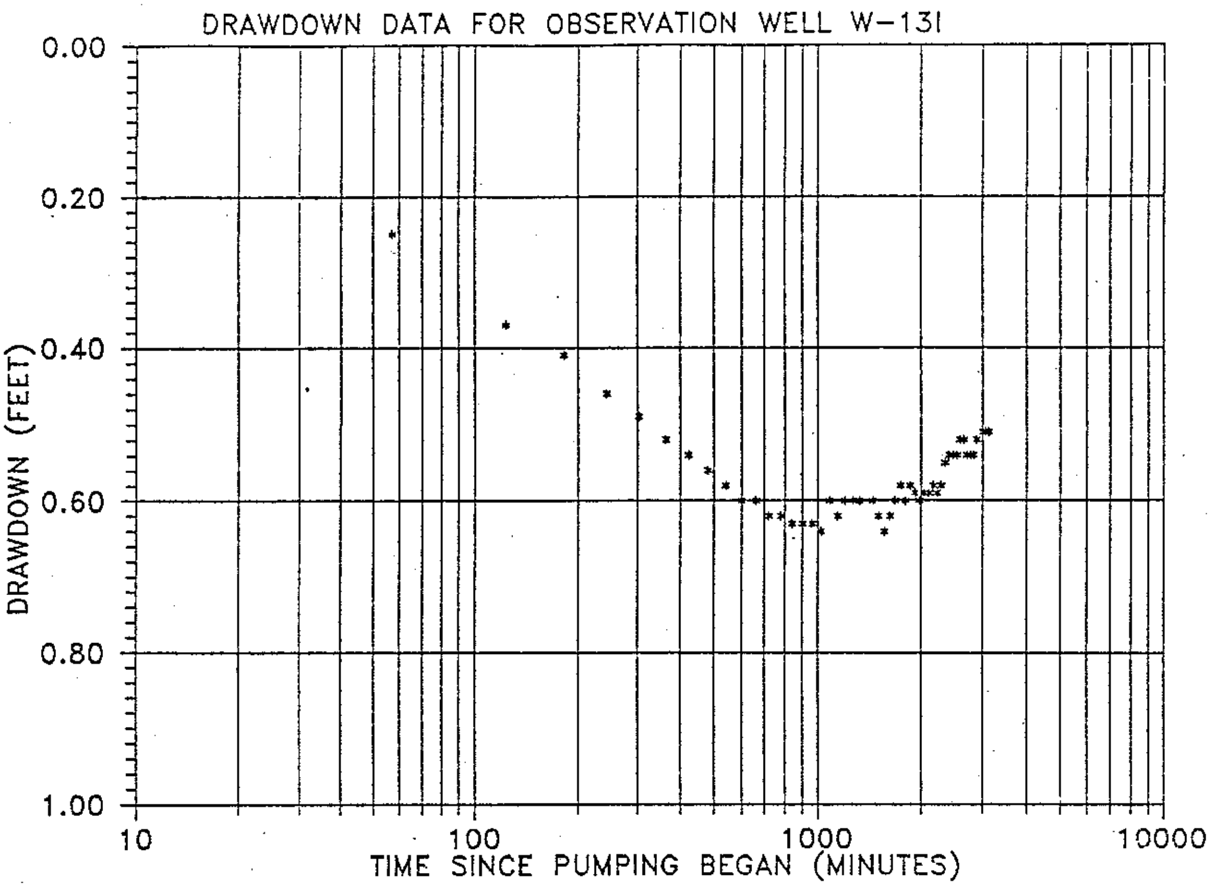


FIGURE 2-8a

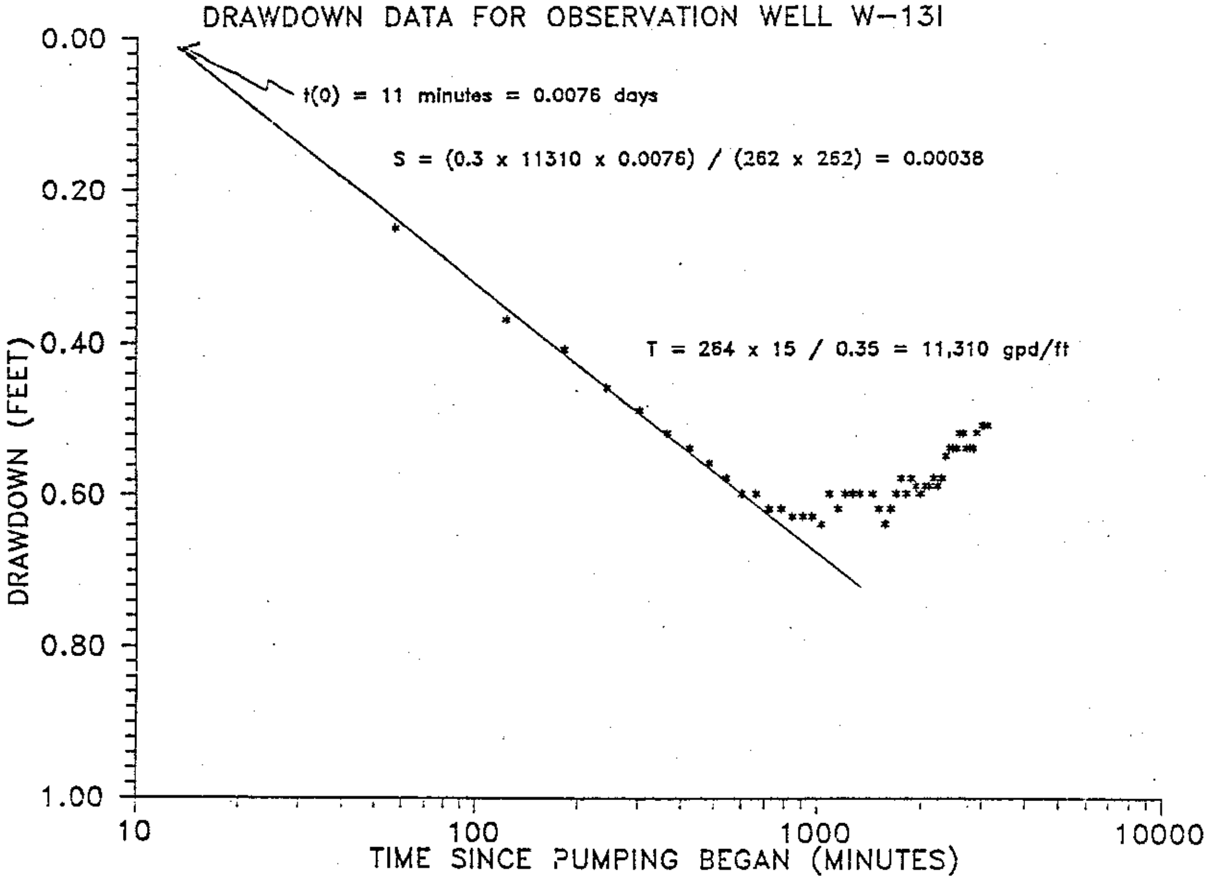


FIGURE 2-8b

The semilog graphs for the remaining observation wells for the W-12I pump test are provided in Appendix C. The transmissivity values calculated from these graphs are 7,920 gpd/ft (from W-3S drawdown data), 6,550 gpd/ft (W-3S recovery data), 9,000 gpd/ft (W-15S drawdown data), 12,375 gpd/ft (W-5I drawdown data) and 11,650 gpd/ft (W-11I drawdown data). Similarly, the storativities calculated from the same graphs are 0.17 (W-3S drawdown data), 0.14 (W-3S recovery data),2 x 10^{-3} (W-15S drawdown data), 4.8 x 10^{-4} (W-5I drawdown data) and 2 x 10^{-4} (W-11I drawdown data).

Theis Curve Matching Method

As stated earlier, the Theis method was also employed to analyze the pump test data. The Theis method consists of plotting the drawdown versus time data on log-log axes and then matching the data to a set of type curves keeping the axes of both plots parallel to each other during the matching procedure. A match point is then selected and used to calculate the transmissivity and storativity.

There are several sets of type curves available. Selection of the curve type depends on the type of aquifer being analyzed. Figure 2-9a displays the set of type curves that are used for an aquifer that is confined, semi-confined or leaky (ie. aquifer receives water influx from adjacent geologic units). Figure 2-9b displays the type curves used for analyzing an unconfined or water table aquifer.

Previous aquifer test analyses indicated that the shallow aquifer at the site was unconfined and the unconfined set of type curves (Figure 2-9b) were used to determine the aquifer properties based on that assumption. However, upon analyzing the W-12I pump test data plots it was discovered that the data closely matched the semi-confined or leaky type curves displayed in Figure 2-9a and not the unconfined aquifer type curves displayed in Figure 2-9b. Therefore, the curves in Figure 2-9a were used to determine the hydraulic properties of the aquifer.

Figure 2-10 is the Theis plot for observation well W-13I. The match point coordinate used from the plot is $s=0.51$ feet, $t=1200$ minutes, $r/B=0.3$, $u=0.01$ and $W(u)=2.71$. The resulting calculated values for transmissivity and storativity using Equations 2.3 and 2.4 are 9,130 gpd/ft and 5.9 x 10^{-4}, respectively.

FIGURE 2-9a

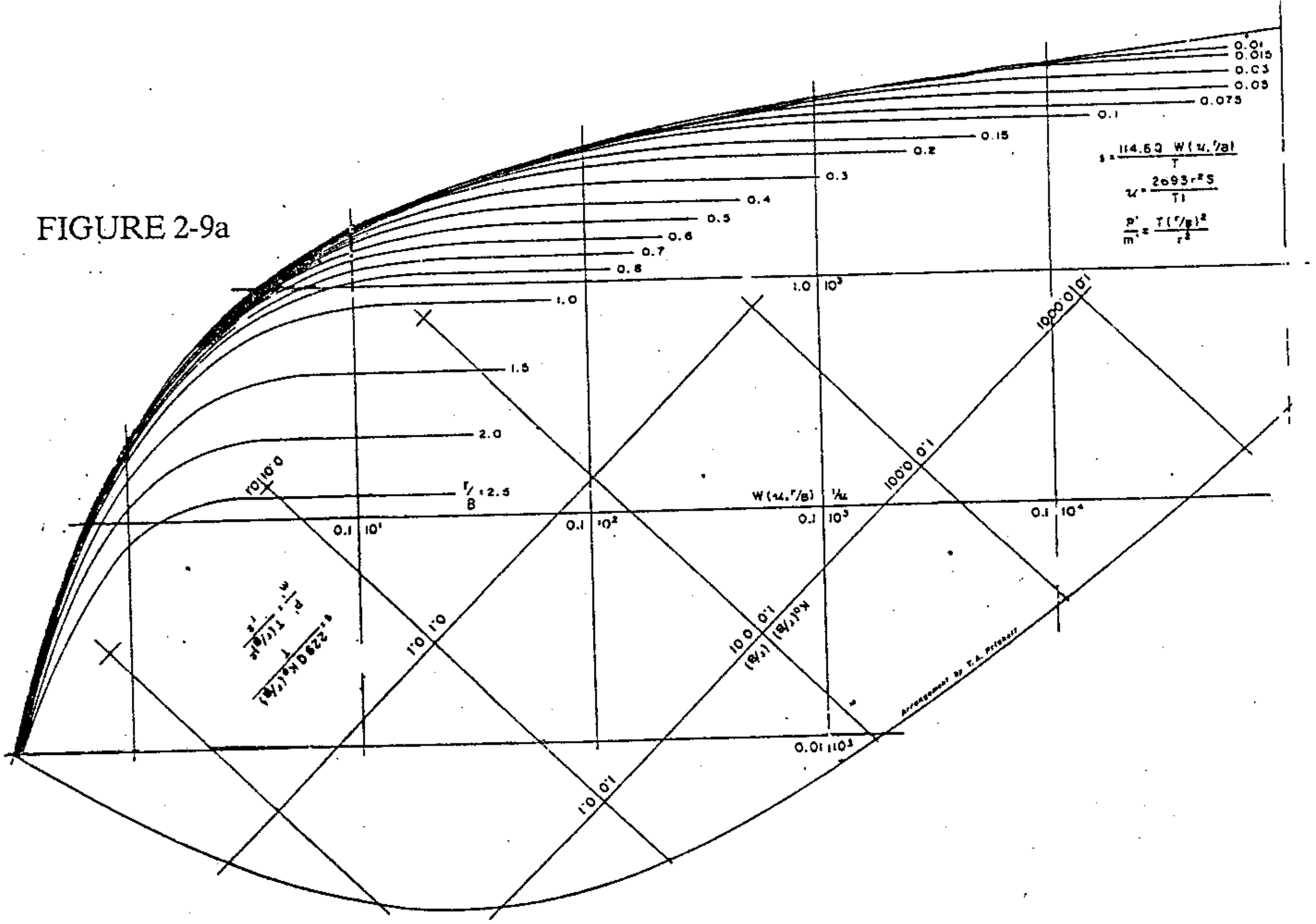
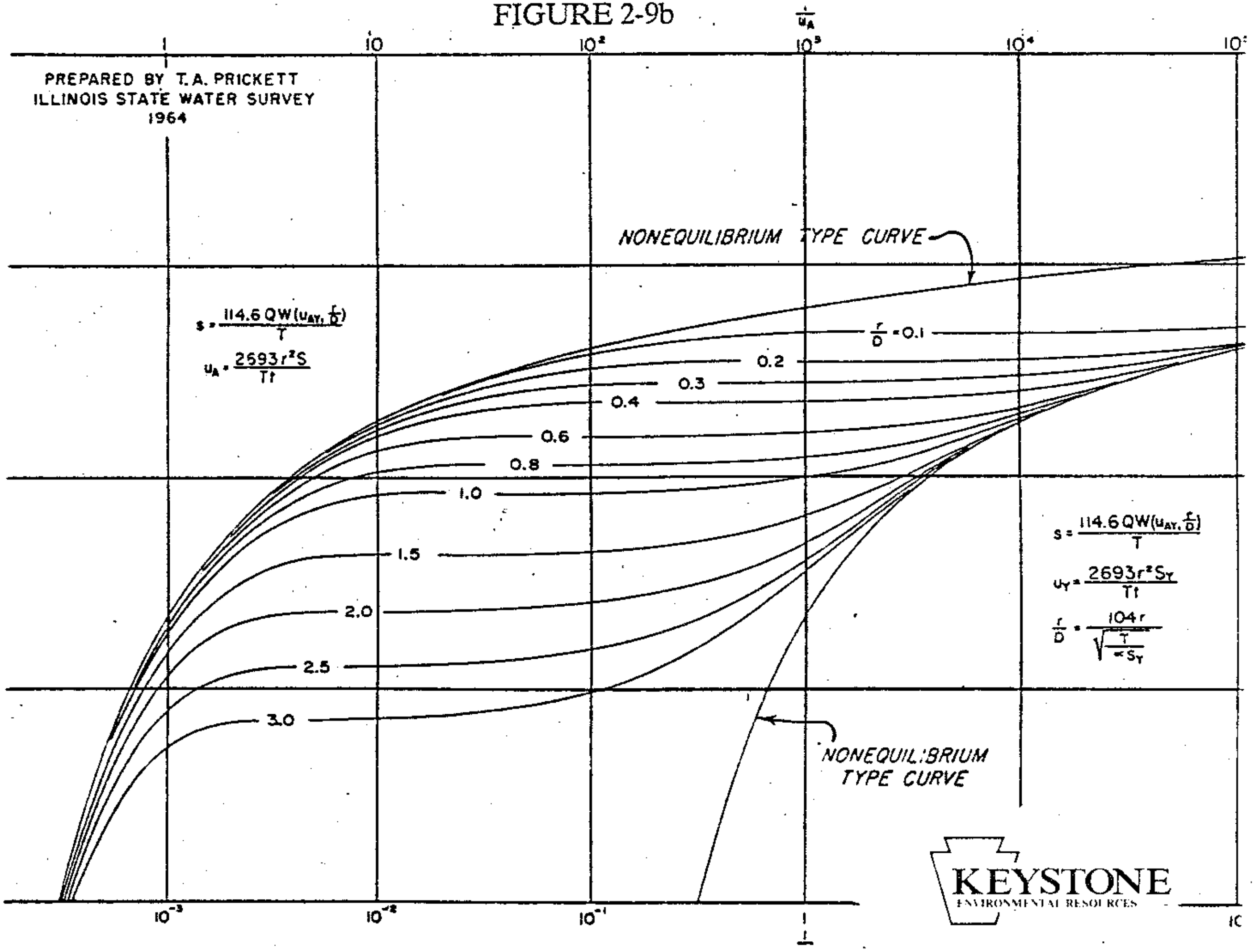


FIGURE 2-9b



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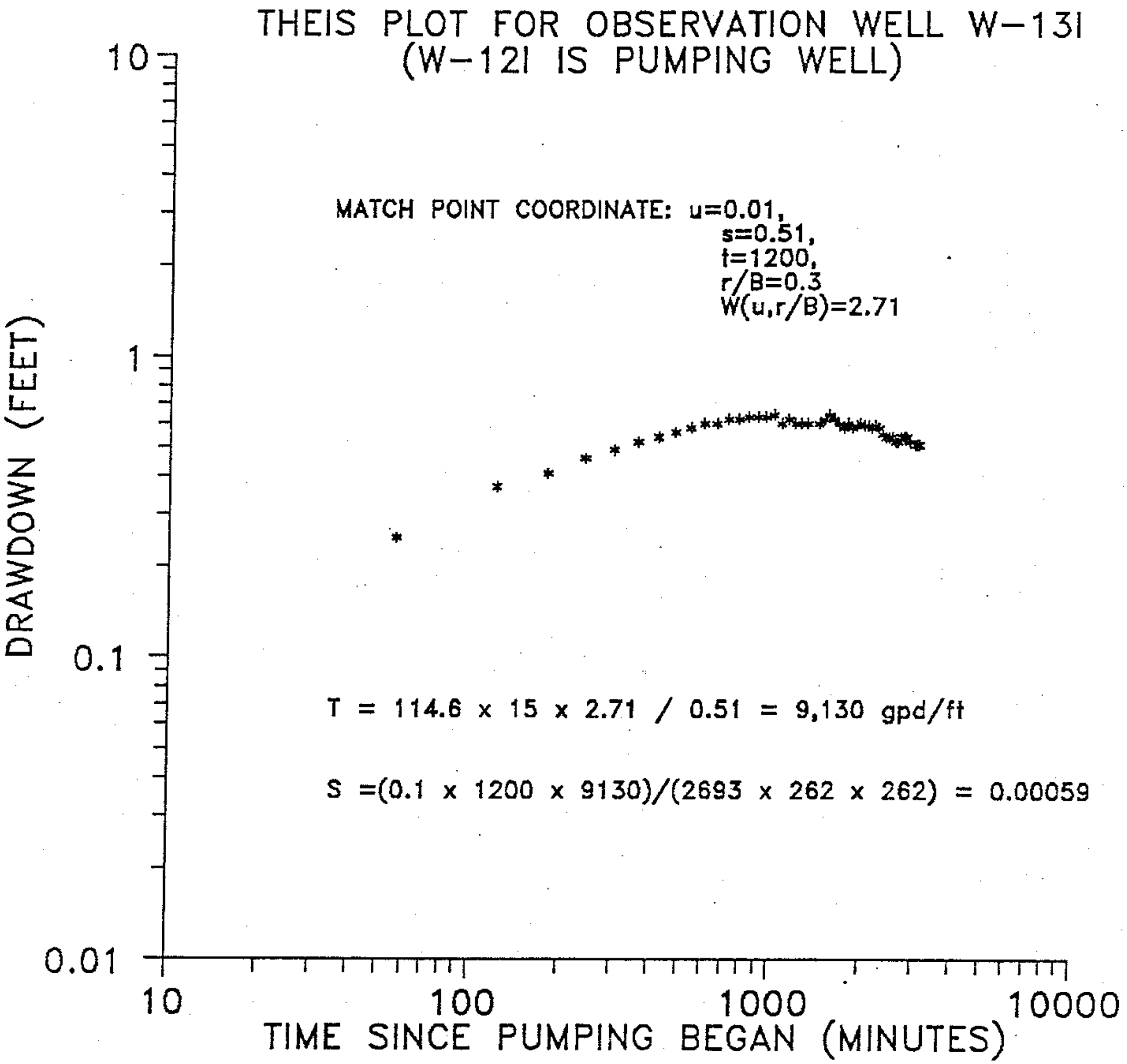
THEIS PLOT FOR OBSERVATION WELL W-13I
(W-12I IS PUMPING WELL)
MATCH POINT COORDINATE: u=0.01,
s=0.51,
t=1200,
r/B=0.3
W(u,r/B)=2.71
T = 114.6 x 15 x 2.71 / 0.51 = 9,130 gpd/ft
S =(0.1 x 1200 x 9130)/(2693 x 262 x 262) = 0.00059
DRAWDOWN (FEET)
10
1
0.1
0.01
10
100
1000
10000
TIME SINCE PUMPING BEGAN (MINUTES)

FIGURE 2-10

$$T = 114.6 \times Q \times W(u,r/B) / s \qquad (2.3)$$

where
T = transmissivity, in gpd/ft
Q = pumping rate, in gpm
$W(u,r/B)$ = match point coordinate, dimensionless
s = change in drawdown between any two times whose ratio is 10 (over one log cycle), in feet

$$S = T \times t \times u / 2693 \times r^2 \qquad (2.4)$$

where
S = storativity, dimensionless
T = transmissivity, in gpd/ft
t = time match point coordinate, in minutes
u = match point coordinate, dimensionless
r = distance, in feet, from the pumped well to the observation well where the drawdown measurements were made

The Theis plots for the remaining wells are provided in Appendix C. The values for transmissivity and storativity calculated from them are 4,950 gpd/ft and 0.27 (W-3S), 5,118 gpd/ft and 2.6×10^{-3} (W-15S), 7,764 gpd/ft and 7.0×10^{-4} (W-5I), 3,924 gpd/ft and 3.0×10^{-4} (W-11I), respectively.

Distance versus Drawdown Analysis

Another method that can be used to independently determine the hydraulic properties of an aquifer by examination of pump test data is the distance versus drawdown semilog plotting method. This method involves plotting the drawdown value of at least three observation wells taken at the same instant in time on the linear axis and the distance of the observation well from the pumping well on the logarithmic axis.

Figure 2-11 is the distance versus drawdown data plotted for the W-12I pump test. The observation wells used for the distance-drawdown plot were W-3S, W-5I, W-13I and W-11I. There are two sets of data plotted on Figure 2-11, one set of data for

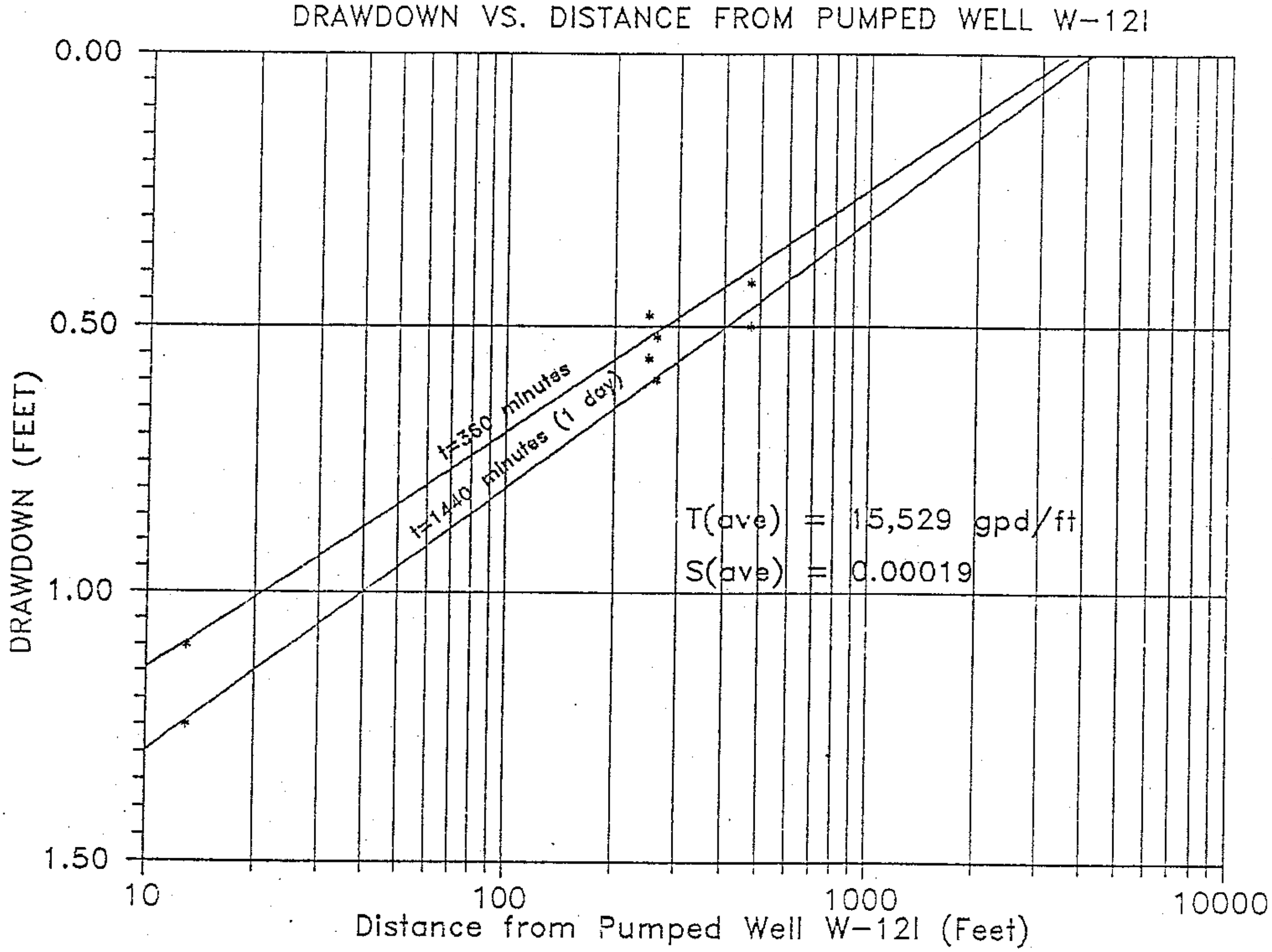

FIGURE 2-11

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t=360 minutes (ie. 360 minutes since pumping began) and the other for t=1440 minutes. The average values of transmissivity and storativity calculated (using Equations 2.5 and 2.6 below) from these data sets are 15,529 gpd/ft and 1.9 x 10^{-4}, respectively.

$$T = 528 \times Q / s \qquad (2.5)$$

where
T = transmissivity, in gpd/ft
Q = pumping rate, in gpm
s = change in drawdown between any two times whose ratio is 10 (over one log cycle), in feet

$$S = (0.3 \times T \times t) / r_o^2 \qquad (2.6)$$

where
S = storativity, dimensionless
T = transmissivity, in gpd/ft
t = time since pumping started, in days
r_o = intercept of extended straight line at zero drawdown, in feet

The use of W-3S in the analysis was necessary because no intermediate depth wells were closer than approximately 200 feet from well W-12I. The problem with using W-3S is that the drawdown values used for W-3S in Figure 2-11 had to be adjusted to compensate for the vertical disparity between the positions of the two well screens (W-3S and W-12I). This was necessary because the screened interval in observation well W-3S is (18 to 28 feet below grade) higher than the screened interval of the pumping well (W-12I) and the other observation wells (W-5I, W-13I and W-11I). The drawdown observed in W-3S is less than would be observed if W-3S was at approximately the same depth as W-12I and the other observation wells. This is because the vertical hydraulic conductivity is less than the horizontal hydraulic conductivity in the aquifer (ie. aquifer is anisotropic).

To apply the correction to the W-3S drawdowns the anisotropic ratio had to be estimated and used in an equation (Walton, 1987) to determine the drawdown adjustment. The ratio was estimated by using a published value (Walton, 1987) for aquifer sediments similar to the Baxter shallow aquifer. A value of 4 was selected for the ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity.

Figure 2-11a presents an approximation of the area of influence of the W-12I pump test after 26 hours of pumping (immediately before recharge effect begins to influence the pump test) at 15 gallons per minute (gpm). The shaded area on the figure represents an inferred area of the site where the drawdown in the peizometric levels created by the pump test are at least 0.5 feet. This drawdown zone would be a capture zone where contaminants in the groundwater within this area would be drawn toward well W-12I and eventually removed in the pump discharge water. The radius of the capture zone on Figure 2-11a is approximately 490 feet.

Table 2-2 summarizes the values of the hydraulic properties (ie. transmissivity and storativity) determined from the W-12I pump test.

Some of the transmissivity and storativity values determined from the aquifer test data and analysis are not considered to accurately represent quantitative values for the hydraulic properties of the aquifer (transmissivity and storativity). These data values are excluded from the mean value calculations presented in Table 2-2 for the reasons explained below.

If the value obtained from the analysis deviated considerably from the general magnitude of the values it was treated as an aberration in the data set. Such is the case with the transmissivity value determined by the Theis method for well W-12I of 201 gpd/ft. All of the other transmissivity values are between approximately 4,000 gdp/ft and 15,529 gpd/ft. Therefore it is reasonable to assume a value of 201 gpd/ft is an anomalous value.

The other reason for excluding certain values in the determination of the mean values for each method of analysis, was the vertical position of the observation well screens compared to the pumping well screen (W-12I). It is desirable to have the pumping well and the observation well screened over approximately the same depth interval in a stratified aquifer to minimize the uncertainties introduced in adjusting drawdowns in the observation well to compensate for the difference between the

TABLE 2-2

SUMMARY OF HYDRAULIC PROPERTIES DETERMINED FROM THE W-12I PUMP TEST
J.H. BAXTER WOOD PRESERVING
EUGENE, OREGON

		Transmissivity (GPD/FT)		Storativity			
Well	Test Type	Theis	Jacob	Theis	Jacob	r	delta s
W-12I	Pumping	*201	11310	--	--	0	8.35
	Recovery	--	8800	--	--		
W-3S	Pumping	*4250	*7920	*.27	*.17	12.9	0.84
	Recovery	--	*6550	--	*.14		
W-13I	Pumping	9130	11310	0.00059	0.00038	262	0.64
W-15S	Pumping	*5118	*9000	*.0026	*.002	215.5	0.5
W-5I	Pumping	7764	12375	0.0007	0.00048	247.6	0.6
W-11I	Pumping	*3924	11650	0.0003	0.0002	471.4	0.52
Distance vs Drawdown	Pumping	--	15529	--	0.00019		
Mean Value		8450	11829	0.00053	0.00031		

Notes:
r – distance in feet from the pumping well
delta s – maximum change in water level during pump test (feet)
* data not used in mean value calculations
GPD/FT – gallons per day per foot

position of the observation well screen and the pumping well screen (partial penetration effect).

This effect is observed because generally aquifers are not isotropic (ie. the vertical hydraulic conductivity is equal to the horizontal hydraulic conductivity) as assumed in the standard analytical methods used to interpret aquifer tests. The horizontal hydraulic conductivity is usually greater than the vertical hydraulic conductivity in an aquifer. This is the result of geologic stratification created by the natural process of sediment deposition in an alluvial environment.

Because the vertical to horizontal hydraulic conductivity ratio is estimated to be 4, less vertical communication occurs in the aquifer. The result of this on the transmissivity and storativity values can be observed in Table 2-2. The transmissivity results for the Theis method indicate that the values obtained from wells W-3S and W-15S (ie. the shallow wells) are less than the values determined from observation wells W-5I and W-13I.

The transmissivity values resulting from the Jacob method of analysis (shown in Table 2-2) show a similar pattern as the Theis method data. The shallow well values are less than the intermediate depth well transmissivity values. The storativity values obtained from the shallow wells are consistently larger than the values obtained from the intermediate wells for the Theis and Jacob methods of analysis.

The data values used to represent the transmissivity and storativity of the aquifer from the W-12I pump test range from approximately 7,500 gpd/ft to 16,000 gpd/ft (transmissivity) and from 1.9×10^{-4} to 7.0×10^{-4} (storativity).

Mean values for the transmissivities and storativities determined from the Jacob semilog method of analysis and the Theis curve matching method are also presented in Table 2-2. A mean transmissivity of 8,450 gpd/ft and a mean storativity of 5.3×10^{-4} was determined from the Theis method. For the Jacob method a mean transmissivity of 11,829 gpd/ft and a mean storativity of 3.1×10^{-4} was determined.

Averaging the mean values from the Theis and Jacob methods results in an average value of approximately 10,000 gpd/ft for the transmissivity and an average value of 4.0×10^{-4} for the storativity of the aquifer determined from the W-12I pump test.

The hydraulic conductivity for the aquifer can be calculated using Equation 2.7.

$$K = 0.134 \times T / b \qquad (2.7)$$

where
K = hydraulic conductivity, in ft/day
T = transmissivity, in gpd/ft
b = the saturated thickness of the aquifer, in feet

Using Equation 2.7 and a transmissivity value of 10,000 gpd/ft and a saturated aquifer thickness of 70 feet (approximate value determined from water level and drill log data for the W-12I location), an average hydraulic conductivity of 2×10^{-4} ft/sec was calculated.

W-13S Pump Test

The W-13S pump test consisted of pumping well W-13S at a constant rate of 7.5 gpm for 3,345 minutes (55.75 hours). At the termination of the pump test, recovery data was recorded for a period of 960 minutes (16 hours). The water level data recorded during the test for well W-13S and the associated observation wells (W-15S, W-13I, W-3S, W-7S and W-1S) are provided in Appendix C.

Jacob Method

The Jacob method was used to analyze the drawdown data for all the test wells and the recovery data for pumping well W-13S, and the nearest shallow observation well, W-15S.

Figure 2-12a is the interpreted semilog plot of the drawdown data for well W-13S and Figure 2-12b is the interpreted plot for the recovery data from well W-13S. The transmissivity values determined from the two graphs using Equation 2.1 are different. The transmissivities are 1,164 gpd/ft (Figure 2-12a) and 3,960 gpd/ft

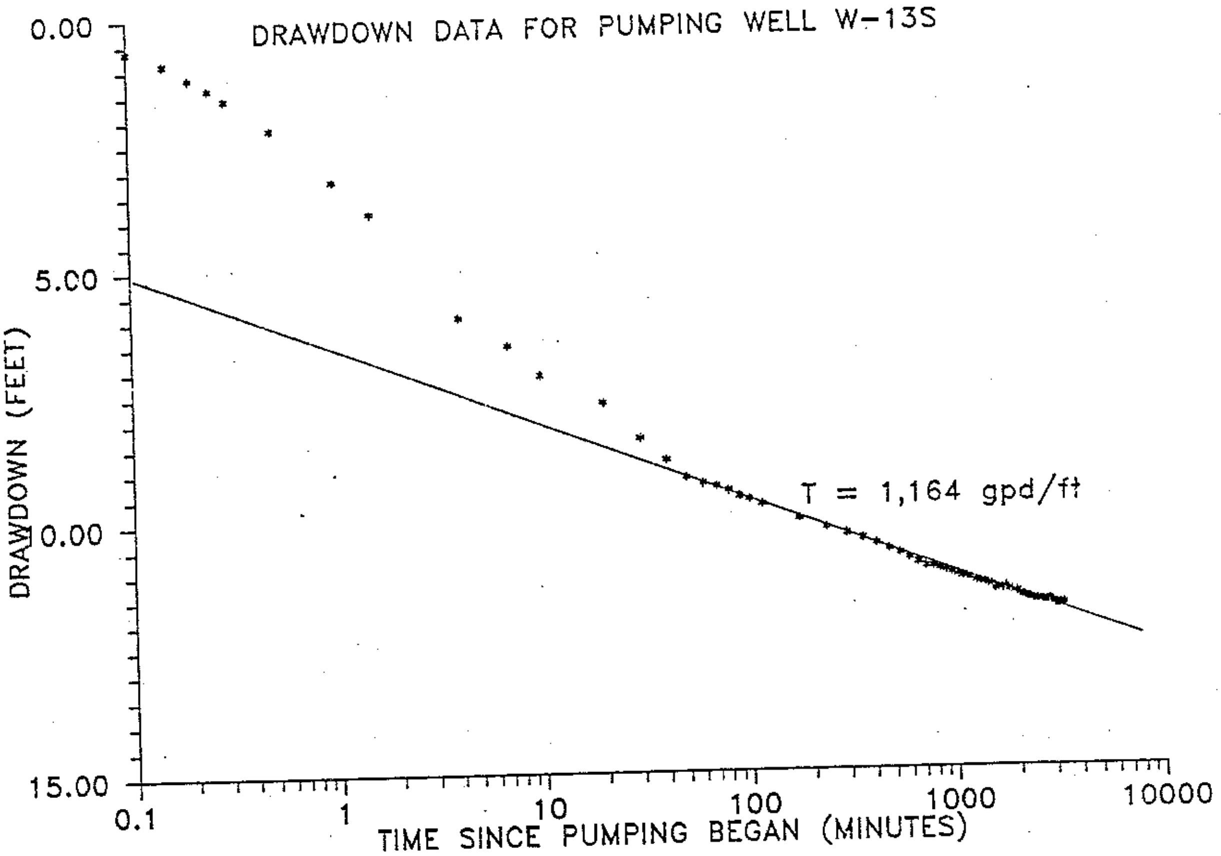

FIGURE 2-12a

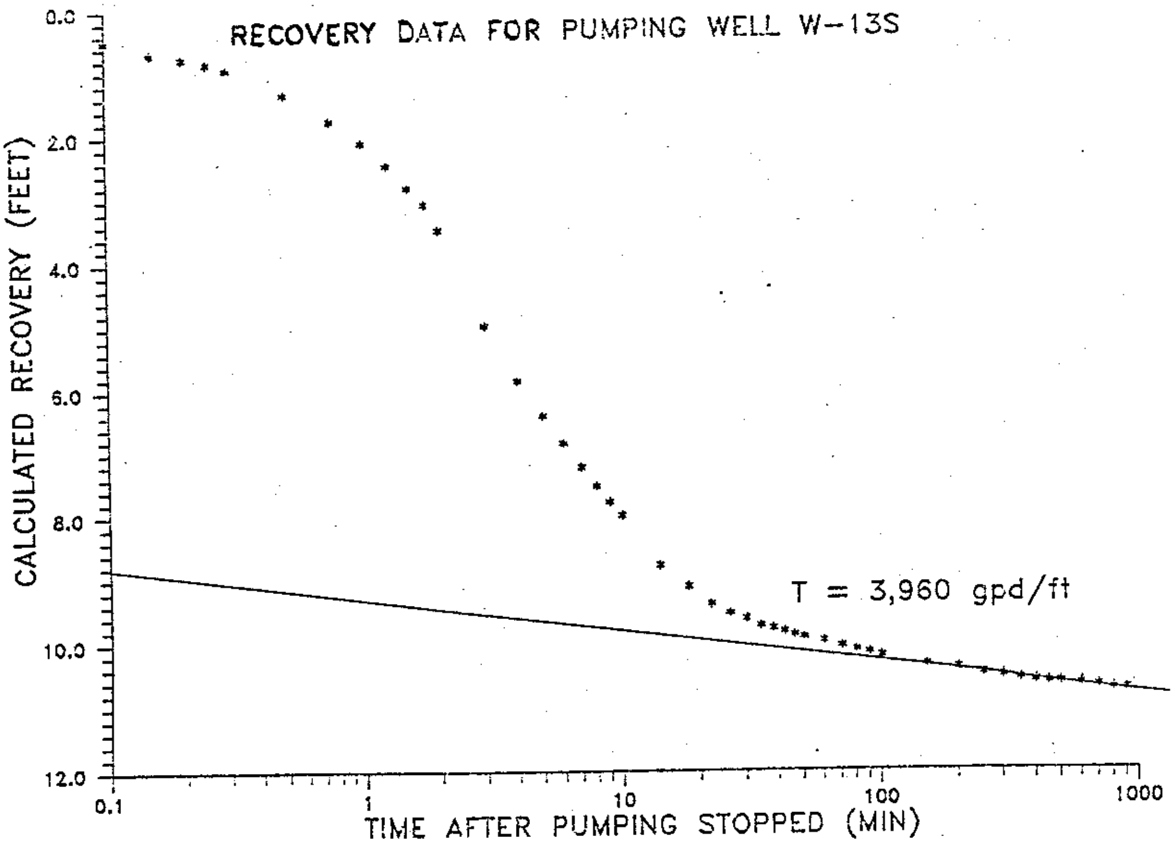

FIGURE 2-12b

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(Figure 2-12b), respectively. The drawdown data for the pumping well is susceptible to errors caused by fluctuating water levels in the well. Therefore, the transmissivity value of 3,960 gpd/ft determined from Figure 2-12b will be used as the transmissivity value determined from these plots.

The value of 3,960 gpd/ft determined from Figure 2-12b was calculated from the slope of the later data on the graph. The earlier time data on the graph which had steeper slopes to the data, meaning lower apparent transmissivities, was not used to determine the transmissivity from the well. This earlier data was possibly influenced by short term transient effects such as water draining from the portion of the sand pack above the water level in the well and water draining back into the well from the pump discharge pipe through the pump. These two effects would produce faster recovery rates (steeper slopes on the recovery graphs) in the water level than would be caused solely from water entering the well from the surrounding aquifer.

The semilog graphs for the observation wells for the W-13S pump test are provided in Appendix C. The transmissivity values calculated from these plots are 4,125 gpd/ft (from W-15S drawdown data), 4,600 gpd/ft (W-15S recovery data), 5,740 gpd/ft (W-13I drawdown data), 5,010 gpd/ft (W-3S drawdown data), 5,430 gpd/ft (W-7S drawdown data) and 6,290 gpd/ft (W-1S drawdown data). Similarly, the storativities calculated from the same graphs are 7.5×10^{-4} (W-15S drawdown data), 6.6×10^{-4} (W-15S recovery data), 8.1×10^{-2} (W-13I drawdown data), 2.3×10^{-3} (W-3S drawdown data), 2.9×10^{-3} (W-7S drawdown data) and 1.8×10^{-3} (W-1S drawdown data).

Theis Curve Matching Method

Upon analyzing the W-13S pump test data it was apparent that the data matched the same set of types curves that were found to match the W-12I pump test data. These were the type curves for semi-confined or leaky aquifers (Figure 2-9a).

Figure 2-13a and 2-13b are the Theis plots for the pumping well, W-13S, and observation well W-15S, respectively. The resulting calculated values for transmissivity using Equation 2.3 are 524 gpd/ft and 2,210 gpd/ft, respectively. The

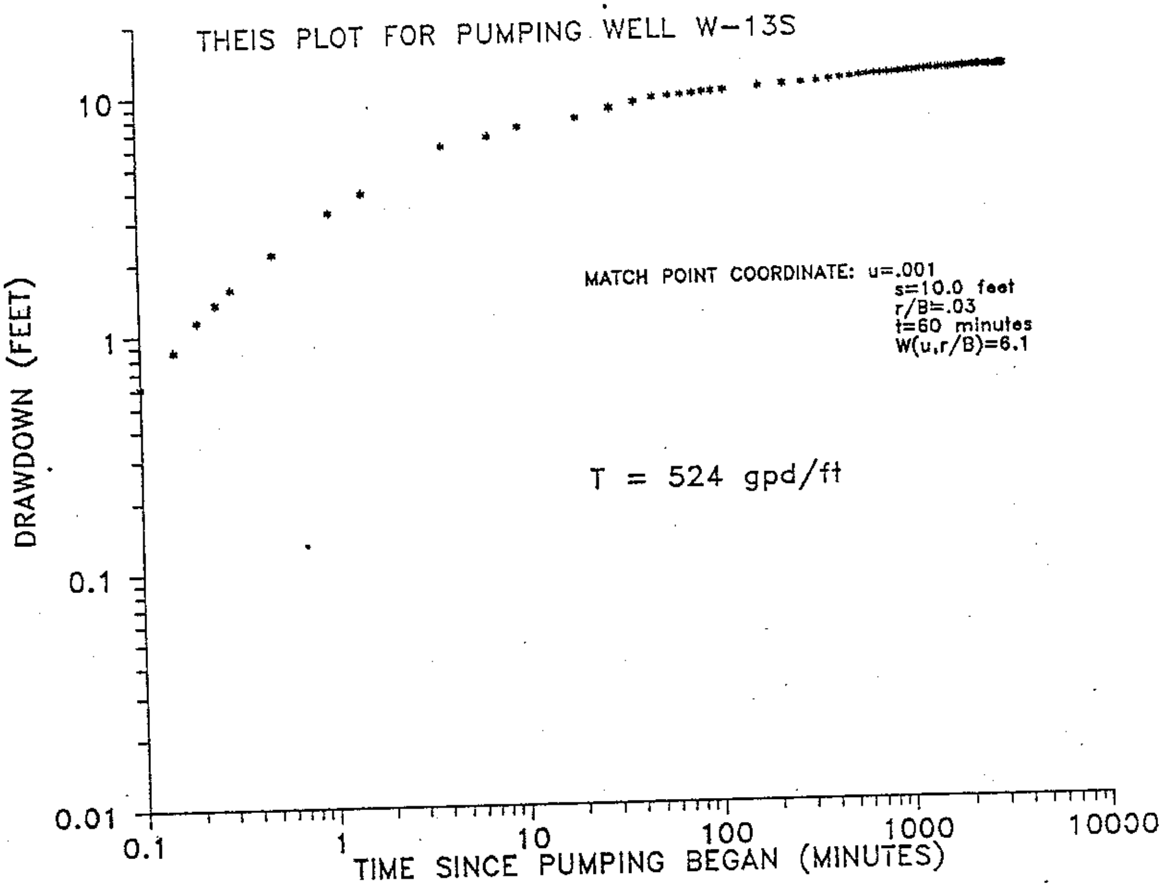

FIGURE 2-13a

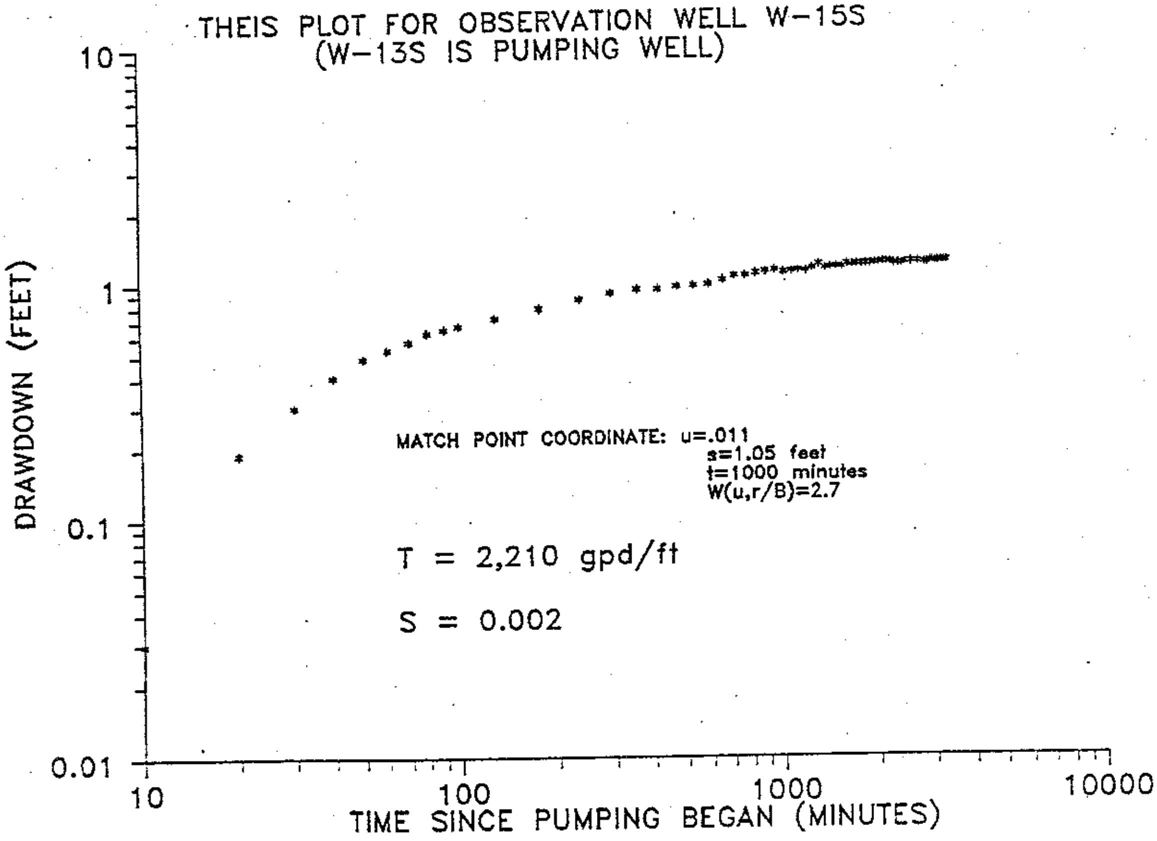

FIGURE 2-13b

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storativity calculated from the Theis plot for well W-15S is 2 x 10^{-3} (using Equation 2.4).

The Theis plots for the remaining wells are provided in Appendix C. The values for transmissivity and storativity calculated from them are 2,080 gpd/ft and 7.6 x 10^{-2} (W-13I), 3,260 gpd/ft and 3.0 x 10^{-3} (W-3S), 3,753 gpd/ft and 2.8 x 10^{-3} (W-7S) and 7,110 gpd/ft and 2.2 x 10^{-3} (W-1S).

Distance versus Drawdown Analysis

Figure 2-14 is the distance versus drawdown data plotted for the W-13S pump test. The observation wells used for the distance-drawdown plot were W-15S, W-3S and W-7S. The three lines drawn on Figure 2-14 display the development of the cone of depression with time. The average values of transmissivity and storativity calculated (using Equations 2.5 and 2.6 below) from the three lines are 2,980 gpd/ft and 6.7 x 10^{-3}, respectively.

Figure 2-14a presents an approximation of the area of influence of the W-13S pump test near the end of the test. The shaded area on the figure represents an inferred area of the site where the drawdown in the peizometric levels created by the pump test are at least 0.5 feet. The radius of this inferred area on Figure 2-14a is approximately 210 feet.

Table 2-3 summarizes the values of the hydraulic properties (ie. transmissivity and storativity) determined from the W-13S aquifer test.

Similar to the W-12I test, some of the transmissivity and storativity values determined from the W-13S aquifer test data and analysis are not used in the final interpretation of the transmissivity and storativity of the aquifer for the same reasons explained previously in the W-12I analysis section. This included the data for well W-13I. Although the transmissivity values for W-13I in Table 2-3 are comparable to the transmissivity values determined from the other observation wells, the storativities are not. To be consistent, neither the transmissivity or storativity values were used in the determination of the average hydraulic properties of the aquifer.

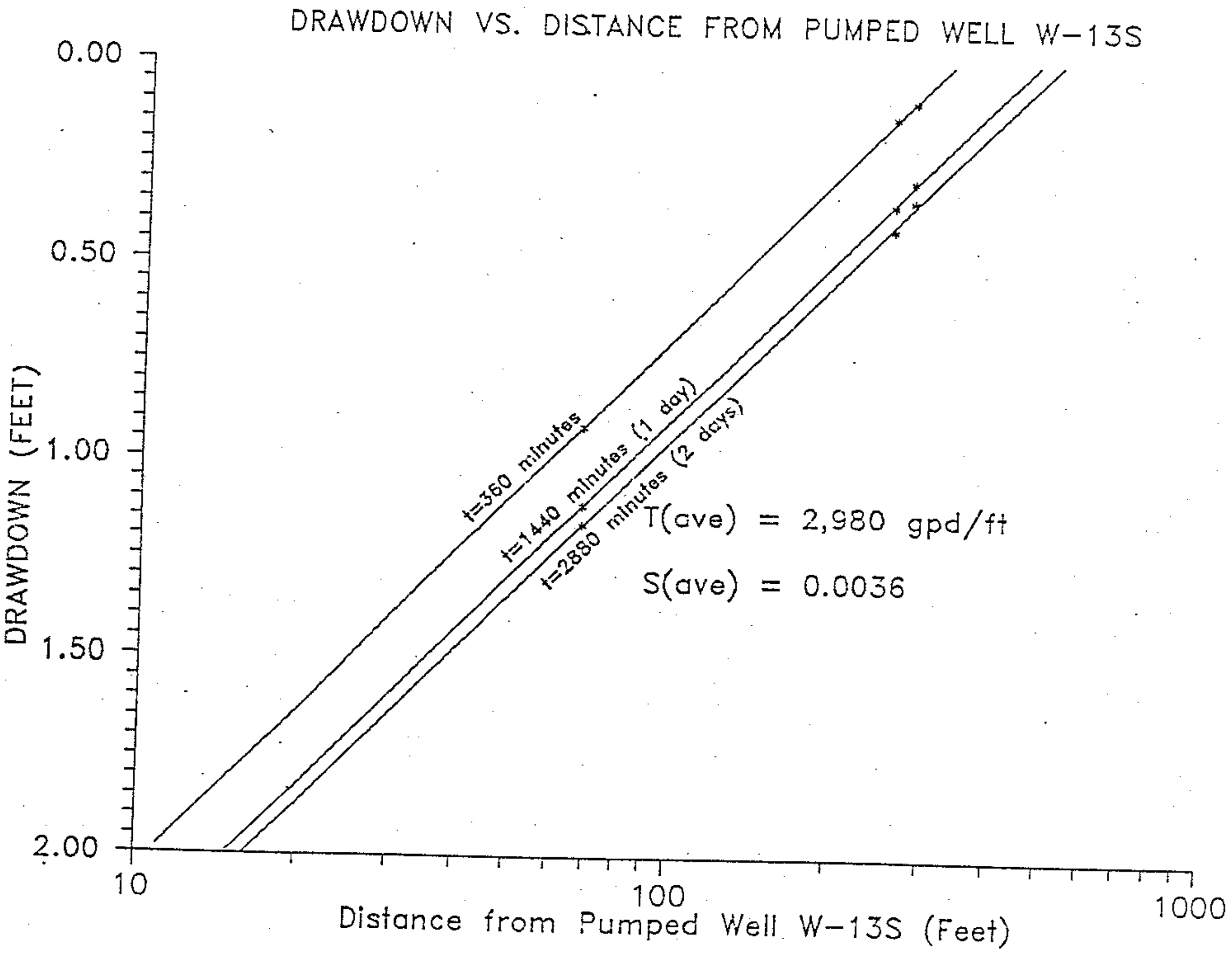

FIGURE 2-14

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TABLE 2-3

SUMMARY OF HYDRAULIC PROPERTIES DETERMINED FROM THE W-13S PUMP TEST
J.H. BAXTER WOOD PRESERVING
EUGENE, OREGON

		Transmissivity (GPD/FT)		Storativity			
Well	Test Type	Theis	Jacob	Theis	Jacob	r	delta s
W-13S	Pumping	*524	*1164	--	--	0	11.81
	Recovery	--	3960	--	--		
W-15S	Pumping	2210	4125	0.002	0.00075	68.3	1.18
	Recovery	--	4600	--	0.00066		
W-13I	Pumping	*2080	*5740	*0.076	*.081	10.1	0.68
W-3S	Pumping	3260	5010	0.003	0.0023	259.3	0.43
W-7S	Pumping	3753	5430	0.0028	0.0029	282.2	0.36
W-1S	Pumping	7110	6290	0.0022	0.0018	486.5	0.33
Distance vs Drawdown	Pumping	--	2980	--	0.0036		
Mean Value		4083	4628	0.0025	0.002		

Notes:
r – distance in feet from the pumping well
delta s – maximum change in water level during pump test (feet)
* data not used in mean value calculations
GPD/FT – gallons per day per foot

However, the data from W-13I did provide valuable information on the characteristics of the aquifer. The significant drawdown observed in W-13I during the W-13S pump test indicates that the shallow wells (eg. W-13S) and intermediate wells (eg. W-13I) are within the same aquifer unit.

Mean values for the transmissivities and storativities determined from the Jacob semilog method of analysis and the Theis curve matching method are also presented in Table 2-3. A mean transmissivity of 4,083 gpd/ft and a mean storativity of 2.5 x 10^{-3} were determined from the Theis method results. For the Jacob method, a mean transmissivity of 4,628 gpd/ft and a mean storativity of 2.0 x 10^{-3} was determined.

Averaging the mean values for the Theis and Jacob methods from Table 2-3 results in a transmissivity value of approximately 4,500 gpd/ft and a storativity value of approximately 2.5 x 10^{-3} for the aquifer.

The hydraulic conductivity determined from the average transmissivity value above (4,500 gpd/ft) is 9.0 x 10^{-5} ft/sec. An aquifer thickness of 70 feet was used to calculate the hydraulic conductivity from the transmissivity. Water level observations during the pump test indicated that the intermediate wells, which are screened at the base of the aquifer, were being drawn down from the pumping of well W-13S. Therefore, it is reasonable to conclude that the water pumped from well W-13S was supplied from the entire thickness of the aquifer.

2.3.2 Groundwater Flow Pattern(s)

The groundwater flow directions beneath the site were assessed by examining water level data obtained from the groundwater sampling round in July 1990, from the performance of the aquifer tests in November 1990 and from water level data obtained on January 17, 1991.

Table 2-4 contains the water level data used to construct the potentiometric surface contour maps presented in Figures 2-15 and 2-16. This water level data was obtained on January 17, 1991. Figure 2-15 is the potentiometric surface map constructed from

TABLE 2-4
GROUNDWATER ELEVATIONS
J.H. BAXTER WOOD PRESERVING
EUGENE, OREGON

WELL	DEPTH OF WELL (fbg)	SCREENED INTERVAL (fbg)	GROUND ELEVATION (*)	TOP OF WELL CASING ELEVATION (*)	DEPTH TO WATER (feet) (1/17/91)	GROUNDWATER ELEVATION (*)
W-1S	22.0	12-22	394.73	395.71	7.38	388.33
W-2S	23.0	13-23	392.22	393.16	3.73	389.43
W-3S	28.0	18-28	394.17	395.01	7.22	387.79
W-4S	19.0	9-19	394.54	396.56	7.75	388.81
W-5I	73.0	63-73	394.63	396.71	8.56	388.15
W-6I	67.0	57-67	395.51	397.77	9.13	388.64
W-7S	17.0	7-17	395.69	397.66	8.79	388.87
W-8S	17.5	7-17	394.12	395.90	4.69	391.21
W-9S	25.0	15-25	395.10	396.45	6.08	390.37
W-9I	67.0	57-67	395.04	396.19	5.70	390.49
W-11S	25.0	15-25	392.52	394.17	6.00	388.17
W-11I	83.0	73-83	392.47	394.17	6.60	387.57
W-12I	78.5	69-79	394.27	395.62	7.76	387.86
W-12D	135.0	123-133	394.10	395.54	13.11	382.43
W-13S	28.0	18-28	395.42	396.71	9.69	387.02
W-13I	70.0	60-70	395.29	396.14	8.38	387.76
W-13D	133.0	123-133	395.25	396.40	13.96	382.44
W-14I	77.5	67-77	394.61	395.60	7.00	388.60
W-15S	28.0	18-28	NA	396.62	9.31	387.31

NOTE: (*) Elevations in feet above mean sea level.
NA – not available.
fbg – feet below grade

the water level data for the shallow wells at the site. Figure 2-16 is the potentiometric surface map created by using the water level data from the intermediate wells on the site.

The potentiometric surface map for the shallow wells indicates that the shallow groundwater flow direction is generally north to northwest. The groundwater flow pattern does deviate from the main flow direction in the vicinity of well W-8S due to a mounding feature in the water table at this location.

An average hydraulic gradient was calculated from Figure 2-15 for the site. The calculated average hydraulic gradient for the site is 0.005 determined from the shallow well data.

The groundwater flow pattern shown in Figure 2-16 reveals a flow direction similar to the general direction of flow observed on Figure 2-15. Groundwater flows to the northwest and has an average hydraulic gradient of 0.003 .

Historical water level data obtained from the quarterly sampling program conducted by Brown and Caldwell indicated similar groundwater flow patterns as shown in Figures 2-15 and 2-16. The groundwater flows north-northwest to northwest throughout the year. A slight, but noticeable change in the flow direction is evident between the summer and winter months. During the summer season the flow direction is northwest and in the winter a northerly component to the flow results in a north-northwest groundwater flow heading. The hydraulic gradient also varies slightly from the winter to the summer months. The average hydraulic gradient for the site in the winter months ranges from 0.005 to 0.006 based on the analysis of the available historical data. During the summer months the average hydraulic gradient increases slightly according to the available water level data (ranges from 0.007 to 0.008).

The water levels in the shallow and intermediate wells at the nested locations on the site provide information on the vertical movement of groundwater in the shallow aquifer. At the locations where shallow and intermediate wells are nested the water levels in the shallow and intermediate wells are generally within 0.5 feet.

Four of the seven well nest locations have intermediate well water levels higher than the shallow well water levels (Table 2-4). This suggests the groundwater has an upward flow component in the vicinity of well nest locations W-1S(W-14I), W-3S(W-12I), W-9S(W-9I) and W-13S(W-13I). The upward flow gradients determined for these well nest locations are approximately 0.005, 0.001, 0.003 and 0.016, respectively.

Similarly, a downward component of groundwater flow was determined in the vicinity of the remaining well nest locations, W-4S(W-5I), W-7S(W-6I) and W-11S(W-11I). The downward hydraulic gradients were also calculated by dividing the groundwater elevation difference in the two wells by the vertical distance between the center of the two well screens in the nest. The resultant downward hydraulic gradients for well nests W-4S(W-5I), W-7S(W-6I) and W-11S(W-11I) are 0.013, 0.005 and 0.007, respectively.

Examination of the past quarterly water level data provides additional information on the vertical movement of groundwater at the W-4S(W-5I) and W-7S(W-6I) well nest locations. The historical data indicates that the vertical movement of groundwater at both of these well nest locations has been consistently downward.

The groundwater elevations in the two deep wells (W-12D and W-13D) are approximately 5 to 7 feet lower than seen in the shallow and intermediate wells. This indicates that wells W-12D and W-13D are screened within a separate confined aquifer unit situated below the thick clay layer. The water level in wells W-12D and W-13D rise significantly above the top of the aquifer in which they are screened indicating the deeper aquifer is under artesian conditions.

2.3.3 Groundwater Velocity

The groundwater velocity can be calculated by using the Darcy equation (Equation 2.8) provided below.

$$V = K \times i / n \qquad (2.8)$$

where V = average linear groundwater velocity,in ft/day analysis because significant responses from the photo-ionization detector (HNu meter) used to screen the soil samples were observed. Although it was felt that the HNu readings were probably erroneous based on the absence of odoriferous evidence and the unusually humid condition at the time, which is known to effect the HNu device, the additional sample was analyzed as a precautionary measure (sample from W-9I at 3 to 4.5 feet below grade).

Five of the six samples were obtained from above the water table (vadose zone) and one sample was obtained at a depth of 7 to 8 feet below grade which would be at, or very near the water table depth at that location. Specifically the six samples were obtained from boring W-9S at 3 to 5 feet below grade, boring W-9I at 3 to 4.5 feet below grade, W-11S at 2.5 to 4 feet below grade, W-12I at 3 to 4.5 feet below grade, W-13S at 1.5 to 3.5 feet below grade and W-14I at 7 to 8 feet below grade.

These soil samples were analyzed for polycyclic aromatic hydrocarbons (PAHs) in accordance with EPA method 8310, phenolics in accordance with EPA method 8040, purgeable aromatics in accordance with EPA method 8020, chromium, copper, iron, manganese and zinc in accordance with EPA method 6010 and arsenic in accordance with EPA method 7060. Additionally, the following conventional parameters, total organic carbon (TOC), nitrate (NO_3), ammonia (NH_3) and phosphate (PO_4), were analyzed in three of the soil samples.

2.4.1.1 Conventional Parameters and Iron and Manganese

The analytical results for these parameters in the soil samples obtained from borings W-9S, W-11S and W-13S, at depths below grade of 3-5 feet, 2.5-4 feet and 1.5-3.5 feet, respectively, are summarized in Table 2-5. These six parameters were analyzed for the purpose of obtaining data which could be used in a remedial option evaluation, which, if necessary, would be performed at a later date.

The iron content of the three soil samples varied from 22,400 mg/kg in W-13S to 36,900 mg/kg in boring W-11S. Manganese concentrations in the samples ranged from 338 mg/kg (W-13S) to 1,110 mg/kg (W-11S). To estimate the nitrogen content in the soil, nitrate and ammonia were analyzed and reported as elemental nitrogen. Ammonia was not detected in any of the soil samples analyzed. Nitrate

K = hydraulic conductivity, in ft/day
i = the hydraulic gradient, in ft/ft
n = the effective porosity

Based on the results of the aquifer testing the average hydraulic conductivity for the aquifer was calculated to be 2.7 x 10^{-4} ft/sec. This value was used for the velocity calculation.

Based on the type and proportions of the various geologic materials observed during the drilling and soil sampling procedures an effective porosity value of 0.35 was used to represent the porosity of the aquifer. This value is within the range of values given for sand and gravel in the literature (Freeze and Cherry, 1979).

Using an annual average hydraulic gradient for the site of 0.006, determined from Figure 2-15 and historical seasonal water level data, the resulting average linear horizontal groundwater velocity beneath the site is estimated to be 0.23 ft/day or 83 ft/year within the shallow aquifer.

2.4 Analytical Results

This section of the report presents and discusses the analytical results of soil, groundwater, sediment, surface water and offsite groundwater samples obtained as part of the Remedial Investigation (RI) performed by Keystone in 1990.

The majority of the analytical data has been summarized in tabular format. The analytical results and QA/QC evaluations are presented in entirety in Appendix B. As part of the QA/QC procedures during the sampling; soil, sediment, surface water and groundwater, field blanks (equipment blanks) and trip blanks were submitted and analyzed.

2.4.1 Soil Quality

A total of six soil samples were obtained from the ten well borings drilled in May to June, 1990 as part of the RI. One soil sample was taken at each well nest location except at the W-9S, W-9I well nest location. Here two samples were retained for

TABLE 2-5
Analytical Results
Soils-Conventional Parameters

Boring No. Sample Depth	W-9S 3-5'	W-11S 2.5-4'	W-13S 1.5-3.5'	EPA Method No
Date Sampled	5/8/90	5/9/90	5/9/90	NA
Ammonia Nitrogen, as Nitrogen	<24	<12.5	<24	350.1
Nitrate, as Nitrogen	0.718	0.168	2.8	NA
Phosphate, as phosphorus	83.5	29.8	1160	NA
Total Organic Carbon (TOC)	5430	5500	5290	NA
Iron	31500	36900	22400	6010
Manganese	639	1110	338	6010

Note: all values reported as mg/kg.
NA not applicable

concentrations varied from 0.168 mg/kg in the sample obtained from boring W-11S to 2.8 mg/kg in the sample collected from boring W-13S. The total organic carbon (TOC) content in the soil samples was consistent, varying between 5,290 mg/kg (W-13S) to 5,500 mg/kg (W-11S). Phosphate was analyzed to estimate the amount of elemental phosphorous in the soil. Reported as phosphorous, the phosphate concentrations in the three samples were 83.5 mg/kg (W-9S), 29.8 mg/kg (W-11S) and 1,160 mg/kg (W-13S).

2.4.1.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Table 2-6 summarizes the results of the PAH analyses in the six soil samples obtained by Keystone in May to June, 1990. Two of the samples did not contain detectable concentrations of any of the PAH compounds analyzed. These samples were taken from well boring W-11S, at 2.5 to 4 feet below grade, and from well boring W-14I, at 7 to 8 feet below grade.

The two samples obtained from the W-9S and W-9I nest had ten PAH compounds detected in each sample. The total PAH concentrations in the samples obtained from W-9S and W-9I were 318 ug/kg and 273 ug/kg, respectively. The majority of the PAH compounds detected in both of these samples were the heavier PAH compounds.

The soil sample obtained from well boring W-12I had seven PAH compounds detected in it. The total concentration of PAHs in the sample was 944 ug/kg. Three PAH compounds contributed 92 percent to the total PAH concentration. These PAHs and their corresponding concentrations were; chrysene at 536 ug/kg, naphthalene at 181 ug/kg and benzo(a)anthracene at 149 ug/kg. At the time this sample was obtained from the boring odoriferous evidence was detected. The odour was similar to diesel fuel.

Nine of the seventeen PAH compounds were detected in the sample obtained from well boring W-13S. Naphthalene comprised approximately 71 percent (487 ug/kg) of the total PAH concentration of 682 ug/kg.

TABLE 2-6
Analytical Results
Soils - PAHs

Boring No.	W-9S	W-9I	W-11S	W-12I	W-13S	W-14I	Detection Limits
Depth	3-5'	3-4.5'	2.5-4'	3-4.5'	1.5-3.5'	7-8'	
EPA Method 8310							
Date Sampled	5/8/90	6/6/90	5/9/90	5/25/90	5/9/90	5/30/90	
Carbazole	<114	<124	<136	<131	<107	<110	200
Naphthalene	<114	<124	<136	181	487	<110	200
Acenaphthylene	<114	<124	<136	<131	<107	<110	200
Acenaphthene	<114	<124	<136	<131	<107	<110	200
Fluorene	<22.8	<20.0	<27.2	<20.0	<21.4	<22.0	20
Phenanthrene	59.3	<50.0	<50.0	<50.0	<50.0	<50.0	50
Anthracene	<50.0	<50.0	<68.0	<50.0	<50.0	<55.0	50
Fluoranthene	43.6	52.1	<20.0	27.1	<20.0	<20.0	20
Pyrene	98.8	45.6	<27.2	<20.0	<21.4	<20.0	20
Benzo(a)anthracene	9.30	10.4	<2.72	149	10.6	<2.20	2
Chrysene	<17.0	69.6	<20.4	536	34.1	<16.5	15
Benzo(b)fluoranthene	16.5	22.4	<2.00	23.6	24.7	<2.20	2
Benzo(k)fluoranthene	5.21	8.75	<2.00	12.5	10.2	<2.20	2
Benzo(a)pyrene	7.94	11.0	<2.00	14.8	14.0	<2.20	2
Dibenzo(a,h)anthracene	45.0	28.9	<4.08	<39.3	64.8	<3.30	3
Benzo(g,h,i,)perylene	22.3	19.3	<6.80	<65.5	25.8	<5.50	5
Indeno(1,2,3-cd)pyrene	10.1	5.34	<6.80	<65.5	10.9	<5.50	5
Total PAHs (detected)	318.05	273.39	0	944	682.1	0	

"<" below quantitation limit given

All values in ug/kg

Of the four samples with PAHs detected in them two were situated together near the southern property boundary and the other two were situated near the northern boundary of the site. The PAH compound characteristics for the samples in the two areas are different. Naphthalene comprised a major part of the total PAH concentration detected in the samples obtained from the northern part of the site. The samples taken from the southern part of the site had no detections of naphthalene. However, it is difficult to characterize the nature of the contaminants in the soil since the soil data is sparse.

2.4.1.3 Phenols

Phenolic compounds were detected in four of the six soil samples obtained at the site during the RI. Table 2-7 summarizes the phenolic compound results for the six soil samples obtained in May to June 1990.

Well borings W-9I and W-14I contained no detectable concentrations of phenolic compounds.

Of the four samples that phenolic compounds in general were detected only the sample from boring W-12I at 3 to 4.5 feet below grade contained PCP. The PCP concentration in this sample was 973 ug/kg.

The sample from well boring W-9S contained four detectable phenolic compounds (2-chlorophenol, 2,4 dimethylphenol, 2,4 dichlorophenol and 4-nitrophenol) totalling a concentration of 926 ug/kg.

In the sample obtained from boring W-11S, 2,4-dimethylphenol and 2,4-dichlorophenol were detected at concentrations of 74.7 ug/kg and 75.5 ug/kg, respectively.

The sample obtained from boring W-13S had two phenolic compounds detected within it. The compounds and corresponding concentrations were, 2,4-dimethylphenol and 4-nitrophenol at 184 ug/kg and 141 ug/kg, respectively.

TABLE 2-7
Analytical Results
Soils - Phenolic Compounds

Boring No. Depth	W-9S 3-5'	W-9D 3-4.5'	W-11S 2.5-4'	W-12I 3-4.5'	W-13S 1.5-3.5'	W-14I 7-8'	Detection Limits
Date Sampled	5/8/90	6/6/90	5/9/90	5/25/90	5/9/90	5/30/90	
EPA Method 8040							
Phenol	<57.0	<62.0	<68.0	79.0	<53.5	<55.0	50
2-Chlorophenol	249	<62.0	<68.0	96.1	<53.5	<55.0	50
2-Nitrophenol	<57.0	<62.0	<68.0	<65.5	<53.5	<55.0	50
2,4-Dimethylphenol	341	<62.0	74.7	478	184	<55.0	50
2,4-Dichlorophenol	105	<62.0	75.5	<65.5	<53.5	<55.0	50
4-Chloro-3-Methylphenol	<57.0	<62.0	<68.0	<65.5	<53.5	<55.0	50
2,4,6-Trichlorophenol	<114	<124	<136	181	<106	<110	100
2,4-Dinitrophenol	<114	<124	<136	<131	<106	<110	100
4-Nitrophenol	231	<124	<136	<131	141	<110	100
2,3,5,6-Tetrachlorophenol	<114	<124	<136	<131	<106	<110	100
2-Methyl-4,6-Dinitrophenol	<114	<124	<136	<131	<106	<110	100
Pentachlorophenol	<114	<124	<136	973	<106	<110	100

"<" below quantitation limit given
All values in ug/kg

Again due to the sparse nature of the soil data it is difficult to make general conclusions regarding the soil quality on the site with respect to phenols.

2.4.1.4 Volatile Aromatics

The volatile aromatic soil results are summarized in Table 2-8. Five of the six samples had no detections of any of the volatile aromatics analyzed.

The sample obtained from boring W-14I had one volatile aromatic compound detected at a concentration of 22 ug/kg (1,2-dichlorobenzene). Since well boring W-14I is situated in the front lawn of the office it improbable that the presence of the compound can be attributed to any surface source at this location.

2.4.1.5 Metals

Table 2-9 summarizes the metal analyses performed on the soil samples obtained at the Baxter site during the RI.

Three soil samples were analyzed for metals as part of the RI. The metals analyzed were arsenic, chromium, copper, and zinc. These metals are directly related to chemicals used in the wood treating process at the Baxter site.

The sample obtained from well boring W-9S contained detectable concentrations of arsenic, chromium, copper and zinc. In the sample obtained from well boring W-11S arsenic was not detected. However, chromium, copper and zinc were detected at concentrations of 30,300 ug/kg, 32,100 ug/kg and 69,900 ug/kg, respectively. The W-13S soil sample also produced results indicating the presence of arsenic, chromium, copper and zinc in the soil.

In general, metals relating to the wood treating processes carried out at the site were detected at scattered locations in the soil on the site.

TABLE 2-8
Analytical Results
Soil - Volatile Aromatics

Boring No. Depth	W-9S 3-5'	W-9D 3-4.5'	W-11S 2.5-4'	W-12I 3-4.5'	W-13S 1.5-3.5'	W-14I 7-8'	Detection Limits
Date Sampled	5/8/90	6/6/90	5/9/90	5/25/90	5/9/90	5/30/90	
EPA Method 8020							
Benzene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	20
Toluene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	20
Chlorobenzene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	20
Ethylbenzene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	20
Xylenes	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	30
Styrene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	30
1,3-Dichlorobenzene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	40
1,4-Dichlorobenzene	<22.8	<24.8	<27.2	<26.2	<21.4	<22.0	40
1,2-Dichlorobenzene	<22.8	<24.8	<27.2	<26.2	<21.4	22.0	40

"<" below quantitation limit given
All values in ug/kg

TABLE 2-9
Analytical Results
Soil - Metals

Boring No. Depth	W-9S 3-5'	W-9D 3-4.5'	W-11S 2.5-4'	W-12I 3-4.5'	W-13S 1.5-3.5'	W-14I 7-8'	Detection Limits
Date Sampled	5/8/90	6/6/90	5/9/90	5/25/90	5/9/90	5/30/90	
EPA Method 6010, 7060(arsenic)							
Arsenic	7060	NA	<2000	NA	4540	NA	2000
Chromium	43500	NA	30300	NA	16300	NA	1000
Copper	35900	NA	32100	NA	23800	NA	2500
Zinc	62200	NA	69900	NA	54400	NA	2000

NA: Not Analyzed
All values in ug/kg
"<" below quantitation limit given

2.4.2 Groundwater Quality

A total of 18 monitoring wells installed at the site were sampled to provide data on the groundwater quality beneath the Baxter property.

A groundwater sampling round was conducted for all the wells at the site in August 1990. These samples were analyzed for; PAHs (in accordance with EPA method 610), phenols (in accordance with EPA method 604), volatile organics (in accordance with EPA method 624), total and dissolved arsenic (in accordance with EPA method 206.2), total and dissolved chromium, copper, zinc, manganese and iron (in accordance with EPA method 200.7).

Table 2-10 summarizes the conventional parameters analyzed in the groundwater samples. The conventional parameters analyzed in the groundwater samples obtained in July/August 1990 were total organic carbon (TOC), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), pH, specific conductance, nitrate as nitrogen, ammonia as nitrogen and phosphate as phosphorous.

Figures 2-17 and 2-18 illustrate the analytical results for the site-related organic and metal constituents of concern in the groundwater from the sampling session in July, 1990.

2.4.2.1 Conventional Parameters and Iron and Manganese

Table 2-10 presents the groundwater analytical results for BOD levels in the groundwater varied from not detectable to 21.3 mg/L. No observable pattern in the BOD levels in particular areas of the site are evident. However, the highest concentrations of BOD are in the wells (wells W-2S, W-7S and W-8S) which also display the highest concentrations of site-related contaminants (eg. PCP). COD concentrations in the groundwater show a similar pattern as the BOD concentrations. The highest COD concentrations are observed in wells W-2S, W-7S and W-8S. The respective COD concentrations in these wells were 138 mg/L, 142 mg/L and 126 mg/L.

TABLE 2-10
Groundwater Analytical Results
Conventional Parameters

	BOD	COD	Ammonia as (N)	Nitrate as (N)	Phosphate as (P)	TDS	TSS	TOC	Manganese	Dissolved Manganese	Iron	Dissolved Iron
EPA METHOD#	405.1	410.4	350.1	353.2	365.2	160.1	160.2	415.1	200.7	200.7	200.7	200.7
Detection Limits	1 mg/L	10 mg/L	1 mg/L	.02 mg/L	0.1 mg/L	1 mg/L	1 mg/L	1 mg/L	15 ug/L	15 ug/L	100 ug/L	100 ug/L
W-1S	<1.00	60	<1.00	2.55	0.206	621	226	4.62	606	<15	16600	<100
W-2S	20.7	138	<1.00	<.02	0.193	845	97	91.2	11300	NR	8570	NR
W-3S	<1.00	40	<1.00	5.61	0.102	506	2	4.92	<15	<15	311	<100
W-4S	<1.00	72	<1.00	<.02	0.3	324	12	4.43	6380	3540	634	<100
W-5I	1.05	10	<1.00	<.02	<.1	476	3	48.7	80.4	86.3	<100	<100
W-6I	<1.00	32	<1.00	0.021	<.1	314	<1	2.43	<15	<15	<100	<100
W-7S	21	142	4.03	<.02	1.8	792	16	54.5	8830	9360	3160	3220
W-8S	21.3	126	2.57	<.02	0.8	397	56	23.7	6710	7110	16500	7110
W-9S	9.3	14	<1.00	1.88	0.115	342	26	1.62	62.4	<15	1840	<100
W-9I	2.7	20	<1.00	0.312	0.125	162	39	<1.00	47.1	<15	705	<100
W-11S	3.3	43	<1.00	<.02	0.142	466	154	68.5	2980	4700	3410	233
W-11I	4.2	43	<1.00	0.023	0.122	227	15	5.63	24.8	18.4	175	<100
W-12I	<1.00	<10.0	<1.00	1.19	0.145	206	8	<1.00	<15	<15	141	<100
W-12D	<1.00	<10.0	<1.00	0.037	0.677	181	7	1.09	23	23.9	239	<100
W-13S	2.7	33	<1.00	3.58	0.161	1120	399	67.3	452	36.8	22500	<100
W-13I	3.9	10	<1.00	0.387	<.1	284	2	4.44	24	37.7	114	<100
W-13D	3.3	20	<1.00	0.073	0.724	196	2	2.3	18.8	21.3	541	<100
W-14I	3	28	<1.00	0.49	<.1	206	2	<1.0	<15	<15	149	<100

Note:

All data values in same units as detection limits given

< below detection limit given.

Samples acquired over period from July 24 to August 3, 1990

BOD – biochemical oxygen demand

COD – chemical oxygen demand

TDS – total dissolved solids

TSS – total suspended solids

TOC – total organic carbon

NR – not requested

Ammonia and nitrate analyses were used to estimate the amount of nitrogen in the groundwater. Ammonia was only detected in two of the monitoring wells, W-7S and W-8S, at concentrations of 4.03 mg/L and 2.57 mg/L, respectively. Nitrate was detected in the majority of the wells at concentrations ranging from 0.023 mg/L (W-11I) to 5.61 mg/L (W-3S). Phosphate analysis, used to estimate the phosphorous content, was less than 1 mg/L except in well W-7S which was 1.8 mg/L of phosphate.

Total dissolved solids (TDS) concentration in the groundwater ranged from 162 mg/L in well W-9I to 1,120 mg/L in well W-13S. Total suspended solids (TSS) concentrations varied from below the detection limit of 1 mg/L in well W-6I to 399 mg/L in well W-13S. The total organic carbon content in the groundwater was less than 1 mg/L in wells W-9I and W-12I and greater than 50 mg/L in wells W-2S, W-7S, W-11S and W-13S.

Total manganese and iron concentrations in the groundwater varied considerably over the site. From less than 15 ug/L to 11,300 ug/L for manganese and from less than 100 ug/L to 22,500 ug/L for iron.

2.4.2.2 PAHs

The PAH analytical results for all of the monitoring wells are summarized in Table 2-11. Figure 2-17 displays the total PAH and naphthalene concentrations in the groundwater at the monitoring wells in July, 1990.

The total PAH concentrations referred to in the following discussion and presented on Figure 2-17 were calculated by summing the detected individual PAH concentrations. For concentrations below the detection limits of the analyses the concentrations were assigned a value of zero.

The highest levels of PAHs were present in wells W-2S, W-7S and W-8S which are located near possible sources of contamination on the site. The total PAH concentrations detected in these wells were 1,641 ug/L, 5,113 ug/L and 3,983 ug/L, respectively. Naphthalene dominated the other individual PAH compounds with respect to the contribution made to the total PAH concentrations observed in these

TABLE 2-11
Groundwater Analytical Results
PAHs

EPA Method 610	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Benzo(g,h,i) perylene	Benzo(k) fluoranthene	Dibenzo(a,h) anthracene
Detection limits	2	2	0.5	0.02	0.02	0.02	0.05	0.02	0.03
W-1S	<2	<2	<0.500	<0.200	0.028	0.034	<0.050	<0.034	<0.030
W-2S	<200	262	38.4	12	7.91	10.2	11.6	3.43	15.5
W-3S	<2	<2	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-4S	<2	<2	<0.500	<0.020	<0.020	<0.020	<0.020	<0.020	<0.030
W-5I	3.35	7.84	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-6I	5.25	13.1	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-7S	116	122	7.42	0.185	0.108	0.105	<0.050	0.027	<0.030
W-8S	350	185	95.1	30.5	19.0	16.3	16.7	6.94	25.5
W-9S	<2.00	<2.00	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-9I	<2.00	<2.00	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-11S	<2.00	<2.00	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-11I	<2.00	<2.00	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-12I	<2.00	<2.00	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-12D	<2.00	<2.00	<0.500	<0.020	<0.020	<0.020	<0.050	<0.020	<0.030
W-13S	<2.00	<2.00	<0.500	<0.020	<0.020	0.032	<0.050	<0.020	<0.030
W-13I	<2.00	<2.00	<0.500	<0.020	<0.020	0.022	<0.050	<0.020	<0.030
W-13D	<2.00	<2.00	<0.500	<0.020	<0.020	0.032	<0.050	<0.020	<0.030
W-14I	<2.00	<2.00	<0.500	<0.020	<0.020	0.030	<0.050	<0.020	<0.030

Samples acquired over period from July 24 to August 3, 1990

Data in ug/L.

"<" below detection limit given.

TABLE 2-11(cont.)
Groundwater Analytical Results
PAHs

EPA Method 610	Chrysene	Fluorene	Fluoranthene	Naphthalene	Phenanthrene	Pyrene	Carbazole	Indeno(1,2,3-cd) pyrene	Total PAHs (detected)
Detection limits	0.15	0.2	0.2	2	0.5	0.2	2	0.05	
W-1S	<0.150	<0.200	<0.200	<2	<0.500	<0.200	<2.00	<0.050	0.06
W-2S	31.0	124	100	710	196	73.3	43.4	1.99	1640.73
W-3S	<0.150	<0.200	<0.200	<2.0	<0.500	<0.200	<2.00	<0.050	0.00
W-4S	<0.150	<0.200	<0.200	<2.0	<0.500	<0.200	<2.00	<0.050	0.00
W-5I	<0.150	0.616	<0.20	5.41	1.43	<0.20	24.8	<0.050	42.02
W-6I	<0.150	1.27	1.02	15.0	0.735	0.600	44.0	<0.050	80.98
W-7S	<0.150	74.5	6.14	4450	47.2	6	283	<0.050	5112.50
W-8S	54.0	296	115	2000	560	104	105	4.36	3983.40
W-9S	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.00
W-9I	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.00
W-11S	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.00
W-11I	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.00
W-12I	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.00
W-12D	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.00
W-13S	<0.150	<0.200	<0.200	2.90	<0.500	<0.200	2.31	<0.050	5.24
W-13I	<0.150	0.375	<0.200	4.87	<0.500	<0.200	6.50	<0.050	11.77
W-13D	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<0.500	<0.050	0.03
W-14I	<0.150	<0.200	<0.200	<2.00	<0.500	<0.200	<2.00	<0.050	0.03

Samples acquired over period from July 24 to August 3, 1990
Data in ug/L
"<" below detection limit given.

wells as shown on Figure 2-17. It was noted by the sampler for the July 1990 sampling session that a floating oil layer was present in wells W-2S and W-8S. Unfortunately, the thickness of the floating layer was not determined at either well.

As anticipated, PAHs were not detected in the upgradient wells W-9S and W-9I, situated near the southern property boundary of the site.

PAHs were also not detected in the downgradient wells W-11S, W-11I, W-12I, W-12D, W-3S and W-4S and low concentrations of PAHs (less than 0.1 ug/L total PAHs) were detected in downgradient wells W-1S, W-13D and W-14I.

The downgradient wells situated near the northern boundary of the site had detectable concentrations of PAHs. Well W-13I had a total PAH concentration of 12 ug/L. Carbazole and naphthalene combined accounted for 11.37 ug/L of the total PAH concentration in this well. The same pattern of detected PAHs was present in well W-13S. Of the total PAH concentration of 5.24 ug/L, carbazole and naphthalene together comprised more than 99 percent of the total PAH concentration. A PAH compound was detected in well W-13D which is screened in the deeper confined aquifer at the site. However, the concentration of the PAH (benzo(b)flouranthene was low (.032 ug/L). Benzo(b)flouranthene was detected in the other two wells in this nest location, W-13S and W-13I, at similar concentrations (.032 ug/L and .022 ug/L, respectively).

Downgradient wells W-5I and W-6I contained elevated concentrations of PAHs in July 1990. In both of these wells carbazole accounted for approximately 50 percent of the total PAH concentration in the wells. In well W-5I carbazole was detected at a concentration of 24.8 ug/L which was higher than the concentrations of the other five PAH compounds detected in the sample (3.35 ug/L for acenaphthene, 7.84 ug/L for acenaphthalene, 0.616 ug/L for flourene, 5.41 ug/L for naphthalene and 1.43 ug/L for phenanthrene). The total PAH concentration in W-6I was 81 ug/L and the concentration of carbazole in the well was 44 ug/L.

The PAHs detected in the groundwater in wells W-13S and W-13I are probably the result of PAH migration in the groundwater from the retort area and to a lesser degree the burn pit area.

The lighter PAHs, especially naphthalene and carbazole, constitute the largest proportion with respect to concentration of PAHs detected in the groundwater. This may be attributed to the fact that naphthalene and carbazole are relatively soluble (in water) and mobile compared to the heavier PAH compounds.

2.4.2.3 Phenols

Table 2-12 summarizes the phenol compound results for the groundwater samples. The analytical data as received by the laboratory is presented in entirety in Appendix B. However, the following discussion is limited to only one phenolic compound, pentachlorophenol (PCP), for several reasons:

1. PCP was generally detected where phenols were detected in the groundwater.

2. PCP was generally present at higher concentrations than other phenols in the groundwater.

3. PCP is used as a wood treating chemical at the site.

4. PCP is considered a potential carcinogen and has a proposed maximum contaminant level (PMCL) concentration of 1 ug/L according to the EPA's Drinking Water Quality Criteria (recently amended, January, 1991).

The higher PCP concentrations in the groundwater in July 1990 (Figure 2-17) are observed at wells W-2S, W-5I, W-6I, W-7S, W-8S, W-13S and W-13I. The respective concentrations of PCP in these wells were 299 ug/L, 299 ug/L, 778 ug/L, 1,240 ug/L, 1,160 ug/L, 1,300 ug/L and 1,000 ug/L. Again, the elevated concentrations seen in wells W-2S, W-6I, W-7S and W-8S can be explained by the position of these wells relative to three possible sources for constituents of concern on the site (burn pit, chemical storage tanks and retorts, surface water retention pond).

TABLE 2-12
Groundwater Analytical Results
Phenolic Compounds

EPA Method 604	Phenol	2,4-Dimethyl-phenol	2-Nitro-phenol	Pentachloro-phenol	2-Chloro-phenol	2,4-Dichloro-phenol	4-Chloro-3-methylphenol	2,4,6-Tri-chlorophenol
Detection limits	0.50	0.50	0.50	1.00	0.50	0.50	0.50	1.00
W-1S	<0.500	<0.500	<0.500	56.7	<0.500	<0.500	0.833	<1.00
W-2S	2.80	6.28	5.36	299	4.13	1.77	<500	11.6
W-3S	<0.500	<0.500	<0.500	<1.00	<0.500	<0.500	1.77	<1.0
W-4S	<0.500	<0.500	<0.500	1.01	<0.500	<0.500	<1	<1
W-5I	0.537	<0.500	<0.500	299	<0.500	2.04	2.57	<1.00
W-6I	0.630	<0.500	<0.500	778	<0.500	0.846	1.14	<1.00
W-7S	<0.500	12.9	<0.500	1240	0.702	0.608	22.7	20.6
W-8S	1.65	6.2	1.87	1160	<0.500	7.46	5.60	10.4
W-9S	<0.500	<0.500	<0.500	<1.00	<0.500	<0.500	<0.500	<1.00
W-9I	<0.500	<0.500	<0.500	<1.00	<0.500	<0.500	<0.500	<1.00
W-11S	<0.500	<0.500	<0.500	29.1	<0.500	<0.500	0.662	<1.00
W-11I	<0.500	<0.500	<0.500	7.49	<0.500	<0.500	1.33	1.48
W-12I	1.07	<0.500	<0.500	48.6	<0.500	2.49	<0.500	3.17
W-12D	0.895	<0.500	<0.500	<1.00	<0.500	1.07	<0.500	<1.00
W-13S	0.663	0.754	<0.500	1300	<0.500	0.594	<0.500	<1.00
W-13I	0.840	<0.500	0.769	1000	<0.500	2.53	<0.500	1.04
W-13D	0.771	<0.500	0.865	<1.00	<0.500	1.13	<0.500	1.14
W-14I	0.792	<0.500	<0.500	4.04	<0.500	1.46	<0.500	1.51

Samples acquired over period from July 24 to August 3,1990
Data in ug/L.
"<" below detection limit given.

TABLE 2-12(cont.)
Groundwater Analytical Results
Phenolic Compounds

EPA Method 604	4-Nitrophenol	2,3,5,6-Tetra-chlorophenol	2-methyl-4,6-Dinitrophenol	2,4-Dinitro-phenol
Detection limits	1.00	1.00	1.00	1.00
W-1S	<1	6.11	<1.00	<1.00
W-2S	43.0	86.3	14.8	22.8
W-3S	<1.0	<1.0	<1.00	<1.0
W-4S	<1	<1	<1.00	<1
W-5I	1.32	25.9	<1.00	2.33
W-6I	1.04	52.9	<1.00	<1.00
W-7S	20.3	<1.00	6.23	23.0
W-8S	163	73.1	100	<20.0
W-9S	<1.00	<1.00	<1.00	<1.00
W-9I	<1.00	<1.00	<1.00	<1.00
W-11S	<1.00	5.39	<1.00	<1.00
W-11I	<1.00	2.96	<1.00	<1.00
W-12I	<1.00	11.0	<1.00	<1.00
W-12D	1.06	1.54	<1.00	<1.00
W-13S	<1.00	22.8	4.30	2.18
W-13I	<1.00	51.2	<1.00	<1.00
W-13D	<1.00	4.19	<1.00	<1.00
W-14I	<1.00	5.07	<1.00	<1.00

Samples acquired over period from July 24 to August 3,1990

Data in ug/L

"<" below detection limit given

The elevated PCP concentrations also observed in wells W-5I, W-13S and W-13I indicate that PCP has migrated downgradient a significant distance and probably extends offsite to the north of the site.

PCP was also detected in wells W-1S, W-14I, W-11S and W-11I, but to a lesser degree than the wells discussed above. PCP was detected in wells W-11S and W-11I at concentrations of 29 ug/L and 7.5 ug/L, respectively. The detection of PCP in these two wells suggests that the PCP plume may have reached the western boundary of the Baxter property. The PCP concentrations detected in well W-14I was 4 ug/L and in well W-1S was 56.7 ug/L.

The analyses of the W-12I pump test groundwater samples indicated that the PCP concentration in the groundwater after approximately 24 hours and 48 hours of pumping were 150 ug/L and 132 ug/L, respectively. Similarly the results for the W-13S pump test were PCP concentrations of 943 ug/L and 453 ug/L after 24 hours and 48 hours of pumping, respectively.

2.4.2.4 Volatile Organic Compounds(VOCs)

Volatile organic compounds (VOCs) were analyzed in the groundwater samples, by EPA method 624, obtained in July 1990. The results are summarized in Table 2-13.

VOCs were detected in four of the monitoring wells on the site (Figure 2-17). The wells were W-6I, W-7S, W-8S and W-13I. The highest VOC concentrations were observed in wells W-6I and W-7S (Figure 2-17). The VOCs detected in well W-6I and their corresponding concentrations were; 1,1-dichloroethene at 81.7 ug/L, 1,1-dichloroethane at 25.7 ug/L and 1,1,1-trichloroethane at 15.7 ug/L (Table 2-13). Benzene, toluene and ethylbenzene were detected in well W-7S at concentrations of 7.1 ug/L, 61.3 ug/L and 97.5 ug/L, respectively. Wells W-6I and W-7S are situated close to the retorts and storage tanks in the treatment area which is likely the source of the volatiles in the groundwater at this location.

Ethylbenzene was detected at 7.9 ug/L in the groundwater in well W-8S. Three VOCs were detected in the groundwater sampled from well W-13I. The VOCs and

TABLE 2-13
Groundwater Analytical Results
Volatile Organic Compounds

Compounds	W-6I	W-7S	W-8S	W-13I	Detection Limits
EPA Method 624					
1,1-dichloroethene	81.7	<5	<5	10.2	5
1,1-dichloroethane	25.7	<5	<5	6.9	5
1,1,1-trichloroethane	<5	<5	<5	<5	5
Benzene	15.7	7.1	<5	8.3	5
Ethyl benzene	<5	97.5	7.9	<5	5
Toluene	<5	61.3	<5	<5	5

Note: Analytes not detected or wells where no analytes detected are not tabulated.
All results are provided in Appendix B.
"<" below detection limit given.
Samples acquired over period from July 24 to August 3,1990
Values in ug/L.

their concentrations were; 1,1-dichloroethene at 10.2 ug/L, 1,1-dichloroethane at 6.9 ug/L and benzene at 8.3 ug/L.

2.4.2.5 Metals

The July 1990 groundwater samples were analyzed for total and dissolved arsenic, chromium, copper and zinc. In the following discussion of the metal analytical results if the word "dissolved" is not used as a qualifier then "total" metal concentrations are implied. The samples collected for the dissolved metal analyses were filtered, on-site, through 0.45 micron filter paper into laboratory cleaned funnels by using a hand vacuum pump. The samples were preserved by adding several drops of concentrated nitric acid to each sample bottle.

The analytical results from the July, 1990 groundwater samples for arsenic, chromium, copper and zinc are summarized in Table 2-14 and are displayed on Figure 2-18.

In general, the vast majority of analyses for metals (ie. arsenic, chromium, copper and zinc) in the wells sampled in July 1990 resulted in concentrations below detection limits.

The highest metal concentration was arsenic at a concentration of 0.18 mg/L in well W-8S. The dissolved arsenic concentration in the well was 0.17 mg/L indicating that in this well the arsenic is dissolved in the groundwater and not associated with fine soil matter.

Arsenic was also detected in wells W-2S and W-7S at concentrations of 0.012 mg/L and 0.039 mg/L, respectively. The dissolved arsenic concentrations in the two wells were below detection limits.

Chromium was detected in wells W-1S, W-7S and W-8S. The concentrations ranged form 0.01 mg/L in wells W-7S and W-8S to 0.014 mg/L in well W-1S. Dissolved concentrations of chromium were not detected in the wells.

TABLE 2-14
Groundwater Analytical Results
Metals

	Arsenic		Chromium		Copper		Zinc	
	total	dissolved	total	dissolved	total	dissolved	total	dissolved
EPA Method No.	206.2	206.2	200.7	200.7	200.7	200.7	200.7	200.7
Detection Limits	0.01	0.01	0.01	0.01	0.025	0.025	0.02	0.02
W-1S	<0.010	<0.010	0.014	<0.010	<0.025	<0.025	0.050	<0.020
W-2S	0.012	NR	<0.001	NR	<0.025	NR	0.042	NR
W-3S	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-4S	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	0.022	<0.020
W-5I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.020
W-6I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.020
W-7S	0.031	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-8S	0.180	0.171	<0.010	<0.010	<0.025	<0.025	0.034	<0.020
W-9S	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-9I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-11S	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	0.044	0.025
W-11I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-12I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-12D	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-13S	<0.010	<0.010	<0.010	<0.010	0.035	<0.025	0.062	0.027
W-13I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-13D	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020
W-14I	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025	<0.020	<0.020

Samples acquired over period from July 24 to August 3,1990

Data in mg/L

"<" below detection limit given.

NR - not requested

Copper was also detected in three wells on the site (W-7S, W-8S and W-13S). The detected concentrations in wells W-7S and W-8S were the same as the quantitation limit for copper (.025 mg/L). In well W-13S copper was detected at 0.035 mg/L. The dissolved copper analyses detected no trace of copper in the wells.

Zinc was present in six of the monitoring wells in July 1990. The detected zinc concentrations ranged from 0.062 mg/L in well W-13S to 0.022 mg/L in well W-4S. Dissolved zinc concentrations were detected in wells W-11S and W-13S (0.025 mg/L and 0.027 mg/L, respectively).

2.4.3 Sediment Quality

A total of seven sediment samples were obtained at the Baxter site in November of 1990 for chemical analyses. The sediment samples were analyzed for PAHs, phenolics, volatile aromatics, arsenic, chromium, copper, iron, manganese, zinc, TOC, nitrate, phosphate and ammonia. Figures 2-19 and 2-20 illustrate the concentrations of the organic and metal constituents of concern at the seven sediment sampling locations (SS-1 to SS-7). A complete set of the analytical results for the sediment analyses are provided in Appendix B.

SS-1 was situated just upstream of the point where the surface water retention pond discharges into the drainage ditch which runs along the southern property boundary of the Baxter site. SS-2 was sampled in the ditch which directly drains the surface water retention pond. SS-3 was located in the portion of the drainage ditch situated at the southeast corner of the site. This sample was intended as a reference sample since it was situated in the furthest upgradient point of the ditch on the Baxter property. SS-4 was situated downstream of the point where the surface water retention pond drains into the drainage ditch approximately 100 feet east of the western property boundary.

SS-5, SS-6 and SS-7 were situated at the bottom of the surface water retention pond.

TABLE 2-15

Sediment Analytical Results

	SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	Detection Limits
Date Sampled	11/5/90	11/5/90	11/6/90	11/6/90	11/6/90	11/6/90	11/6/90	
PAHs EPA Method 8310								
Carbazole	1190	325	35.9	136	24000	13200	13000	200
Naphthalene	1320	238	114	177	52600	181000	48000	200
Acenaphthylene	711	2800	128	544	91400	35900	18100	200
Acenaphthene	<612	<64.2	<66.8	<342	<2340	72800	33100	200
Fluorene	193	532	21.3	102	78300	60500	21500	20
Phenanthrene	258	948	127	209	346000	296000	102000	50
Anthracene	84.8	343	3.94	63.0	132000	88700	37700	50
Fluoranthene	494	4420	164	1250	367000	295000	139000	20
Pyrene	691	1700	197	263	680000	447000	370000	20
Benzo(a)anthracene	777	2860	14.9	1300	51700	26000	25900	2
Chrysene	926	4560	116	2160	73700	43400	42200	15
Benzo(b)fluoranthene	<800	2220	37.0	581	32300	17700	12600	2
Benzo(k)fluoranthene	<800	764	6.78	<68.4	15900	9340	5860	2
Benzo(a)pyrene	<800	1880	15.7	179	20300	11100	8710	2
Dibenzo(a,h)anthracene	<1200	3930	84.2	1060	5440	4190	2940	3
Benzo(g,h,i,)perylene	<1500	1070	22.1	628	2920	3820	2370	5
Indeno(1,2,3-cd)pyrene	<1500	2550	10.5	926	4830	4300	3500	5
Phenols EPA Method 8040								
Phenol	121	<125	31.6	<195	23300	2390	4790	50
2-Chlorophenol	<109	3710	239	3810	24300	6270	9240	50
2-Nitrophenol	<109	<125	<25.0	<195	5870	731	1830	50
2,4-Dimethylphenol	<109	<125	209	<195	<2850	199	<454	50
2,4-Dichlorophenol	<109	<125	<25.0	<195	7290	1180	1430	50
4-Chloro-3-Methylphenol	<109	<125	28.4	<195	6330	1050	810	50
2,4,6-Trichlorophenol	<218	<250	<50.0	<390	<5700	<2450	3180	100
2,4-Dinitrophenol	<218	<250	<50.0	<390	<5700	<2450	<908	100
4-Nitrophenol	<218	<250	<50.0	<390	21400	4100	4190	100
2,3,5,6-Tetrachlorophenol	<218	<250	<50.0	<390	<5700	<2450	1950	100
2-Methyl-4,6-Dinitrophenol	<218	538	<50.0	481	256000	35800	59500	100
Pentachlorophenol	950	4730	77.2	5060	52500	196000	95300	100

"<" below quantitation limit given.

All values in ug/kg

2.4.3.1 PAHs

PAHs were detected in all seven of the sediment samples obtained on the site. Table 2-15 summarizes the PAH results for the sediment samples and Figure 2-19 displays the total PAH and naphthalene concentrations in the sediment samples.

In sediment sample SS-1, ten of the seventeen PAH compounds analyzed were detected. The individual detected PAH concentrations in the sample ranged from 84.8 ug/kg for anthracene to 1,320 ug/kg for naphthalene. The total detected PAH concentration in sample SS-1 was 6,645 ug/kg. The majority of the PAH compounds detected in sample SS-1 were the lighter PAH compounds.

The sediment sample SS-2, situated in the ditch draining the retention pond contained elevated concentrations of PAHs. The highest individual PAH concentration detected was chrysene at a concentration of 4,560 ug/kg. The total detected PAH concentration in sample SS-2 was 31,100 ug/kg.

Sediment sample SS-3 had low concentrations of PAH compounds detected. The individual detected PAH concentrations ranged from 3.94 ug/kg of anthracene to 197 ug/kg of pyrene. The total detected PAH concentration in sample SS-3 was 1,100 ug/kg.

Individual detected PAH concentrations in sediment sample SS-4 varied from 63 ug/kg of anthracene to 2,160 ug/kg of chrysene. A total detected PAH concentration of 9,580 ug/kg was determined for sample SS-4.

Elevated concentrations of PAHs were detected in sediment sample SS-5. Individual detected PAH concentrations ranged from 2,920 ug/kg of benzo(g,h,i)perylene to 680,000 ug/kg of pyrene. The total detected PAH concentration was 1,878,000 ug/kg of PAHs in sediment sample SS-5.

Similar to samples SS-2, SS-4 and SS-5, elevated levels of PAHs were detected in sample SS-6. Pyrene was again detected as the PAH compound with the highest concentration in the sediment sample (447,000 ug/kg) and benzo(g,h,i)perylene was

TABLE 2-15(cont.)
Sediment Analytical Results

	SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	Detection Limits
Date Sampled	11/5/90	11/5/90	11/6/90	11/6/90	11/6/90	11/6/90	11/6/90	
Volatiles EPA No. 8020								
Benzene	<32.6	<37.4	<30.0	<58.4	<85.4	2350	<272	20
Toluene	<54.8	89.4	56.6	86.1	835	3000	309	20
Chlorobenzene	<32.6	<37.4	<30.0	<58.4	<85.4	<1470	<272	20
Ethylbenzene	<32.6	<37.4	<30.0	<58.4	2950	<1470	<272	20
Xylenes	53.1	59.1	<45.0	<58.4	8090	7290	488	30
Styrene	<32.6	<37.4	<30.0	<58.4	1510	<1470	<272	30
1,3-Dichlorobenzene	<32.6	<37.4	<30.0	<58.4	<85.4	<1470	<272	40
1,4-Dichlorobenzene	<32.6	<37.4	<30.0	<58.4	<85.4	<1470	<272	40
1,2-Dichlorobenzene	<32.6	<37.4	<30.0	<58.4	<85.4	<1470	<272	40
Metals								
Arsenic	115000	220000	36800	82800	1500000	1530000	1580000	2000
Chromium	43600	52600	33500	36900	121000	160000	98400	1000
Copper	172000	574000	53400	932000	4320000	4360000	3900000	2500
Zinc	162000	27700	79400	216000	1340000	960000	1290000	2000

"<" below quantitation limit given.
All values in ug/kg

the detected PAH compound with the lowest concentration in the sample (3,820 ug/kg). The total detected PAH concentration in sample SS-6 was 1,610,000 ug/kg.

Sediment sample SS-7, similar to samples SS-5 and SS-6, was obtained from the bottom of the surface water retention pond. Elevated levels of PAHs were detected. The total detected PAH concentration in SS-7 was 887,000 ug/kg.

The PAH concentrations in the sediment samples obtained from the bottom of the surface water retention pond (SS-5, SS-6 and SS-7) are higher than the concentrations detected in the other sediment samples obtained from the drainage ditches (SS-1 to SS-4).

The drainage ditch sediment samples presented in order, according to their total detected PAH concentrations (from highest to lowest) were, SS-2 (31,100 ug/kg), SS-4 (9,580 ug/kg), SS-1 (6,640 ug/kg) and SS-3 (1,100 ug/kg), respectively.

2.4.3.2 Phenols

Table 2-15 also presents the phenolic compound analytical results for the sediment samples and Figure 2-19 displays the PCP concentrations detected at each sediment sampling location. The findings of the phenol analyses in the sediment samples are discussed below.

Two phenolic compounds were detected in sediment sample SS-1. The compounds were phenol and PCP at concentrations of 121 ug/kg and 950 ug/kg, respectively.

In sediment sample SS-2 three phenols were detected. The compounds were 2-chlorophenol at 3,710 ug/kg, 2-methyl-4,6-dinitrophenol at 538 ug/kg and PCP at 4,730 ug/kg.

Several phenols were detected in sediment sample SS-3. The compounds and corresponding concentrations were phenol at 31.6 ug/kg, 2-chlorophenol at 239 ug/kg, 2,4-dimethylphenol at 209 ug/kg, 4-chloro-3-methylphenol at 28.4 ug/kg and PCP at 77.2 ug/kg.

In sample SS-4, three phenols were detected at a total phenols concentration of 9,351 ug/kg. PCP was one of the compounds and was detected at a concentration of 5,060 ug/kg.

Sediment sample SS-5 had eight phenolic compounds detected within it. The detected phenolic compounds ranged in concentration from 5,870 ug/kg of 2-nitrophenol to 256,000 ug/kg of 2-methyl-4,6-dinitrophenol. PCP was detected at a concentration of 52,500 ug/kg.

The phenolic compounds detected in sample SS-6 range in concentration from 199 ug/kg for 2,4-dimethylphenol to 196,000 ug/kg for PCP. In total nine phenolic compounds were detected in the sample SS-6.

The highest concentration of any of the phenol compounds in SS-7 was 95,300 ug/kg of PCP. The other phenols detected totaled a concentration of 86,920 ug/kg.

In general, PCP is present at higher concentrations than the other phenol compounds in the sediment samples.

The pattern of relative phenol concentrations detected in the sediment samples is similar to the relative PAH concentrations in the sediment samples. The highest concentrations are observed in the samples obtained from the bottom of the surface water retention pond (SS-5, SS-6 and SS-7). Of the remaining sediment samples the total phenol compound levels decrease proceeding from sample SS-2 to SS-4 to SS-1 and finally to SS-3.

2.4.3.3 Volatile Aromatics

At least one volatile aromatic compound was detected in each of the sediment samples obtained during the RI. Table 2-15 presents the analytical results for the volatile aromatics in the sediment samples.

Xylenes were the only volatile aromatics detected in sediment sample SS-1. The concentration of xylenes in the sample was 53.1 ug/kg. Two volatile aromatic compounds were detected in sediment sample SS-2. The compounds and their corresponding concentrations were, toluene at 89.4 ug/kg and xylenes at 59.1 ug/kg.

In samples SS-3 and SS-4, one volatile aromatic compound was detected. The compound was toluene at a concentration of 56.6 ug/kg in sample SS-3 and 86.1 ug/kg in sample SS-4.

In sediment sample SS-5 several volatile aromatic compounds were detected. The compounds were toluene, ethylbenzene, xylenes and styrene at concentrations of 835 ug/kg, 2,950 ug/kg, 8,090 ug/kg and 1,510 ug/kg, respectively.

The volatile aromatic analyses performed on sediment sample SS-6 detected three compounds. Benzene, toluene and xylenes were detected at concentrations of 2,350 ug/kg, 3,000 ug/kg and 7,290 ug/kg, respectively.

Two volatile aromatics were detected in sediment sample SS-7. The two compounds and their corresponding concentrations were; toluene at 309 ug/kg and xylenes at 488 ug/kg.

Toluene and xylenes were the most frequently detected volatile aromatic compounds detected in the sediments. Toluene was detected in six of the sediment samples and xylenes were detected in five of the sediment samples.

2.4.3.4 Metals

Arsenic, chromium, copper and zinc were detected in each of the seven sediment samples. Table 2-15 includes a summary of the arsenic, chromium, copper and zinc concentrations in the sediment samples. Figure 2-20 displays the arsenic, chromium, copper and zinc concentrations in the sediment samples at each sampling location.

The highest concentrations of arsenic, chromium, copper and zinc were detected in the bottom sediments of the retention pond (SS-5, SS-6 and SS-7). The arsenic concentration in these samples was greater than 1,000,000 ug/kg. Similarly the copper concentration in each retention pond sediment sample was greater than 1,000,000 ug/kg of copper.

Sediment sample SS-3 had the least overall levels of arsenic, chromium, copper and zinc.

In sediment sample SS-1 the detected concentrations of arsenic, chromium, copper and zinc were 115,000 ug/kg, 43,600 ug/kg, 172,000 ug/kg and 162,000 ug/kg, respectively.

The metal concentrations determined for sample SS-2 were arsenic at 220,000 ug/kg, chromium at 52,600 ug/kg, copper at 574,000 ug/kg and zinc at 27,700 ug/kg.

For sample SS-3, situated at the eastern end of the drainage ditch, the arsenic, chromium, copper and zinc concentrations were 36,800 ug/kg, 33,500 ug/kg, 53,400 ug/kg and 79,400 ug/kg, respectively.

In sediment sample SS-4 the arsenic, chromium, copper and zinc concentrations were 82,800 ug/kg, 36,900 ug/kg, 932,000 ug/kg and 216,000 ug/kg, respectively.

The arsenic, chromium, copper and zinc concentrations in sediment sample SS-5 were 1,500,000 ug/kg, 121,000 ug/kg, 4,320,000 ug/kg and 1,340,000 ug/kg, respectively.

In sediment sample SS-6 the arsenic, chromium, copper and zinc concentrations were 1,530,000 ug/kg, 160,000 ug/kg, 4,360,000 ug/kg and 960,000 ug/kg, respectively.

In the sediment obtained from location SS-7 arsenic, chromium, copper and zinc were detected at concentrations of 1,580,000 ug/kg, 98,400 ug/kg, 3,900,000 ug/kg and 1,290,000 ug/kg, respectively.

2.4.4 Surface Water Quality

Seven surface water samples were obtained in November 1990 at the identical locations as the sediment samples. The surface water samples collected in the surface water retention pond (SW-5, SW-6 and SW-7) were obtained from approximately one to two feet below the surface of the water in the pond. Several inches of water were available in the drainage ditches for sampling purposes at locations SW-1, SW-2, SW-3 and SW-4.

The surface water samples were analyzed for PAHs, phenolics, volatile organic compounds (VOCs), arsenic, chromium, copper, iron, manganese, zinc, TOC, nitrate, phosphate and ammonia, total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD). Figures 2-21 and 2-22 illustrate the concentrations of the organic and metals constituents of concern at the seven surface water sampling locations (SW-1 through SW-7).

Table 2-16 summarizes the analytical results for the surface water samples. Included in Table 2-16 are the acute and chronic concentrations set for certain compounds in freshwaters by the EPA (Ambient Water Quality Criteria, U.S. EPA, 1990). The complete analytical results for the surface water analyses are presented in Appendix B. Figures 2-21 and 2-22 display the concentrations of organics and metals in the surface water samples, respectively.

2.4.4.1 Conventional Parameters

Biochemical oxygen demanding (BOD) substances detected in the surface water samples range in concentration from 2 mg/L at sampling location SW-3 (ie. upgradient location in drainage ditch) to 22.3 mg/L in sample SW-7 situated in the surface water retention pond. Chemical oxygen demanding (COD) substances are present in the surface water at higher concentrations than BOD. The highest COD concentrations were detected in sample SW-2, collected from the drainage ditch, and samples SW-5, SW-6 and SW-7, which were obtained from the surface water retention pond.

Ammonia concentrations, were highest in the samples obtained from the retention pond, and the sample obtained in the drainage ditch immediately downstream of the retention pond as can be seen in Table 2-16. Nitrate, also used to define nitrogen levels in the surface waters at the site, were detected at concentrations of approximately 6 mg/L in the retention pond and location SW-2, downstream of the

TABLE 2-16
Surface Water Analytical Results
PAHs

EPA Method 610	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	Detection Limits	Freshwater Acute/Chronic
Date Sampled	11/5/90	11/5/90	11/6/90	11/6/90	11/6/90	11/6/90	11/6/90		
Carbazole	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	2	NA/NA
Naphthalene	<2.00	4.56	<2.00	<2.00	<2.00	<2.00	<2.00	2	NA/NA
Acenaphthylene	<2.00	2.80	<2.00	<2.00	<2.00	<2.00	<2.00	2	NA/NA
Acenaphthene	<2.00	37.4	<2.00	<2.00	<2.00	<2.00	2.49	2	NA/NA
Fluorene	<0.200	2.15	<0.200	0.222	0.301	0.266	0.473	0.2	NA/NA
Phenanthrene	<0.500	7.93	<0.500	0.579	1.59	1.17	2.33	0.5	NA/NA
Anthracene	<0.500	8.58	<0.500	0.508	2.1	1.18	3.49	0.5	NA/NA
Fluoranthene	<0.200	78.7	<0.200	2.94	15.1	8.41	25.1	0.2	NA/NA
Pyrene	<0.200	11.2	<0.200	1.81	11.1	6.02	18.5	0.2	NA/NA
Benzo(a)anthracene	0.088	6.85	<0.020	0.462	4.28	2.20	7.53	0.02	NA/NA
Chrysene	<0.150	0.386	<0.150	1.21	5.29	2.61	10.7	0.15	NA/NA
Benzo(b)fluoranthene	0.064	9.76	<0.020	0.306	1.00	1.52	3.72	0.02	NA/NA
Benzo(k)fluoranthene	<0.020	2.98	<0.020	0.076	0.449	0.395	1.15	0.02	NA/NA
Benzo(a)pyrene	<0.020	2.15	<0.020	<0.020	<0.200	0.720	0.454	0.02	NA/NA
Dibenzo(a,h)anthracene	0.086	3.97	<0.030	<0.020	0.754	2.03	1.38	0.03	NA/NA
Benzo(g,h,i,)perylene	0.081	2.96	<0.050	0.090	0.550	0.486	1.13	0.05	NA/NA
Indeno(1,2,3-cd)pyrene	<0.050	1.17	<0.050	0.073	0.437	0.154	0.729	0.05	NA/NA
Total PAHs	0.32	183.55	0.00	8.28	42.95	27.16	79.18		
EPA Method 604				Phenols					
Phenol	1.32	2.23	<0.500	<0.500	1.04	1.92	2.42	0.5	10200/2560
2-Chlorophenol	<0.500	0.934	<0.500	<0.500	<0.500	0.661	0.527	0.5	NA/NA
2-Nitrophenol	3.25	2.40	<0.500	3.02	2.58	1.83	1.49	0.5	NA/NA
2,4-Dimethylphenol	<0.500	0.855	<0.500	<0.500	0.650	0.649	0.805	0.5	NA/NA
2,4-Dichlorophenol	<0.500	0.920	<0.500	<0.500	0.523	0.517	0.599	0.5	2020/365
4-Chloro-3-Methylphenol	<0.500	0.787	<0.500	<0.500	<0.500	<0.500	<0.500	0.5	NA/NA
2,4,6-Trichlorophenol	1.32	4.16	<1.00	1.40	2.91	3.38	3.32	1.00	NA/970
2,4-Dinitrophenol	<1.00	1.97	<1.00	1.12	1.62	11.8	1.79	1.00	NA/NA
4-Nitrophenol	<1.00	4.82	<1.00	<1.00	1.30	2.62	1.12	1.00	NA/NA
2,3,5,6-Tetrachlorophenol	2.96	23.8	<1.00	3.93	9.76	17.1	20.2	1.00	NA/NA
2-Methyl-4,6-Dinitrophenol	<1.00	146	<1.00	26.8	67.3	109	130	1.00	NA/NA
Pentachlorophenol	12.2	596	<1.00	44.4	135	317	402	1.00	22/13

"<" below detection limit given.

All values in ug/L

Freshwater limits from Ambient Water Quality Criteria, U.S. EPA

NA - not available

KEYSTONE
ENVIRONMENTAL RESOURCES

TABLE 2-16 (cont.)
Surface Water Analytical Results
Metals

	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	Detection	Freshwater
Date Sampled	11/5/90	11/5/90	11/6/90	11/6/90	11/6/90	11/6/90	11/6/90	Limit	Acute/Chronic
Arsenic	79.6	1760	13.0	698	1630	1180	1840	10	850/48
Chromium	<10.0	40.2	<10.0	<10.0	10.7	18.6	24.8	10	16/11*
Copper	67.4	2610	<25.0	267	611	1230	1510	25	18/12**
Zinc	51.5	992	29.8	179	380	569	627	20	120/110
EPA Method 624				**Volatiles**					
Chloromethane	<100	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10	NA/NA
Bromomethane	<100	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10	NA/NA
Vinyl Chloride	<100	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10	NA/NA
Chloroethane	<100	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10	NA/NA
Methylene chloride	65.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	11000/NA
Trichlorofluoromethane	<100	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10	NA/NA
1,1-Dichloroethene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	11600/NA
1,1-Dichloroethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
trans-1,2-Dichloroethene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Chloroform	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,2-Dichloroethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,1,1-Trichloroethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Carbon Tetrachloride	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Bromodichloromethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,2-Dichloropropane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
cis-1,3-Dichloropropene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Trichloroethene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Benzene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Dibromochloromethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,1,2-Trichloroethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
trans-1,3-Dichloropropene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
2-Chloroethylvinyl ether	<100	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	10	NA/NA
Bromoform	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,1,2,2-Tetrachloroethane	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Tetrachloroethene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Toluene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	17500/NA
Chlorobenzene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
Ethyl benzene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	32000/NA
1,2-Dichlorobenzene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,3-Dichlorobenzene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA
1,4-Dichlorobenzene	<50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5	NA/NA

"<" below detection limit given.

All values in ug/L

NA - not available

* criteria for chromium (VI)

** at a water hardness of 100 mg/L $CaCO_3$

Freshwater limits from Ambient Water Quality Criteria, U.S. EPA

TABLE 2-16 (cont.)
Surface Water Analytical Results
Conventional Parameters

	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	Detection Limit	Freshwater Acute/Chronic
Date Sampled	11/5/90	11/5/90	11/6/90	11/6/90	11/6/90	11/6/90	11/6/90		
BOD	3.11	16.9	2.0	6.22	18.1	21.1	22.3	1	NA/NA
COD	25	89	23	27	59	74	71	10	NA/NA
Conductivity	230	480	300	320	460	470	470	1	NA/NA
Ammonia as N	<1.0	26.8	<1.0	9.85	27.5	27.6	28.1	1	NA/NA
Nitrate as N	2.04	6.09	0.962	4.08	6.3	6.23	6.15	0.02	NA/NA
pH	6.8	6.7	6.6	6.7	6.6	6.6	6.6	-	NA/6.5-9
Phosphate as P	<.1	78.6	<.1	23.6	73.4	71.6	76.5	0.1	NA/NA
TDS	225	520	273	302	513	523	578	1	NA/NA
TOC	15.5	39.7	11.5	17.9	37.3	37.8	43.6	1	NA/NA
TSS	205	566	49	62	91	144	230	1	NA/NA
Iron	1960	9320	972	1960	1740	3810	4960	0.1	NA/NA
Manganese	101.0	278	366	155	205	222	229	0.015	NA/NA

"<" below detection limit given.
All values in mg/L
NA - not available
BOD - biochemical oxygen demand
COD - chemical oxygen demand
TDS - total dissolved solids
TSS - total suspended solids
TOC - total organic carbon

retention pond. Phosphate concentrations varied from undetected in samples SW-1 and SW-3 to greater than 70 mg/L in samples SW-2, SW-5, SW-6 and SW-7.

Total organic carbon (TOC) concentrations in the surface waters ranged from approximately 37 mg/L to 44 mg/L in the samples obtained from locations SW-2, SW-5, SW-6 and SW-7. The remaining surface water samples had TOC concentrations between approximately 11 mg/L and 18 mg/L. The higher TOC concentrations in samples SW-2, SW-5, SW-6 and SW-7 correlate with the higher organic contaminant concentrations (eg. PCP) detected in the same surface water samples.

Total dissolved solid (TDS) concentrations in the surface water samples, similar to several other of the conventional parameters, were elevated in samples SW-2, SW-5, SW-6 and SW-7, relative to SW-1, SW-3 and SW-4 surface water samples. Total suspended solids (TSS) in the surface water samples ranged in concentration from 49 mg/L at SW-3 to 566 mg/L at SW-2. pH of the surface water samples ranged between 6.6 and 6.8 which is considered a normal range for pH of natural freshwaters.

Total iron concentrations in the surface water samples varied from 972 mg/L (SW-3) to 4,960 mg/L (SW-7). Manganese concentrations ranged from 101 mg/L in sample SW-1 to 366 mg/L in sample SW-3.

2.4.4.2 PAHs

PAHs were detected in six of the seven surface water samples obtained on the site. The sample with non-detectable concentrations of PAHs in the surface water was SW-3.

Surface water sample SW-1 had several PAHs detected. They were benzo(a)anthracene at .088 ug/L, benzo(b)flouranthene at .064 ug/L, dibenzo(a,h)anthracene at .086 ug/L and benzo(g,h,i)perylene at .081 ug/L. The total detected PAH concentration was .32 ug/L (Figure 2-21).

The individual PAH concentrations in SW-2 ranged from 0.386 ug/L of chrysene to 78.7 ug/L of flouranthene. The total detected PAH concentration in SW-2 was 184 ug/L. PAHs were not detected in surface water sample SW-3. In surface water sample SW-4 eleven PAH compounds were detected. The highest individual detected PAH concentration was flouranthene at 2.94 ug/L. The total detected PAH concentration in the sample was 8.3 ug/L.

Flouranthene was the PAH compound at the highest concentration in each of samples SW-5 (15.1 ug/L), SW-6 (8.41 ug/L) and SW-7 (25.1 ug/L). The total detected PAH concentrations in samples SW-5, SW-6 and SW-7 were 43 ug/L, 27 ug/L and 79 ug/L, respectively.

Acute or chronic criteria have not been set for any PAH compounds in freshwaters (Table 2-16).

2.4.4.3 Phenols

Phenols were detected in surface water samples SW-1, SW-2, SW-4, SW-5, SW-6 and SW-7. In each of these samples PCP was the phenol compound detected at the highest concentration in the samples.

For reasons presented earlier only PCP will be discussed in detail. The other phenol compound analytical results for the surface water samples are provided in Table 2-16 and in Appendix B.

In samples SW-1, SW-2, SW-4, SW-5, SW-6 and SW-7 PCP was detected at concentrations of 12.2 ug/L, 596 ug/L, 44.4 ug/L, 135 ug/L, 317 ug/L and 402 ug/L, respectively. All of these PCP concentrations exceed the MCL concentration for PCP of 1 ug/L. The acute and chronic concentrations set for PCP in freshwaters are 22 ug/L and 13 ug/L, respectively. Therefore, the surface water samples from sampling locations SW-2, SW-4, SW-5, SW-6 and SW-7 have PCP concentrations which exceed these criteria set for freshwater.

2.4.4.4 Volatile Organic Compounds(VOCs)

Only one VOC was detected in any of the surface water samples. The compound was methylene chloride at a concentration of 65 ug/L. It was detected in sample SW-1. It is probable that the source of the methylene chloride in the sample is from laboratory contamination since methylene chloride is commonly used as a solvent in laboratory environments. Evidence to support this statement was the detection of methylene chloride at a concentration of 5.8 ug/L in the QA/QC lab blank (Appendix B).

2.4.4.5 Metals

Table 2-16 summarizes the analytical results for arsenic, chromium, copper and zinc in the surface water samples. Figure 2-22 displays the metal analytical results at each surface water sampling location. The analytical results for the metals in surface water, as received by Keystone's laboratory, are presented in Appendix B.

Arsenic, copper and zinc were detected in surface water sample SW-1. Their concentrations were 79.6 ug/L, 67.4 ug/L and 51.5 ug/L, respectively.

In surface water sample SW-2, arsenic, chromium, copper and zinc were detected at concentrations of 1,760 ug/L, 40.2 ug/L, 2,610 ug/L and 992 ug/L, respectively.

The SS-3 surface water sample had arsenic and zinc detected at concentrations of 13 ug/L and 29.8 ug/L, respectively. Chromium and copper were not detected in sample SW-3.

In surface water sample SS-4 arsenic, copper and zinc were detected at concentrations of 698 ug/L, 267 ug/L and 179 ug/L, respectively. Arsenic, chromium, copper and zinc were detected in sample SW-5 at concentrations of 1,630 ug/L, 10.7 ug/L, 611 ug/L and 380 ug/L, respectively.

Surface water sample SS-6 had detectable levels of arsenic, chromium, copper and zinc. The detected metal concentrations were arsenic at 1,180 ug/L, chromium at 18.6 ug/L, copper at 1,230 ug/L and zinc at 569 ug/L.

Arsenic, chromium, copper and zinc were detected in sample SW-7 at concentrations of 1,840 ug/L, 24.8 ug/L, 1,510 ug/L and 627 ug/L, respectively.

To summarize the surface water metal results, arsenic, chromium, copper and zinc were detected in each of the surface water samples obtained on the Baxter property.

2.4.5 Offsite Well Sampling Results

Brown and Caldwell sampled a total of nineteen residential water wells in the vicinity of the Baxter plant site in November 1990. Figure 2-23 displays the locations of these wells and the location of the Baxter site. A total of 102 water wells were indentified by Brown and Caldwell in their survey of the residences in the vicinity of the plant. The addresses for the 102 residents are provided in Appendix B. These residences are situated at radii from the site ranging from approximately 1/10th of a mile to 2/3 of a mile.

The analytical results for the offsite groundwater samples and the sampling and decontamination protocols used for the offsite sampling are provided in Appendix B.

The wells sampled are situated downgradient (north and northwest) of the Baxter site. The distance of the sampled wells from the plant site ranges from approximately 500 feet to approximately 2,500 feet.

Four of the nineteen sampled wells are used as the source of drinking water for the residence. One of these four wells is located at a building which has been vacant for two years and has been condemned by the City. The remaining fifteen wells are reported to be used for irrigation. The three wells currently used for drinking water are situated approximately 1,000 to 1,500 feet north of the Baxter property.

The sampled wells were analyzed for pentachlorophenol (PCP). The analyses were performed by Water Analysis and Consulting, Inc. of Eugene, Oregon and two duplicate samples were analyzed by Pacific Environmental Laboratory Inc. in Portland, Oregon.

PCP was not detected in any of the nineteen water samples or duplicate samples. The detection limit for all but one of the analyses was 10 ug/L. At the time the sampling was conducted (fall 1990) the proposed maximum contaminant level for pentachlorophenol (PMCL) was 200 ug/L and was not changed to 1 ug/L until January, 1991 by the EPA. Therefore, the 10 ug/L detection limit for pentachlorophenol used for the off-site samples was suitable in November, 1990. One sample had a large amount of suspended solids in the water which interfered with the analytical method and resulted in a detection limit of 400 ug/L. This sample was obtained from the well situated on the condemned residential property.

Unfortunately, well construction information was not available for any of the wells sampled. Therefore, it is not possible to conclude whether PCP has migrated in the groundwater from the Baxter site to the location of any of these wells.

3.0 NATURE AND EXTENT OF CONTAMINATION

This section of the report utilizes the investigative results presented in the previous section to provide an evaluation on the nature and extent of contamination detected at the Baxter site. This section presents descriptions and interpretations regarding the following characteristics of the contamination detected at the site.

- The horizontal extent of contamination.
- The vertical extent of contamination.
- Potential source areas of contamination.

These characteristics of the detected contamination are discussed for each of the four media investigated at the site. The media were; soil, groundwater, sediment and surface water.

3.1 Extent of Detected Contamination

Constituents of concern related to the wood treating operations of J.H. Baxter have been detected in the site soils, groundwater, sediment and surface waters. The extent of these constituents in the soil, groundwater, sediment and surface waters is presented and discussed in the following sections.

3.1.1 Soils

The interpretation on the extent of contamination in the soil is based on the results of fourteen soil samples obtained from the well borings drilled on the site in 1986 and 1990. Conclusions regarding the overall soil quality on the site are not formulated. Only specific areas regarding constituents of concern in the soil can be identified due to the limited data on soils.

PAHs were detected in six of the fourteen soil samples obtained at the site. The six samples were; W-7S (6.5 to 7 feet below grade), W-8S (5.5 to 6 feet below grade), W-9S (3 to 5 feet below grade), W-9I (3 to 4.5 feet below grade), W-12I (3 to 4.5 feet below grade) and W-13S (1.5 to 3.5 feet below grade). However, PAHs were not analyzed in soil samples obtained from well borings W-1S, W-2S and W-3S during the initial monitoring well installation program performed by Brown and Caldwell.

These PAH results indicate that the highest PAH concentrations observed in the soil were at locations W-7S and W-8S which are situated near the treating and chemical storage areas of the plant (W-7S) and the past location of the burn pit (W-8S). PAHs were also detected in the soil near the perimeter of the Baxter property. W-13S, W-9S and W-9I are located close to the northern property boundary of the site (W-13S) and near the southern property boundary of the site (W-9S and W-9I).

The vertical depth range or extent of the soil samples with detectable concentrations of PAHs was 1.5 feet to 7 feet below grade. This range is generally above the water table depth observed at the site (approximately 6 to 8 feet below grade).

PCP was detected in soil samples obtained at W-2S (20 to 21 feet below grade), W-8S (5.5 to 6 feet below grade) and W-12I (3 to 4.5 feet below grade). PCP was not detected in the soil samples acquired from the well borings located near the perimeter of the Baxter property (eg. W-11S, W-13S, W-9S and W-9I). Although PCP was detected in the soil sample obtained from W-2S it was recovered from below the water table or in the saturated zone of the soil profile. Therefore, it is possible and probable, considering W-2S's proximity to the retention pond, that the PCP was present in the groundwater which has migrated to W-2S and contaminated the soil at that depth in this location.

Volatile aromatics were only analyzed in the six soil samples obtained as part of the RI. These samples are taken from well borings which are generally situated near the boundaries of the property and therefore examine the soil quality with respect to volatiles only in those areas.

Only one aromatic compound was detected in only one soil sample (W-14I) at a low concentration (22 ug/kg). Considering that W-14I is located in the present and historic lawn area immediately outside the office it is unlikely that the surface of the soil would have been exposed to constituents of concern.

Three soil samples were analyzed for arsenic, chromium, copper and zinc at the site (W-9S, W-12I and W-13S). One soil sample was analyzed for arsenic and chromium (W-3S). Similar to the soil sample obtained from W-2S, the soil sample obtained from W-3S was recovered from well below the water table. Therefore it is possible that arsenic and chromium may have been introduced into the soil at W-3S by the groundwater. Arsenic has been detected in the groundwater in well W-3S but chromium has not.

Arsenic was not detected in the sample from W-11S but was detected in the other three soil samples (W-9S, W-13S and W-3S). Chromium, copper and zinc were detected at elevated concentrations at locations W-9S, W-11S and W-13S. Since most or all of the wood treating related metals were detected in the soil samples analyzed it is possible the metals would be discovered at other locations in the soil on the site.

3.1.2 Groundwater

Ten wells were installed on the site for the RI and in July/August 1990 all eighteen available monitoring wells at the site were sampled for wood treating related constituents. This data provided the basis for the characterization of the extent of the constituent plumes.

To determine the extent of constituent plumes in the groundwater the analytical data from the July 1990 sampling round was used. Figures 3-1 through 3-4 present a pictorial representation of the estimated areal extent of total PAHs, PCP, benzene and total arsenic in the groundwater on the site. At well nest locations more than one constituent concentration value is available. For the figures the highest concentration value was used to represent the constituent concentration at each well nest location. It is important to remember when analyzing the figures that the concentration isopleths are approximate and are used in the figures to provide a general indication of the extent of the constituents.

PAHs

The extent of PAHs in the groundwater in July 1990 is approximated in Figure 3-1 which displays isopleths for the total PAH concentration in the groundwater. From Figure 3-1 it is evident that the highest concentrations of PAHs in the groundwater (eg. greater than 1 mg/L total PAHs) extends south to north from the area of the surface water retention pond to immediately north of the retort area and extends west to east from well W-2S to immediately west of the office complex, respectively. However, the .01 mg/L contour for total PAHs extends beyond the northern property boundary of the site suggesting that PAHs have migrated in the groundwater offsite to the north.

The four well nest locations where PAHs were detected provides information on the vertical distribution and extent of PAHs in the groundwater. At well nest location W-1S(W-14I) the total PAH concentrations are .06 ug/L (W-1S) and .03 ug/L (W-14I). Therefore the PAHs in the groundwater at surface location W-1S(W-14I) extend down to the top of the clay aquitard which represents the base of the shallow aquifer.

At well nest W-13S(W-13I) PAHs were detected in both wells with total PAH concentrations of 5 ug/L (W-13S) and 12 ug/L (W-13I). Therefore PAHs are present throughout the vertical extent of the shallow aquifer at this well nest location. The higher PAH concentration observed in the intermediate depth well indicates the propensity for PAHs (particularly the larger PAH molecules) to migrate downwards in the groundwater. One PAH compound was detected in well W-13D, which is screened below the thick clay aquitard, at a concentration of .03 ug/L. However, it is probable that the low concentration of PAHs observed in this well are due to slight cross-contamination between the shallow and deep aquifers during an unavoidable delay in the completion of well W-13D.

Well nest location W-4S(W-5I) displays a PAH pattern in the groundwater similar to that observed at nest location W-13S(W-13I). In well W-4S PAHs were not detected. However, in well W-5I a total PAH concentration of 43 ug/L was detected. At this location the PAH concentration is also greater in the deeper zone of the shallow aquifer.

The fourth well nest location where PAHs were detected is W-7S(W-6I). At this location the concentration of PAHs in the shallow well (5,113 ug/L, W-7S) were significantly higher than the concentration of PAHs in the intermediate well (81 ug/L, W-6I). This pattern is opposite to the pattern observed at well nests W-13S(W-13I) and W-4S(W-5I). A possible explanation for this is that W-7S(W-6I) are closer to a source of PAHs on the site than the other two well nests. It would take time for PAHs to move downward in the aquifer and during this time the groundwater is flowing and the PAHs are migrating further from their source. Depending on many factors the PAHs will travel a certain distance from their source before they reach the deeper zone of the aquifer if a significant near-horizontal hydraulic gradient exists.

Pentachlorophenol(PCP)

Figure 3-2 displays the PCP concentration isopleths for the groundwater samples obtained in July 1990. The maximum contaminant level concentration for PCP in "drinking water" has been recently proposed by the EPA at 1 ug/L. The shaded area on Figure 3-2 approximately represents the area of the site where the PCP concentration in the groundwater exceeds 0.01 mg/L. The figure suggests that the PCP contaminant plume has migrated offsite both to the north and possibly west and south of the site. It is difficult to assess with any level of confidence the distance the plume extends beyond the northern property boundary of the Baxter site. Hypothetically, assuming the geologic and hydrogeologic characteristics of the site can be extrapolated northwards it is reasonable to assume that the PCP plume (defined by greater than 1 ug/L in concentration) may have travelled approximately 1,000 feet north of the Baxter property if the onsite dimensions of the plume can be mirrored offsite.

If the average linear groundwater velocity determined in section 2.3.3 (83 ft/year) is used to estimate the possible extent of PCP downgradient from the retort and tank farm areas, assuming PCP entered the groundwater at the earliest possible date

(PCP first used at the site in 1945), then PCP may have migrated approximately 3,700 feet downgradient (ie. north-northwest) of any source areas. However, this method for estimating the distance PCP may have migrated in the groundwater has several questionable assumptions inherent in it.

- The groundwater velocity used is representative of the groundwater velocity over the past 45 years and that the velocity of the groundwater offsite extending northwards from the site remains constant. This implies the shallow aquifer characteristics onsite extend offsite for a significant distance (3000 feet) and that the average hydraulic gradient offsite to a distance of approximately 3000 feet is the same as the hydraulic gradient onsite.

- There were no retardation effects on PCP migrating through the subsurface soils (eg. absorption, biodegradation).

- Significant PCP contamination of the groundwater has been occurring since 1945.

Considering the above questionable assumptions, the estimation of offsite extent of PCP, using the linear groundwater velocity calculated from onsite data, has significant uncertainty associated with it.

PCP in the groundwater extends throughout the depth profile of the shallow aquifer. PCP is detected in both the shallow and intermediate wells on the site. There does not appear to be a consistent pattern relating the concentrations of PCP determined in the shallow and in the intermediate wells. However, at the northernmost and westernmost well nest locations (W13S-W13I and W11S-W11I) the PCP concentrations at depth and in the shallow zone of the aquifer are comparable.

Benzene

Although several volatile organic compounds were detected in the groundwater at the site, only benzene was detected at concentrations exceeding its MCL of 5 ug/L.

Therefore, Figure 3-3 was prepared to assess the areal extent of benzene in the groundwater in July 1990. The shaded area in the northern central part of the site represents the approximate area of benzene above the 5 ug/L concentration. As the figure indicates the benzene plume extends beyond the northern property boundary of the Baxter site. However, based on the approximate dimensions of the plume onsite, the distance it extends offsite is probably less than the distance the PCP plume extends northwards from the site.

The benzene detected at well nest location W-13S and W-13I was in well W-13I and not the shallower well as might be expected since benzene is a relatively light organic compound.

Metals

Of the metals analyzed in the groundwater related to wood treating chemicals only arsenic exceeded its MCL concentration of .05 mg/L in July 1990. Chromium was not been detected at a concentration greater than its MCL of .05 mg/L. Copper also was not detected in the groundwater at concentrations greater than its proposed maximum contaminant level (PMCL) of 1.3 mg/L. An MCL or PMCL has not been established for zinc, however a secondary level of 5 mg/L has been established for zinc based on aesthetic criteria. Zinc concentrations in the groundwater on the site did not exceed even 1 mg/L. Therefore the extent of arsenic in the groundwater is discussed as it presents a potential concern at the site.

Figure 3-4 reveals the inferred extent of arsenic (ie. shaded area) in the groundwater above the MCL concentration for arsenic of .05 mg/L. It is evident from the figure that the arsenic plume at concentrations above the MCL is contained within the property boundaries of the Baxter site.

3.1.3 Sediment

The extent of constituents of concern in sediment is analyzed in the surface water retention pond and the drainage ditches near the southern property boundary of the

3.1.4 Surface Waters

Seven surface water samples were obtained in the identical locations where the seven sediment samples were obtained. Evaluation of the extent of contamination in surface waters will be restricted to the retention pond and drainage ditch near the southern property boundary.

Retention Pond

PAHs, PCP, arsenic, chromium, copper and zinc were detected at in the surface water samples recovered from the retention pond (SW-5, SW-6 and SW-7). Naphthalene, one of the lighter PAH compounds, and volatile organic compounds were not detected in the retention pond water samples.

PCP and arsenic concentrations in the retention pond are above their MCL concentrations for drinking water of 1 ug/L and 50 ug/L, respectively. PCP concentrations also exceed the acute and chronic Ambient Water Quality Criteria concentrations of 22 ug/L and 13 ug/L, respectively, set by the EPA for PCP in freshwaters. The copper concentration in one of the samples (SW-7) is above its PMCL concentration of 1.3 mg/L. Therefore, the retention pond water is contaminated with respect to PCP, arsenic and copper.

Elevated levels of PAHs in samples SW-5, SW-6 and SW-7 indicate PAH contamination in the retention pond.

Onsite Drainage Ditch

Constituents of concern were detected in the surface water samples obtained in the drainage ditch. Only in sample SW-3 were none of the organic constituents of concern detected. The other three samples had detectable concentrations of PAHs and PCP.

site. Three sediment samples were obtained from the retention pond and four sediment samples were obtained from the drainage ditches.

Retention Pond

All three of the sediment samples recovered from the bottom of the retention pond had elevated levels of PAHs and PCP detected. Volatile aromatic compounds such as toluene, xylenes and benzene were also detected in the sediment obtained from the retention pond. The metal constituents of concern; arsenic, chromium, copper and zinc were detected in the three sediment samples.

Therefore the sediment results indicate that probably the bottom sediments of the entire retention pond are contaminated with respect to the wood treating related constituents analyzed (PAHs, PCP, arsenic, chromium, copper and zinc, volatile aromatics).

Onsite Drainage Ditches

The four sediment samples obtained from the drainage ditches contained detectable levels of PAHs, PCP, volatile aromatics, arsenic, chromium, copper and zinc. However, the sample obtained in the southeast corner of the site (SS-3), in general, had lower concentrations of constituents than the other three sediment samples (SS-1, SS-2 and SS-4).

The extent of contamination in the drainage ditch which parallels the southern property boundary and exits offsite in the southwest corner of the site was not determined. The furthest downstream sediment sample (SS-4) was obtained approximately 100 feet east of the western property of the site and was contaminated. Therefore additional sediment samples are required to determine the extent of sediment contamination to the west (downstream) of sample SS-4 in the drainage ditch.

SW-4 which is downstream of the retention pond near the property boundary had PCP and arsenic levels in the water which exceeded their respective MCL concentrations. Copper in sample SW-4 exceeded its PMCL concentration.

The MCL concentration for PCP in drinking water was also exceeded in samples SW-1 and SW-2. The PCP concentrations in samples SW-2 and SW-4 exceed the acute and chronic concentrations in freshwater defined by the EPA in their Ambient Water Quality Criteria.

The extent of site-related contamination in the surface waters of the drainage ditch at the south property boundary has not been determined. The data indicates that it is possible that constituents of concern have migrated offsite in the water in the drainage ditch which drains the retention pond.

3.2 Potential Source Areas

To determine possible source areas of contamination detected in site soils, groundwater, sediment and surface waters the following information has been utilized:

- Historical information.
- Analytical results of all soil, groundwater, sediment and surface water samples obtained at the site.
- Extent and nature of present contamination.
- Knowledge of groundwater flow patterns.

After examining the above information which is presented in this report, it is evident that three main source areas of contamination can be defined:

1. Former burn pit area.
2. Retort and chemical storage area.
3. Surface water retention pond.

The level of contamination near these three areas is higher than at other areas investigated on the property. The extent of contamination in the groundwater (Figures 3-1 through 3-4) combined with the knowledge of the groundwater flow direction on the site (north to northwest) enabled the estimation of the contaminant migration paths back to their probable origin which were the three areas stated above.

Other possible source areas of contamination may contribute to the overall contaminant levels observed in the various media, but to a lesser degree. These additional source areas would be areas where treated wood is presently stored or has been historically stored on the site and areas in the vicinity of the retort charge loading and unloading tracks.

4.0 PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

This section presents the Public Health and Environmental Assessment (PHEA) performed for J.H. Baxter and Company Wood Preserving Facility in Eugene, Oregon. The PHEA investigates the potential for chemical constituents to affect public health or the environment, either now or in the future, under a no action scenario.

This PHEA was conducted in accordance with the Risk Assessment Guidance for Superfund, Vol. I, Human Health Evaluation Manual (Part A), U.S. EPA, 1989a. In addition to this guidance document, the Superfund Exposure Assessment Manual (U.S. EPA, 1988) and the Exposure Factors Handbook (U.S. EPA, 1989b) were also utilized. The PHEA identifies areas of interest and chemical constituents at the site. This information, together with the geographical, demographic, chemical, physical, and biological characteristics of the site are brought together to identify potential exposure pathways and receptors. The chemical and physical properties of the constituents present are then used to estimate concentrations at the end points of these exposure pathways. Finally, intakes by potential receptors are determined and combined with the toxicological properties to estimate the potential public health and environmental risks posed by constituents at the site.

The components of the PHEA include:

- toxicity assessment;
- fate and transport;
- identification of potential constituents of concern;
- identification of potential exposure pathways and potentially affected populations;
- exposure assessment;
- risk characterization; and
- sources of uncertainty.

This PHEA is divided into 7 sections, with Section 4.1 describing the potential for constituents to give rise to adverse effects in an exposed population. Section 4.2

discusses environmental fate and transport processes. Potential constituents of concern are identified in Section 4.3, which defines compounds at the site having the greatest relative potential to affect human health and the environment. Section 4.4 discusses potential current and future exposure scenarios, and identifies associated onsite and offsite potential exposure pathways. The exposure assessment presented in Section 4.5 estimates the type and magnitude of exposures to chemicals of potential concern that are present at the site. The results of the exposure assessment are combined with chemical-specific toxicity information to characterize potential risks in Section 4.6 that are associated with the site. Section 4.7 discusses sources of uncertainties in this PHEA. A conceptual site model presenting the exposure mechanisms and pathways pertinent to the J.H. Baxter site is provided in Figure 4-1. Issues assessed in this report are included in the model as well as issues to be addressed in the future.

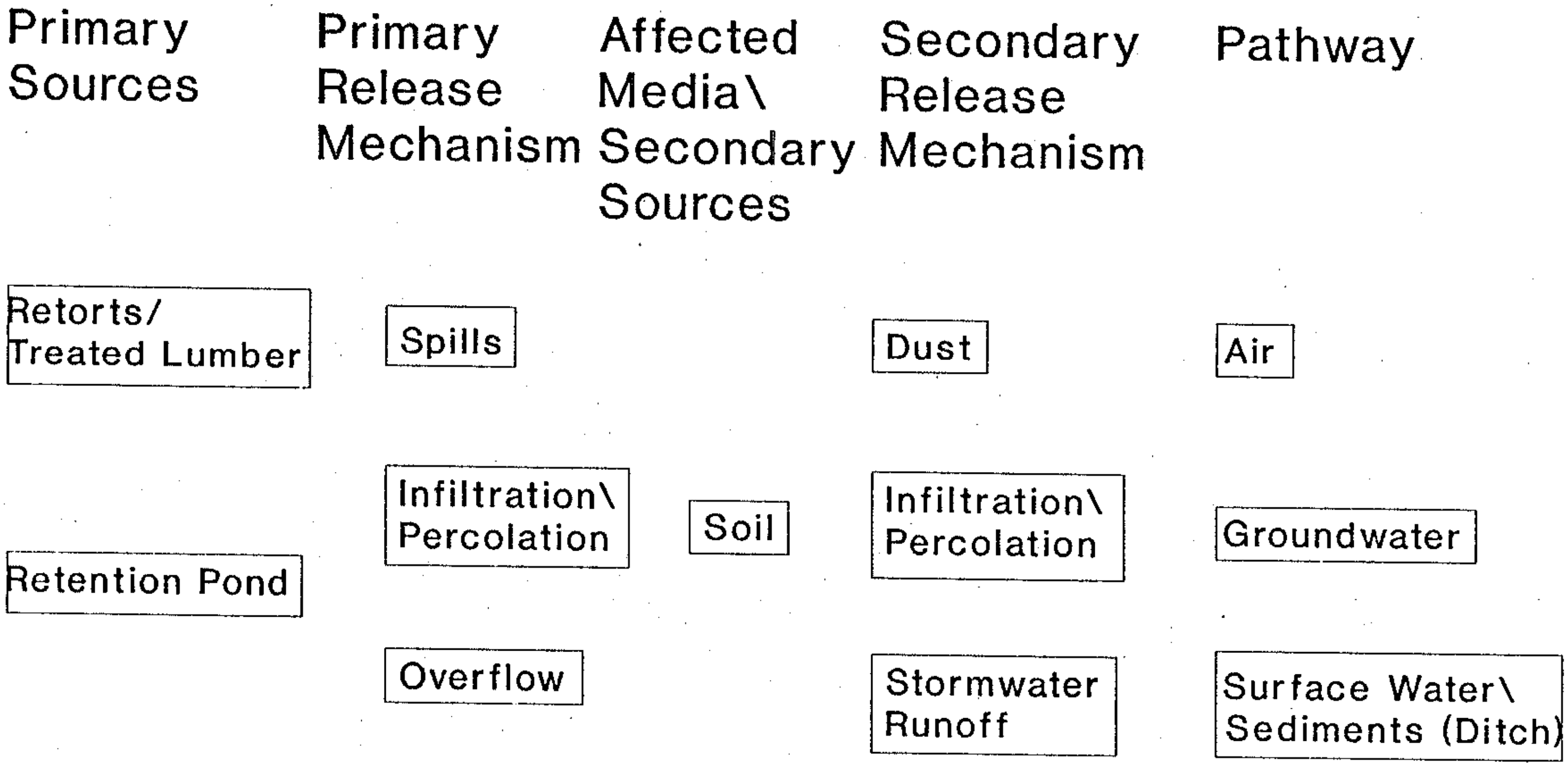
Appendix B presents the analytical data for groundwater, soil, sediment and surface water monitoring. Appendix D consists of toxicological profiles of the potential constituents of concern. Appendix E lists presents the input variables and a summary of the dose estimates.

4.1 Toxicity Assessment

4.1.1 Toxicological Evaluation

The purpose of this section is to identify the potential health and environmental effects associated with exposure to constituents at the site. A toxicological evaluation characterizes the inherent toxicity of a compound. It consists of the review of scientific data to determine the nature and extent of the human health and environmental effects associated with exposure to the various chemicals. The end product is a toxicological profile of each constituent presented in Appendix D. Toxicological profiles provide the qualitative and quantitative weight-of-evidence that site constituents pose regarding their actual or potential health and environmental effects.

FIGURE 4-1
Conceptual Site Model
Public Health and Environmental Assessment
J.H. Baxter site
Eugene, Oregon



To Receptors
Following Page

FIGURE 4-1 (cont')
Conceptual site model - Public Health and Environmental Assessment
J.H. Baxter site
Eugene, OR

PATHWAY	RECEPTORS						
		HUMANS				BIOTA	
	EXPOSURE ROUTE	CURRENT RESIDENTS	FUTURE RESIDENTS	ON-SITE WORKERS	TRESPASSERS	AQUATIC	TERRESTRIAL
AIR	INHALATION	x	x	x			o
SOIL (surface)	INGESTION	o		o			o
	DERMAL	o		o			o
GROUNDWATER	INHALATION	o	x				
	INGESTION	o	x				
	DERMAL	o	x				
SURFACE WATER\ SEDIMENTS	INHALATION	o					o
	INGESTION	o				o	o
	DERMAL	o			x	o	o

x - pathway addressed in Phase I
o - pathway to be addressed in Phase II

Toxic effects considered in these profiles include potential noncarcinogenic (toxic) and potential carcinogenic health effects as well as potential environmental effects. Toxicological endpoints, routes of exposure, and doses in humans and/or animal studies are discussed. Routes of exposure and doses in humans and/or animal studies are provided. Also considered is the EPA weight-of-evidence (Table 4-1) for a compound's potential carcinogenicity:

- Group A, known human carcinogens;
- Group B, probable human carcinogens;
- Group C, possible human carcinogens;
- Group D, not classifiable as to its carcinogenicity;
- Group E, evidence of noncarcinogenicity for humans.

Potential environmental effects include acute and chronic toxic effects to aquatic biota.

Available toxicological information may indicate that many of the site-related constituents have both noncarcinogenic and potential carcinogenic health effects in humans and/or experimental animals. Although many may potentially cause health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of potential effects, as discussed in the following section.

4.1.2 Dose-Response Evaluation

An important component of the risk assessment process is the relationship between the dose of a compound (amount to which an individual or population is exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. The published information on doses and responses is used in conjunction with information on the nature and magnitude of human exposure in order to develop an estimate of health risks.

TABLE 4-1

U.S. EPA
WEIGHT-OF-EVIDENCE AND CATEGORIES FOR POTENTIAL CARCINOGENS

U.S. EPA Category	**Description of Category**	**Description of evidence**
A	Human Carcinogen	Sufficient evidence exists from epidemiologic studies to support a causal association between exposure and cancer.
B	Probable Human Carcinogen	B_1: The EPA concludes that limited human data are available for evidence of carcinogenicity in humans.
B	Probable Human Carcinogen	B_2: Sufficient evidence exists of carcinogenicity in animals.
C	Possible Human	Limited evidence of carcinogenicity in animals.
D	Not classified	Inadequate evidence exists of carcinogenecity in animals to classify in humans.
E	No evidence of Carcinogenecity in Humans	No evidence exists for carcinogenecity.

Reference:

U.S. EPA, 1989a.

Standard reference doses and/or carcinogenic slope factors have been developed for many compounds. This section provides a brief description of these and other quantitative indices of toxicity pertinent to the risk assessment.

Reference Dose (RfD) - The RfD is developed for chronic and/or subchronic human exposure to chemicals and is based solely on the noncarcinogenic effects of chemical substances. It is defined as an estimate of a daily dose for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect by an appropriate "uncertainty factor (UF)." NOAELS, etc., are determined from laboratory or epidemiological toxicity studies. The uncertainty factor (UF) is based on the availability of toxicity data.

Uncertainty factors usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These uncertainty factors are presented below and were taken from the "Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (U.S. EPA 1989a):

- A UF of 10 is used to account for variation in the general population and is intended to protect sensitive subpopulations (e.g., elderly, children).

- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.

- A UF of 10 is used when a NOAEL is derived from a subchronic study instead of a chronic study and is used as the basis for a chronic RfD.

- o A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UF's, a Modifying Factor (MF) is applied to each reference dose and is defined as:

- o A MF ranging from is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default value for the MF is 1.

Thus by incorporating uncertainty factors the RFD maintains a margin of safety so that potential chronic human health effects are not underestimated. The RfD is an acceptable guideline for evaluation of noncarcinogenic effects, although the associated uncertainties preclude its use for precise risk quantitation.

<u>Carcinogenic Slope Factor (CSF)</u> - Carcinogenic slope factors are used to estimate an upper-bound lifetime probability of an individual potentially developing cancer as a result of exposure to a particular level of a potential carcinogen (U.S. EPA 1989a). This factor is generally reported in units of kg-day/mg and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95 percent confidence limit.

These slope factors are also accompanied by weight-of-evidence classifications which designate the strength of the evidence that a particular compound is a potential human carcinogen.

This section also presents a description of available regulatory standards or guidelines for use in evaluating constituents of concern. Regulatory standards and guidelines may be used for comparative purposes to infer the potential for health risks and environmental impacts. Relevant regulatory standards and guidelines include the Ambient Water Quality Criteria, Maximum Contaminant Levels, Maximum Contaminant Level Goals, and Health Advisories.

Maximum Contaminant Levels (MCLs) - MCLs are enforceable standards for public drinking water supplies. MCLs are promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day, but also reflect the technical feasibility of removing the constituent from a public water supply. These enforceable standards also reflect the fraction of the constituent expected to be absorbed by the gastrointestinal tract.

Maximum Contaminant Level Goals (MCLGs) - MCLGs are specified as zero for potentially carcinogenic substances, based on the assumption of nonthreshold toxicity, and do not consider the technical or economic feasibility of achieving these goals. MCLGs are nonenforceable guidelines based entirely on the potential for health effects. The MCLs have been set as close to the MCLGs as technically and economically feasible.

Ambient Water Quality Criteria (AWQC) - AWQC are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms. They may also be used for identifying potential human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), and from ingestion of water alone (2 liters/day). The AWQCs for protection of human health for carcinogenic substances are based on the EPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 10^{-7} to 10^{-5} range).

Health Advisories (HAs) - HAs are guidelines developed by the EPA Office of Drinking Water for nonregulated constituents in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight of 10 kg) who consume 1 liter of water per day or in adults (assumed body weight of 70 kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1 day), subchronic (10 days), and chronic (longer-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels of potential human carcinogens.

Quantitative indices of toxicity are used in identifying constituents of concern for evaluation in the PHEA. The hierarchy (U.S. EPA 1989a) for choosing these values is as follows:

- Integrated Risk Information System (IRIS);
- Health Effects Assessment Summary Tables (HEAST); and,
- other EPA documents.

The IRIS data base is updated monthly and contains both verified RfD's and CSF's. The EPA has formed a RfD Workgroup to review existing data used to derive RfD's. Once this task has been completed the verified RfD appears in IRIS. Like the RfD Workgroup, EPA has also formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and validate toxicity values used in developing CSF's. Once the slope factors have been verified via extensive peer review, they also appear in the IRIS data base.

The HEAST on the other hand provides both interim (unverified) and verified RfD's and CSF's. This document is published quarterly and incorporates any applicable changes to its data base.

Other EPA reference documents (i.e. ATSDR Toxicological Profiles which may list Minimal Risk Level values) can be used to obtain quantitative indices of toxicity only after review of the literature to assess whether these data are current.

Dose-response relationships for environmental effects are limited to comparisons with the Ambient Water Quality Criteria (AWQC) for the protection of aquatic life. These criteria specify the concentration of a compound in surface water which, if not exceeded, should protect most aquatic life. These criteria are derived from both plant and animal data and were developed to protect the types of organisms necessary to support a healthy aquatic community. However, they may not protect all aquatic life under all conditions. AWQC consider both acute (short-term) and chronic (long-term) effects.

4.2 Fate and Transport

The potential for a chemical to migrate spatially in an environmental setting is a critical component in assessing the potential for human and environmental exposure. The environmental mobility of a chemical will be influenced primarily by its physical and chemical properties in combination with the physical and chemical properties of the environment. This section is an evaluation of these properties with emphasis on environmental mobility and persistence.

The long-term environmental fate and distribution of constituents will be influenced by three main factors.

- Physical-chemical properties of the individual constituents
- Physical-chemical properties of the environmental setting
- Reactions in the environment which modify the chemical structure and behavior of the contaminants

Persistence and mobility are characteristics that are used in identifying constituents of concern. They are influenced by such factors as specific gravity, vapor pressure, water solubility, octanol/water partition coefficient, organic carbon partition coefficient, Henry's Law constant and plant uptake factor. Calculated values, which were obtained using approximation methods, are presented when literature values are unavailable. A discussion of the environmental significance of each of these parameters follows.

- Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a constituent will have a tendency to float or sink in water if it is present as a pure compound or at very high concentrations.

- Vapor pressure (Vp) provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating contaminated groundwater and subsurface soils. Vapor pressures for monocyclic aromatics are generally many times higher than vapor pressures for polycyclic aromatic hydrocarbons (PAHs). Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is an environmental fate process for volatile organics in surface water.

- The rate at which a chemical is leached from a waste deposit by infiltrating precipitation is directly proportional to solubility in water. More soluble chemicals are more readily leached than less soluble chemicals. Water solubilities indicate that the volatile organic chemicals, including monocyclic aromatics, are usually several orders of magnitude more soluble than the PAHs.

- The octanol/water partition coefficient (Kow) is a measure of the equilibrium partitioning of chemicals between an organic phase and water. A linear relationship between the octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been determined (Lyman et al., 1982). It is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available. PAHs are several orders-of-magnitude more likely to partition to fatty tissues than the more water-soluble volatile organics. The octanol/water partition coefficient is also used to estimate bioconcentration factors in aquatic organisms.

- The organic carbon partition coefficient (Koc) indicates the tendency of an organic chemical to bind to the organic fraction of soil/sediment particles. Chemicals with high (Koc) generally have low water solubilities. This parameter may be used to infer the relative rates at which the more mobile chemicals (monocyclic aromatics) are transported in the aqueous media. Chemicals such as PAHs are relatively immobile in the environment and are preferentially bound to the soil phase. These compounds are not subject to aqueous transport to the extent of compounds with higher water solubilities. However, these immobile chemicals are easily transported by erosional processes if they are present in surface soils.

- Both the vapor pressure and the water solubility are of use in determining volatilization rates from surface-water bodies and from groundwater. The ratio of these two parameters is the Henry's Law constant (H) and is used to calculate the equilibrium contaminant concentrations in the vapor (air) versus the liquid (water) phases for the dilute solutions commonly encountered in environmental settings.

- Plant uptake factors (Bv) are used to estimate the transfer of substances from soil, water and air to plants. Relationships have been developed for uptake of chemicals in plants via foliar deposition and root uptake.

A semi-quantitative assessment of mobility has been developed (Laskowski, 1983) that uses water solubility (S), vapor pressure (VP) and organic carbon partition coefficient (K_{oc}). Laskowski defines a mobility index (MI) as:

$$MI = \log((S \times VP)/K_{oc})$$

A scale to evaluate MI is presented by Ford and Gurba (1984):

Relative MI	Mobility Descriptor
MI > 5	extremely mobile
0 < MI < 5	very mobile
-5 < MI < 0	slightly mobile
-10 < MI < -5	immobile
MI < -10	very immobile

4.3 Identification of Potential Constituents of Concern

This section identifies potential constituents of concern (PCOCs) for the J.H. Baxter and Company Wood Preserving facility based on the findings of the Remedial Investigation (RI) study. PCOCs are site-related constituents used to quantitatively estimate potential human and environmental exposures. Four environmental media were investigated during the RFI: soil, groundwater, surface water and sediments. The PCOCs that are identified in this section are those that were detected in at least one of these media. The first part of this section discusses criteria used in selecting PCOCs. The second part of this section applies these criteria to select PCOCs for the site.

4.3.1 Criteria for Selecting Potential Constituents of Concern

After reviewing site chemical data, preliminary constituents of concern have been identified for the site. PCOCs are compounds or elements detected at the site that have the greatest relative potential to affect human health and the environment based on four criteria. These criteria, which are used in selecting the PCOCs, are toxicity, mobility, persistence, and prevalence. Analytical data from sampled media are evaluated using these criteria and PCOCs are either screened or retained for quantitative evaluation.

A brief description of each of the selection criteria used in determining the PCOCs is given below:

TOXICITY

Potential toxicity of the preliminary PCOCs is important when evaluating their potential effects on possible receptors either onsite or offsite. Some characteristics related to potential toxicity are the systemic effects and the carcinogenic, mutagenic, and teratogenic properties of the chemical for both human and environmental receptors. Reproductive toxicity and acute and chronic systemic effects will also be addressed. Bioaccumulation and bioconcentration properties will be evaluated for environmental receptors if relevant data exist.

Toxicological profiles have been developed that address the PCOCs at the site and are included in Appendix D. In these toxicological profiles, both human and animal data are presented, where available. Human epidemiological data from occupational exposures are often insufficient for determining quantitative indices of toxicity due to uncertainties in exposure estimates, and to inherent difficulties in determining causal relationships from epidemiological studies. For this reason, animal bioassays are conducted under controlled conditions and their results extrapolated to humans.

There are two stages to this extrapolation. First, to account for species differences, conversion factors are used to extrapolate from test animals to humans. Second, the relatively high doses administered to test animals must be extrapolated to the lower doses more typical of human exposures. For potential noncarcinogens, safety factors are applied to animal results when developing acceptable human doses. For potential carcinogens, mathematical models are used to extrapolate from potential risks at high doses to potential risks at lower doses.

MOBILITY

Physical and chemical properties of a compound control its transport and fate in the environment. For example, these attributes determine whether a chemical will readily volatilize into the air or be transported via advection or diffusion through the soil, groundwater, and surface water. These characteristics also describe a chemical's tendency to adsorb onto soil/sediment particles, in turn reducing its mobility through the environment.

PERSISTENCE

Persistence of a chemical in the environment depends on factors such as the microbial content of soil and water and the ability of these organisms to degrade the chemical. In addition, chemical and photochemical degradation may contribute to the elimination of a particular compound.

PREVALENCE

Frequency of detection and concentration of PCOCs are parameters that characterize the extent of constituent impact in the various media studies. As an example, a frequency of detection of 5 percent (U.S. EPA, 1989a) is sometimes used as a cutoff point for retention of PCOCs for quantitative evaluation.

In addition to these compound-specific characteristics, several other factors are evaluated when selecting PCOCs. These factors are as follows:

- Comparison of analytical results with native or background concentrations in soil or groundwater. This information is available in the literature for most metals.
- Comparison of analytical results with "background" sample locations at the site.
- Comparison of results with current established criteria for a specific compound in groundwater (Maximum Contaminant Levels/Maximum Contaminant Level Goals--MCLs/MCLGs), surface water (ambient water quality criteria), and other media where available.

4.3.2 Selection of Potential Constituents of Concern

By combining the selection criteria defined in Section 4.3.1 with the compounds detected above sample quantitation limits (SQL), potential constituents of concern (PCOCs) can be selected. For ease of presentation, those compounds not detected above SQLs, with a frequency of detection less than 5%, or detected in only one sample at a concentration below the MCL will not be discussed in the following sections.

The sample quantitation limit (SQL) is the lowest level at which a chemical may be accurately and reproducibly quantitated. The SQL concentration reported takes into account the particularities of the sample (e.g moisture content), sample preparation and analytical adjustments. In all data presented in this report, a non detected compound is presented as less than the SQL. In contrast, the practical quantitation limit is the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. SQLs are preferred to PQLs as they are more specific to the conditoins of each sample.

The group of compounds not assessed is limited to the volatile compounds listed below:

1,1,2,2-tetrachloroethane
1,1,2-trichloroethane
1,2-dichloroethane
1,2-dichloropropane
1,3-dichlorobenzene
1,4-dichlorobenzene
2-chloroethyl vinyl ether
bromodichloromethane
bromoform
bromomethane
chloroform
carbon tetrachloride
1,1,1-trichloroethane
chlorobenzene
chloroethane
chloromethane
cis-1,3-dichloropropene
dibromochloromethane
trans-1,2-dichloroethene
trans-1,3,dichloropropene
tetrachloroethene
trichloroethene
trichlorofluoromethane
vinyl chloride
methylene chloride

The above compounds had frequencies of detection of zero except for methylene chloride and 1,1,1-trichloroethane. Methylene chloride was detected in only one out of eighteen samples and is a common laboratory contaminant. 1,1,1-trichloroethane was detected in only one out of eighteen samples, at a concentration significantly below the MCL. As 1,1,1-trichloroethane is not considered a potential carcinogen and is considered protective of human health at the concentration at which it was detected, 1,1,1-trichloroethane was excluded from this assessment.

Volatiles were analyzed in groundwater, soil, sediments, and surface water sediments.

The minimum and maximum concentrations detected in the compounds retained, their frequency of detection, the SQLs and the location of the maximum concentration for individual compounds are summarized in Tables 4-2 to 4-5. Each individual compound is discussed below with a summary of the toxicological profile. The analytical data for samples from all media is summarized in Tables 2-4 to 2-13 Section 2.0.

TABLE 4-2
Groundwater Analytical Data Summary

Compounds	Sample Quantitation limit ug/L	Minimum Detected Value ug/L	Maximum Detected Value ug/L	Location with Maximum Detected Value ug/L	Frequency of Detection
Non Carcinogenic PAHs					
Naphthalene	2.00	2.90	4450	W-7	7/18
Acenaphthylene	2.00	7.84	262	W-2	5/18
Acenaphthene	2.00	3.35	350	W-8	4/18
Fluorene	0.200	0.375	296	W-8	6/18
Phenanthrene	0.500	0.735	560	W-8	5/18
Anthracene	0.500	7.42	95.1	W-8	3/18
Fluoranthene	0.200	1.02	115	W-8	4/18
Pyrene	0.200	0.600	104	W-8	4/18
Benzo(g,h,i,)perylene	0.050	11.6	16.7	W-8	2/18
Potentially Carcinogenic PAHs					
Carbazole	2.00	2.31	283	W-7	7/18
Chrysene	0.150	31.0	54.0	W-8	2/18
Benzo(a)anthracene	0.200	0.185	30.5	W-8	3/18
Benzo(b)fluoranthene	0.020	0.022	16.3	W-8	8/18
Benzo(k)fluoranthene	0.020	0.027	6.94	W-8	3/18
Benzo(a)pyrene	0.020	0.028	19.0	W-8	4/18
Dibenzo(a,h)anthracene	0.030	15.5	25.5	W-8	2/18
Indeno(1,2,3-cd)pyrene	0.050	1.99	4.36	W-8	2/18
Phenolic Compounds					
Phenol	0.500	0.537	2.80	W-2	10/18
2-Chlorophenol	0.500	0.702	4.13	W-2	2/18
2-Nitrophenol	0.500	0.769	5.36	W-2	4/18
2,4-Dimethylphenol	0.500	0.754	12.9	W-7	4/18
2,4-Dichlorophenol	0.500	0.594	7.46	W-8	11/18
4-Chloro-3-Methylphenol	0.500 - 5.00	0.662	22.7	W-7	11/18
2,4,6-Trichlorophenol	1.00	1.04	20.6	W-7	8/18
2,4-Dinitrophenol	1.00	2.18	23.0	W-7	4/18
4-Nitrophenol	1.00	1.04	163	W-8	6/18
2,3,5,6-Tetrachlorophenol	1.00	1.54	86.3	W-2	13/18
2-Methyl-4,6-Dinitrophenol	1.00	4.30	100	W-8	4/18
Pentachlorophenol	1.00	1.01	1300	W-13S	13/18

TABLE 4-2 (continued)
Groundwater Analytical Data Summary

Compounds	Sample Quantitation limit ug/L	Minimum Detected Value ug/L	Maximum Detected Value ug/L	Location with Maximum Detected Value ug/L	Frequency of Detection
Metals (total)					
Arsenic	10.0	12.0	180	W-8	3/18
Chromium	10.0		14.0	W-1	1/18
Copper	25.0		0.035	W-13S	1/18
Zinc	20.0	22.0	62.0	W-13S	6/18
Volatile Compounds Detected					
1,1-dichloroethene	5.00	10.2	81.7	W-6	2/18
1,1-dichloroethane	5.00	6.9	25.7	W-6	2/18
1,1,1-trichloroethane	5.00		15.7	W-6	1/18
Benzene	5.00	7.1	8.3	W-13I	2/18
Ethyl benzene	5.00	7.9	97.5	W-7	2/18
Toluene	5.00		61.3	W-7	1/18

TABLE 4-3
Soil Analytical Data Summary

Compounds	Range of Adjusted Sample Quantitation limit ug/kg	Minimum Detected Value ug/kg	Maximum Detected Value ug/kg	Location with Maximum Detected Value ug/kg	Frequency of Detection
Non Carcinogenic PAHs					
Naphthalene	100 - 136	50	36000	W-8	7/11
Acenaphthylene	100 - 136	50	50	W-4 to W-8	5/11
Acenaphthene	100 - 136	50	23000	W-8	5/11
Fluorene	20.0 - 100	50	20000	W-8	5/11
Phenanthrene	50.0 - 100	50	15000	W-8	6/11
Anthracene	50.0 - 100	50	15000	W-8	5/11
Fluoranthene	20.0 - 100	27.1	3000	W-7	8/11
Pyrene	20.0 - 100	45.6	13000	W-8	7/11
Benzo(g,h,i,)perylene	5.00 - 65.5	19.3	25.8	W-13S	3/6
Potentially Carcinogenic PAHs					
Carbazole	100 - 136	ND	ND		
Chrysene	15 - 100	34.1	3300	W-8	8/11
Benzo(a)anthracene	2.00 - 100	9.30	3300	W-8	9/11
Benzo(b)fluoranthene	2.00 - 100	16.5	1100	W-8	9/11
Benzo(k)fluoranthene	2.00 - 100	5.21	1100	W-8	9/11
Benzo(a)pyrene	2.00 - 100	7.94	1100	W-8	9/11
Dibenzo(a,h)anthracene	3.00 - 39.3	28.9	64.8	W-13S	3/6
Indeno(1,2,3-cd)pyrene	5.00 - 65.5	5.34	10.9	W-13S	3/6
Phenolic Compounds					
Phenol	53.5 - 68.0	50	79.0	W-12I	6/11
2-Chlorophenol	53.5 - 68.0	96.1	249	W-12I	2/6
2-Nitrophenol	53.5 - 68.0	ND	ND		0/6
2,4-Dimethylphenol	53.5 - 68.0	74.7	478	W-12I	4/11
2,4-Dichlorophenol	53.5 - 68.0	75.5	105	W-9S	2/6
4-Chloro-3-Methylphenol	53.5 - 68.0	ND	ND		0/6
2,4,6-Trichlorophenol	106 - 136		181	W-12I	1/6
2,4-Dinitrophenol	106 - 136	ND	ND		0/6
4-Nitrophenol	106 - 136	141	231	W-9S	2/11
2,3,5,6-Tetrachlorophenol	106 - 136	ND	ND		0/6
2-Methyl-4,6-Dinitrophenol	106 - 136	ND	ND		0/6
Pentachlorophenol	106 - 136	50	* 1200	W-8	9/14

TABLE 4-3 (continued)
Soil Analytical Data Summary

Compounds	Range of Adjusted Sample Quantitation limit ug/kg	Minimum Detected Value ug/kg	Maximum Detected Value ug/kg	Location with Maximum Detected Value ug/kg	Frequency of Detection
Metals (total)					
Arsenic	1000 - 2000	2000	7060	W-9S	3/4
Chromium	1000	14000	43500	W-9S	4/4
Copper	2500	28800	35900	W-9S	3/3
Zinc	2500	54400	69900	W-11S	3/3
Volatile Compounds Detected					
1,2-dichlorobenzene	21.4 - 27.2		22.0	W-14I	1/6

Note:

*: one sample collected from below the water table had a concentration of 58,000 ug/kg

TABLE 4-4
Sediment Analytical Data Summary

		Samples from the pond and discharge point (SS-2, SS-5, SS-6, SS-7)				Samples from the drainage ditch (SS-1, SS-3, SS-4)			
Compounds	Sample Quantitation limit ug/L	Minimum Detected Value ug/L	Maximum Detected Value ug/L	Location with Maximum Detected Value ug/L	Frequency of Detection	Minimum Detected Value ug/L	Maximum Detected Value ug/L	Location with Maximum Detected Value ug/L	Frequency of Detection
Non Carcinogenic PAHs									
Naphthalene	100	238	181000	SS-6	4/4	114	1320	SS-1	3/3
Acenaphthylene	100	2800	91400	SS-5	4/4	128	711	SS-1	3/3
Acenaphthene	100 - 2340	33100	72800	SS-6	2/4	ND	ND		0/3
Fluorene	20.0	532	78300	SS-5	4/4	21.3	193	SS-1	3/3
Phenanthrene	50.0	948	346000	SS-5	4/4	127	258	SS-1	3/3
Anthracene	50.0	343	132000	SS-5	4/4	3.94	84.8	SS-1	3/3
Fluoranthene	20.0	4420	367000	SS-5	4/4	164	1250	SS-4	3/3
Pyrene	20.0	1700.0	680000	SS-5	4/4	197	691	SS-1	3/3
Benzo(g,h,i,)perylene	5.00	1070	3820	SS-6	4/4	22.1	628	SS-4	2/3
Potentially Carcinogenic PAHs									
Carbazole	100	325	24000	SS-5	4/4	35.9	1190	SS-1	3/3
Chrysene	15.0	4560.0	73700	SS-5	4/4	116	2160	SS-4	3/3
Benzo(a)anthracene	2.00	2860.00	51700	SS-5	4/4	14.9	1300	SS-4	3/3
Benzo(b)fluoranthene	2.00	2220	32300	SS-5	4/4	37.0	581	SS-4	2/3
Benzo(k)fluoranthene	2.00	764	15900	SS-5	4/4		6.78	SS-3	1/3
Benzo(a)pyrene	2.00	1880	20300	SS-5	4/4	15.7	179	SS-4	2/3
Dibenzo(a,h)anthracene	3.00	2940	5440	SS-5	4/4	84.2	1060	SS-4	2/3
Indeno(1,2,3-cd)pyrene	5.00	2550	4830	SS-5	4/4	10.5	926	SS-4	2/3

TABLE 4-4 (continued)
Sediment Analytical Data Summary

Compounds	Sample Quantitation limit ug/kg	Samples from the pond and discharge point (SS-2, SS-5, SS-6, SS-7) Minimum Detected Value ug/kg	Maximum Detected Value ug/kg	Location with Maximum Detected Value ug/kg	Frequency of Detection	Samples from the ditch (SS-1, SS-3, SS-4) Minimum Detected Value ug/kg	Maximum Detected Value ug/kg	Location with Maximum Detected Value ug/kg	Frequency of Detection
Phenolic Compounds									
Phenol	16.7 - 195	2390	23300.0	SS-5	3/4	31.6	121	SS-1	2/3
2-Chlorophenol	16.7 - 109	3710	24300	SS-5	4/4	239	3810	SS-4	2/3
2-Nitrophenol	16.7 - 195	731	5870	SS-5	3/4	ND	ND		0/3
2,4-Dimethylphenol	16.7 - 2850		199	SS-6	1/4		209	SS-3	1/3
2,4-Dichlorophenol	16.7 - 195	1180	7290	SS-5	3/4	ND	ND		0/3
4-Chloro-3-Methylphenol	16.7 - 195	810	6330	SS-5	3/4		28.4	SS-3	1/3
2,4,6-Trichlorophenol	33.3 - 5700		3180	SS-7	1/4	ND	ND		0/3
2,4-Dinitrophenol	33.3 - 5700	ND	ND		0/4	ND	ND		0/3
4-Nitrophenol	33.3 - 390	4100	21400	SS-5	3/4	ND	ND		0/3
2,3,5,6-Tetrachlorophenol	33.3 - 5700		1950	SS-7	1/4	ND	ND		0/3
2-Methyl-4,6-Dinitrophenol	33.3 - 218	538	256000	SS-5	4/4	ND	ND		0/3
Pentachlorophenol	33.3	4730	196000	SS-6	4/4	77.2	5060	SS-4	3/3
Metals (total)									
Arsenic	1000.0	220000	1580000	SS-7	4/4	36800	115000	SS-1	3/3
Chromium	1000	52600	160000	SS-6	4/4	33500	43600	SS-1	3/3
Copper	2500	574000	4360000	SS-6	4/4	53400	932000	SS-4	3/3
Zinc	2000	27700	1340000	SS-5	4/4	79400	216000	SS-4	3/3
Volatile Compounds Detected									
Benzene	0.20		2350.0	SS-6	1/4		ND		0/3
Toluene	0.2	89.4	3000	SS-6	4/4		56.6	SS-3	1/3
Ethyl benzene	0.2		2950	SS-5	1/4		ND		0/3
Xylenes	0.3	59.1	8090	SS-5	4/4		53.2	SS-1	1/3
Styrene	0.3		1510	SS-5	1/4		ND		0/3

TABLE 4-5
Surface Water Analytical Data Summary

Compounds	Sample Quantitation limit ug/L	Samples from the pond and discharge point (SW-2, SW-5, SW-6, SW-7)				Samples from the drainage ditch (SW-1, SW-3, SW-4)			
		Minimum Detected Value ug/L	Maximum Detected Value ug/L	Location with Maximum Detected Value ug/L	Frequency of Detection	Minimum Detected Value ug/L	Maximum Detected Value ug/L	Location with Maximum Detected Value ug/L	Frequency of Detection
Non Carcinogenic PAHs									
Naphthalene	2.00		4.56	SW-2	1/4		ND		0/3
Acenaphthylene	2.00		2.80	SW-2	1/4		ND		0/3
Acenaphthene	2.00	2.49	37.4	SW-2	2/4		ND		0/3
Fluorene	0.200	0.266	2.15	SW-2	4/4		0.222	SW-4	1/3
Phenanthrene	0.500	1.17	7.93	SW-2	4/4		0.579	SW-4	1/3
Anthracene	0.500	1.18	8.58	SW-2	4/4		0.508	SW-4	1/3
Fluoranthene	0.200	8.41	78.7	SW-2	4/4		2.94	SW-4	1/3
Pyrene	0.200	6.02	18.5	SW-7	4/4		1.81	SW-4	1/3
Benzo(g,h,i,)perylene	0.050	0.486	2.96	SW-2	4/4	0.081	0.090	SW-4	2/3
Potentially Carcinogenic PAHs									
Carbazole	2.00		ND		0/4		ND		0/3
Chrysene	0.150	0.386	10.7	SW-7	4/4		1.21	SW-4	1/3
Benzo(a)anthracene	0.020	2.20	7.53	SW-7	4/4	0.088	0.462	SW-4	2/3
Benzo(b)fluoranthene	0.020	1.00	9.76	SW-2	4/4	0.06	0.306	SW-4	2/3
Benzo(k)fluoranthene	0.020	0.395	2.98	SW-2	4/4		0.076	SW-4	1/3
Benzo(a)pyrene	0.020	0.454	2.15	SW-2	3/4		ND		0/3
Dibenzo(a,h)anthracene	0.030	0.754	3.97	SW-2	4/4		0.086	SW-1	1/3
Indeno(1,2,3-cd)pyrene	0.050	0.154	1.17	SW-2	4/4		0.073	SW-4	1/3

TABLE 4-5 (continued)
Surface Water Analytical Data Summary

Compounds	Sample Quantitation limit ug/kg	Samples from the pond and discharge point (SW-2, SW-5, SW-6, SW-7)				Samples from the drainage ditch (SW-1, SW-3, SW-4)			
		Minimum Detected Value ug/kg	Maximum Detected Value ug/kg	Location with Maximum Detected Value ug/kg	Frequency of Detection	Minimum Detected Value ug/kg	Maximum Detected Value ug/kg	Location with Maximum Detected Value ug/kg	Frequency of Detection
Phenolic Compounds									
Phenol	0.500	1.04	2.42	SW-7	4/4		1.32	SW-1	1/3
2-Chlorophenol	0.500	0.527	0.934	SW-2	3/4		ND		0/3
2-Nitrophenol	0.500	1.49	2.58	SW-5	4/4	3.02	3.25	SW-1	2/3
2,4-Dimethylphenol	0.500	0.649	0.855	SW-2	4/4		ND		0/3
2,4-Dichlorophenol	0.500	0.517	0.920	SW-2	4/4		ND		0/3
4-Chloro-3-Methylphenol	0.500		0.787	SW-2	1/4		ND		0/3
2,4,6-Trichlorophenol	1.00	2.91	4.16	SW-2	4/4	1.32	1.40	SW-4	2/3
2,4-Dinitrophenol	1.00	1.62	11.8	SW-6	4/4		1.12	SW-4	1/3
4-Nitrophenol	1.00	1.12	4.82	SW-6	4/4		ND		0/3
2,3,5,6-Tetrachlorophenol	1.00	9.76	23.8	SW-2	4/4	2.96	3.93	SW-4	2/3
2-Methyl-4,6-Dinitrophenol	1.00	67.3	146	SW-2	4/4		26.8	SW-4	1/3
Pentachlorophenol	1.00	135	596	SW-2	4/4	12.2	44.4	SW-4	2/3
Metals (total)									
Arsenic	10.0	1180	1760	SW-2	4/4	13.0	698	SW-4	3/3
Chromium	10.0	10.7	40.2	SW-2	4/4		ND		0/3
Copper	25.0	611	2610	SW-2	4/4	67.4	267	SW-4	2/3
Zinc	20.0	380	992	SW-2	4/4	29.8	179	SW-4	3/3
Volatile Compounds Detected									
Methylene Chloride			ND		0/4		65.0	SW-1	1/3

Volatile Organic Compounds

The analytical data are summarized in Tables 4-2 to 4-5. The relevant drinking water criteria (MCLs, MCLGs and SMCLs) for the volatile compounds detected in groundwater are presented in Table 4-6. The water quality criteria for the protection of freshwater aquatic organisms are presented in Table 4-7. The PCOCs detected in the surface waters are further discussed in Section 4.6.2.

1,1-Dichloroethene

1,1-Dichloroethene was analyzed in the groundwater and surface water samples. It was not analyzed in the soil and sediment samples. 1,1-Dichloroethene was detected in two out of eighteen groundwater samples at concentrations of 81.7 ug/L in W-6 and 10.2 in W-13I. It was not detected in the surface water samples and thus not retained for this medium.

Volatilization is a significant contributor toward the removal of 1,1-dichloroethene from aquatic systems (U.S. EPA, 1979). Once in the troposphere, the double bond reacting with hydroxyl radicals produces a variety of byproducts. 1,1-Dichloroethene has a solubility of 400 mg/L and a vapor pressure of 591 torr at $20^{\circ}C$ (U.S. EPA, 1982). Its Henry's Law constant is 1.9×10^{-1} atm-m^3/mol. The rate of volatilization is dependent on the agitation and mixing of the water.

The relatively low log octanol water partition coefficient (K_{ow}) of 1.48 indicates sorption probably has minimal effect in the aquatic fate process (U.S. EPA, 1979). The processes of photolysis, bioaccumulation, biotransformation and biodegradation have no significant effect on the fate process (U.S. EPA, 1979).

Due to reactions with free radicals in both volatilized and aqueous phases, oxidation and hydrolysis appear to play significant roles in the fate process of 1,1-dichloroethene (U.S. EPA, 1979).

1,1-Dichloroethene has been found to cause neurological disorders in humans contacting the compound by the inhalation and dermal routes (Quast et al., 1983).

TABLE 4-6
Relevant Criteria and Guidelines for Volatile Compounds
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

Volatile Compounds	MCL (ug/l)	MCLG (ug/l)	SMCL (ug/l)
1,2- Dichlorobenzene	600(F)	600(F)	NA
1,1,1-Trichloroethane	200(F)	200(F)	NA
1,1-Dichlororoethane	NA	NA	NA
1,1-Dichloroethene	7(F)	7(F)	NA
Methylene Chloride	5(T)	Zero(F)	NA
Benzene	5(F)	Zero(F)	NA
Ethylbenzene	700(F)	700(P)	30(P)
Styrene	100(F)	100(F)	NA
Toluene	1000(F)	1000(F)	NA
Xylenes	10,000(F)	10,000(F)	NA

Notes:

P - Proposed (Phase II Draft Proposal)
F - Final
D - Draft
L - Listed for Regulation
T - Tentative (Phase V)
NA - Not Available
MCL - Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
SMCL - Secondary Maximum Contaminant Level

References:

U.S. EPA, 1990
U.S. EPA. 1991a
U.S. EPA, 1991b

TABLE 4-7

Summary of Available Water Quality Criteria for PCOCs retained in Surface Water
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

PCOC	Surface Water (ug/L) Freshwater Acute Criteria	Freshwater Chronic Criteria
Volatiles		
Methylene chloride	11000	NA
Phenolics		
Phenol	10200	2560
2,4-dichlorophenol	2020	365
2,4,6-trichlorophenol	NA	970
Pentachlorophenol	(1) 55	(1) 3.2
Metals		
Arsenic	850	48
Chromium (III)	980	120
Chromium (VI)	16	11
Copper	(2) 18	(2) 12
Zinc	(2) 320	47

Notes:

(1) Insufficient data to develop criteria. Value presented is based on L.O.E.L. (Lowest Observed Effect Level)

(2) Hardness dependent criteria. 100 mg/l used.

Reference:

U.S. EPA, 1986

Experimental studies on rats resulted in increased incidences of tumors and lesions in the kidneys, liver, and adrenal glands of animals exposed to 50 ppm in drinking water over a two year period and 10 to 25 ppm by gavage over one year (Quast et al., 1983; U.S. EPA, 1984a).

The U.S. EPA established an oral reference dose (RfD) of 0.009 mg/kg/day based on the study of those rats exposed to 50 ppm of 1,1-dichloroethene in drinking water for two years. Oral and inhalation cancer slope factors (CSF) of 0.6 and 1.2 $(mg/kg/day)^{-1}$, respectively, were derived based on studies of rats exposed to 10 to 25 ppm 1,1-dichloroethene by gavage for over one year. The CSF values were based on the development of adrenal and kidney tumors in rats and mice, respectively. 1,1-Dichloroethene is classified as a Group B carcinogen (Probable Human Carcinogen). 1,1-Dichloroethene has a MCL of 0.007 mg/L in drinking water (U.S. EPA, 1990a). The acute criteria for freshwater aquatic organisms is 11.6 mg/L.

1,1-Dichloroethane

1,1-Dichloroethane was not analyzed in the soil and sediment samples. It was analyzed in the groundwater samples and in the surface water samples. 1,1-Dichloroethane was detected in two out of eighteen groundwater samples at concentrations of 6.9 ug/l in well W-13I and 25.7 ug/L in well W-6. It was not detected in the surface water samples and thus not retained as a PCOC in this medium.

Man-made 1,1-dichloroethane is used as an extraction solvent, fumigant and as a constituent of medicine and in the formation of stone, clay and glass products (Infante & Tsongas, 1982). 1,1-Dichloroethane is emitted into the environment during manufacturing processes and during the use of the compound as a solvent or fumigant (Infante & Tsongas, 1982). The production of 1,1,1-trichloroethane and 1,2-dichloroethane account for most of the 1,1-dichloroethane released (Pellizzari, 1982), and most releases are emitted into the atmosphere (Perwak et al., 1982). Release of 1,1-dichloroethane into surface water, groundwater and soil is minimal (Perwak et al., 1982; EPA, 1988b).

Because of its high volatility and low water solubility (5500 mg/L) (Grayson, 1978), removal of 1,1-dichloroethane from the atmosphere by precipitation is not significant (EPA, 1985b). Once in surface water, 1,1-dichloroethane is expected to reenter the atmosphere because of its high vapor pressure (230 torr at 25^{o} C) (HSDB, 1988);(Dilling et al., 1975).

In the atmosphere, 1,1-dichloroethane reacts with hydroxyl radicals (Singh et al., 1981; U.S. EPA, 1980a; Howard & Everson, 1976). In water and soil, no significant degradation occurs before volatilization into the atmosphere (Dilling et al., 1976; Wilson et al., 1981). 1,1-Dichloroethane is formed by biodegradation of 1,1,1-trichloroethane (McCarty et al., 1986) and further degradation occurs by reductive dehydrohalogenation by anaerobic methane-producing bacteria (Tabek et al., 1981). In the soil, the compound is expected to sorb to soils with high organic content (Wilson et al., 1983).

1,1-Dichloroethane has a chronic oral RfD set at 0.1 mg/kg/day and a chronic inhalation RfD set at 0.1 mg/kg/day (U.S. EPA, 1989d). This compound is classified as a class B2 - Probable Human Carcinogen by the EPA with its effect being hemangiosarcoma (U.S. EPA 1984b; NCI, 1978; U.S. EPA, 1985b). The oral carcinogen slope factor (CSF) for 1,1-dichloroethane is 9.1×10^{-2} $(mg/kg/day)^{-1}$ (U.S. EPA, 1984b; NCI, 1978; U.S. EPA, 1985b). No MCL for 1,1-dichloroethene currently exists or is proposed.

1,2-Dichlorobenzene

1,2-dichlorobenzene was analyzed in the soil and sediment samples. It was detected in one out of six soil sample (W-14I) at a concentration of 22 ug/kg, and was retained for assessment in this medium. 1,2-dichlorobenzene was not detected in the sediment samples and , therefore not retained for assessment in this medium.

1,2-dichlorobenzene (1,2-DCB) is used as a solvent for waxes, gums, resins, tars, rubbers and asphalts. It is also used as an insecticide for termites and locust borers and as a fumigant (Merck, 1989).

The major source of atmospheric 1,2-DCB is, reportedly, solvent applications which account for approximately 25 percent of the annual emission of the chemical. The half-life for the vapor phase of 1,2-DCB is estimated at approximately 24 days (Howard, 1989). It is eliminated predominantly through reactions with photochemically produced hydroxyl radicals. Removal by rain washout is also possible.

1,2-DCB is moderately to tightly adsorbed to soils, and volatilization may be an important transport mechanism. Volatilization from surface soils may be attenuated by tight adsorption or leaching (Elder at al., 1981). 1,2-DCB may be biodegraded slowly in soils under anaerobic conditions. Hydrolysis, oxidation or direct photolysis are not expected to occur.

1,2-DCB is volatilized from surface waters, with an estimated half-life of 4 to 5 hours. Degradation of the compound in aerobic conditions may occur after microbial adaptation. However, 1,2-DCB is not expected to biodegrade under anaerobic conditions which may exist in pond or lake sediments or various groundwaters.

Mean 1,2-DCB Bioconcentration Factor (BCF) values of 270 to 560 were derived experimentally for rainbow trout exposed for as long as 119 days. Other species for which BCFs have been derived include bluegill sunfish, exposed over a 28 day period. Their BCF was estimated to be 66. BCFs derived empirically using water solubility and the low K_{ow} range from 36 to 218 (Howard, 1989).

Exposure to 1,2-DCB by the general population can occur incidentally given the widespread environmental occurrence of the chemical. Occupational exposure is also possible as 1,2-DCB is widely under various forms in the industry.

U.S. EPA (1991a) has established a verified oral reference dose (RfD) of 0.09 mg/kg/day on the basis of liver necrosis, lymphocyte depletion, renal tubular degeneration (male rats only) and decreased hematocrit and red blood cell counts in study animals. Developmental toxicity was not evident. An uncertainty factor of 1000 was used in the extrapolation of dose levels from animals to humans, human variability and adequacy of chronic toxicity studies.

The potential carcinogenecity of 1,2-DCB is currently under review by the U.S. EPA and a risk assessment summary is forthcoming.

Final MCL and final MCLG values of 0.6 mg/L have been proposed by the U.S. EPA for 1,2-DCB as a category III (non-carcinogenic) constituent (U.S. EPA, 1991b). These values were derived from DWEL of 3.0 mg/L, applying a 20 percent contribution of 1,2-DCB from drinking water.

Unless the Office of Management and Budget (OMB) object to the MCL and MCLG values current status as "proposed final", the MCL and MCLG value become final as of February 13, 1991 and are effective July 30, 1992.

Benzene

Benzene was analyzed in the groundwater samples, the June 1990 soil samples and the November 1990 sediment and surface water samples. It was detected in one out of seven sediment samples at a concentration of 2,350 ug/kg, and in two out of eighteen groundwater samples at concentrations of 7.1 ug/L (W-7) and 8.3 ug/L (W-13I). It was not detected in the other media and is retained as a PCOC for the groundwater assessment only.

Benzene is used in the manufacture of detergents, pesticides, solvents and paint removers. It is an intermediate in the production of many organic chemicals and is present in gasoline (Proctor et al., 1988).

The most significant factor regarding the aquatic transport of benzene is volatilization especially where the water is turbulent or agitated (U.S. EPA, 1979). Direct photolysis of benzene in the stratosphere is an unlikely process due to the relatively rapid and complete rate of its reaction with hydroxyl radicals in the troposphere. Also, because of benzene's propensity to volatilize, there is minimal photooxidation in the aqueous medium.

The solubility of benzene is 1780 mg/L at 25°C. Its vapor pressure at 25°C is 95.2 torr (U.S. EPA, 1982). Its Henry's Law constant is 5.5 x 10^{-3} atm-m^3/mol. The log octanol-water coefficient is 2.13. Sorption processes may be a relatively significant contributor to benzene's aquatic fate under conditions of constant exposure (U.S. EPA, 1979).

Other destructive processes are not as significant as volatilization. Bioaccumulation is probably low. Some soil bacteria have been noted to degrade benzene, but this process was noted to have been facilitated by the presence of other hydrocarbons. There also is evidence of biodegradation at low concentrations by aquatic microorganisms.

Benzene has been classified as a Class A Human Carcinogen (U.S. EPA, 1990). Occupational exposure to benzene has been associated with increased incidences of nonlymphocytic leukemias. Acute benzene exposure causes central nervous system depression while chronic exposure results in depression of the hematopoietic system (Proctor et al., 1988). Verified oral and inhalation Carcinogenic Slope Factors (CSF) are both 0.029 $(mg/kg/day)^{-1}$ (U.S. EPA, 1990a).

No lifetime drinking water Health Advisory has been determined for Benzene. The MCL is 0.005 mg/L in drinking water (U.S. EPA, 1990a). A final MCLG has been set at 0 mg/L for benzene based on carcinogenic data (U.S. EPA, 1990a). The ambient water quality criteria for benzene for water and fish consumption is 0.66 ug/L. An acute lowest effect concentration (L.E.C) of 5,300 ug/L has been determined for freshwater organisms, respectively (U.S. EPA, 1990a).

Ethylbenzene

Ethylbenzene was analyzed in all media. It was detected in two out of eighteen groundwater samples at concentrations of 97.5 ug/L (well W-7) and 7.90 ug/L (W-8), below the MCL of 700 ug/L. Ethyl benzene was also detected in one out of seven sediment samples (SS-5) at a concentration of 2,950 ug/kg. This sample (SS-5) was collected from the retention pond. It was not detected in sediment or surface water samples collected from the drainage ditch and has therefore not been retained for these two media (sediment, surface water).

Ethyl benzene was not detected in the surface water and soils samples. It was therefore not retained for these media.

Volatilization contributes significantly toward removal of ethylbenzene from the aquatic environment (U.S. EPA, 1979). Ethylbenzene has a solubility in water of 152 mg/L and relatively low vapor pressure, 7 torr, at 20^{o}C (U.S. EPA, 1982). Its Henry's Law constant is 6.6×10^{-3} atm-m^3/mol. The rate of volatilization is likely to be dependent upon the rate of agitation and mixing of the water. Once in the atmosphere, ethylbenzene is photooxidized.

Ethylbenzene has a relatively high log octanol-water coefficient of 3.3 indicating that sorption processes may be a significant factor in ethylbenzene's aquatic fate (U.S. EPA, 1979). Other destructive processes, such as hydrolysis, oxidation and biodegradation, probably contribute very little overall to the general degradation of ethylbenzene in the environment.

Ethylbenzene is an irritant of the skin and mucous membranes (Proctor et al., 1988). While experimental animals experienced narcosis and death at 10,000 ppm of ethylbenzene, intolerable irritation of human nose and eyes occurs at 5000 ppm. Despite its structural similarity to benzene, ethylbenzene does not seem to cause damage to the hematopoietic system.

The U.S. EPA established an oral reference dose (RfD) of 0.1 mg/kg/day for ethylbenzene based on a 182-day rat study in which ethylbenzene was administered by gavage 5 days per week at doses of 13.6, 136, 408 or 608 mg/kg/day. Histopathological changes were noted in the liver and kidney at the 408 mg/kg/day dose level (U.S. EPA, 1990a). An inhalation RfD has not been established. The U.S. EPA carcinogenicity classification for ethylbenzene is Group D - not classified.

Ethylbenzene has a proposed MCL and MCLG of 0.700 mg/L and SMCL of 0.03 mg/L (U.S. EPA, 1990a). The ambient water quality criteria for ethylbenzene has been set at 1.4 mg/L for water and fish consumption (U.S. EPA, 1990a). The acute criteria for freshwater aquatic organisms is set at 32 mg/L. A lifetime health advisory of 0.68 mg/L has been established for humans.

Styrene

Styrene was not analyzed in the groundwater or surface water samples. It was analyzed in the sediment samples and the June 1990 soil samples. Styrene was detected in one out of seven sediment samples (SS-5) at a concentration of 1,510 ug/kg. This sample being collected from the retention pond, styrene was not retained as a PCOC. Styrene was not detected in the soil samples.

Styrene is used in the manufacturing processes of polymerized synthetic materials including plastics, synthetic rubber and resins (Proctor et al., 1988). It is produced from the dehydrogenation of ethylbenzene (U.S. EPA, 1987).

The vapor pressure of styrene at 20°C is 4.53 torr and at 25 °C is 6.18 torr. The water solubility at 20°C is 300 mg/L (Verschueren, 1983). These parameters indicate that volatilization and entry to the atmosphere is likely to be dependent upon the rate of agitation and mixing of the water. The log octanol-water coefficient is 2.95 which indicates that sorption processes may be a relatively significant contributor to styrene's aquatic fate (U.S. EPA, 1987).

Styrene is an irritant of the eyes and mucous membranes and a central nervous system depressant (Proctor et al., 1988). Humans exposure to 376 ppm for 15 minutes resulted in eye and nasal irritation. After one hour, effects indicated transient neurologic impairment. Although upper respiratory and eye irritation may occur at 50 ppm, no evidence of lower respiratory effects in pulmonary function was reported. Styrene is mainly excreted in the urine after metabolism to mandelic acid and phenylglyoxylic acid.

The U.S. EPA established an oral reference dose (RfD) of 0.2 mg/kg/day for styrene based on several studies (U.S. EPA, 1990a). A study involving beagle dogs gavaged with doses of styrene monomer of 0, 200, 400, or 600 mg/kg-bw/day for 560 days indicated changes in red blood cells and accumulation of iron and Heinz bodies in the liver. Studies in rats and mice for 120 weeks showed liver, kidney and stomach lesions for rats dosed weekly with 500 mg/kg styrene, and no effects for mice dosed weekly with 300 mg/kg. Chronic toxicity risk assessment could not be performed with the rodent studies because of the dosing schedule.

U.S. EPAs Health Effects Assessment Summary Tables (Third Quarter, FY-90) (EPA, 1990b) lists styrene as a B2-probable human carcinogen currently under review by the CRAVE work group. A CSF of 0.03 $(mg/kg/d)^{-1}$ is proposed. For the sake of conservatism, styrene will be assessed as a B2 carcinogen in this study.

The OSHA Permissible Exposure Limit (PEL-TWA) for styrene is 50 ppm (215 mg/m^3). The Short Term Exposure Limit (STEL) is 100 ppm (425 mg/m^3) (OSHA, 1989). Final MCL and MCLG values of 1 mg/L have been set for styrene (U.S. EPA, 1991a).

Toluene

Toluene was analyzed in the July 1990 groundwater samples, the June 1990 soil samples, the surface water and sediment samples. It was detected in one out of eighteen groundwater samples at a concentration of 61.3 ug/L in well W-7, below the MCL of 1 mg/L. Toluene is not considered a potential carcinogen by the EPA and was therefore not retained for the groundwater assessment. Toluene was also detected in five out of seven sediment samples. It was present in the four sediment samples collected from the retention pond (SS-5, SS-6, SS-7) and the outfall to the ditch (SS-2) at a maximum concentration of 3,000 ug/kg (SS-6). Toluene was detected in one sediment sample collected from the drainage ditch (SS-3) at a concentration of 56.6 ug/kg and was thus retained for this medium.

Toluene was not detected in the surface water and soil samples.

Toluene is a liquid at ambient conditions. It has a moderate solubility in water, 535 mg/L at 25°C. It has a vapor pressure of 28.7 torr at 20°C, and its Henry's Law constant is 6.6 x 10^{-3} atm-m^3/mol. The log octanol-water coefficient is 2.79 (U.S. EPA, 1982).

Volatilization is the major transport process for removal of toluene from aquatic systems (U.S. EPA, 1979). Once in the troposphere, reaction with free hydroxyl radicals occurs at a relatively rapid rate. The benzyl radical produced subsequently reacts with molecular oxygen to form benzyl hydroperoxide. Further dissociation to benzyl alcohol and benzaldehyde complete the removal of toluene from the atmosphere. Direct photolysis probably does not occur since photooxidation destroys toluene before it can reach the stratosphere.

Oxidation and hydrolysis occur to a far lesser extent than the volatilization driven transport of toluene, and are considered to be relatively insignificant contributors to the fate of this compound.

Sorption processes may be influenced by the relatively high log octanol-water coefficient. Bioaccumulation, biotransformation and biodegradation probably occur to some degree but are not expected to be significant when compared to volatilization processes.

Toluene does not produce the hematopoietic effects caused by benzene, although it is structurally similar. Toluene is a central nervous system depressant (Proctor et al., 1988). Currently, toluene has the U.S. EPA carcinogenic classification of Group D - Not Classified. Toluene has a verified oral reference dose (RfD) of 0.2 mg/kg/day (U.S. EPA, 1990a). The inhalation RfD for toluene is currently being reviewed by an EPA work group. There are no current data available to determine and establish oral and inhalation CSFs for toluene.

Toluene has final MCL and MCLG values of 1.0 mg/L for drinking water (U.S. EPA, 1991a). A proposed SMCL of 0.04 mg/L has also been established by the EPA (FR Vol. 54, No. 97, 5/89). Human health ambient water quality criteria for fish and water consumption is established at 14.3 mg/L (U.S. EPA, 1990a). The acute criteria for freshwater aquatic organisms is set at 17.5 mg/L. A lifetime health advisory of 1 mg/L in drinking water has been determined for toluene.

Xylenes

Xylenes were not analyzed in the groundwater and surface water samples. They were analyzed in the June 1990 soil samples and the sediment samples. Xylenes were detected in five out of seven sediment samples at concentrations ranging from 53.1 ug/kg (SS-1) to 8,090 ug/kg (SS-5). One of the five sediment samples in which xylenes were detected was collected from the drainage ditch. Xylenes were therefore retained for assessment in the sediments.

Xylenes were not detected in the soil samples.

Xylene is a colorless liquid which is used as a solvent and is present in gasoline and petroleum distillation products. Three isomers of xylene exist in commercial preparations: *o*-xylene; *m*-xylene; and *p*-xylene (U.S. EPA, 1985). Physical parameters for the mixed isomers (o/m/p) are as follows: solubility in water at 20°C, 175/160/198 mg/L; vapor pressure at 20°C, 5/6/6.5 torr; log octanol-water coefficient, 3.12/3.20/3.15; specific gravity at 20°C, 0.88/0.864/0.86.

Volatilization appears to be the most significant process for removal of xylenes from water. Sorption to sediments varies depending upon the organic matter content. In the air, degradation is rapid, with a half-life of a few days (U.S. EPA, 1987). However, photolysis is not a significant degradation process as xylenes do not absorb light greater than 300 nanometers well (U.S. EPA, 1985c). Biodegradation in soil is rapid, but varies depending on the susceptibility of the microorganisms to xylene toxicity (U.S. EPA, 1985c).

Xylene vapor irritates the eyes, mucous membranes and skin. Liquid xylene irritates the skin and can cause erythema, dryness, and defatting. Inhalation of xylene vapor can cause narcosis. Xylenes are absorbed well via inhalation and metabolized in humans to methyl hippuric acid (95%) and xylenols (1-2%) (U.S. EPA, 1987). Hematological effects reported in the literature can apparently be attributed to contamination of xylene preparations with benzene (Proctor et al., 1988).

The OSHA Permissible Exposure Limit (PEL-TWA) for xylene is 100 ppm (435 mg/m^3). The Short Term Exposure Limit (STEL) is 150 ppm (655 mg/m^3) (OSHA, 1989). The U.S. EPA established a verified oral reference dose (RfD) of 2.0 mg/kg/day, and an unverified inhalation RfD of 0.3 mg/kg/day (U.S. EPA, 1990b). The U.S. EPA (1990) carcinogenicity classification for xylenes is Group D - not classified. The final MCL and MCLG values for drinking water are 10 mg/L (U.S . EPA, 1991a).

Phenolic Compounds

The analytical data are summarized in Tables 4-2 to 4-5. The MCL criteria for the phenolic compounds are presented in Table 4-8.

Pentachlorophenol

Pentachlorophenol (PCP) was detected above SQLs in nine out of fourteen soil samples, seven out of seven sediment samples, six out of seven surface water samples, and in thirteen out of eighteen groundwater samples.

In groundwater, the concentrations ranged from 1.01 ug/L in well W-4 to a maximum of 1,300 ug/L in well W-13S. In soils, the concentrations detected in thirteen samples collected above the water table ranged from 50 ug/kg (W-1, W-3 to -7) to 1,200 ug/kg (W-8). PCP was detected at 58,000 ug/kg in one sample collected below the groundwater table, at 20.0 to 21.0 feet below ground surface. This data point, and the maximum of 1,200 ug/kg, originate from samples collected by Brown and Caldwell in 1986.

PCP concentrations in sediments collected from the south drainage ditch (SS-1, SS-3 and SS-4) ranged from 950 ug/kg to 5,060 ug/kg. A sample collected from the discharge point of the surface runoff retention pond to the ditch (SS-2) had a PCP concentration of 4,730 ug/kg. The three sediment samples collected at the bottom of the surface runoff retention pond exhibited PCP concentrations of 52,500 ug/kg, (SS-5), 196,000 ug/kg (SS-6), and 95,300 ug/kg (SS-7).

TABLE 4-8
Relevant Criteria and Guidelines for Phenolic Compounds
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

Phenolics	MCL ug/l	MCLG ug/l	SMCL ug/l
2,3,5,6-Tetrachlorophenol	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA
2-Chlorophenol	NA	NA	NA
2-Methyl-4,6-dinitrophenol	NA	NA	NA
2-Nitrophenol	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA
4-Nitrophenol	NA	NA	NA
Pentachlorophenol	1 (P)	0 (P)	30 (P)
Phenol	NA	NA	NA

Notes:
P - Proposed (Phase II Draft Proposal)
NA - Not Available
MCL - Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
SMCL - Secondary Maximum Contaminant Level

References:

U.S. EPA, 1990
U.S. EPA, 1991b

PCP was detected in two out of three surface water samples collected from the drainage ditch at concentrations of 12.2 ug/L (SW-1) and 44.4 ug/L (SW-4). At the pond discharge point (SW-2), PCP was detected at a concentration of 596 ug/L. In the surface water samples collected directly from the retention pond, concentrations ranged from 135 ug/L (SW-5) to 402 ug/L (SW-7).

PCP was retained for all the media assessed.

Pentachlorophenol has a proposed MCL set at 1 ug/L. It is expected this MCL will be promulgated in June 1991, and will become effective January 1993. In all the groundwater samples where it was detected, concentrations were above 1 ug/L. The wells in which pentachlorophenol was not detected were W-3, W-9S and 9I, W-12D and W-13D.

Quality criteria for freshwater toxicity have been set by the U.S. EPA at 22 ug/L for acute toxicity and 13 ug/L for chronic toxicity. The criteria for acute and chronic toxicity are exceeded in five surface water samples, and one additional sample exceeds the chronic criteria only.

Pentachlorophenol (PCP) consists of a fully substituted six carbon aromatic ring containing one hydroxyl group and five chlorine atoms. PCP is a weak acid with a pKa of approximately 10^{-5} (U.S. EPA, 1979).

In aquatic organisms bioconcentration in higher trophic level aquatic organisms varies inversely to pH (Kobayashi and Kishino, 1980; Spehar et al., 1985) and occurs mostly within the gall bladder (Glickman et al., 1977), with residue levels rapidly dropping upon termination of exposure. Other factors influence acute toxicity to freshwater fish include: lifestage, water temperature, and dissolved oxygen concentration.

Biodegradation and photolysis appear to be important fate processes in the environment for PCP, whereas hydrolysis, oxidation, and volatilization are not as significant in the fate processes (U.S. EPA, 1979). Mobility of PCP in soils generally increases with increasing pH and temperature. Adsorption of PCP onto acidic soils is greater than adsorptive processes observed in neutral soils (Hiatt et al., 1960).

The U.S. EPA has recently classified PCP as a class B2-Probable Human Carcinogen (CRAVE, 1990). An oral Cancer Slope Factor (CSF) of 0.12 $(mg/kg/day)^{-1}$ was established by the U.S. EPA (1990) based on a National Toxicology Program study of the carcinogenic effects of PCP in B6C3F1 mice (NTP, 1989). Doses of 17 and 35 mg/kg/day (females) and 18 and 35 mg/kg/day (males) of technical grade PCP (TG-PCP) were administered for 103 weeks. Dowicide (EC-7) was administered at 18, 38 and 118 mg/kg/day (males) and 17, 34 and 114 mg/kg/day (females) for 103 weeks. For both groups, significant increases in incidences of hepatocellular adenomas, adrenal gland medulla pheochromocytomas and malignant pheochromocytomas were found as well as hemangiomas and hemangiosarcomas of the vascular system.

Pentachlorophenol has a final MCL of 1 ug/L, enforceable as of January 1993 (EPA, 1991c). A proposed MCLG of 0 mg/l has also been suggested based on the carcinogenic potential of the compound. A lifetime health advisory of 0.2 mg/l has been established for PCP based on the assumption of 20% exposure by drinking water (U.S. EPA, 1990c).

Nitrophenols

Nitrophenols (2,4-dinitrophenol, 2-methyl-4,6-dinitrophenol, 2-nitrophenol, and 4-nitrophenol) were analyzed in all media.

In groundwater, 2,4-dinitrophenol was detected in four out of eighteen groundwater samples at concentrations ranging from 2.18 ug/L (W-13S) to 23.0 ug/L (W-5); 2-methyl-4,6-dinitrophenol in four out of eighteen samples at concentrations of 4.3 ug/L (W-13S) to 100 ug/L (W-8); 4-nitrophenol in six out of eighteen samples at concentrations of 1.04 ug/L (W-6) to 163 ug/L (W-8); and 2-nitrophenol in four out of eighteen samples at concentrations of 0.769 ug/L (W-13I) to 5.36 ug/L (W-2).

2,4-dinitrophenol was detected in surface water samples (five out of seven) at concentrations ranging from 1.12 to 11.8 ug/L (SW-4 and SW-6, respectively), but was not detected in the sediment or soil samples. 2-methyl-4,6-dinitrophenol was detected in five out seven surface water samples at concentrations of 26.8 ug/L (SW-4) to 146 ug/L (SW-2), and in five out of seven sediment samples (481 ug/kg to 256,000 ug/kg in SS-4 and SS-5, respectively - the maximum concentration in the ditch being 538 ug/kg in SS-2), but was not present in the soil. 4-nitrophenol was detected in four out of seven surface water samples collected from the retention pond and the discharge point, at a maximum concentration of 4.82 ug/L (SW-2); in sediments, three out of seven samples all collected from the retention pond, at a maximum concentration of 21,400 ug/kg (SS-5); and in soil (2 out of seven samples analyzed) at concentrations of 141 ug/kg (W-13S, 1.5 - 3.5 feet) and 231 ug/kg (W-9S, 3 -5 feet). 2-nitrophenol was detected in six out of seven surface water samples with a maximum concentration of 3.25 ug/L found in a sample from the ditch (SW-1). It was detected in three out of seven sediment samples (SS-5, SS-6, SS-7), all collected from the retention pond. The maximum concentration detected was 5,870 ug/kg. 2-nitrophenol was not detected in the soil samples.

All nitrophenol compounds previously mentioned were retained for the groundwater assessment. None of these nitrophenol compounds were detected in the sediments samples from the drainage ditch. They were therefore not retained in this media. The only nitrophenol not retained for the surface water assessment was 4-nitrophenol as it was not detected in the samples collected from the ditch. 4-nitrophenol was also the only nitrophenol assessed for the soil assessment.

There are no freshwater quality criteria or MCL and MCLG values for the nitrophenols mentioned above.

Photooxidation appears to be the primary degradative pathway for the nitrophenols based on studies with 4-nitrophenol (U.S. EPA, 1979). The low vapor pressure, high water solubility, and moderate ionization constant suggest that volatilization is not an important transport process. Although biotransformation of nitrophenols by microbes can be demonstrated under optimal conditions, studies suggest that nitrophenols are very persistent in aqueous soil cultures and can inhibit microbial growth in aquatic systems. Other studies suggest that nitrophenols are rapidly degraded (Clement, 1985).

Little information regarding the toxicity of nitrophenols is available. Evidence in animal studies suggests that nitrophenols cause liver and kidney injury. Significant increases in blood platelet levels were observed in rats after interpretational injection of 2-nitrophenol (U.S. EPA, 1980b).

Symptoms of exposure to the nitrophenols include profuse sweating, weakness, dizziness and nausea. However, no EPA health-based criteria are available because it is believed that data were inadequate for quantitative risk assessment. Moreover, nitrophenols do not appear to pose carcinogenic or mutagenic hazard (U.S. EPA, 1980a). Ambient water quality criteria of 70 ug/l and 230 ug/l were developed for 2,4-dinitrophenol and the mononitrophenols (2- and 4- nitrophenol), respectively (U.S. EPA, 1980a). An oral reference dose of 0.002 mg/kg/day was established for 2,4-dinitrophenol (U.S. EPA, 1990a).

Chlorophenols

Chlorophenols (2,3,5,6-tetrachlorophenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2-chlorophenol, and 4-chloro-3-methylphenol) were analyzed in all media.

In groundwater, 2,3,5,6-tetrachlorophenol was detected at a frequency of thirteen out of eighteen samples at concentrations ranging from 1.54 ug/L (W-12D) to 86.3 ug/L (W-2); 2,4,6-trichlorophenol in eight out eighteen samples at concentrations of 1.04 ug/L (W-13I) to 20.6 ug/L (W-7); 4-chloro-3-methylphenol in eight out of eighteen samples at concentrations ranging from 0.662 ug/L (W-11S) to 22.3 ug/L (W-7); 2,4-dichlorophenol in eleven out of eighteen samples at concentrations of 0.594 ug/L (W-13S) to 7.46 ug/L (W-8); and 2-chlorophenol in two out of eighteen samples at concentrations of 4.13 ug/L (W-2) and 0.702 ug/L (W-7). No MCLs or MCLGs have been set for the above-mentioned chlorophenols.

In surface water samples, 2,3,5,6-tetrachlorophenol was detected at a frequency of six out of seven samples at concentrations of 2.96 (SW-1) to 23.8 ug/L (SW-2), the maximum in the ditch being 3.93 ug/L; 2,4,6-trichlorophenol in four out of seven samples 1.32 (SW-1) to 4.16 ug/L (SW-2), the maximum in the ditch being 1.40 ug/L

(SW-4); 2,4-dichlorophenol in three out of seven samples, all from the retention pond, at 0.517 ug/L to 0.920 ug/L; 2-chlorophenol was detected in two samples from the pond and at the discharge point (SW-2), at concentrations of 0.527 (SW-7) to 0.934 ug/L (SW-2); and 4-chloro-3-methylphenol in one out of seven samples at a concentration of 0.787 ug/L (SW-2). Acute and chronic freshwater criteria were developed for 2,4-dichlorophenol (2020 ug/L and 365 ug/L, respectively). A chronic criteria for 2,4,6-trichlorophenol was set at 970 ug/L. None of the concentrations detected in the surface samples exceed any of these criteria.

2-chlorophenol was detected in sediment samples at a frequency of five out of seven samples at concentrations of 239 ug/kg (SS-3) to 24,300 ug/kg(SS-5), the maximum concentration in the ditch being 3,810 ug/kg (SS-4); 4-chloro-3-methylphenol in four out of seven samples at 28.4 ug/kg (SS-3), the maximum in the ditch being 6,330 ug/kg (SS-5); 2,4-dichlorophenol in three out of seven samples, all from the retention pond, at a maximum concentration of 7,290 ug/kg (SS-5); and 2,3,5,6-tetrachlorophenol in one out of seven samples at a concentration of 1,950 ug/L (SS-7). 2,4,6-trichlorophenol was not detected in the sediment samples.

In soil samples, 2-chlorophenol and 2,4-dichlorophenol were detected in two out of seven samples analyzed at concentrations of 96.1 ug/kg (W-12I, 3-4.5 feet) and 249 ug/kg (W-9S, 3-5 feet), and 75.5 ug/kg (W-11S, 2.5-4 feet) and 105 ug/kg (W-9S, 3-5 feet), respectively. 2,4,6-trichlorophenol in was detected in one out of seven samples at a concentration of 181 ug/kg (W-12I, 3-4.5 feet). 2,3,5,6-tetrachlorophenol and 4-chloro-3-methylphenol were not detected above sample quantitation limit in the soil samples.

All chlorophenols previously mentioned were retained for assessment in the groundwater. For surface water, 2-chlorophenol, 2,4-dichlorophenol and 4-chloro-3-methylphenol were not retained for assessment as they were not detected in the samples from the ditch. Likewise, 2,4-dichlorophenol, 2,4,6-trichlorophenol and 2,3,5,6-tetrachlorophenol were not retained as PCOCs in the sediment assessment. 2-chlorophenol, 4-chloro-3-methylphenol and 2,3,5,6-tetrachlorophenol were not detected in the soil samples and therefore not retained as PCOCs.

Chlorophenols are ubiquitous environmental contaminants to which a large segment of the human and animal population are exposed. They are used as antifungal agents and wood preservatives, herbicides, pesticides and are formed as byproducts of water chlorination for disinfection or deodorization.

Chlorophenols, their sodium salts, and certain chlorocresols have been shown to be toxic to aquatic life. In aquatic organisms it appears that the acute toxicity increases directly with the degree of chlorination. Transport and fate data vary for the individual chlorophenols. Their persistence in the environment depends upon the individual physical and chemical properties, whether biodegradation occurs, and their susceptibility to natural degradation processes.

Chlorophenols range from the simple monosubstituted variety (2-, 3, or 4-chlorophenol), to di-, tri-, or tetrachlorophenols, and chlorocresols. Molecular weights range from 128.56 (monochlorophenol) to 231.88 (tetrachlorophenol). Reported water solubilities of the chlorophenols range from 28,500 mg/L for 2-chlorophenol to 4500 mg/L for 2,4-dichlorophenol, and 3850 mg/L for 4-chloro-3-methylphenol (U.S. EPA, 1979, 1980c; Clement, 1985).

Volatilization, oxidation and hydrolysis probably do not play a large role in the fate and transport of chlorophenols. Biodegradation by soil and aquatic microorganisms has been reported for several of the chlorinated phenols and may be a significant degradation process. Photodegradation also may occur to a large degree (U.S. EPA, 1979, 1980c; Clement, 1985).

2,4-Dimethylphenol

2,4-dimethylphenol was analyzed in all media.

In groundwater, 2,4-dimethylphenol was detected in four out of eighteen samples at concentrations of 0.754 ug/L (W-13S) to 12.9 ug/L (W-7). 2,4-dimethylphenol was present in nine out of eleven soil samples analyzed, at concentrations of 50 ug/kg (W-5 to -8) to 478 ug/kg (W-12I). It was detected in two out of seven sediment samples at concentrations of 199 (SS-6) and 209 ug/kg (SS-3), the maximum being in the ditch

(SS-3), and in four out of seven surface water samples at concentrations of 0.649 (SW-6) to 0.855 ug/L (SW-2), and was not detected in the surface water samples collected from the ditch.

2,4-dimethylphenol was not retained as a PCOCs for the surface water assessment only.

MCL or MCLG criteria have not been set for 2,4-dimethylphenol. There are no freshwater acute or chronic criteria either.

2,4-Dimethylphenol is a weak acid (pKa = 10.60) existing principally in the protonated, non-ionized form in surface water. This compound can complex with metal cations which can influence the rate of its photolytic degradation. Photolysis may be an important degradative factor in aerated, clear surface water. 2,4-Dimethylphenol can react in the atmosphere with hydroxyl radicals in a manner similar to the atmospheric degradation of benzene or toluene (U.S. EPA, 1979).

Volatilization is not expected to play a significant role in the degradation of 2,4-dimethylphenol as the vapor pressure is low (0.062 atm-m^3/mol) and water solubility is moderately high (590 mg/L at 25 ^{o}C) (U.S. EPA, 1982). The log octanol-water coefficient is 2.3.

Sorption processes are probably not significant in the fate and transport of this compound. Like other phenolic compounds, 2,4-dimethylphenol can be degraded by soil organisms. 2,4-Dimethylphenol has been shown to be degraded by enrichment cultures of microorganisms. Therefore, there is a potential that the aqueous biodegradation of this compound may contribute to its overall fate.

This compound has not been evaluated by the U.S. EPA for its human carcinogenicity potential. No MCL has been determined for 2,4-dimethylphenol.

Phenol

Phenol was analyzed in all media. It was detected above sample quantitation limit in ten out of eighteen groundwater samples at concentrations ranging from 0.537 ug/L (W-5) to 2.8 ug/L (W-2). Phenol was detected in six out of eleven soil samples at concentrations of 50 to 79 ug/kg in W-4 to -8 and W-12I, respectively; in five out of seven sediment samples at 31.6 ug/kg (SS-3) to 23,300 ug/kg(SS-5), the maximum in the ditch being 121 ug/kg (SS-1); and in five out of seven surface water samples at 1.04 ug/L (SW-5) to 2.42 ug/L (SW-7), the maximum in the ditch being 1.32 ug/L (SW-1).

Phenol was retained for assessment in all media.

MCL or MCLG criteria were not set for phenol. Freshwater water quality criteria were set for acute and chronic toxicity (10,200 ug/L and 2,560 ug/L, respectively). The concentrations detected in the five surface water samples do not exceed these criteria.

Photooxidation, metal-catalyzed oxidation and biodegradation are likely to be the primary fates of phenol in the aquatic environment (U.S. EPA, 1979). Microbial degradation of phenol is also considered to be of significance for degrading concentrations of phenol in the aquatic environment. Some volatilization into the atmosphere may occur, however, volatilization is most likely followed by rapid oxidation in the troposphere. Neither bioaccumulation or sorption processes appear to be important aquatic fates of phenol. Hydrolysis is not considered to be a relevant environmental elimination process.

Phenol is reported to be highly reactive with chlorine over a wide pH range. Chlorophenols are produced inadvertently by chlorination reactions occurring during disinfection of drinking water sources or wastewater effluents. This property exacerbates the organoleptic problems associated with phenol contamination in the aquatic environment.

Phenol has a molecular weight of 94.11. The melting point is 41 ^{O}C, and the boiling point is 182.0^{O}C. The log octanol water coefficient is 1.46 (Verschueren, 1983). Vapor pressures are 0.2 torr at 20^{O}C and 0.34 torr at 25^{O}C, and the solubilities in water are 82,000 mg/L and 93,000 mg/L at 15^{O}C and 25^{O}C respectively (Verschueren, 1983; U.S. EPA, 1979).

Phenol is an irritant of the eyes, mucous membranes and skin. Phenol can be absorbed by inhalation or ingestion, however the skin is the primary route of entry for vapor, liquid and solid phenol (Proctor et al., 1988). The chronic oral reference dose (RfD) is 0.6 mg/kg/day (U.S. EPA, 1990a). There is no inhalation RfD. The Occupational Safety and Health Administration (OSHA, 1989) set the Permissible Exposure Limit (PEL-TWA) at 5 ppm (19 mg/m^3).

U.S. EPA (1980d) ambient water quality criteria (AWQC) are available for phenol and include acute and chronic freshwater criteria (10,200 ug/L and 2,560 ug/L respectively), acute marine criteria (5,800 ug/L) and water concentrations for the protection of human health upon consumption of water and fish (3,500 ug/L).

Metals

Arsenic, chromium, copper and zinc were analyzed and detected above sample quantitation limit in all media. In sediment samples, metals were detected in seven out of seven samples at maximum concentrations of 1,580 - arsenic (SS-7), 160 ug/kg - chromium (SS-6), 4,360 ug/kg - copper (SS-6), and 1,340 ug/kg - zinc (SS-5). All these maximums were detected in the retention pond. In the ditch, maximums were as follows: arsenic - 115 ug/kg (SS-1), chromium - 43.6 ug/kg (SS-1), copper - 932 ug/kg (SS-4), and zinc - 216 ug/kg (SS-4).

Surface water analytical results indicate arsenic (seven out of seven), copper (six out of seven), and zinc (seven out of seven) were present above SQLs in the surface water retention pond and the south drainage ditch. Maximum concentrations in the pond were 1840 ug/L (SW-7) for arsenic, 1,510 ug/L (SW-7) for copper, and 627 ug/L (SW-7) for zinc. Chromium was present in the surface retention pond and discharge point (SW-2) only. These represent three out of seven samples with a maximum concentration of 40.2 ug/L (SW-2).

The acute and chronic freshwater criteria for arsenic are exceeded in two samples from the ditch and in the three samples from the surface water retention pond. The acute and chronic values for copper are exceeded in all but one sample, and for chromium (VI), the probable form of chromium the environment, these are exceeded in one sample from the ditch and two samples from the pond. The quality criteria for the protection of freshwater aquatic organism were previously presented in Table 4-7. These criteria and the metal concentrations detected in the surface water samples form the ditch are further discussed in Section 4.6.2.

In soil, arsenic was detected above SQLs in three out of four samples, chromium in four out of four samples, and copper and zinc in three out of three samples. The maximum concentrations were 7,060 ug/kg for arsenic (W-9S), 43,500 ug/kg for chromium (W-9S), 35,900 ug/kg for copper, and 69,900 ug/kg for zinc.

The U.S. EPA (1989a) recommends the comparison of sample geometric mean concentration with background literature values. Since too few samples were collected to perform statistical analyses, the maximum concentrations were compared. The maximum value found in the samples collected at the site are well within the range of literature background concentrations presented in Table 4-9.

In groundwater, total arsenic was detected above SQLs three out of eighteen samples at a maximum concentration of 0.18 mg/L (W-8) and dissolved arsenic was detected in only one sample at a concentration of 0.171 mg/L. Total chromium was present in one out of eighteen samples at a concentration of 0.014 mg/L (W-1), below the MCL of 50 ug/L, and dissolved chromium was not detected. Total copper was present in one out of eighteen sample at a concentration of 0.035 mg/L (W-13S) and dissolved copper was not detected in any samples. Total zinc was detected in six out of eighteen samples at a maximum concentration of 0.062 mg/L (W-13S) and dissolved zinc in two samples at concentrations of 0.025 and 0.027 mg/L in W-11S and W-13S. MCLs for metals are presented in Table 4-10.

TABLE 4-9

NATIVE CONCENTRATIONS OF METALS IN SOILS, ug/kg FROM LITERATURE

	Metal Concentration (ug/kg)					
METAL	Lindsay, 1979(1)	Tox. Profiles	Tox. of Metals, 1986(3)	Dragun, 1988(4)	Modern Env.Tox.XI,1987(5)	U.S. Geological Survey(6) (Western Portion U.S.)
Arsenic	1,000 - 50,000	100 - 80,000 (2)	<40,000	100 - 40,000	Trace - 40,000	<100 - 97,000
Cadmium	10 - 700	NA	<1,000	10 - 7,000	<1,000 (Up to 30,000)	NA
Chromium	1,000 - 100,000	NA	Trace - 250,000	5,000 - 3,000,000	Trace - 250,000	3,000 - 2,000,000
Copper	2,000 - 100,000	NA	2,000 - 100,000	2,000 - 100,000	NA	2,000 - 300,000
Lead	2,000 - 200,000	10,000 - 30,000 (7)	2,000 - 200,000	2,000 - 200,000	10,000 - 700,000	<10,000 - 700,000
Zinc	10,000 - 300,000	NA	10,000 - 300,000	10,000 - 300,000	NA	10,000 - 2,100,000

NOTES:
NA Information not available.

REFERENCES:
(1) Lindsay, 1979.
(2) U.S. EPA, 1987
(3) Friberg et al., 1986.
(4) Dragun, 1988
(5) Mehlman, 1987
(6) Shacklette and Boerngen, 1984
(7) U.S. EPA, 1988

TABLE 4-10
RELEVANT CRITERIA AND GUIDELINES FOR METALS
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

Metal	MCL (ug/l)	PMCL (ug/l)*	PMCLG (ug/l)*	PSMCL (ug/l)*
Arsenic	50(T)	NA	NA	NA
Chromium	50	100	100	NA
Copper	NA	1300	1300	NA
Zinc	NA	NA	NA	5000

Notes:

T - Tentative
* Proposed
NA: Not Available
MCL - Maximum contaminant level
PMCL - Proposed maximum contaminant level
PMCLG - Proposed maximum contaminant level goal
PSMCL - Proposed secondary maximum contaminant level

References:

Federal Register, 1989
U.S. EPA, 1990a
U.S. EPA, 1990b

All metals were retained for assessment in all the media investigated, except for chromium. Chromium was not detected in the surface water samples collected from the drainage ditch and therefore not retained for assessment in that medium.

Arsenic

Arsenic is very mobile in air and water. In the atmosphere, most arsenic transfer to other media occurs via wet or dry deposition while particulate-bound (particle size less than 2 um) (Coles et al., 1979). In natural waters mobility of arsenic is heavily dependent upon oxidation state with the pentavalent form being the most prevalent. In natural waters, sorption onto clays, iron oxides, manganese compounds, and organic material is an important fate of arsenic. Once in the aquatic system, arsenic cycles through several components, i.e., the water column, the sediment, the biota, and the atmosphere. Volatilization of methylated forms may occur in groundwater, but may be prevented by nonporous soil and vegetative cover. Transformation from the volatile to the non-volatile forms and subsequent adsorption onto organic clay matter, and iron and aluminum complexes is another impedance to volatilization (ATSDR, 1988).

Bioconcentration of arsenic occurs primarily in algae and lower invertebrates, however, some fish and invertebrates may contain high levels of arsenic compounds which are toxicologically inert. The speciation of arsenic in natural waters is significantly influenced by the biota (ATSDR, 1988).

Humans extensively absorb arsenic from the gastrointestinal tract and the respiratory tract. The extent of arsenic absorption is directly related to the water solubility of the arsenic compound (Vahter, 1983; Dutkiewicz, 1977). Systemic effects following ingestion include gastrointestinal tract irritation, anemia, neuropathy, and hepatic or renal injury (ATSDR 1988). The primary effects resulting from exposure to airborne arsenic includes irritation of skin and mucous membranes (Vallee et al., 1960). Women who live near smelters have higher than normal abortion rates (Nordstrom et al., 1978). Humans with above average exposure to airborne arsenic report above average lung cancer rates.

The U.S. EPA has categorized arsenic as a Group A carcinogen (Human Carcinogen). An inhalation cancer slope factor of 50 $(mg/kg/day)^{-1}$ was based on the observation of increased lung cancer mortality in populations exposed primarily through inhalation (U.S. EPA, 1990a). No oral CSF is available at this time. An unverified oral reference dose of 0.001 mg/kg/day (U.S. EPA, 1990b) was based on the incidence of keratosis and hyperpigmentation in humans receiving arsenic at a dose of 1 mg/kg/day (Tseng, 1977). No inhalation RfD has been determined.

The ambient water quality criterion for the consumption of water and fish is 0.0022 ug/L (U.S. EPA, 1990a). The acute and chronic criteria for freshwater aquatic organisms are set at 0.85 mg/L and 0.048 mg/L, respectively. An MCLG of 0.05 mg/L (U.S. EPA, 1990a) has been proposed based on the current MCL of 0.05 mg/L. Its potential essential nutrient value was considered in determination of an MCLG.

Chromium

In the environment, chromium can exist in three principal states: elemental (Cr), trivalent (CrIII), and hexavalent (CrVI) (Westbrook, 1979). Mobility of chromium in water is dependent upon its oxidation state. In most natural waters the hexavalent chromium will be in the form of the chromate ion (U.S. EPA, 1979). All of the anionic forms are quite soluble, and are thus quite mobile in the aquatic environment (Towill et al., 1978). Trivalent chromium is relatively insoluble in salt water since it precipitates in a complex series of reactions with the various inorganic ions in seawater.

The toxicity of chromium is dependent upon its oxidation state. The strongly oxidizing hexavalent forms, such as chromic acid or chromate salts, are potentially more toxic than the trivalent chromium compounds. The main effect of trivalent chromium is contact dermatitis in sensitive individuals. Inhalation of hexavalent chromium causes irritation and inflammation of the nasal mucosa, and ulceration and perforation of the nasal septum. Hexavalent chromium also produces kidney and liver damage (U.S. EPA, 1984c, 1984d).

The U.S. EPA has classified CrIII as Group D (Not Classified) based on inadequate carcinogenic data. The U.S. EPA has classified CrVI as a Group A Carcinogen (Human Carcinogen). Oral reference doses of 1.0 and 0.005 mg/kg/day have been derived for chromium III and VI, respectively, based on dietary studies conducted in rats (U.S. EPA, 1990a, 1990a). A verified inhalation cancer slope factor (CSF) of 41 $(mg/kg/day)^{-1}$ for CrVI is based on existing evidence of respiratory cancer in occupationally exposed workers (U.S. EPA, 1990a). No oral CSF has been determined. There are no CSFs for CrIII.

The MCL for total chromium in drinking water is 0.05 mg/L. The proposed MCLG for total chromium is 0.10 mg/L. The proposed MCLG for total chromium in drinking water is 0.001 mg/L (U.S. EPA, 1990a, 1990b). No proposed SMCL or final MCLG have been determined for total chromium.

The ambient water quality criteria for water and fish consumption for CrIII and CrVI, respectively, are 170 mg/L and 50 ug/L. The acute and chronic freshwater criteria for Cr (III) are 0.98 mg/L and 0.12 mg/L respectively , and for Cr (VI), 0.016 mg/L and 0.011 mg/L, respectively.

Copper

Copper is a metallic element which primarily exists in two valence states (+1 and +2). In water, copper complexes with humic substances; sorbs to hydrous metal oxides, clays and organic materials; and bioaccumulates. Because copper compounds are readily soluble, it is very mobile in soil and other surface environment. (Clement Associates, 1985).

Exposure to metallic copper dust can cause short-term illness similar to metal fume fever that is characterized by chills, fever, aching muscles, and headache. Exposure to dusts of copper salt may exhibit nasal mucous membrane congestion. Copper salts may also irritate the gastrointestinal tract upon incidental ingestion and produce an itching eczema upon dermal contact (U.S. EPA, 1984e).

Copper has a Group D (Not Classified) carcinogen classification. An oral RfD of 1.3 mg/l has been established by the U.S. EPA (1990b). There is no inhalation RfD or oral or inhalation CSF established for copper. The proposed MCL and MCLG value for copper is 1.3 mg/L. The freshwater acute and chronic criteria are dependent upon water hardness. At a hardness of 100 mg/L $CaCO_3$, the criteria are 0.018 mg/L (acute) and 0.012 mg/L (chronic).

Zinc

Zinc (Zn) is a metallic element that occurs in nature in the elemental (zero) and +2 valence states. Zinc may form complexes with organic and inorganic ligands. The typical range of zinc concentrations in natural soils is 10 to 300 mg/kg (Dragun, 1988). Zinc is associated with relatively low toxicity and is an essential trace element for the survival of humans and many domestic animals (NRC, 1978).

The transport of zinc in the aquatic environment is controlled by the speciation of the ion. Formation of complexes with organic and inorganic ligands can increase the solubility of zinc and probably increases the tendency of zinc to be adsorbed. Complexes with the common ligands in surface water are soluble in neutral and acidic solutions making zinc one of the most mobile of the heavy metals in natural waters. Precipitation with sulfide is an important control of the mobility of zinc in reducing environments. The precipitation with hydroxide, carbonate, or basic sulfate can occur where zinc concentrations are high (U.S. EPA, 1979).

Zinc is bioaccumulated by all organisms. Since zinc is an essential nutrient, bioaccumulation can occur even in the absence of unusually high zinc concentrations (U.S. EPA, 1979).

Symptoms of acute toxicity from ingestion of zinc in humans have been reported to include: pulmonary edema, jaundice, vomiting, diarrhea, and oliguria (Brock et al., 1977), dizziness, nausea, and headaches (Lapham et al., 1983). Deleterious effects to both the immunologic and cardiovascular systems have also been noted.

Effects from chronic exposure due to inhalation have been reported to include: coughing, dyspnea, weakness, fatigue, aching muscles and joints and general malaise (Anseline, 1972; Fishburn and Zenz, 1969), chronic respiratory tract infections, conjunctivitis and dermatitis (Chmielewski et al., 1974). Occupational exposure to zinc oxide fume causes an influenza-like illness named "metal fume fever" (Proctor et al., 1988).

The U.S. EPA Secondary MCL is 5 mg/L in drinking water. An unverified oral RfD of 0.2 mg/kg/day for zinc has been established (U.S. EPA, 1989c). The freshwater acute and chronic criteria are dependent upon water hardness and, at a hardness of 100 mg/L $CaCO_3$, the criteria are 0.12 and 0.11 mg/L for the acute and chronic effects, respectively.

Polycyclic Aromatic Hydrocarbons

The analytical data is summarized in Tables 4-2 to 4-5. The relevant MCL and MCLG criteria for PAHs are presented in Table 4-11. No freshwater quality criteria have been set for PAHs compounds.

All PAHs analyzed by EPA Method 8310 were detected in two out of seven sediment samples (SS-6 and SS-7). Acenaphthene was the only compound not detected above SQLs in three samples (SS-2, SS-3 and SS-5), along with benzo(k)fluoranthene in SS-4. Acenaphthene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene were not detected in sample SS-1. Maximum concentrations for individual PAHs compounds in the sediment samples are presented in Table 4-4.

None of the PAHs were detected above SQLs in the surface water sample from SW-3, the upgradient sample collected from the drainage ditch. Carbazole was not detected in any of the other surface water samples. The only compounds detected in SW-1 were benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h) anthracene and benzo(g,h,i)perylene. Naphthalene and acenaphthylene were detected in SW-2 only and acenaphthene was detected in SW-2 and SW-7 only. Additionally, benzo(a)pyrene was not detected in SW-4 and SW-5, and dibenzo(a,h)anthracene

TABLE 4-11

Relevant Criteria and Guidelines
for Polycyclic Aromatic Hydrocarbons
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

PolyAromatic Hydrocarbons	MCL (ug/l)	MCLG (ug/l)	SMCL (ug/l)
<u>Noncarcinogenic</u>			
Acenapthene	NA	NA	NA
Acenapthylene	NA	NA	NA
Anthracene	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA
Fluoranthene	NA	NA	NA
Fluorene	NA	NA	NA
Napthalene	NA	NA	NA
Phenanthrene	NA	NA	NA
Pyrene	NA	NA	NA
<u>Potentially Carcinogenic</u>			
Benzo(a)anthracene	0.1 (T)	Zero (T)	NA
Benzo(a)pyrene	0.2 (T)	Zero (T)	NA
Benzo(b)fluoranthene	0.2 (T)	Zero (T)	NA
Benzo(k)fluoranthene	0.2 (T)	Zero (T)	NA
Carbazole	NA	NA	NA
Chrysene	0.2	Zero	NA
Dibenz(a,h)anthracene	0.3 (T)	Zero (T)	NA
Indeno(1,2,3-cd)pyrene	0.4 (T)	Zero (T)	NA

Notes:

T - Tenative (Phase V)
NA - Not Available
MCL - Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
SMCL - Secondary Maximum Contaminant Level

Reference:
U.S. EPA, 1990a

was not detected in SW-4. Maximum concentrations and their locations are presented in Table 4-5.

No PAHs were detected above SQLs in soil samples from monitoring wells W-4 (14 to 15 feet), W-5 (5.5 to 6 feet), W-11S (2.5 to 4 feet) and W-14I (7 to 8 feet). Naphthalene was the only compound detected above SQL in W-6 (15.5 to 16 feet). Acenaphthylene was not detected above SQLs in any of the samples. Out of these six soil samples collected in June 1990 (W-9S to W-14I), carbazole was not detected in any samples. PAHs were detected in W-7 - 6.5 to 7 feet - (except for naphthalene) and in W-8 - 5.5 to 6 feet - (except for naphthalene and fluoranthene). The frequency of detection of individual PAHs compounds in soil and their maximum concentrations are presented in Table 4-3.

All PAHs were retained as PCOCs in the groundwater and soil media. Acenaphthene was not retained for the sediment exposure assessment and, naphthalene, acenaphthylene, acenaphthene, carbazole and benzo(a)pyrene were not retained for the assessment of the surface water as these were not detected in the samples from the drainage ditch, where exposure would occur.

MCLs for the potentially carcinogenic PAHs except for carbazole are presented in Table 4-11. MCLs exceeded in the wells where the compounds were detected are as follows: benzo(a)anthracene (MCL 0.1 ug/L) in three out of three wells (W-2, W-7 and W-8), benzo(a)pyrene (MCL 0.2 ug/L) in two out of four wells (W-2 and W-8), benzo(b)fluoranthene (MCL 0.2 ug/L) in two out of eight wells (W-2 and W-8), benzo(k)fluoranthene (MCL 0.2 ug/L) in two out of three wells (W-2 and W-8), and chrysene (MCL 0.2 ug/L), dibenzo(a,h)anthracene (MCL 0.3 ug/L), and indeno(1,2,3-cd)pyrene (MCL 0.4 ug/L) in two out of two wells (W-2 and W-8).

The fate of polycyclic aromatic hydrocarbons (PAHs) in the environment is variable. As molecular weight increases, their solubility and ease of biodegradation tend to decrease (U.S. EPA, 1979). Consequently, higher molecular weight PAH species tend to be more persistent in environmental media.

Most PAHs, especially those that are more water soluble, absorb solar radiation at wavelengths greater than the solar cutoff and can undergo direct photooxidation (U.S. EPA, 1976). PAHs also undergo microbial degradation in soil, (NAS, 1972; U.S. EPA, 1976) however, biodegradation in water probably is slower than in the soil (U.S. EPA, 1979).

The highest vapor pressures are observed in two-ringed moieties. For these compounds, volatilization can be an important process, but as molecular weight increases, vapor pressures decrease. Thus, volatilization is unlikely to be an important transport process for the carcinogenic PAHs.

As molecular weight or ring size increases, the log octanol-water partition coefficients (K_{ow}) for PAHs also increase. This indicates that these compounds have the potential to adsorb to suspended particulates in water, especially those particulates containing organic matter (U.S. EPA, 1979).

Naphthalene, the simplest of the polycyclics, has an unverified RfD of 0.004 mg/kg/day (U.S. EPA, 1990b). This value is based on a study in which rats received naphthalene in their diet at a dose of 41 mg/kg/day for 700 days, 6 days/week. The rats experienced ocular and internal lesions. Recently, EPA (1990a) provided verified RfD values for other noncarcinogenic PAHs. These include: acenaphthene, 0.06 (mg/kg/d); anthracene, 0.3 (mg/kg/d); fluoranthene, 0.04 (mg/kg/d); fluorene, 0.04 (mg/kg/d); and pyrene, 0.03 (mg/kg/d).

The U.S. EPA derived oral and inhalation cancer slope factors (q_1*) of 11.5 and 6.11 $(mg/kg/day)^{-1}$, respectively, for benzo(a)pyrene. The q_1*s represent the upper bound estimate of the low dose slope of the dose response curve as determined by the multistage procedure. The oral q_1* was based on a study in which benzo(a)pyrene was administered to mice at doses of 1-250 ppm in the diet for 110 days (Neal and Rigdon, 1967). The incidences of stomach tumors were used to derive the oral q_1*. The inhalation q_1* was based on a study in which male hamsters were exposed to benzo(a)pyrene at levels of 0-46.5 mg/m^3 for 10-96 weeks (Thyssen et al., 1981). The respiratory tumor response in male hamsters was used to derive the inhalation q_1*.

Although benzo(a)pyrene is classified as a B2 carcinogen, the q_1*s were withdrawn from the IRIS database for further review. However, it was suggested by EPA (Sept. 18, 1990) that the derived oral and inhalation cancer slope factors be used as interim values at Superfund sites. It was also recommended in the same document that all B2 carcinogen be evaluated using these values. As recommended by the Oregon Department of Environmental Quality, this approach will be used for the exposure assessment of carcinogenic PAHs at the J.H. Baxter site in Eugene, OR.

Table 4-12 summarizes those compounds, by media, which will be retained for quantitative evaluation in the Risk Characterization (Section 4.6). The PCOCs have been determined after reviewing the four selection criteria (toxicity, mobility, persistence and prevalence).

4.4 Identification of Potential Sources and Exposure Pathways

Potential exposure pathways are routes through which PCOCs may migrate from a source to a receptor. Potential exposure to a PCOC is dependent upon the existence of a reasonable exposure pathway. These pathways require four components: 1) a source; 2) the release of a PCOC from a source and subsequent migration through environmental media; 3) contact between a potential receptor and the medium; and 4) uptake by the receptor.

This section begins by establishing processes for the migration of PCOCs from one medium to another, or from one point to another within a medium. Next, the potential human and environmental receptors and exposure pathways are identified and subjected to evaluation.

4.4.1 Potential Sources and Migration Routes

Potential sources of constituents include soils and groundwaters associated with the historical operation of the wood preserving facility. The migration of PCOCs from these source areas can potentially occur by the following routes:

TABLE 4-12
SUMMARY OF RETAINED PCOCs BY MEDIA

J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

	MEDIA			
Potential Constituent of Concern	Sediments	Surface Water	Soils	Ground Water
Volatile Compounds				
1,1-Dichloroethene				o
1,1-Dichloroethane				o
1,2 Dichlorobenzene			o	
Benzene				o
Ethylbenzene				o
Styrene				
Toluene	o			
Xylenes	o			
Phenolics				
2,3,5,6-Tetrachlorophenol		o		o
2,4,6-Trichlorophenol		o	o	o
2,4-Dichlorophenol			o	o
2,4-Dimethylphenol	o		o	o
2,4-Dinitrophenol		o		o
2-Chlorophenol	o			o
2-Methyl-4,6-dinitrophenol		o		o
2-Nitrophenol		o		o
4-Chloro-3-methylphenol	o			o
4-Nitrophenol			o	o
Pentachlorophenol	o	o	o	o
Phenol	o	o	o	o
Metals				
Arsenic	o	o	o	o
Chromium	o		o	o
Copper	o	o	o	o
Zinc	o	o	o	o

TABLE 4-12 (Continued)
SUMMARY OF RETAINED PCOCs BY MEDIA
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

	MEDIA			
PCOC	Sediments	Surface Water	Soils	Ground Water
Noncarcinogenic PAHs				
Acenaphthene			o	o
Acenaphthylene	o		o	o
Anthracene	o	o	o	o
Benzo(g,h,i)perylene	o	o	o	o
Fluoranthene	o	o	o	o
Fluorene	o	o	o	o
Naphthalene	o		o	o
Phenanthrene	o	o	o	o
Pyrene	o	o	o	o
Potentially Carcinogenic PAHs				
Benzo(a)anthracene	o	o	o	o
Benzo(a)pyrene	o		o	o
Benzo(b)fluoranthene	o	o	o	o
Benzo(k)fluoranthene	o	o	o	o
Carbazole	o		o	o
Chrysene	o	o	o	o
Dibenz(a,h)anthracene	o	o	o	o
Indeno(1,2,3-c,d)pyrene	o	o	o	o

- vertical migration of PCOCs from surface soils to subsurface water bearing zones and subsequent off-site migration;
- surface runoff to the south drainage ditch;
- migration of windblown dust and volatilized gases.

4.4.1.1 Site Specific PCOC Fate and Transport

Tables 4-13 and 4-14 present the physico-chemical data and the pertinent environmental fate reactions for the PCOC groups developed in Section 4.3. The remainder of this section presents a qualitative discussion of the projected long-term environmental fate and distribution of the site-associated PCOCs.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs), i.e. benzene, ethylbenzene, and toluene, tend to be relatively mobile in the environment. This fact is reflected in the high water solubilities, high vapor pressures, low K_{ow} and K_{oc} values, and high mobility indices presented in Table 4-13. VOCs were present in all media analyzed and could potentially migrate off-site by advection. As they are transported, PCOC concentrations can be expected to decrease due to volatilization , chemical reactions, and dispersion.

Phenolic Compounds

Phenolic compounds (represented by PCP) could potentially be released to the environment from onsite soils by dissolution, leaching, and erosion of soils. The environmental mobility, however, tends to be somewhat less than the VOCs. In addition, it is recognized that PCP does have different physical properties as compared to the other phenolic compounds detected. However, since PCP is considered a primary constituent of concern, and a known process related compound, it was chosen to represent the fate and transport of the phenolics.

Table 4-13
Chemical and Physical Parameters for Organic PCOCs
J.H. Baxter and Company
Woos Preserving Facility
Eugene, Oregon

PCOC	Molecular Weight (g/mol)	Specific Gravity	Water Solubility (mg/l)	Henry's Law Constant (atm-m3/mol)	Kow Octanol Water Part. Coeff.	Koc Organic Carb. Part. Coeff	Vapor Pressure (mm Hg)	Relative Mobility Index(1)
Volatile Compounds								
1,1,1-Trichloroethane	133.4	1.35	720(25 C)	3.00E-02	320	152	123(25 C)	2.77
1,1-Dichloroethane	98.96	1.174	5,500 (20 C)	4.26E-03	63	30	180 (20 C)	4.51
1,1-Dichloroethene	96.95	1.218	400 (20 C)	1.9E-02	135	65	591 (25 C)	3.56
Benzene	78	0.8786	1,750 (25 C)	5.59E-03	130	83	95.2 (25 C)	3.3
1,2-Dichlorobenzene			100	1.93E-03	3980	1700	1.0	
Ethylbenzene	106	0.867	152	6.43E-03	1,400	1,100	7 (20 C)	-0.014
Styrene	104.14	0.905	300 (20 C)	2.28E-03	490	417	5	0.56
Toluene	92	0.867	535 (25 C)	6.37E-03	540	300	28.7 (25 C)	1.71
Xylenes	106.16	0.87	180 (20 C)	4.64E-03	1,047	692	6	0.19
Phenolics								
2,3,5,6-Tetrachlorophenol	231.9	1.6 (60 C)	220 (20 C)	NA	1.04E+04	3,600	60 (190 C)	-0.56
2,4,6-Trichlorophenol	197.5	1.49 (75 C)	800 (25 C)	4.0E-06	4,100	2,000	0.012 (20 C)	-2.32
2,4-Dichlorophenol	163	1,383	4.6E-03(20 C)	2.8E-06	790	380	0.059 (20 C)	-0.15
2,4-Dimethylphenol	122.2	1.036	590 (25 C)	1.70E-05	200	96	0.062 (20 C)	-0.419
2,4-Dinitrophenol	184.1	1,683 (24 C)	5.6E-03 (18 C)	6.45E-10	34.7	16.6	1.49E-05 (18 C)	-2.3
2-Chlorophenol	128.56	1.241	2.85E+04	1.03E-05	1.86	2.18	1.77	2.52
2-Methyl-4,6-dinitrophenol	198.1	NA	290 (25 C)	4.0E-05	501	239	.05 (20 C)	-1.22
2-Nitrophenol	139.1	NA	2.1E-03 (20 C)	7.56E-06	56	27	0.0021 (20 C)	1.07
4-Chloro-3-methylphenol	142.6	NA	3.85E-03 (20 C)	2.5E-06	1,258	602	0.05 (20 C)	-0.49
4-Nitrophenol	139.1	NA	1.6E+04 (25 C)	2.5E-05	93	45	2.2 (146 C)	2.9
Pentachlorophenol	266.4	1.978	14 (20 C)	2.80E-06	1.1E+05	5.3E+04	1.1E-04 (20 C)	-7.5
Phenol	94.11	107	9.3E+04 (25 C)	4.54E-07	30	14.2	0.341 (25 C)	3.3
Noncarcinogenic PAH's								
Acenapthene	154	NA	3.42 (20 C)	9.20E-05	1.0E+04	4,600	1E-03-1E-02 (20C)	-5.5
Acenapthylene	152	0.899	3.93 (20 C)	1.48E-03	5,000	2,500	1E-03-1E-02 (20C)	-6.7
Anthracene	178	1.25	0.045 (20 C)	1.02E-03	2.8E+04	1.4E+04	1.95E-04 (20 C)	-7.8
Benzo(g,h,i)perylene	276	NA	0.0007 (20 C)	5.34E-08	3.33E+06	1.6E+06	~1E-10 (20 C)	-20
Fluoranthene	202	NA	0.206 (20 C)	6.46E-06	8.0E+04	3.8E+04	1E-06-1E-04 (20C)	-9.4
Fluorene	116	NA	1.69 (25 C)	6.42E-05	1.6E+04	7,300	1E-03-1E-02 (20C)	-6.7
Napthalene	128.2	1.162	31.7 (25 C)	4.60E-04	2,000	670	4.92E-02 (20 C)	-0.24
Phenanthrene	178	1.025	1.0 (25 C)	1.59E-04	2.9E+04	1.4E+04	6.8E-04 (20 C)	-7.5
Pyrene	202	NA	0.132 (25 C)	5.04E-06	7.6E+04	3.8E+04	6.85E-07 (20 C)	-11.9

Table 4 (Continued)
Chemical and Physical Constants of PCOC's
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

PCOC	Molecular Weight (g/mol)	Specific Gravity	Water Solubility (mg/l)	Henry's Law Constant (atm-m3/mol)	Kow Octanol Water Part. Coeff.	Koc Organic Carb. Part. Coeff	Vapor Pressure (mm Hg)	Relative Mobility Index(1)
Carcinogenic PAH's								
Benzo(a)anthracene	228	NA	0.0057 (20 C)	1.16E-06	4.0E+04	1.38E+06	5.0E-09 (20 C)	-15.5
Benzo(a)pyrene	252	NA	0.0012 (25 C)	1.55E-06	1.2E+06	5.5E+06	5.0E-09 (25 C)	-16.4
Benzo(b)fluoranthene	252	NA	0.014 (25 C)	1.19E-05	1.2E+06	5.5E+05	1E-11-1E-06 (20 C)	-14
Benzo(k)fluoranthene	252	NA	0.0043 (25 C)	3.94E-05	1.2E+06	5.5E+05	9.59E-11 (20 C)	-19
Carbazole	167.2	1.1	0.9 (25 C)	NA	3.51	3.29	0.81 (20 C)	-7.1
Chrysene	228	1.274	0.0018 (25 C)	1.05E-06	4.0E+04	2.0E+05	1E-11-1E-06 (20 C)	-13.7
Dibenzo(a,h)anthracene	278	NA	0.0005 (25 C)	7.33E-08	6.3E+06	3.3E+06	~1E-10 (20 C)	-20
Indeno(1,2,3-cd)pyrene	276	NA	0.00053	6.86E-08	3.2E+06	1.6E+06	~1E-10 (20 C)	-18

Chemical and Physical Parameters for Inorganic PCOCs

Metals	Kd (ml/g)	BV (g/g)
Arsenic	200	0.04
Chromium	850	0.0075 (2)
Copper	35	0.4
Zinc	40	1.5

NOTES:
NA-Not Available

(1) Relative Mobility Index	Mobility Descriptor
>5.0	Extremely Mobile
0 to 5.0	Very Mobile
-5.0 to 0	Slightly Mobile
-10.0 tp -5.0	Immobile
<-10.0	Very Immobile

(2) Chromium (VI)

REFERENCES:
U.S. EPA, 1979
U.S. EPA, 1982
Verschueren, 1983
Lyman et al., 1982
Ford and Gurba, 1984
Baes et al., 1984

TABLE 4-14

SIGNIFICANCE OF ENVIRONMENAL FATE PROCESSES
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

	Environmental Fate Process				
Chemical Class	Photolysis/ Oxidation	Hydrolysis	Chemical Speciation	Bioaccumulation	Biotransformation/ Biodegradation
Monocyclic Aromatic Hydrocarbons	Insignificant	Insignificant	NA	Insignificant	Unknown
Chlorinated Aliphatic Hydrocarbons	Insignificant	Insignificant	NA	Insignificant	Insignificant
Polycylic Aromatic Hydrocarbons	Significant	Insignificant	NA	Insignificant	Significant
Chlorophenols	Significant	Insignificant	NA	Significant	Significant
Inorganics	Insignificant	Insignificant	Significant	Significant	NA

NOTES:

NA Not Applicable

References:

U.S. EPA, 1979
Clement Associates, Inc., 1985

Phenolic compounds are fairly soluble in aqueous solution. Phenolics will dissociate in aqueous solution, depending on the solution pH. Low pH enhances their solubility. Under mildly acidic to neutral groundwater conditions (pH 5.6-7.9), the phenolics will dissociate moderately and could potentially be transported as solutes by groundwater advection. Organic chemicals exhibiting log K_{OW}'s, less than about 3.69, have been demonstrated to move relatively rapidly in groundwater (Schwarzenbach, et al., 1983). As with the VOCs, solution concentrations will be reduced because of retardation from adsorption processes and hydrodynamic dispersion during transport. Surface water concentrations will be reduced along the stream reach by adsorption and simple dilution. Low Henry's Law Constant values indicate that volatilization from aqueous solution will not be appreciable.

Transport of soil particles containing phenolics by overland flow could potentially occur. Sedimentation in slow-moving reaches could occur and PCOCs may be deposited.

Soils containing phenolics could be a source of organic compounds through particulate airborne migration.

Polycyclic Aromatic Hydrocarbons (PAHs)

Generally, PAHs will not migrate appreciable distances through groundwater or surface waters as solutes. Low water solubilities, high Log K_{OW}'s and Log K_{OC}'s indicate a strong tendency for adsorption. Predictably, their mobility indices indicate that they are essentially immobile from a physical-chemical standpoint. Exceptions are naphthalene, methylnaphthalene and anthracene, which are slightly mobile in solution (groundwater and surface water) due to water solubilities higher than for other PAHs.

Transport of soil particles containing adsorbed PAHs will continue to be the primary migration mechanism. Overland flow of surface water carrying entrained particles to the south drainage ditch and then to the Amazon Creek and the Fern Ridge Reservoir and subsequent sedimentation, resuspension and settling is indicated.

PAHs lack sufficient vapor pressures to be transmitted via vaporization and subsequent airborne transport. Surface and shallow surface soil particles containing adsorbed PAHs could potentially be subject to airborne transport and deposition.

Metals

Metals are found as solid complexes at normal temperature and pressure conditions such as in soils at the site. Metal ions exist in pure solutions as hydrated ions. However, saturated groundwater, as opposed to a pure solution, is a highly complex geochemical system which is heavily influenced by the geo-minerology of the soil matrix. Factors affecting leaching and transport of metals in saturated soils are interactive and far more complex and numerous than those affecting the transport of organic chemicals.

Transport of metallic species in groundwater is mainly a function of the metal's solubility in solution under the conditions in the soil-solution matrix. The metal must be dissolved (i.e., in solution) for leaching and transport by advection with the groundwater to occur. Generally, dynamic and reversible processes control solubility and transport of the dissolved metal ions. Such processes include precipitation/dissolution, adsorption/desorption, and ion exchange.

Metals were retained for assessment in all media.

4.4.2 Potential Human Receptors

In choosing potential human receptor groups, current potential exposure scenarios are developed by considering the aforementioned site information for the J.H. Baxter site. These include potential exposure to soils, groundwater, surface water/sediment, and air. Future potential exposure to the constituents detected in onsite groundwater will also be assessed under a no action scenario.

Characteristics of residential communities in the vicinity of the site are provided in Section 1.1. The following is a list of potential human receptors which will be assessed for inclusion in the quantitative health risk analysis presented in Section 4.6:

- on-site workers (current exposure)
- off-site residents (adult and child)- current exposure to PCOCs originating from the site;
- children trespassing on the Oregon site;
- off-site residents (adult and child) - future potential exposure to PCOCs originating from the site.

Construction workers, which would be exposed should there be decommissioning or redevelopment activities at the site, were not retained as potential receptors at the site. J.H. Baxter will continue to operate this facility for the foreseeable future. Redevelopment to another use is not a consideration. Only construction activities related to drip pad modifications and possible remedial actions are anticipated. Until the nature of the remedial actions is defined, quantitative risk analysis is not appropriate for onsite construction workers. A future on-site residential scenario was not considered either as the site is not intended for future residential development. J.H Baxter and Company will provide institutional controls to ensure that the site is not redeveloped for residential purposes.

Dermal exposure to on-site soils for on-site workers was not retained as a potential pathway. On-site workers are required to wear long pants, long sleeved shirts and gloves while they work in the site yard. Dermal exposure is therefore minimized to contact of airborne soil with the face skin, a contact which would not create significant intake.

There does exist the potential for human receptors to be exposed to PCOCs from the ingestion of fish and water downstream of the facility's storm water discharge point. Insufficient information is available, however, on the amount of dilution and degradation that may occur prior to reaching the receiving water body. Hence, this migration route and exposure pathway will be retained for a qualitative assessment only.

Exposure to PCOCs for human receptors by ingestion and dermal contact with off-site soils has not been retained for assessment. The potential exposure pathway involves the transport of PCOCs in the groundwater and the introduction of PCOCs to surface soils through irrigation use of the groundwater. There is currently no off-site soil quality data. In addition, PCOCs have not been detected in the off-site groundwater wells. This pathway will be retained for future consideration when off-site soil data is available (this data will be collected during the Phase II of this project, and exposure of human receptors to off-site soil will then be assessed).

4.4.3 Potential Human Exposure Pathways

This section describes the various potential exposure pathways associated with each medium and qualitatively evaluates each exposure pathway for further consideration in the quantitative risk analysis.

4.4.3.1 Groundwater

Human exposure to groundwater may occur in the residential area adjacent to the facility. Three households are reported to currently use well water as a drinking water supply. A fourth house, unoccupied for two years, also has a domestic water supply well. This property, however, has been condemned by the City of Eugene. Other households may use well water for showering and bathing, irrigation of gardens and lawns, washing of automobiles, and for water sprinkler systems in which children may play.

Groundwater beneath the site is not currently being used by the facility.

Analytical results for selected onsite and offsite wells will be used in this risk assessment in order to characterize the current and future exposure potential to a receptor. Potential dermal contact, inhalation of vapors and ingestion scenarios for child and adult receptor groups will be retained for further evaluation where applicable.

4.4.3.2 Surface Water/Sediment

The drainage ditch which carries the facility's surface runoff water is not sufficient to support swimming activities by trespassing children or fishing. The ditch could, however, be used by trespassing children as a play area. Hence, the potential exists for dermal contact to both surface water and sediment.

Other potential exposure pathways include the ingestion of fish and water in a receiving water body downstream of the surface water drainage course discharge. As indicated previously, insufficient data are available to quantitatively assess this migration route. However, these pathways will be retained for qualitative assessment.

After evaluating the surface waters and sediments within the study area, the potential human exposure pathway for both surface waters and sediments is dermal contact to surface water and sediments in the drainage ditch

4.4.3.3 Air

A potential human exposure pathway exists in air via inhalation of fugitive dust emissions from soils containing PCOCs and inhalation of chemicals volatilized from soils or from groundwater during bathing.

Fugitive dust emissions at the Oregon facility may result from the wind erosion of soils. PCOCs adhering to these airborne soil particles may be inhaled by offsite individuals and by onsite workers. Inhalation of fugitive dust will be assessed using current and future residential scenarios as well as current onsite workers exposure scenario.

The release of chemicals as a result of volatilization from soils is primarily dependent upon the chemical and physical properties of the chemical, i.e., vapor pressure, organic carbon partition coefficient (Koc), etc. It has been assumed that the volatile PCOCs in groundwater would have been reduced shortly after irrigation to insignificant levels due to high volatilization rates encountered in the spraying of water in open air and high dissemination rates resulting from wind factors. Hence this pathway was not included in the assessment.

However, inhalation of PCOCs via volatilization of PCOCs from the groundwater while showering will be assessed for the adult and child residential scenarios. This pathway was retained since volatilization of PCOCs in water occur in a confined space and a potential receptor is in close proximity to the water.

4.4.4 Potential Environmental Exposure

PCOCs from the site may travel via site surface water runoff to the south drainage ditch which in turn discharges to the City of Eugene storm drainage system, or via groundwater migration. Potential exposure pathways for aquatic biota include direct contact, ingestion of constituents in sediments or surface waters, or inadvertently in the food chain.

4.5 Exposure Assessment

Quantitative risk calculations for potentially carcinogenic compounds estimate risk as the potential excess individual lifetime cancer risk. This estimate is the potential lifetime cancer risk that is over and above the background cancer risk in unexposed individuals. For example, an excess lifetime cancer risk level (RL) of 1×10^{-6} indicates that, for lifetime exposure, one additional case of cancer is expected per one million exposed individuals.

The excess lifetime potential cancer risk level to individuals is estimated from the following relationship:

$$RL = (CSF_1 * CDI_1) + (CSF_2 * CDI_2) + (CSF_i * CDI_i) = SUM\ CSF_i * CDI_i \quad (4.1)$$

where:

CSF_i = cancer slope factor $[(mg/kg/day)^{-1}]$ for compound *i*,
CDI_i = the chronic daily intake (mg/kg/day) for compound *i*.

The cancer slope factor is defined in most instances as an upper 95th percentile confidence limit of the probability of a response based on experimental animal data and the CDI is defined as the exposure expressed as mass of a substance contacted per unit body weight per unit time, averaged over a long period of time (i.e. seven years to a lifetime). The above equation was derived assuming that cancer is a non-threshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

The above equation is only valid at low risk levels (i.e. below estimated risks of 0.01). When estimated risks are high (i.e. greater than 0.01) the following equation should be used.

$$RL_i = 1 - \exp(-CDI_i \times CSF_i) \qquad (4.2)$$

In contrast to the above approach for potentially carcinogenic effects, the potential for health effects for noncarcinogenic compounds assumes a threshold toxicological effect. Therefore, the potential for noncarcinogenic effects are calculated by comparing chronic intake levels with threshold levels (reference doses) below which noncarcinogenic effects are unlikely.

The potential for noncarcinogenic effects or Hazard Index (HI) is defined as:

$$HI = HQ_1 + HQ_2 + ... + HQ_i = SUM\ HQ_i \qquad (4.3)$$

where:

HQ_i = CDI_i/RfD_i (4.4)

HQ_i = hazard quotient,

CDI_i = chronic daily intake (mg/kg/day) of compound *i*,

RfD_i = reference dose (mg/kg/day) of compound *i* over a prolonged period of exposure.

A method for estimating the potential carcinogenic risks and the potential for noncarcinogenic health effects associated with potential direct contact exposures to PCOCs across retained exposure pathways is described below. Direct contact exposures that will be evaluated include: 1) dermal contact, 2) incidental ingestion, and 3) inhalation. The mathematical expression for estimating these doses, as well as inputs needed to solve the equations are presented in the following sections.

For potential carcinogens, the potential excess lifetime cancer risk level (RL) for each potential receptor group can be computed by multiplying the computed intake for incidental ingestion, dermal absorption, and inhalation for each PCOC, by its respective oral or inhalation cancer slope factors (U.S. EPA, 1989):

$$RL = SUM_i\,(CSF_{oral(i)} \times CDI_{ing(i)}) + SUM_i\,(CSF_{oral(i)} \times CDI_{derm(i)}) + SUM_i\,(CSF_{inh(i)} \times CDI_{inh(i)}) \quad (4.5)$$

where:

RL = excess lifetime potential cancer risk level for compound i, unitless

$CSF_{inh(i)}$ = cancer slope factor for compound *i* for exposure via inhalation $[(mg/kg/day)^{-1}]$

$CSF_{oral(i)}$ = cancer slope factor for compound *i* for exposure via incidental ingestion, $[(mg/kg/day)^{-1}]$

$CDI_{ing(i)}$ = chronic daily intake of compound *i* via incidental ingestion (mg/kg/day)

$CDI_{derm(i)}$ = chronic daily intake of compound *i* via dermal contact, (mg/kg/day)

$CDI_{inh(i)}$ = chronic daily intake of compound *i* via inhalation (mg/kg/day).

For noncarcinogens, the Hazard Quotient (HQ) for each potential receptor group can be computed by dividing the sum of the computed intakes for ingestion, dermal contact, and inhalation by the appropriate reference dose (RfD) (U.S.EPA, 1989a):

$$HI = SUM_i\,(CDI_{ing(i)}/RfD_{ing(i)}) + SUM_i\,(CDI_{derm(i)}/RfD_{ing(i)}) + SUM_i\,(CDI_{inh(i)}/RfD_{inh(i)}) \quad (4.6)$$

Where:

HI = Hazard Index (unitless)

$RfD_{ing(i)}$ = Reference Dose for compound *i* for exposure via incidental ingestion, (mg/kg/day)

$RfD_{inh(i)}$ = Reference Dose for compound *i* for exposure via inhalation, contact (mg/kg/day)

$CDI_{ing(i)}$ = chronic daily intake of compound *i* via incidental ingestion (mg/kg/day)

$CDI_{derm(i)}$ = chronic daily intake of compound *i* via dermal contact, (mg/kg/day)

$CDI_{inh(i)}$ = chronic daily intake of compound *i* via inhalation, (mg/kg/day)

The appropriate cancer slope factors and reference doses used to calculate RL's and HI's can be found in Table 4-15.

The procedures for computing chronic daily intakes of compound *i* are described in the following sections. The following subsections provide route-specific estimates of PCOCs to which a receptor may be exposed. Estimated doses of constituents are presented in Appendix E.

TABLE 4-15
SUMMARY OF PCOC CANCER SLOPE FACTORS AND REFERENCE DOSES
J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

Compound	Cancer Slope Factor Oral (1)	Cancer Slope Factor Inhalation (1) (8)	Reference Dose Oral (2) mg/kg/day	Reference Dose Inhalation (2) mg/kg/day	Weight of Evidence Classification (3)	Uncertainty Factor
Volatile Compounds						
1,1,1-Trichloroethane	NA	NA	0.09 (11)	0.3 (9)	D	1000
1,1-Dichloroethane	NA	NA	0.1 (9)	0.1 (9)	C	1000
1,1-Dichloroethene	0.6 (11)	NA	0.009 (11)	NA (4)	C	1000
Methylene Chloride	0.0075 (11)	NA	0.06 (11)	NA	B2	100
Trichlorofluoromethane	NA	NA	0.3 (11)	0.2 (9)	NA	1000 (10,000) (7)
Benzene	0.029 (11)	NA	NA	NA	A	NA
Ethylbenzene	NA	NA	0.1 (11)	NA (4)	D	1000
Styrene	0.03 (9)	0.002 (9)	0.2 (11)	NA (4)	B2	1000
Toluene (5)	NA	NA	0.2 (11)	NA	D	1000
Xylenes	NA	NA	2.0 (11)	NA (4)	D	100
Phenolics						
2,3,5,6-Tetrachlorophenol	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	0.011 (9)	0.011 (9)	NA	NA	B2	NA
2,4-Dichlorophenol	NA	NA	0.003 (11)	NA	NA	100
2,4-Dimethylphenol	NA	NA	0.02 (11)	NA	NA	3000
2,4-Dinitrophenol	NA	NA	0.002 (11)	NA	NA	1000
2-Chlorophenol	NA	NA	0.005 (11)	NA	NA	1000
2-Methyl-4,6-dinitrophenol	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA
Pentachlorophenol	0.12 (12)	NA	0.03 (11)	NA (4)	B2	100
Phenol	NA	NA	0.6 (11)	NA	D	100
Metals						
Arsenic	1.75 (6) (11)	50 (9)	0.001 (9)	NA	A	1
Chromium (+6)	NA	41 (9)	0.005 (11)	NA	A (Inhalation)	500
Copper	NA	NA	NA	NA	D	NA
Zinc	NA	NA	0.2 (9)	NA	NA	NA
Noncarcinogenic PAHs						
Acenaphthene	NA	NA	0.06	NA	NA	3,000
Acenaphthylene	NA	NA	NA	NA	D	NA
Anthracene	NA	NA	0.3 (11)	NA	D	3,000
Benzo(g,h,i)perylene	NA	NA	NA	NA	D	NA
Fluoranthene	NA	NA	0.04 (11)	NA	D	3,000
Fluorene	NA	NA	0.04 (11)	NA	D	3,000
Naphthalene	NA	NA	0.004 (9)	NA	D	10,000
Phenanthrene	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	0.03 (11)	NA	D	3,000

TABLE 4-15 (Continued)
SUMMARY OF PCOC CANCER SLOPE FACTORS AND REFERENCE DOSES

J.H. Baxter and Company
Wood Preserving Facility
Eugene, Oregon

Compound	Cancer Slope Factor Oral (1)	Cancer Slope Factor Inhalation (1)	Reference Dose Oral (2)	Reference Dose Inhalation (2)	Weight of Evidence Classification (3)	Uncertainty Factor
<u>Potentially Carcinogenic PAHs</u>						
Benzo(a)anthracene	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Benzo(a)pyrene	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Benzo(b)fluoranthene	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Benzo(k)fluoranthene	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Carbazole	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Chrysene	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Dibenz(a,h)anthracene	11.5 (10)	6.1 (10)	NA	NA	B2	NA
Indeno(1,2,3-cd)pyrene	11.5 (10)	6.1 (10)	NA	NA	B2	NA

Notes:

NA - Not Available
(1) units of (1/mg/kg/day)
(2) units of (mg/kg/day)
(3) See Table 4-1 for description of classification
(4) Inhalation reference doses have not been determined, therefore the oral RfD will be used as a surrogate for the inhalation exposure route.
(5) Withdrawn from IRIS Data Base as of 07/01/90, but was re-entered on 8/1/90.
(6) Estimated from a unit risk value of 5E-5 1/(ug/l) assuming a 70kg adult ingests 2 l/day.
(7) Inhalation uncertainty factor.
(8) Inhalation CSF's were only retained when available in Heart (Third Quarter July 1990) due to the Iris directive to remove all inhalation CSF's from Section II of the IRIS database.

References:

(9) U.S. EPA, Health Assessment Summary Tables, Third Quarter, FY-1990,July.
(10) Taken from U.S. EPA, Available Toxicity Information for PAHs, Environmental Criteria and Assessment Office Memo, Chemical Mixtures Assessment Branch, April 2, 1990.
(11) U.S. EPA, 1990:IRIS Data Base. Current as of the date of this report.
(12) U.S. EPA Memorandum, October 29, 1990, Pentachlorophenol Cancer Slope Factor, Office of Solid Waste and Emergency Response.

A dose is defined as the amount of a compound (in mg) absorbed (per day) by a receptor (per kg of body weight). Doses can be calculated for a lifetime exposure (for carcinogenic effects) or for chronic/subchronic exposures (noncarcinogenic effects). A dose is generally estimated as follows:

$$\text{Dose} = \frac{C \times CR \times EFD}{BW} \times \frac{1}{AT} \qquad (4.7)$$

Where:

Dose = intake; the amount of chemical at the exchange boundary (mg/kg body weight-day)

C = chemical concentration; the average concentration contacted over the exposure period (e.g., mg/liter water)

CR = contact rate; the amount of contaminated medium contacted per unit time or event (e.g., liters/day)

EFD = exposure frequency and durations; describes how long and how often exposure occurs. Often calculated using two terms (EF and ED):

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight; the average body weight (kg)

AT = averaging time; period over which exposure is averaged (days)

The following sections provide the methodologies and assumptions to be used to quantitatively estimate the potential for exposure (dose) via the exposure pathways identified in Section 4.4.

The risk levels and hazard quotients associated with the estimated doses are presented in Section 4.6.

4.5.1 Ingestion of Groundwater

Residential (Adult and Child)

Exposure to PCOCs via ingestion of groundwater is a future potential exposure pathway for both children and adults. $CDI_{ing(i)}$, the daily intake of compound *i* via incidental ingestion, is:

$$CDI_{ing(i)} = \frac{CW \times IR \times EF \times ED}{BW \times AT} \qquad (4.13)$$

Where:

CW = Concentration of the compound in groundwater (mg/liter)
IR = Ingestion rate (liters/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

A value of 0.5 liters/day (U.S. EPA, 1989a) will be used as the amount of water consumed for children (IR) in the age range 1 through 4 years. This age range represents a conservative exposure estimate to protect young children who are considered a more sensitive subpopulation as opposed to older children, adolescents, or adults. This value assumes that children obtain all the water they drink from the same source 365 day/year (which represents the exposure frequency, EF).

Exposure duration (ED) for children was defined as 4 years, with an average body weight (BW) of 10 kg (U.S. EPA, 1989a). An averaging time (AT) of 70 years (25,550 days) was used for potentially carcinogenic compounds and 365 day/year times the exposure duration (ED) was used for noncarcinogenic exposure.

As with children, an adult may also be exposed to constituents in groundwater under a no action scenario. The daily intake, $\mathrm{CDI}_{\mathrm{ing}(i)}$ and exposure frequency (EF) is defined in the same way as residential children scenario. However, exposure durations (ED) are estimated to be 30 years (U.S. EPA, 1989a), which represents the national upper-bound time (90th percentile) at one residence. The IR is 2 liters/day which represents a reasonable worst-case value (U.S. EPA 1989a). In addition, the averaging time (AT) for noncarcinogens is 10,950 days (ED of 30 years times 365 day/year) while the AT for potential carcinogens is estimated to 25,550 days.

All concentrations of PCOCs measured at the off-site wells were below the detection limit. Hence this exposure pathway was not assessed for current residences.

The future potential risk to residences will be estimated using onsite groundwater concentrations measured at the facility's property line; refer to Table 4-16. It has been assumed that no retardation or degradation occurs during the transport of PCOCs through groundwater; a health conservative assumption. Selected wells will be chosen from onsite and offsite areas which best represent exposure estimates, conservative of human health.

4.5.2 Dermal Contact of Groundwater (Bathing)

Residential (Adult and Child)

Children and adults may be exposed to PCOCs via dermal contact with groundwater during bathing. $\mathrm{CDI}_{\mathrm{derm}(i)}$, the absorbed dose of compound i via dermal contact with groundwater, is:

$$\mathrm{CDI}_{\mathrm{derm}(i)}=\frac{\mathrm{CW \times SA \times PC \times CF \times ET \times EF \times ED}}{\mathrm{BW \times AT}} \tag{4.14}$$

TABLE 4-16

Maximum Concentrations for Retained PCOCs Used for the Quantitative Assessment

COMPOUNDS	GROUNDWATER		SOIL ONSITE (ug/kg)	SURFACE WATER (ug/L)	SEDIMENT (ug/kg)
	ONSITE (ug/L)	OFFSITE (ug/L)			
VOLATILES:					
Benzene	8.3	NS	ND	ND	ND
Toluene	NA	NS	ND	ND	56.6
Chlorobenzene	ND	NS	ND	ND	ND
Ethylbenzene	97.5	NS	ND	ND	ND
Xylenes	ND	NS	ND	NS	53.2
Styrene	ND	NS	ND	NS	ND
1,1-Dichloroethane	25.7	NS	NS	ND	NS
1,1-Dichloroethene	81.7	NS	NS	ND	NS
1,2-Dichlorobenzene	ND	NS	22	ND	ND
PHENOLICS;					
Phenol	2.8	NS	79	1.32	121
2-Chlorophenol	4.13	NS	249	ND	3810
2-Nitrophenol	5.36	NS	ND	3.25	ND
2,4-Dimethylphenol	12.9	NS	478	ND	209
2,4-Dichlorophenol	7.46	NS	105	ND	ND
4-Chloro-3-Methylphenol	22.7	NS	ND	ND	28.4
2,4,6-Trichlorophenol	20.6	NS	181	1.4	ND
2,4-Dinitrophenol	23	NS	ND	1.12	ND
4-Nitrophenol	163	NS	231	ND	ND
2,3,5,6-Tetrachlorophenol	86.3	NS	ND	3.93	ND
2-Methyl-4,6-Dinitrophenol	100	NS	ND	26.8	ND
Pentachlorophenol	1300	ND	1200	44.4	5060

TABLE 4-16 (continued)
Maximum Concentrations for Retained PCOCs
Used for the Quantitative Assessment

COMPOUNDS	GROUNDWATER ONSITE (ug/L)	GROUNDWATER OFFSITE (ug/L)	SOIL ONSITE (ug/kg)	SURFACE WATER (ug/L)	SEDIMENT (ug/kg)
METALS:					
Arsenic	180	ND	7060	698	115000
Chromium	NA	ND	43500	ND	43600
Copper	35	ND	35900	267	932000
Zinc	62	ND	69900	179	216000
NONCARCINOGENIC PAHS:					
Naphthalene	4450	ND	36000	ND	1320
Acenaphthylene	262	ND	50	ND	711
Acenaphthene	350	ND	23000	ND	ND
Fluorene	296	ND	20000	0.222	193
Phenanthrene	560	ND	15000	0.579	258
Anthracene	95.1	ND	15000	0.508	84.3
Fluoranthene	115	ND	3000	2.94	1250
Pyrene	104	ND	13000	1.81	691
Benzo(g,h,i)perylene	16.7	ND	25.8	0.090	628
POTENTIAL CARCINOGENIC PAHS:					
Carbazole	283	ND	ND	ND	1190
Benzo(a)anthracene	30.5	ND	3300	0.462	1300
Chrysene	54	ND	3300	1.21	2160
Benzo(b)fluoranthene	16.3	ND	1100	0.306	581
Benzo(k)fluoranthene	6.94	ND	1100	0.076	6.78
Benzo(a)pyrene	19	ND	1100	ND	179
Dibenzo(a,h)anthracene	25.5	ND	64.8	0.086	1060
Indeno(1,2,3-cd)pyrene	4.36	ND	10.9	0.073	926

NOTES:
ND: not detected
NS: not sampled
NA: Not Assessed

Where:

CW = Concentration of compound in groundwater (mg/liters)
SA = Skin surface area available for contact (cm^2)
PC = Chemical-specific dermal permeability constant (cm/hr)
CF = Volumetric conversion factor for water (1 liter/1000 cm^3)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

As with ingestion of groundwater, it was assumed that bathing would take place 365 day/year (EF) using the groundwater as the sole source of supply.

The skin surface area (SA) exposed for dermal absorption by children was estimated to be whole body representing 7100 cm^2 (age range <4 years) of skin area (U.S. EPA, 1989a). For the adult a value of 19 400 cm^2 was employed (U.S. EPA, 1989a).

The permeability constant (PC) reflects the movement of the chemical across the skin and into the blood stream. It is important to evaluate this process to determine actual absorption doses. However, many compounds do not have literature PC values. For these compounds, it was assumed that they are carried through the skin barrier at the same rate as that of water (U.S. EPA, 1988), which, in all likelihood would be the controlling factor in PCOC absorption. Therefore, the permeability constant for water (8.0×10^{-4} cm/hr) will be used as recommended based on U.S. EPA 1989, because the PC values present in SEAM (U.S. EPA, 1988) are currently being reviewed and should not be used at this time (U.S. EPA, 1989a). This value may in fact be a more realistic estimate of the absorption rate of a chemical when PCOC concentrations are in the part-per-billion range.

The exposure time (ET) per bathing is estimated to be 0.25 hours/day (U.S. EPA, 1989a). Exposure duration (ED) for children was estimated to be 4 years. Average body weight (BW) for ages 1 through 4 years was estimated to be 10 kg (U.S. EPA, 1989a). Noncarcinogenic averaging time (AT) was estimated at 1,460 days and potential carcinogens at 25,550 days.

As with children, adults could also be exposed to PCOCs via dermal exposure to groundwater during bathing. The intake, $CDI_{ing(i)}$ is defined similarly as in the residential child scenario. However, exposure durations (ED) are estimated to be 30 years (U.S. EPA, 1989a), which represents the national upper-bound time (90th percentile) at one residence. EF and ET remain the same at 365 days/yr and 0.25 hrs/day, respectively. In addition, adult body weight (BW) remains at 70 Kg. The averaging time for noncarcinogens is increased to 10,950 days (ED times 365 day/year where ED equals 30 years) whereas potential carcinogens remain the same at 25,550 days.

4.5.3 Inhalation of VOCs While Showering

Residential Adults

Adults may be exposed to volatile organic constituents in groundwater through the inhalation of these compounds during showering. Children (ages 1 through 4 years) are less likely to be exposed via this pathway because younger children tend not to shower (but bathe instead). The $CDI_{inh(i)}$ can be estimated by the equation:

$$CDI_{inh(i)} = \frac{Ca \times IR \times ET \times EF \times ED}{BW \times AT} \qquad (4.15)$$

Where:

Ca = Estimated constituent concentration in shower air (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/d)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yrs)
BW = Body weight (Kg)
AT = Averaging time (d)

The average concentration of a volatile compound in the shower air, Ca, over a specified time period is estimated using the Andelman model which is described below (Andelman, 1984; 1985a; 1985b). An inhalation rate of 0.6 m^3/hr was used for a showering adult (U.S. EPA 1989a). As for bathing, the ET is assumed to be 0.25 hours/day (U.S. EPA 1989a) and the EF is 365 d/yr, with an exposure duration (ED) of 30 years. Again, adult body weight (BW) was set equal to 70 kg (U.S. EPA, 1989a). The averaging time (AT) for noncarcinogens was 10,950 days and for potential carcinogens, 25,550 days.

The Andelman model for shower air concentration is expressed as (Andelman, 1984; 1985a; 1985b).

$$Ca = Cinf\,[1+(1/(kE_t))(\exp(-kE_t)-1)] \qquad (4.16)$$

Where:

Ca = Shower air concentration (mg/m^3)
$Cinf$ = Asymptotic concentration in air (mg/m^3)
E_t = Showering time (min)
k = Rate constant (min-1)

$$Cinf = [(E)(Fw)(Cw/1000)]/Fa$$

Where:

E = The efficiency of release-water to air
Fw = The flow rate of water in the shower (L/min)
Cw = Constituent concentration in shower water (ug/L)
Fa = Flow rate of air in the shower (m^3/min)

$$k = Fa/Vb$$

Where:

Vb = The volume of an average bathroom (m^3)

$$Ei = (Etce)(Hi)/(Htce)$$

Where:

Ei = The relative efficiency of release of chemical vs. TCE
$Etce$ = The efficiency of release of TCE
Hi = The Henry's constant for chemical *i* (m^3 atm/mol)
$Htce$ = The Henry's constant for TCE (m^3 atm/mol)

The efficiency of release (Etce) and Henry's (Htce) constant for TCE employed in the model are 0.6 and 9.1×10^{-3} m^3 atm/mol, respectively. The flow rate of water and air in the shower employed will be 8 L/min and 2.4 m^3/min, respectively. The volume of the average bathroom used will be 12 m^3. Henry's constant for each PCOC are presented in Table 4.11.

4.5.4 Dermal Contact With Surface Water

Trespassing Children

During the course of their daily recreational activities, children could potentially trespass onto the site in the area adjacent to the drainage ditch. Thus the children could potentially be exposed to PCOCs in the surface water via dermal contact. Dermal Exposure during wading, $CDI_{derm(i)}$, can be estimated by the equation:

$$CDI_{derm(i)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT} \qquad (4.17)$$

Where:

CW = Chemical concentration in water (mg/liter)
SA = Skin surface area available for contact (cm^2)
PC = Chemical-specific dermal permeability constant (cm/hr)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Volumetric Conversion Factor for Water (1 liter/1000 cm^3)
BW = Body Weight (kg)
AT = Averaging Time (period over which exposure is averaged--days)

Chemical concentrations in the drainage ditch employed in the assessment are presented in Table 4.16.

An older child, i.e. 9 to 16 years old, was selected because of the difficulty a younger child would encounter gaining access to the site. The site is located in an industrial area, at a distance from residential neighborhoods. To gain access to the drainage ditch, an individual must cross several hazard areas: four lane arterial road and fenced, active industrial complex. This ditch is within a railway Right-of-Way (R.O.W.), representing a risk in itself. The significant hazards associated with gaining access to the ditch and its proximity to residential areas suggests that an older child (aged 9 to 16 inclusive) represent the most probable, potential receptor group.

The skin surface area (SA) exposed for dermal absorption by children 9-16 years old was estimated to be legs representing 3100 cm^2 of skin area (U.S. EPA, 1989c).

PC values follow the same rationale given in Section 4.5.2, Dermal Contact of Groundwater (Bathing), where, 8.0×10^{-4} cm/hr was used (U.S. EPA, 1989a). The exposure time (ET) and exposure frequency (EF) are defined as 4 hours/day and 12 days/year, respectively. The twelve days per year represent four event during June, July and August.

Exposure duration is defined to span an 8 year period (representing the age group 9 to 16 years old) with an average body weight (BW) of 45 kg (U.S. EPA, 1985g). The averaging time for noncarcinogens and potential carcinogens is 2,920 and 25,550 days, respectively.

4.5.5 Dermal Contact of Sediments

Trespassers Children

Just as dermal contact with PCOCs may occur during children's recreational activities at the site, they can also absorb chemicals via dermal contact with sediments. $CDI_{derm(i)}$, the absorbed dose of compound i via dermal contact, is given by:

$$CDI_{derm(i)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT} \qquad (4.18)$$

Where:

CS = Chemical concentration in sediments (mg/kg)
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin Surface area available for contact (cm^2/event)
AF = Sediment to Skin Adherence Factor (mg/cm^2)
ABS = Absorption Factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (period over which exposure is averaged -- days)

The concentration of PCOCs employed in the assessment are from the sediments collected in the ditch, and are presented in Table 4.16.

A skin surface area (SA) for dermal exposure to sediments of 3100 cm^2 representing the child's legs (9 to 16 years old) has been employed (U.S. EPA, 1989b). Literature values for sediment adherence factors (AF) are not known to be available; therefore, 1.45 mg/cm^2 is used to provide a conservative estimate of exposure (which represents commercial potting soil, U.S. EPA, 1989a). Dermal absorption factors (ABS) for PCOCs, defined previously for dermal contact of soils will remain the same for this exposure scenario. The exposure frequency (EF) for contact with sediments is estimated to be 12 events/year, i.e. once a week during June, July and August. The exposure duration (ED) and body weight (BW) are 8 years (representing the age group 9 to 16 years) and 45 kg, respectively.

An exposure time of 70 years or 25,550 days was used for exposure to potentially carcinogenic compounds and an averaging time of 365 days/year times the exposure duration (ED) was used for noncarcinogenic exposure (U.S. EPA, 1989a).

4.5.6 Air

During the course of outside activities, residents and site workers may also be exposed to PCOCs through inhalation. Exposures via inhalation are difficult to assess given the spatial and temporal variation of constituents in air and their physical state (i.e. particulates, vapors). The CDI via inhalation is given by:

$$CDI_{inh(i)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT} \qquad (4.19)$$

Where:

CA = Constituent concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/d)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yrs)
BW = Body weight (kg)
AT = Averaging time (d)

Where:

$$CA = PM10 \times Fs \times Cs \times Cf \qquad (4.20)$$

PM10 = Respirable particulate concentration (mg/m^3)
Cf = Conversion factor (1×10^{-6} mg/kg)
Fs = Fraction of particulate which is on-site soil
Cs = Constituent concentration in on-site soil (mg/kg)

For the residential scenario assessment, the inhalation rate (IR) for both children and adults was estimated to be 2.1 m^3/hour and 2.0 m^3/hour, respectively for moderate activity (U.S. EPA, 1989a). An Exposure time (ET) of 8 hours per day was considered to be the same for both adults and children, however, the exposure frequency (EF) was estimated to be 260 days/year for children and 104 days/year for the adult because children would be outdoors more often (5 days per week for the child and 2 days per week for the adult). The exposure durations were defined for children and adults as 4 years and 30 years, respectively.

For the on-site workers exposure, an inhalation rate (IR) of 3.9 m^3/hour was estimated for an elevated level of activity. The exposure time (ET) was estimated at 8 hours/day and the exposure frequency (EF) was estimated as 260 days (based on a work week of five days). The exposure duration was defined as 30 years. An average body weight (BW) of 70 kg corresponding to an adult was employed in the assessment.

To conservatively estimate the airborne concentration of PCOCs, values of 10.24 ug/m^3 and 0.25 were employed for offsite PM10 particulate concentration and fraction of particulate which originates from on-site soil (Fs). The PN10 value employed was obtained from the SCREEN model and represent the concentration of respirable soil particulates for the summer time. The winter time PM10 concentration is lower, thus the use of the summer value for this assessment is a conservative assumption. The resulting calculations of the model are provided in Appendix E.

Average body weights (BW) for children and adults are 10 kg and 70 kg, respectively. Averaging times (AT) for noncarcinogens were estimated at 1,460 days (child) and 10,950 day (adults) and potential carcinogens were the same at 25,550 days.

4.5.7 Incidental Ingestion of On-Site Soil

This pathway was evaluated for on-site workers since they may ingest some of the on-site soil during the course of their activities. The exposure frequency (EF) was assumed to be an 8 hour work day and the fraction of on-site soil ingested by a worker (FI) was estimated at 0.5 g/g since only a fraction of their total daily soil intake (FI) will originate from the site. The exposure duration (ED) was estimated at 30 years, the body weight at 70 kg, and the ingestion rate at 100 mg/day. The averaging times (AT) were estimated as 10 950 days for non-carcinogens and 25 550 days for carcinogens.

The exposure was calculated with the following equation:

$$CDI_{(ing)i} = \frac{IR \times FI \times EF \times ED \times CS \times CF}{BW \times AT}$$

Where:

IR = Ingestion Rate (mg soil/day)
FI = Fraction of on-site soil ingested
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CS = Chemical concentration in soil
CF = Conversion factor (10^{-6} kg/mg)
BW = Body weight (kg)
AT = Averaging time (days)

4.6 Risk Characterization

This section presents and discusses estimated potential risks and hazard indices for identified population groups and environmental receptors who could potentially be exposed to PCOCs via the potential exposure pathways discussed in Section 4.4.3 of this report.

Estimated potential risks (represented by potentially carcinogenic compounds), as recommended by U.S. EPA (1989a), will be compared to a target risk range of 10^{-4} to 10^{-6} which the U.S. EPA considers to be safe and protective of public health (U.S. EPA, 1989a). A value of 1.0 is used for comparison of the hazard index (HI) (represented by noncarcinogenic compounds) based on the fact that the hazard index is calculated by comparing estimated allowable daily intakes with threshold levels below which there is no potential for noncarcinogenic health effects.

The estimated potential risks and hazard indices are discussed by media in the following subsections. Quantitative dose estimates for specific PCOCs can be found in Appendix E.

4.6.1 Human Health Risks

4.6.1.1 Overall Exposure

Tables 4-17 and 4-18 present the total potential risk levels (RL) and hazard indices (HI) for current and future residential receptors (adult and child), and trespassers via hypothetical ingestion, dermal contact and inhalation.

The total potential risk level (RL) for current residents (adult, trespasser and child) were estimated to be 8.21 x 10^{-7}, 1.36 x 10^{-5} and 2.71 x 10^{-}6, respectively (Table 4-17). The total potential hazard index (HI) was zero for the adult and child, and 1.01 x 10^{-3} for the trespasser (Table 4-18). The potential RL for the adult is below the target risk range of 10^{-4} to 10^{-6} (as defined by the U.S. EPA, 1989a). The total potential RL for the child and the trespasser are within the range. The total potential HI for the trespasser (1.01 x 10^{-3}), as well as for the adult and child (0 for both), are well below the target value of 1.0 (Table 4-18).

For future hypothetical residences (adult and child), the major exposure route is ingestion of groundwater. The RLs for ingestion are 6.83 x 10^{-2} and 1.59 x 10^{-2} for the adult and child, respectively; values well above the 10^{-4} to 10^{-6} risk range. The maximum HIs are 41.3 and 67.9 for the adult and child, respectively, both well above the target of 1.0.

4.6.1.2 Air

Dust

Hypothetical inhalation of airborne particulate was considered for the receptor groups of adult and child (current and future residents), and on-site workers. The data indicates that the RL values for both the adult (8.21 x 10^{-7}) and child (1.36 x 10^{-5}) for the future residence scenario are below or within the target risk range (Tables 4-19). The RLs for the current residence scenario are similar to those for the future scenario (Table 4-20). The RL for the on-site worker group is 1.42 x 10^{-6}, at the

TABLE 4-17

Overall Potential Risk Levels for all Exposure Pathways and Receptors Assessed

COMPOUNDS	FUTURE RESIDENCE						CURRENT RESIDENCE		TRESPASSER	ON-SITE WORKER	
	ADULT			CHILD			ADULT	CHILD			
	INHAL.	INGEST	DERMAL	INHAL.	INGEST	DERMAL	INHAL.	INHAL.	DERMAL	INHAL.	INGEST
VOLATILES:											
Benzene	NA	2.95E-06	6.00E-09	NA	6.88E-07	2.05E-09	NA	NA	0.00E+00	NA	0.00E+00
Styrene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1,1-Dichloroethene	NA	6.00E-04	1.22E-06	NA	1.40E-04	4.18E-07	NA	NA	0.00E+00	NA	0.00E+00
PHENOLICS:											
2,4,6-Trichlorophenol	NA	2.77E-06	5.65E-09	NA	6.47E-07	1.93E-09	NA	NA	1.34E-11	NA	4.01E-10
Pentachlorophenol	NA	1.91E-03	3.89E-06	NA	4.46E-04	1.33E-06	NA	NA	2.74E-08	NA	2.90E-08
METALS											
Arsenic	3.14E-07	3.86E-03	7.86E-06	5.24E-06	9.00E-04	2.68E-06	3.14E-07	5.24E-06	1.06E-06	9.75E-07	2.49E-06
Chromium	5.02E-07	NA	NA	8.36E-06	NA	NA	5.02E-07	8.36E-06	NA	4.93E-06	NA
POTENTIAL CARCINOGENIC PAHS:											
Carbazole	0.00E+00	3.99E-02	8.12E-05	0.00E+00	9.30E-03	2.77E-05	0.00E+00	0.00E+00	2.57E-07	0.00E+00	0.00E+00
Benzo(a)anthracene	1.51E-09	4.29E-03	8.75E-06	3.36E-09	1.00E-03	2.99E-06	1.51E-09	3.36E-09	2.85E-07	5.56E-08	1.53E-05
Chrysene	1.51E-09	7.60E-03	1.55E-05	3.36E-09	1.77E-03	5.29E-06	1.51E-09	3.36E-09	4.78E-07	5.56E-08	1.53E-05
Benzo(b)fluoranthene	5.03E-10	2.30E-03	4.68E-06	1.12E-09	5.36E-04	1.60E-06	5.03E-10	1.12E-09	1.28E-07	1.85E-08	5.09E-06
Benzo(k)fluoranthene	5.03E-10	9.77E-04	1.99E-06	1.12E-09	2.28E-04	6.80E-07	5.03E-10	1.12E-09	2.22E-09	1.85E-08	5.09E-06
Benzo(a)pyrene	5.03E-10	2.68E-03	5.45E-06	1.12E-09	6.24E-04	1.86E-06	5.03E-10	1.12E-09	3.86E-08	1.85E-08	5.09E-06
Dibenzo(a,h)anthracene	2.97E-11	3.59E-03	7.31E-06	6.59E-11	8.38E-04	2.50E-06	2.97E-11	6.59E-11	2.30E-07	1.09E-09	3.00E-07
Indeno(1,2,3-cd)pyrene	4.99E-12	6.14E-04	1.25E-06	1.11E-11	1.43E-04	4.27E-07	4.99E-12	1.11E-11	2.01E-07	1.84E-10	5.05E-08
TOTAL	8.21E-07	6.83E-02	1.39E-04	1.36E-05	1.59E-02	4.75E-05	8.21E-07	1.36E-05	2.71E-06	6.07E-06	4.87E-05

NA: Not Available

TABLE 4-18
Overall Potential Hazard Indices for all Exposure Pathways and Receptors Assessed

COMPOUNDS	FUTURE RESIDENCE						CURRENT RESIDENCE		TRESPASSER	ON-SITE WORKER	
	ADULT			CHILD			ADULT	CHILD			
	INHAL.	INGEST	DERMAL	INHAL.	INGEST	DERMAL	INHAL.	INHAL.	DERMAL	INGEST	INHAL
VOLATILES:											
Toluene	NA	8.76E-03	1.78E-05	NA	1.53E-02	4.57E-05	NA	NA	1.86E-08	0.00E+00	NA
Ethylbenzene	NA	2.79E-02	5.67E-05	NA	4.88E-02	1.45E-04	NA	NA	0.00E+00	0.00E+00	NA
Xylenes	NA	0.00E+00	0.00E+00	NA	0.00E+00	0.00E+00	NA	NA	1.75E-09	0.00E+00	NA
Styrene	NA	0.00E+00	0.00E+00	NA	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	NA
1,1-Dichloroethane	1.47E-07	3.15E-03	6.41E-06	1.38E-07	7.34E-04	2.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1,1-Dichloroethene	NA	1.11E-01	2.26E-04	NA	2.59E-02	7.73E-05	NA	NA	0.00E+00	0.00E+00	NA
PHENOLICS:											
Phenol	NA	1.33E-04	2.72E-07	NA	2.33E-04	6.96E-07	NA	NA	8.30E-08	1.95E-07	NA
2-Chlorophenol	NA	2.36E-02	4.81E-05	NA	4.13E-02	1.23E-04	NA	NA	2.50E-04	0.00E+00	NA
2,4-Dimethylphenol	NA	1.84E-02	3.75E-05	NA	3.23E-02	9.62E-05	NA	NA	3.43E-06	1.12E-05	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	4.26E-06	NA	NA
Pentachlorophenol	NA	5.31E-01	1.08E-03	NA	1.24E-01	3.69E-04	NA	NA	7.62E-06	8.05E-06	NA
METALS:											
Arsenic	NA	2.20E+00	4.49E-03	NA	5.14E-01	1.53E-03	NA	NA	6.07E-04	1.42E-03	NA
Chromium	NA	3.43E-02	6.98E-05	NA	8.00E-03	2.39E-05	NA	NA	0.00E+00	1.75E-03	NA
Zinc	NA	8.86E-03	1.80E-05	NA	1.55E-02	4.62E-05	NA	NA	6.80E-06	1.64E-04	NA
NONCARCINOGENIC PAHS:											
Naphthalene	NA	3.18E+01	6.48E-02	NA	5.56E+01	1.66E-01	NA	NA	5.42E-05	8.45E-03	NA
Acenaphthylene	NA	1.87E+00	3.80E-03	NA	3.28E+00	9.77E-03	NA	NA	2.93E-05	1.17E-05	NA
Acenaphthene	NA	1.67E-01	3.40E-04	NA	2.92E-01	8.70E-04	NA	NA	0.00E+00	3.60E-04	NA
Fluorene	NA	2.11E-01	4.30E-04	NA	3.70E-01	1.10E-03	NA	NA	8.35E-07	4.70E-04	NA
Phenanthrene	NA	4.00E+00	8.15E-03	NA	7.00E+00	2.09E-02	NA	NA	1.17E-05	3.52E-03	NA
Anthracene	NA	9.06E-03	1.84E-05	NA	1.59E-02	4.73E-05	NA	NA	5.89E-08	4.70E-05	NA
Fluoranthene	NA	8.21E-02	1.67E-04	NA	1.44E-01	4.29E-04	NA	NA	5.69E-06	7.05E-05	NA
Pyrene	NA	9.90E-02	2.02E-04	NA	1.73E-01	5.17E-04	NA	NA	4.23E-06	4.07E-04	NA
Benzo(g,h,i)perylene	NA	1.19E-01	2.43E-04	NA	2.09E-01	6.22E-04	NA	NA	2.60E-05	6.06E-06	NA
TOTAL	1.47E-07	4.13E+01	8.42E-02	1.38E-07	6.79E+01	2.03E-01	0.00E+00	0.00E+00	1.01E-03	1.67E-02	0.00E+00

NA: Not Available

TABLE 4-19
INHALATION OF SOIL (DUST)
RISK LEVELS AND HAZARD INDEX
FUTURE RESIDENCE SCENARIO

COMPOUNDS	ADULT		CHILD	
	RL	HI	RL	HI
METALS				
Arsenic	3.14E-07	NA	5.24E-06	NA
Chromium	5.02E-07	NA	8.36E-06	NA
POTENTIAL CARCINOGENIC PAHS				
Carbazole	0.00E+00	NA	0.00E+00	NA
Benzo(a)anthracene	1.51E-09	NA	3.36E-09	NA
Chrysene	1.51E-09	NA	3.36E-09	NA
Benzo(b)fluoranthene	5.03E-10	NA	1.12E-09	NA
Benzo(k)fluoranthene	5.03E-10	NA	1.12E-09	NA
Benzo(a)pyrene	5.03E-10	NA	1.12E-09	NA
Dibenzo(a,h)anthracene	2.97E-11	NA	6.59E-11	NA
Indeno(1,2,3-cd)pyrene	4.99E-12	NA	1.11E-11	NA
TOTAL	8.21E-07	NA	1.36E-05	NA

TABLE 4-20
INHALATION OF SOIL (DUST)
RISK LEVELS AND HAZARD INDEX
CURRENT RESIDENCE SCENARIO

COMPOUNDS	ADULT		CHILD	
	RL	HI	RL	HI
METALS				
Arsenic	3.14E-07	NA	5.24E-06	NA
Chromium	5.02E-07	NA	8.36E-06	NA
POTENTIAL CARCINOGENIC PAHS				
Carbazole	0.00E+00	NA	0.00E+00	NA
Benzo(a)anthracene	1.51E-09	NA	3.36E-09	NA
Chrysene	1.51E-09	NA	3.36E-09	NA
Benzo(b)fluoranthene	5.03E-10	NA	1.12E-09	NA
Benzo(k)fluoranthene	5.03E-10	NA	1.12E-09	NA
Benzo(a)pyrene	5.03E-10	NA	1.12E-09	NA
Dibenzo(a,h)anthracene	2.97E-11	NA	6.59E-11	NA
Indeno(1,2,3-cd)pyrene	4.99E-12	NA	1.11E-11	NA
TOTAL	8.21E-07	NA	1.36E-05	NA

lower boundary of the target risk range of 10^{-4} to 10^{-6} (Table 4-21). Hazard indices for all groups are 0.

Vapors

The potential inhalation of volatile chemicals during showering was assessed for the future residences. The HI for the adult (1.47×10^{-7}) and child (1.38×10^{-7}) are well below the target value (Table 4-22). RL values for both receptors are 0.

4.6.1.3 Groundwater

Exposure to PCOCs in groundwater can come from dermal contact and ingestion. Tables 4-23 and 4-24 present the RL and HI values for residences (adult and child) for both dermal contact and ingestion, respectively.

Dermal

The RL for the child (4.75×10^{-5}) is within the target risk levels. However, the RL for the adult (1.39×10^{-4}) is slightly above the upper range limit of 10^{-4}. The HI values are well below the target value for the adult (8.48×10^{-2}) and child (2.04×10^{-1}) (Table 4-23).

Ingestion

The RL for the adult (6.83×10^{-2}) and child (1.59×10^{-2}) are well above the target range. The HI are also well above the target range: adult (41.6) and child (68.6) (Table 4-24).

4.6.1.4 Surface water and sediments

Exposure resulting from dermal contact to surface waters and sediments in the south drainage ditch offsite of the property was assessed for trespassers. The RL value for surface water (1.09×10^{-6}) is within the target range and the RL for sediment (1.62×10^{-6}) are below the target risk range (Tables 4-25 and 4-26). The HI for surface

TABLE 4-21

INHALATION OF SOIL (DUST) RISK LEVELS AND HAZARD INDICES ON-SITE WORKER EXPOSURE

COMPOUNDS	RL	HI
METALS		
Arsenic	2.27E-07	NA
Chromium	1.15E-06	NA
POTENTIAL CARCINOGENIC PAHS		
Benzo(a)anthracene	1.29E-08	NA
Chrysene	1.29E-08	NA
Benzo(b)fluoranthene	4.32E-09	NA
Benzo(k)fluoranthene	4.32E-09	NA
Benzo(a)pyrene	4.32E-09	NA
Dibenzo(a,h)anthracene	2.54E-10	NA
Indeno(1,2,2-cd)pyrene	4.28E-11	NA
TOTAL	1.42E-06	0.00E+00

TABLE 4-22

INHALATION OF PCOCs IN GROUNDWATER WHEN SHOWERING RISK LEVELS AND HAZARD INDEX FUTURE RESIDENCE SCENARIO

COMPOUNDS	ADULT		CHILD	
	RL	HI	RL	HI
VOLATILES:				
1,1-Dichloroethane	NA	1.47E-07	NA	1.38E-07
TOTAL	NA	1.47E-07	NA	1.38E-07

NA: Not Available

TABLE 4-23
DERMAL EXPOSURE TO PCOCs IN GROUNDWATER WHEN BATHING RISK LEVELS AND HAZARD INDEX FUTURE RESIDENCE SCENARIO

COMPOUNDS	ADULT		CHILD	
	RL	HI	RL	HI
VOLATILES:				
Benzene	6.00E-09	NA	2.05E-09	NA
Toluene	NA	1.78E-05	NA	4.57E-05
Ethylbenzene	NA	5.67E-05	NA	1.45E-04
1,1-Dichloroethane	NA	6.41E-06	NA	2.19E-06
1,1-Dichloroethene	1.22E-06	2.27E-04	4.18E-07	7.73E-05
PHENOLICS;				
Phenol	NA	2.72E-07	NA	6.95E-07
2-Chlorophenol	NA	4.80E-05	NA	1.23E-04
2,4-Dimethylphenol	NA	3.76E-05	NA	9.60E-05
2,4,6-Trichlorophenol	5.65E-09	NA	1.94E-09	NA
2,4-Dinitrophenol	NA	6.70E-04	NA	1.72E-03
Pentachlorophenol	3.89E-06	1.08E-03	1.33E-06	3.70E-04
METALS				
Arsenic	7.86E-06	4.49E-03	2.68E-06	1.53E-03
Chromium	NA	6.98E-05	NA	2.38E-05
Zinc	NA	1.81E-05	NA	4.62E-05
NONCARCINOGENIC PAHS:				
Naphthalene	NA	6.48E-02	NA	1.66E-01
Acenaphthylene	NA	3.80E-03	NA	9.78E-03
Acenaphthene	NA	3.40E-04	NA	8.70E-04
Fluorene	NA	4.30E-04	NA	1.10E-03
Phenanthrene	NA	8.15E-03	NA	2.09E-02
Anthracene	NA	1.84E-05	NA	4.73E-05
Fluoranthene	NA	1.67E-04	NA	4.28E-04
Pyrene	NA	2.02E-04	NA	5.17E-04
Benzo(g,h,i)perylene	NA	2.43E-04	NA	6.23E-04
POTENTIAL CARCINOGENIC PAHS:				
Carbazole	8.12E-05	NA	2.77E-05	NA
Benzo(a)anthracene	8.75E-06	NA	2.99E-06	NA
Chrysene	1.55E-05	NA	5.29E-06	NA
Benzo(b)fluoranthene	4.68E-06	NA	1.60E-06	NA
Benzo(k)fluoranthene	1.99E-06	NA	6.80E-07	NA
Benzo(a)pyrene	5.45E-06	NA	1.86E-06	NA
Dibenzo(a,h)anthracene	7.31E-06	NA	2.50E-06	NA
Indeno(1,2,2-cd)pyrene	1.25E-06	NA	4.27E-07	NA
TOTAL	1.39E-04	8.48E-02	4.75E-05	2.04E-01

NA: Not Available

TABLE 4-24
INGESTION OF GROUNDWATER CARRYING PCOCs
RISK LEVELS AND HAZARD INDEX
FUTURE RESIDENCE SCENARIO

COMPOUNDS	ADULT		CHILD	
	RL	HI	RL	HI
VOLATILES:				
Benzene	2.96E-06	NA	6.87E-07	NA
Toluene	NA	8.76E-03	NA	1.53E-02
Ethylbenzene	NA	2.79E-02	NA	4.88E-02
1,1-Dichloroethane	NA	3.15E-03	NA	7.34E-04
1,1-Dichloroethene	6.00E-04	1.11E-01	1.40E-04	2.59E-02
PHENOLICS;				
Phenol	NA	1.33E-04	NA	2.33E-04
2-Chlorophenol	NA	2.36E-02	NA	4.14E-02
2,4-Dimethylphenol	NA	1.85E-02	NA	3.23E-02
2,4,6-Trichlorophenol	2.77E-06	NA	6.48E-07	NA
2,4-Dinitrophenol	NA	3.29E-01	NA	5.75E-01
Pentachlorophenol	1.91E-03	5.30E-01	4.45E-04	1.24E-01
METALS				
Arsenic	3.85E-03	2.20E+00	9.00E-04	5.14E-01
Chromium	NA	3.42E-02	NA	8.00E-03
Zinc	NA	8.85E-03	NA	1.55E-02
NONCARCINOGENIC PAHS:				
Naphthalene	NA	3.18E+01	NA	5.58E+01
Acenaphthylene	NA	1.87E+00	NA	3.28E+00
Acenaphthene	NA	1.67E-01	NA	2.92E-01
Fluorene	NA	2.12E-01	NA	3.70E-01
Phenanthrene	NA	4.00E+00	NA	7.00E+00
Anthracene	NA	9.07E-03	NA	1.59E-02
Fluoranthene	NA	8.23E-02	NA	1.44E-01
Pyrene	NA	9.90E-02	NA	1.73E-01
Benzo(g,h,i)perylene	NA	1.19E-01	NA	2.09E-01
POTENTIAL CARCINOGENIC PAHS:				
Carbazole	3.99E-02	NA	9.30E-03	NA
Benzo(a)anthracene	4.29E-03	NA	1.00E-03	NA
Chrysene	7.60E-03	NA	1.77E-03	NA
Benzo(b)fluoranthene	2.30E-03	NA	5.36E-04	NA
Benzo(k)fluoranthene	9.78E-04	NA	2.28E-04	NA
Benzo(a)pyrene	2.68E-03	NA	6.24E-06	NA
Dibenzo(a,h)anthracene	3.59E-03	NA	8.38E-04	NA
Indeno(1,2,2-cd)pyrene	6.14E-04	NA	1.44E-04	NA
TOTAL	6.83E-02	4.16E+01	1.53E-02	6.86E+01

NA: Not Available

TABLE 4-25
DERMAL EXPOSURE TO SURFACE WATER FROM THE SOUTH DRAINAGE DITCH RISK LEVELS AND HAZARD INDEX FOR ADOLESCENT TRESPASSER

COMPOUNDS	TRESPASSER	
	RL	HI
PHENOLICS;		
Phenol	NA	1.67E-08
2,4,6-Trichlorophenol	1.34E-11	NA
2,4-Dinitrophenol	NA	4.26E-06
Pentachlorophenol	4.63E-09	1.29E-06
METALS		
Arsenic	1.06E-06	6.07E-04
Zinc	NA	6.80E-06
NONCARCINOGENIC PAHS:		
Fluorene	NA	4.23E-08
Phenanthrene	NA	1.10E-06
Anthracene	NA	1.29E-08
Fluoranthene	NA	5.60E-07
Pyrene	NA	4.60E-07
Benzo(g,h,i)perylene	NA	1.71E-07
POTENTIAL CARCINOGENIC PAHS:		
Benzo(a)anthracene	4.62E-09	NA
Chrysene	1.21E-08	NA
Benzo(b)fluoranthene	3.06E-09	NA
Benzo(k)fluoranthene	7.60E-10	NA
Dibenzo(a,h)anthracene	8.60E-10	NA
Indeno(1,2,2-cd)pyrene	7.30E-10	NA
TOTAL	1.09E-06	6.22E-04

NA: Not Available

TABLE 4-26
DERMAL EXPOSURE TO SEDIMENTS FROM THE SOUTH DRAINAGE DITCH RISK LEVELS AND HAZARD INDEX FOR ADOLESCENT TRESPASSER

COMPOUNDS	CHILD	
	RL	HI
VOLATILES:		
Toluene	NA	1.86E-08
Xylenes	NA	1.75E-09
PHENOLICS;		
Phenol	NA	6.62E-08
2-Chlorophenol	NA	2.50E-04
2,4-Dimethylphenol	NA	3.43E-06
Pentachlorophenol	2.28E-08	6.33E-06
NONCARCINOGENIC PAHS:		
Naphthalene	NA	5.43E-05
Acenaphthylene	NA	2.93E-05
Fluorene	NA	7.93E-07
Phenanthrene	NA	1.06E-05
Anthracene	NA	4.60E-08
Fluoranthene	NA	5.13E-06
Pyrene	NA	3.77E-06
Benzo(g,h,i)perylene	NA	2.58E-05
POTENTIAL CARCINOGENIC PAHS:		
Carbazole	2.56E-07	NA
Benzo(a)anthracene	2.81E-07	NA
Chrysene	4.66E-07	NA
Benzo(b)fluoranthene	1.25E-07	NA
Benzo(k)fluoranthene	1.46E-09	NA
Benzo(a)pyrene	3.86E-08	NA
Dibenzo(a,h)anthracene	2.29E-07	NA
Indeno(1,2,2-cd)pyrene	2.00E-07	NA

TOTAL 1.62E-06 3.89E-04

NA: Not Available

water (6.22×10^{-4}) and sediment (3.89×10^{-4}) are both well below the target value of 1.0.

4.6.1.5 Incidental Ingestion of On-Site Soil

On-site workers will also be potentially exposed to on-site soils. The RL value for incidental ingestion of soil, 4.87×10^{-5}, is within the target range. The HI value, 1.67×10^{-2}, is well below the target of 1:0 (Table 4-27).

4.6.2 Environmental Risks

Table 4-28 presents available freshwater aquatic toxicity criteria for the PCOCs present above SQLs in the south drainage ditch (U.S. EPA, 1986). The surface water concentrations employed are maximum concentrations, and do not take into account any mitigating factors, such as dilution, biodegradation, volatilization, etc. which may render the concentrations of the PCOCs to acceptable levels before they reach a receiving water body. The use of SQLs is a conservative approach.

All three samples from the surface water retention pond (SW-5, SW-6 and SW-7) exceed the acute and chronic toxicity criteria for all metals, except for one out of three chromium samples. The chromium concentrations in the samples collected are compared to the criteria for chromium (VI) as this is the most toxic form of chromium.

The sample from the outfall from the pond (SW-2) and a sample from the drainage ditch, downgradient from the pond (SW-4), have arsenic concentrations exceeding both the acute (360 ug/l) and chronic (190 ug/l) criteria. Copper was detected above both the chronic toxicity value (12 ug/l) and the acute toxicity value (18 ug/l) in all samples except SW-3 (sample collected upgradient in the ditch) where it was not detected. Chromium was detected above both acute (16 ug/l) and chronic (11 ug/l) criteria for chromium (VI) in the outfall sample (SW-2) only. Zinc was detected at concentrations exceeding chronic (47 ug/l) values in all samples except SW-3 and above acute (320 ug/l) values in the sample from the outfall (SW-2) and the downgradient sample from the drainage ditch (SW-4).

TABLE 4-27
INCIDENTAL INGESTION OF SOIL
RISK LEVELS AND HAZARD INDICES
ON-SITE WORKER EXPOSURE

COMPOUNDS	RL	HI
PHENOLICS:		
Phenol	NA	6.18E-08
2-Chlorophenol	NA	2.34E-05
2,4-Dimethylphenol	NA	1.13E-05
2,4,6-Trichlorophenol	4.00E-10	NA
Pentachlorophenol	2.90E-08	8.07E-06
METALS:		
Arsenic	2.49E-06	1.42E-03
Chromium	NA	1.75E-03
Zinc	NA	1.64E-04
NONCARCINOGENIC PAHS		
Naphthalene	NA	8.45E-03
Acenaphthylene	NA	1.18E-05
Acenapthene	NA	3.60E-04
Fluorene	NA	4.70E-05
Phenanthrene	NA	3.53E-03
Anthracene	NA	4.70E-05
Fluoranthene	NA	7.05E-05
Pyrene	NA	4.07E-04
Benzo(g,h,i)perylene	NA	6.05E-06
POTENTIAL CARCINOGENIC PAHS		
Benzo(a)anthracene	1.53E-05	NA
Chrysene	1.53E-05	NA
Benzo(b)fluoranthene	5.09E-06	NA
Benzo(k)fluoranthene	5.09E-06	NA
Benzo(a)pyrene	5.09E-06	NA
Dibenzo(a,h)anthracene	3.00E-07	NA
Indeno(1,2,3-cd)pyrene	5.05E-08	NA
TOTAL	4.87E-05	1.63E-02

TABLE 4-28
Ambient Water Quality Criteria (AWQC)
and Regulatory Standards
J.H. Baxter and Co.
Wood Preserving Facility
Eugene, Oregon

	Media			
PCOC	Human Health AWQC Water and Fish Consumption	Human Health AWQC Fish Consumption Only	Aquatic Organisms AWQC Freshwater * Acute/Chronic	Aquatic Organisms AWQC Marine * Acute/Chronic
	(ug/L)	(ug/L)	(ug/L)	(ug/L)
<u>Volatile Compounds</u>				
1,1,1-Trichloroethane	18400	1,036,000	NA/NA	NA/NA
1,1-Dichloroethene	0.033	1.85	11600/NA	224000/NA
1,1-Dichloroethane	NA	NA	NA/NA	NA/NA
1,2 Dichlorobenzene	NA	NA	NA/NA	NA/NA
Benzene	0.66	4	NA/NA	NA/NA
Ethylbenzene	1400	3280	32000/NA	430/NA
Styrene	NA	NA	NA/NA	NA/NA
Toluene	14300	42400	17500/NA	6300/5000
Xylenes	NA	NA	NA/NA	NA/NA
<u>Phenolics</u>				
2,3,5,6-Tetrachlorophenol	NA	NA	NA/NA	NA/NA
2,4,6-Trichlorophenol	1.2	3.6	NA/970	NA/NA
2,4-Dichlorophenol	3090	3090	2020/365	NA/NA
2,4-Dimethylphenol	NA	NA	NA/NA	NA/NA
2,4-Dinitrophenol	NA	NA	NA/NA	NA/NA
2-Chlorophenol	NA	NA	NA/NA	NA/NA
2-Methyl-4,6-dinitrophenol	NA	NA	NA/NA	NA/NA
2-Nitrophenol	NA	NA	NA/NA	NA/NA
4-Chloro-3-methylphenol	NA	NA	NA/NA	NA/NA
4-Nitrophenol	NA	NA	NA/NA	NA/NA
Pentachlorophenol	1010	1010	22/13	NA/NA
Phenol	300	NA	10200/2560	5800/NA

TABLE 4-28 (continued)
Ambient Water Quality Criteria (AWQC)
and Regulatory Standards
J.H. Baxter and Co.
Wood Preserving Facility
Eugene, Oregon

	Media			
PCOC	Human Health AWQC Water and Fish Consumption (ug/L)	Human Health AWQC Fish Consumption Only (ug/L)	Aquatic Organisms AWQC Freshwater * Acute/Chronic (ug/L)	Aquatic Organisms AWQC Marine * Acute/Chronic (ug/L)
Metals				
Arsenic	0.0022	0.0175	850/48	NA/NA
Chromium (III)	170000	343300	980/120	NA/NA
Chromium (VI)	170000	343300	16/11	1100/50
Copper	1000	1000	18/12 (1)	2.9/2.9
Zinc	5000	5000	120/110	95/86
Noncarcinogenic PAHs				
Acenaphthene	NA	NA	NA/NA	NA/NA
Acenaphthylene	NA	NA	NA/NA	NA/NA
Anthracene	NA	NA	NA/NA	NA/NA
Benzo(g,h,i)perylene	NA	NA	NA/NA	NA/NA
Fluoranthene	NA	NA	NA/NA	NA/NA
Fluorene	NA	NA	NA/NA	NA/NA
Naphthalene	NA	NA	NA/NA	NA/NA
Phenanthrene	NA	NA	NA/NA	NA/NA
Pyrene	NA	NA	NA/NA	NA/NA
Potentially Carcinogenic PAHs				
Benzo(a)anthracene	NA	NA	NA/NA	NA/NA
Benzo(a)pyrene	NA	NA	NA/NA	NA/NA
Benzo(b)fluoranthene	NA	NA	NA/NA	NA/NA
Benzo(k)fluoranthene	NA	NA	NA/NA	NA/NA
Carbazole	NA	NA	NA/NA	NA/NA
Chrysene	NA	NA	NA/NA	NA/NA
Dibenz(a,h)anthracene	NA	NA	NA/NA	NA/NA
Indeno(1,2,3-c,d)pyrene	NA	NA	NA/NA	NA/NA

(*) No criteria have been established. Acute/Chronic values based on L.E.C. (Lowest Effect Concentration)
(1) At a water hardness of 100 mg/L CaCO3
NA - Not Available

References:
U.S. EPA, 1990a
U.S. EPA, 1991a

The maximum concentrations of phenol, 2,4-dichlorophenol and 2,4,6-trichlorophenol detected in the surface water samples are below the freshwater acute and chronic criteria set for these compounds. Pentachlorophenol was detected in all samples but SW-3, the sample collected upgradient in the ditch. Samples from the retention pond (SW-5, SW-6 and SW-7) as well as the outfall from the pond (SW-2) are found at concentrations exceeding the acute and chronic criteria (22 ug/L and 13 ug/L, respectively) for pentachlorophenol for freshwater aquatic organisms. Pentachlorophenol was detected in three out of four samples collected from the ditch (SW-1 and SW-4). The sample from SW-1 exceeds the chronic criteria only, but the sample from SW-4 exceeds both criteria.

PAHs compounds were detected in all surface water samples except in one sample from the ditch, collected upgradient to the site (SW-3). There are presently no freshwater acute or chronic criteria set for PAHs compounds.

4.7 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing a risk assessment. This section discusses the sources of uncertainty in the following activities:

- analytical data;
- identifying potential constituents of concern;
- indices of toxicity;
- environmental fate and transport modeling;
- performing exposure assessments, and;
- on-site worker exposure assessment.

Uncertainties associated with this risk assessment are summarized in Table 4-29 and are discussed in detail below.

TABLE 4-29
SUMMARY OF UNCERTAINTIES

EFFECT ON POTENTIAL RISKS AND HAZARD INDICES (1)

Potential Uncertainty	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Magnitude for Over or Under Estimation of Risks
<u>Environmental Sampling and Analysis</u>			
Sufficient samples may not have been collected to characterize the media being evaluated.			Low
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
<u>Development of Toxicological Profiles</u>	Low		
<u>Exposure Assessment</u>			
The standard assumptions regarding body weight, period exposure, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Low
The amount of media intake is assumed to be constant and representative of any actual exposure.	Moderate		
Assumption of daily lifetime exposure for residents.	Moderate		
Use of maximum measured values to estimate intakes.		Low	
Compounds not quantitatively evaluated.		Low	
Lack of references for cancer slope factors (CSF) or Reference Doses (RfD)		Moderate	

(1) As a general guideline, assumptions marked as "Low" may affect estimates or risks by less than one order of magnitude; assumptions marked as "Moderate" may affect estimates of risk between one and two orders of magnitude.

Analytical Data

The development of a risk assessment depends on the reliability and uncertainties with the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the method of analysis. In addition, the statistical methods used to compile and analyze the data (mean concentrations, detection frequencies) are subject to the overall uncertainty.

Potential Constituents of Concern

The identification of PCOCs begins with the prevalence of the compounds found during site investigation work. The compounds found at a site are dependant upon the analytical methods used during the investigation. For the Oregon site, PAHs, VOCs, acid extractable phenolics, and metals were selected as PCOCs. These constituents were selected due to the history of the facility and general familiarity with the processes used at the site. Any uncertainty associated with using PAHs, VOCs, phenols, and metals in the risk process is counterbalanced with the expectation that the PCOCs chosen are known to be the most significant compounds encountered at the facility.

Indices of Toxicity

In making quantitative estimates of the potential toxicity of different doses of a compound to people, uncertainties arise from two sources. First, data on human exposure and effects are usually incomplete, if they are available at all. Therefore, animal studies are often used and uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment relative to typical environmental exposures. However, when applying the results of the experiment to more typical situations, the effects at the high doses must be extrapolated to effects at lower doses.

In extrapolating effects from animals to people and high doses to low doses, scientific judgement and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- studies are preferred where the animal closely mimics human pharmacokinetics,
- studies are preferred where dose intake and duration most closely mimics the intake route and duration for humans, and
- studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e. potential noncarcinogens) safety factors are employed in the extrapolation of effects from animals to humans, and from high doses to low doses.

The use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate actual toxic effects, but may overestimate these effects by an order of magnitude or more.

Environmental Fate and Transport

Environmental fate of the PCOCs has uncertainty associated with it, especially when related to equilibrium. In some instances, groundwater samples may be used as exposure point locations, however, pure product encountered during sampling and analysis may artificially raise the water concentrations and consequently increase potential risk levels.

Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the transport and fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the U.S. EPA. The U.S. EPA has published an Exposure Factors Handbook which contains the best and latest values. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited numbers on individuals. In all instances values used in this risk assessment represent the upper 90 to 95 percentile of the population. For this risk assessment, scientific judgements and conservative assumptions agree with those of the U.S. EPA. Conservative assumptions designed as not to underestimate daily intakes were employed throughout this risk assessment and should err conservatively, protecting human health.

On-Site Worker Exposure Assessment

Large uncertainties arise in the exposure assessment of on-site workers to PCOCs in soil. As surface soil data was not available for the assessment, subsurface soil data was used to quantify potential workers exposure to PCOCs present on-site. To obtain an accurate exposure estimate, surface soil data are required.

5.0 SUMMARY AND CONCLUSIONS

The Phase I Remedial Investigation (RI) was performed by Keystone Environmental Resources, Inc. on behalf of J.H. Baxter Wood Preserving for the Oregon Department of Environmental Quality (DEQ) to further assess the extent and nature of contamination that may be associated with the wood treating operations, past and present, at the J.H. Baxter facility in Eugene, Oregon. To accomplish this task, the installation of monitoring wells and the sampling of soil, sediment, groundwater and surface waters were performed on the J.H. Baxter property.

The data collected during the RI was insufficient to define the extent of several contaminants in the soil, groundwater, sediment and surface waters.

It is evident from the data that several constituents of concern have migrated offsite in the groundwater, or the surface waters in the drainage ditches. Therefore, additional investigative data will be required to define the extent of offsite contamination. The following sections summarize the findings of the RI.

5.1 Site Geology

The geology at the site consists of four general stratigraphic units composed of alluvial deposits. The uppermost geologic unit is a layer of clay and gravel or gravelly clay. This unit is relatively uniform in thickness (approximately 10 to 15 feet) over the area of the site investigated by drilling programs. Immediately beneath this surface layer is a heterogeneous layer comprised of gravels with varying amounts of finer materials such as silt, sand and clay. The main geologic component in this unit is gravels but sand and clay lenses were encountered during drilling. This layer extends to a depth of approximately 80 feet below grade.

At the base of the gravel sediments is a thick clay aquitard (approximately 30 feet thick in the northwest portion of the site) which is comprised of two distinct clay units. The upper clay can be described as brown to gray, moist and plastic (classified as "CH" according to Unified Soil Classification System). The lower clay is blue to gray, lean and stiff (classified as "CL"). The contact between the two conformable clays is sharp. The top of the upper clay dips to the northwest at an average grade of 1.25 percent.

Beneath the thick clay aquitard, in the northwest part of the site, are medium to coarse sands and gravels. The sands and gravels were encountered to a depth of 135 feet below grade. The base of this lower sand and gravel sequence was not determined.

5.2 Site Hydrogeology

The water table on the site is situated at approximately 8 to 10 feet below grade. The gravel sediment sequence underlying the surface clay and gravel layer is considered to be one aquifer unit and is semi-confined in nature. Supporting evidence for the semi-confined aquifer conclusion includes the geology which indicates the water table is positioned within a surface aquitard material (clay/gravel layer), the pump test Theis curves match semi-confined (leaky) type curves and the storage coefficients determined from the pump tests are in the range indicative of confined or semi-confined aquifers.

The thick clay layer at a depth of approximately 80 feet below grade (brown to gray and blue to gray clay) represents an aquitard at the site. Beneath the clay aquitard is a coarse sequence of deposits which represent a deeper confined artesian aquifer unit.

Aquifer Tests

The two aquifer tests conducted at J.H. Baxter on wells W-13S and W-12I were used to determine the hydraulic properties of the shallow alluvial aquifer at the site.

The transmissivity, storativity and hydraulic conductivity determined from the W-12I pump test are approximately 10,000 gpd/ft, 4.0×10^{-4} and 2.2×10^{-4} ft/sec, respectively. Correspondingly, the transmissivity, storativity and hydraulic conductivity determined from the W-13S pump test are approximately 4,500 gpd/ft, 2.5×10^{-3} and 9.3×10^{-5} ft/sec, respectively.

The differences seen in the above values for the transmissivity and associated hydraulic conductivity indicates the aquifer is heterogeneous. The shallower portion of the aquifer has less ability to conduct water than the deeper portion of the aquifer.

The transmissivity, storativity and hydraulic conductivity values determined for the aquifer correspond to a geologic stratum consisting primarily of sand and gravel with lesser amounts of silt and clay, according to published values of hydraulic properties for various geologic materials (Walton, 1987). This agrees with the aquifer geology observed during the installation of the monitoring wells at the site and presented in this report.

The storativity values presented above, 4×10^{-4} and 2.5×10^{-3}, are in the range representative of semi-confined or confined aquifer conditions. The Theis type curves which matched the data (Figure 2-9a) for both pump tests support the semi-confined aquifer representation for the shallow aquifer.

In addition to being heterogeneous, the aquifer is also anisotropic. The vertical hydraulic conductivity was observed to be less than the horizontal hydraulic conductivity in the aquifer. Evidence for this conclusion is provided by a comparison of the drawdowns observed in wells W-15S and W-13I for the W-13S pump test. The drawdown values were greater for well W-15S than W-13I even though W-15S is situated approximately 68 feet from W-13S and W-13I is only 10 feet away from W-13S. This indicates the degree of vertical hydraulic communication is less than the amount of horizontal hydraulic communication.

Groundwater Movement

The groundwater beneath the site in the shallow aquifer flows north to northwest with an average hydraulic gradient of 0.006. The average linear groundwater velocity beneath the site in the shallow aquifer was estimated to be approximately 83 ft/year. However, this does not mean that the contaminants in the groundwater are necessarily moving at this velocity. Some of the constituents would be subjected to various mechanisms of retardation (chemical and physical) which would inhibit their movement in the subsurface. These retardation mechanisms may include adsorption, biodegradation, ion exchange etc.

5.3 Analytical Results

Constituents of concern related to wood treating chemicals used at the site were detected in subsurface soils sampled on the property. PAHs, PCP, arsenic, chromium, copper and zinc were detected in the subsurface soil.

PAHs, PCP, volatile organics, arsenic, chromium, copper and zinc were detected in the groundwater. Benzene and arsenic were detected at concentrations exceeding their respective MCL concentrations. PCP exceeded it's PMCL limit in most of the downgradient wells screened within the shallow aquifer at the site. Total PAHs were detected in several monitoring wells at concentrations exceeding 1 mg/L.

The sediment samples recovered from the bottom of the surface water retention pond and the bottom of the drainage ditches contained elevated levels of PAHs, PCP, volatile organics, arsenic, chromium, copper and zinc. The sediments with the highest concentrations of the constituents were the samples obtained from the retention pond and drainage ditch downstream of the retention pond.

The surface water analytical results reveal a pattern similar to the sediments with respect to the relative levels of the organic and metal constituents detected in the samples. The samples from the surface water retention pond exhibited elevated levels of PAHs, PCP, arsenic and copper. The arsenic concentrations exceeded the MCL limit for arsenic in drinking water (0.05 mg/L). Copper and PCP concentrations in the pond exceeded their PMCL limits for drinking water (1.3 mg/L and 0.001 mg/L, respectively). PCP concentrations in six of the seven surface water samples (SW-1, SW-2, SW-4, SW-5, SW-6 and SW-7) exceeded the acute and chronic Ambient Water Quality Criteria concentrations, 22 ug/L and 13 ug/L, respectively, defined by the EPA in 1990.

Elevated levels of the same constituents detected in the retention pond were discovered in the surface water samples obtained downstream of the retention pond in the drainage ditches. Arsenic and PCP at surface sampling location SW-4 exceeded their respective MCL and PMCL limits.

5.4 Nature and Extent of Contamination

The extent of contaminants in the soil is difficult to ascertain given the sparse nature of the available soil data. Further investigative work is necessary to adequately evaluate the soil quality on the site. However, site-related constituents of concern were detected in most of the soil samples obtained at the site (eg. borings W-7S, W-8S, W-12I, W-9I, W-9S, W-11S and W-13S).

In the groundwater, PAH, PCP and benzene contaminant plumes extend beyond the site property boundaries. PAHs have migrated north of the site in the groundwater. The PCP plume has migrated north, and possibly west and south of J.H. Baxter's property. Benzene in the groundwater has migrated north of the Baxter site but its areal extent offsite is probably less than PCP's areal extent offsite. The areal extent of the arsenic plume is within the boundaries of the Baxter site.

The contaminant plumes discussed above have a vertical extent which encompasses the entire depth of the shallow aquifer. The clay aquitard at the base of the shallow aquifer probably acts as an impermeable boundary to the constituents in the groundwater. The dip of the top of this clay aquitard is important in evaluating the possible migration pathways for any dense non-aqueous liquids (DNAPLs) which may be present in the groundwater. The top of the clay dips northwest which is similar to the direction of groundwater flow. Therefore, DNAPLs beneath the site in the shallow aquifer would tend to move in the same general direction as the groundwater (ie. north to northwest).

The surface water retention pond is contaminated in its sediment and surface water with respect to site-related constituents of concern. The extent of sediment and surface water contamination in the drainage ditch downstream of the retention pond has not been determined. It is possible that the surface water and sediment in this drainage ditch, offsite to the west, is contaminated with PCP, PAHs and arsenic.

5.5 PHEA

The quantitative risk assessment evaluated the public health and environmental risk associated with the PCOCs found on the site (PAHs, phenolic compounds, metals, and selected volatile organic compounds (VOCs)).

The potential receptors retained for the health evaluation were an adult and child (1 to 4 years) for a residential scenario, an adolescent (9 to 16 years) trespassing onto the site and gaining access to the south drainage ditch, and on-site workers. The exposure routes assessed were inhalation of soil (dust) for future and current scenarios as well as on-site workers; ingestion of groundwater, dermal exposure to groundwater when bathing, and inhalation of VOCs from the groundwater when showering for a future residence scenario; dermal exposure to sediments and surface water from the south drainage ditch for an adolescent trespasser; and incidental ingestion of soil for on-site workers.

The Risk Levels (RL) and Hazard Index (HI) were compared to target risk ranges of 10^{-4} to 10^{-6} and 1.0, respectively (EPA, 1989a). The highest exposure to PCOCs for the future residence scenario was through ingestion of groundwater for both the adult and child. The exposure assessment yielded risk levels of 6.83×10^{-2} and 1.59×10^{-2} for the adult and child, respectively. These values are above the target risk range. The hazard indices were 41.3 and 67.9 (adult and child, respectively), also above the target of 1.0. For the same scenario, the risk level for dermal exposure to groundwater for an adult is 1.39×10^{-4}. This level is slightly elevated when compared to the target risk range.

Other exposure pathways assessed yielded RLs and HIs within or below the target risk ranges.

The environmental assessment used maximum concentrations found in the surface water of the retention pond and the south drainage ditch to evaluate the possible effects of PCOCs to aquatic life in a receiving water body. Mitigating effects such as volatilization, biodegradation, dilution, etc., were not taken into account. The maximum concentrations were compared to available Ambient Water Quality Criteria (AWQC).

In the drainage ditch, acute and chronic freshwater criteria are exceeded in one out of three samples for arsenic, and in two out of three samples for chromium. The chronic criteria for zinc was exceeded in two out of three samples and the acute criteria in one out of three.

Three phenolic compounds have AWQC for freshwater aquatic life: phenol, 2,4-dichlorophenol and 2,4,6-trichlorophenol. The maximum concentrations for these compounds detected in the surface water samples do not exceed these criteria. Chronic and acute criteria are also set for pentachlorophenol. The chronic criteria is exceeded in two samples from the ditch and the acute in one of these two samples. Three samples collected from the retention pond and one collected from the pond outfall to the ditch are found at concentrations exceeding both the acute and chronic criteria.

No criteria have been set for PAHs. Volatiles were not detected in surface water samples.

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