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INVESTIGATION OF HYDROCARBON CONTAMINATION IN GROUND WATER AND SOIL PORT OF PASCO PASCO, WASHINGTON

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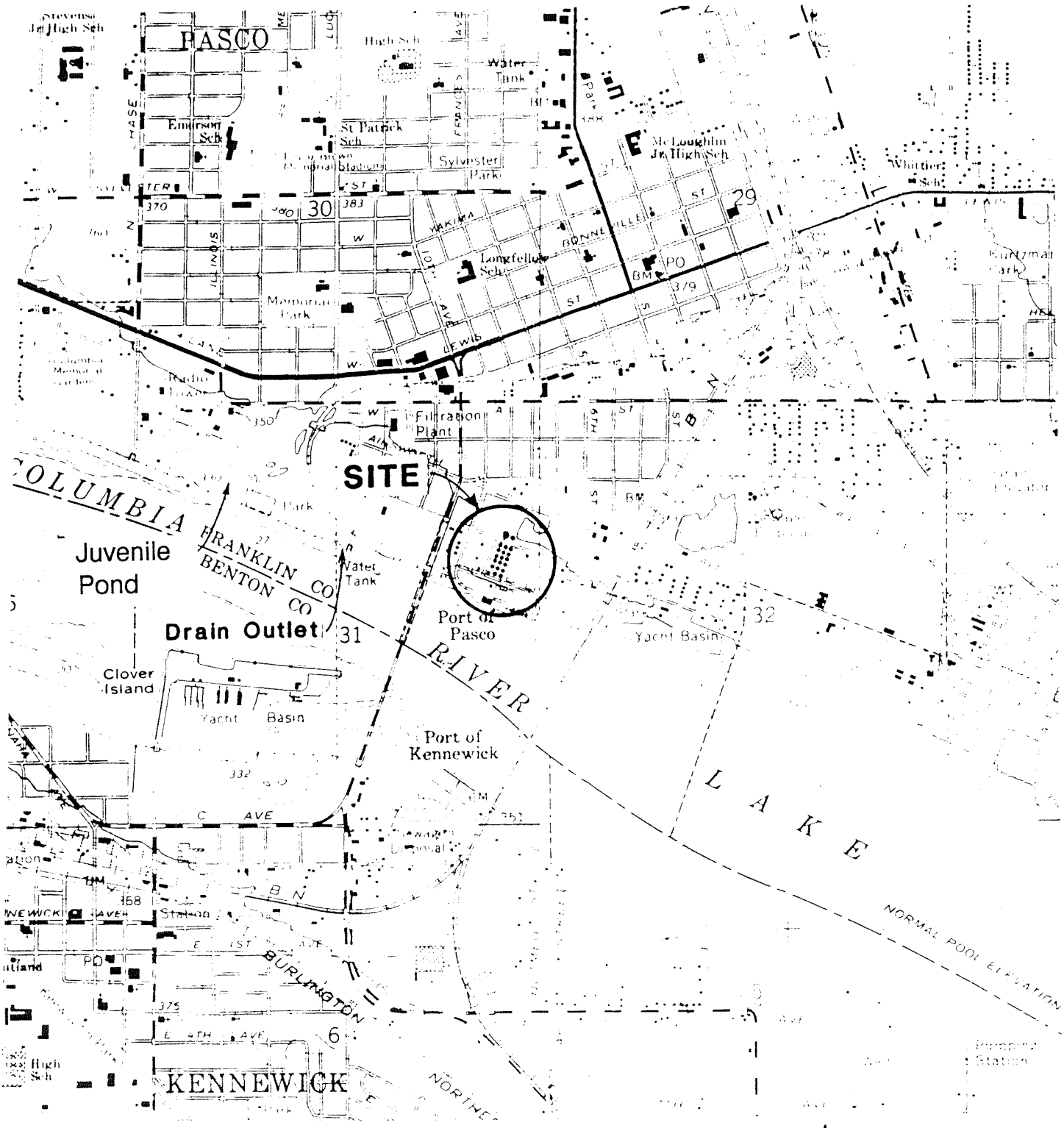
ABSTRACT

The Toxics Investigations and Ground Water Monitoring Section of the Department of Ecology was requested by the Eastern Regional Office to characterize ground water and soil contamination at the Port of Pasco Bulk Terminal. Twelve ground water and six composite soil samples were collected and analyzed for volatile and semi-volatile organic compounds, pesticides, polychlorinated biphenyls, and dissolved priority pollutant metals. Analytical results showed dissolved aromatic and aliphatic hydrocarbons and 1,2-dichloropropane in the ground water. Soil sampling revealed the presence of 1,2-dichloropropane and various pesticides in soils surrounding bulk storage tanks 41 and 42. No polychlorinated biphenyls were detected.

Figure 1: Vicinity Map



Reference: USGS 7.5 Quadrangle Map, Pasco, Washington
(from GeoEngineers, 1988)

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INTRODUCTION

Previous Work

Petroleum product contamination at the Port of Pasco Bulk Terminal was first documented by Ecology in 1973 (Russell, 1973). Other than an attempt to pump floating product in 1974, no remedial actions have been taken. Studies by Johnson and Norton (1986), and Johnson (1987), showed aromatic and chlorinated hydrocarbons in sediments, surface water, and ground water associated with the site. GeoEngineers, consultants for the Port, defined the apparent thickness and extent of free hydrocarbon product using a network of 30 ground water monitoring wells installed in early 1987. Sample analyses of free product showed contaminants to be gasoline and diesel mixed in varying proportions (GeoEngineers, 1988).

Objectives

Ground water and soil samples were collected from the Port of Pasco and adjacent Pacific Power and Light (PPL) property on February 27, 28, and March 1, 1989, to help determine appropriate remedial actions. The objectives of this study were to: 1) characterize contamination below the product/water interface; 2) determine soil contamination from spills around tanks used for herbicide storage; and 3) determine PCB contamination in soils surrounding a former PPL transfer substation.

Site Description

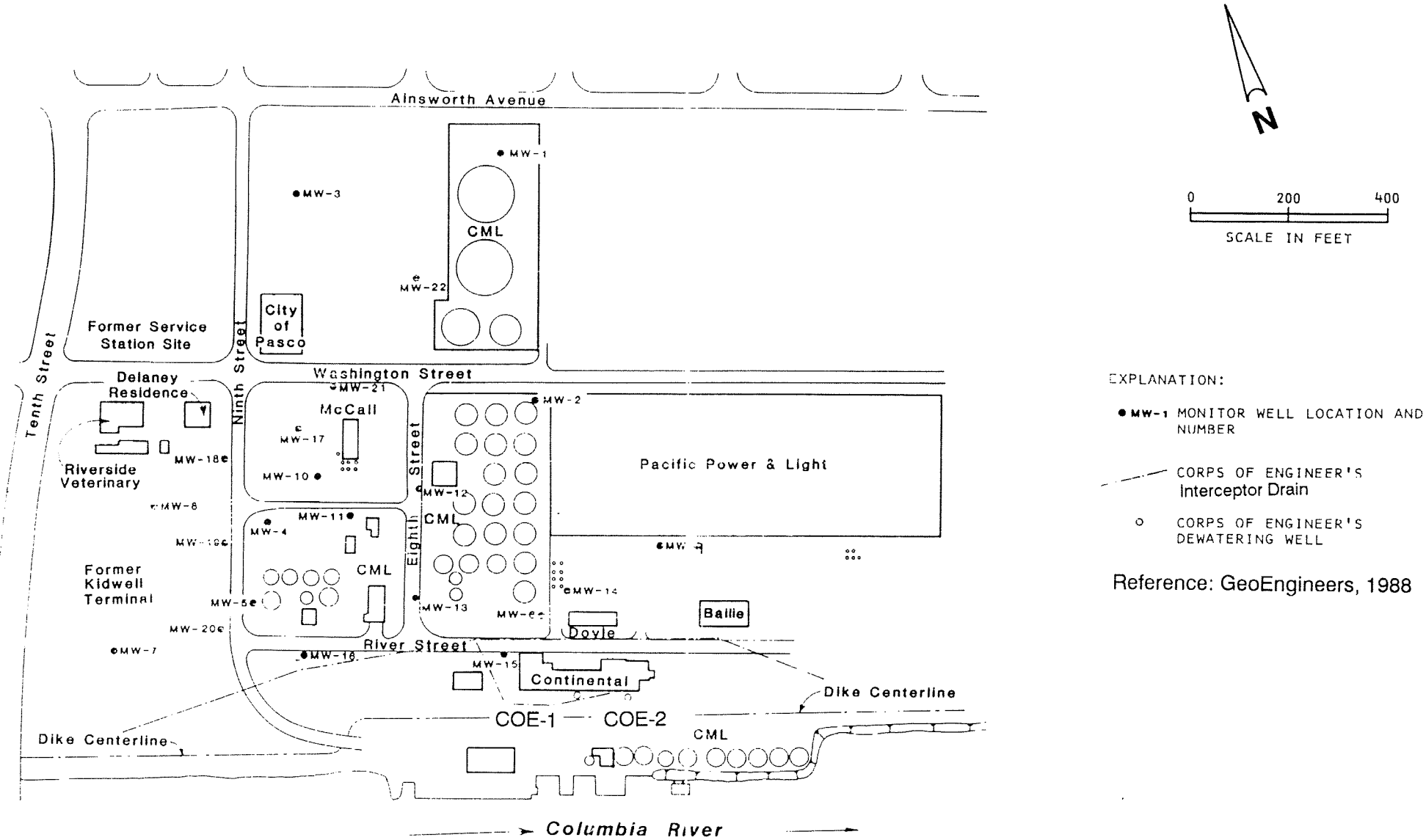
The Port of Pasco, located at T9N, R30E in Franklin County, Washington on the north bank of the Columbia River, has been a petroleum storage facility since the 1930s (Figure 1). Currently, three bulk terminals are located on Port property (Figure 2). These facilities are operated by Tidewater Barge Lines, McCall Oil, and Doyle Brothers Inc. Previously, Columbia Marine Lines, Kidwell Oil, Bailie (a petroleum product distributor), and a service station were located on-site. Prior to the late 1940s, Pacific Power and Light Company operated a transfer substation located within the Port's boundary. The PPL facility was dismantled except for a three story brick building which may have housed a generator and synchronous capacitor used to direct electricity (H. Stanton, personal communication). It is unknown whether transformers containing PCBs were located on-site.

GEOLOGY AND HYDROGEOLOGY

Regional

The Port of Pasco is located within the Pasco Basin, a broad downwarp composed of Yakima Basalt of the Columbia River group. The basalt is up to 5,000 feet thick. Overlying the Columbia River basalt are the Ellensburg and Ringold formations. The Ellensburg formation is composed of interbedded conglomerate, sand, silt, and clay. The Ringold formation is composed of stratified clay, silt, sand, and gravel. Unconsolidated glaciofluvial deposits overlie the Ringold. The Ringold and glaciofluvial sediments comprise an upper unconfined aquifer which is separated

Figure 2: Port of Pasco Site Map



Reference: GeoEngineers, 1988

from the lower Yakima Basalts by the Beverly clay, a member of the Ellensberg formation. Regional ground water flow in the upper aquifer is south toward the Columbia River (Tanaka *et al.*, 1974, Brown, 1979). Using specific capacity data from driller's logs in the Pasco Basin, a regional mean hydraulic conductivity value of 1300 ft/day was calculated for the unconfined Pasco Basin aquifer (B. Drost, personal communication).

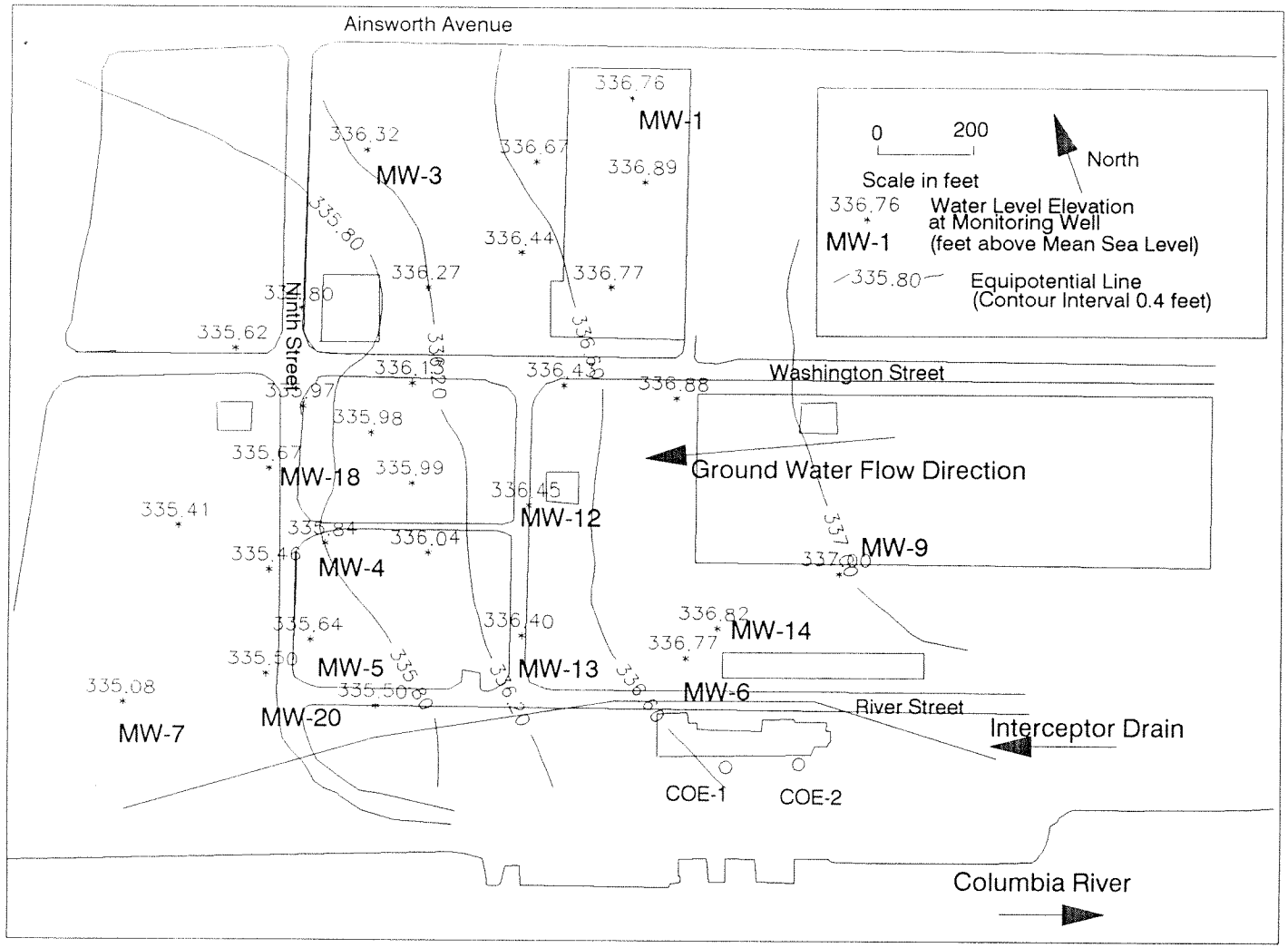
Local

Monitoring well logs from the site show unconsolidated gravel, sand, silt, and clay of glaciofluvial origin (GeoEngineers, 1987, 1988). Sediments in the western portion of the site consist of sand and silt. Sand and gravel underlie the northern and eastern parts of the site. The unconsolidated sediment is approximately 25 to 40 feet thick in the southwestern portion of the site. It is underlain by Ringold formation clay (Russell, 1974).

Local ground water flow is toward the west. Figure 3 shows the piezometric surface for February 1989 after correcting for floating product in monitoring wells. Calculations for data correction are included in Appendix A. In situ tests to determine the hydraulic conductivity of the on-site aquifer have not been conducted at the Port of Pasco. Using specific capacity values from driller's logs for wells located within five miles of the site, estimated hydraulic conductivity of the unconsolidated sediment ranges from 67 to 7300 ft/day (B. Drost). The horizontal hydraulic gradient across the site is 0.0013 after correction for floating product. Vertical gradients could not be calculated because there are no nested wells on-site. Using hydraulic conductivity values of 67 and 7300 ft/day, a hydraulic gradient of .0013, and assuming a porosity of 0.2 (poorly sorted sand and gravel), calculated average linear velocities range from 0.4 to 47 ft/day.

On-site ground water flow is influenced by flood control structures including a slurry wall, drain, and two pumps built by the Corps of Engineers (COE) and by manipulation of McNary Pool stage height for optimal power generation at McNary Dam. The slurry wall extends 25 to 42 feet deep to the top of the Ringold formation. Its purpose is to inhibit ground water flow under the levees from McNary pool. To prevent ground water buildup on Port property, a 42 to 48 inch diameter interceptor drain was installed at an elevation of 330 feet (10 feet below ground surface) at the base of the levee (Figure 2). This drain collects ground water and surface water which is pumped into the Columbia River via Juvenile Fishing Pond located west of the site (Figure 1). Russell (1973) suggested that petroleum product is discharged though this drain in response to fluctuations in McNary pool. Two automatic pumps, COE-1 and COE-2, located at the Port of Pasco near the Continental Grain elevator, were installed to remove ground water backed up along the slurry wall. Water levels measured in the two COE pumping wells by GeoEngineers are 15 feet below those measured in monitoring wells on-site. Since 1983, the pumps have been activated only four times: May and June of 1987, and October and November of 1988. Pumping rates averaged only 0.1 cubic feet per second during these periods.

Figure 3: Water Table Elevation Map
Port of Pasco
February, 1989



METHODS

Decontamination

Stainless steel and teflon sampling equipment was decontaminated using a LiquiNox wash and rinsed using tap water, deionized water, 10 percent nitric acid/water solution, methylene chloride, and acetone. All tubing was dedicated with the exception of silastic tubing in the pump head (approximately 12 inches). This tubing was flushed with 500 mL each of 10 percent nitric acid solution and deionized water prior to sampling at each well, and was changed daily.

Ground Water Sampling

Investigation of ground water contamination at the Port of Pasco involved collection of 12 ground water samples. Figure 4 shows locations of wells sampled. Prior to sample collection, an ORS interface tape was used to measure depth to water, or depth to product and product/water interface in all 30 monitoring wells located on-site. Monitoring wells containing floating product were purged and sampled using a peristaltic pump, 0.25 inch I.D. polyethylene tubing, and medical grade silicon tubing. Polyethylene tubing was lowered through the product layer while maintaining positive pressure with the peristaltic pump. When the tubing was approximately one foot below the product/water interface, the pump direction was reversed. Product thickness was monitored using the interface tape during purging to ensure no product was drawn into the tubing.

Wells which did not contain floating product were purged using a centrifugal pump or teflon bailer. Wells were purged until grab samples indicated stable pH, specific conductance, and temperature measurements. At least three well volumes were removed prior to sampling. Two pH meters failed during sampling, probably due to cold temperatures. Samples collected for priority pollutant metals analyses were field filtered using a 0.45 um filter and preserved with one ml Ultrex nitric acid to a pH less than two.

Soil Sampling

Reconnaissance soil sampling at the Port of Pasco consisted of six composite soil samples from two areas suspected of contamination: 1) the bulk storage tanks in the area leased by Tidewater Barge Lines, and 2) the former PPL transfer substation. Two samples and one reference sample were collected from each of these two areas. Reference samples were collected from uncontaminated areas within the same soil or fill type. Figure 5 shows soil sampling locations. SB-1, SB-2, and reference sample SB-3 were obtained from the Tidewater Bulk storage area. The specific locations were determined based on interviews with Tidewater personnel concerning an employee who developed a rash while doing excavation work in the fill (M. Porter, Personal Communication). The storage tanks are on soil and surrounded by gravel fill. Six to twelve inches of clayey coarse sand and gravel fill overlay the concrete. Samples were collected at 8 to 13 nodes within each grid. SB-4, SB-5 and reference sample SB-6 were collected from PPL property in areas of possible PCB

Figure 4: Port of Pasco
Monitoring Well Sampling Locations
February 1989

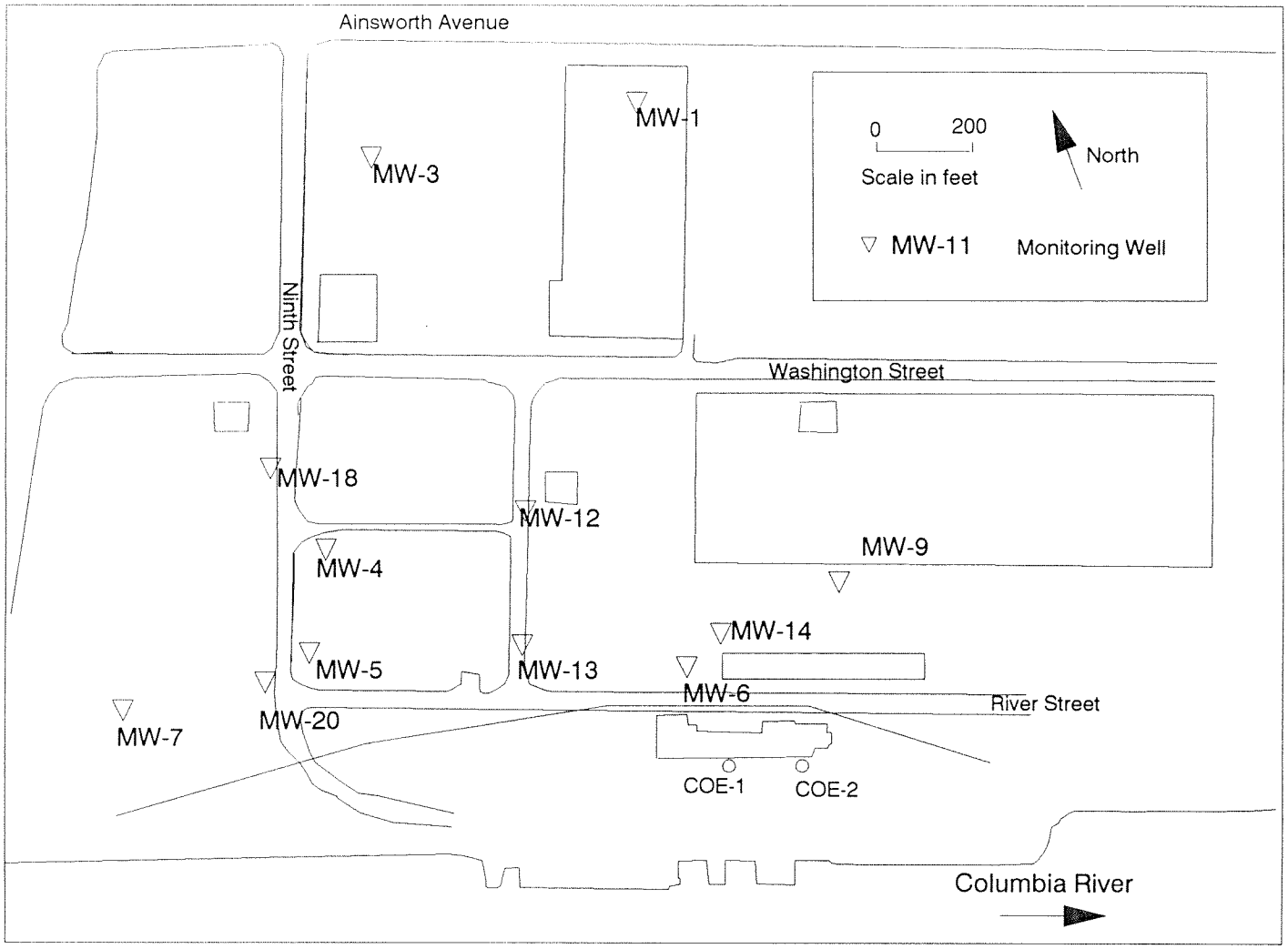
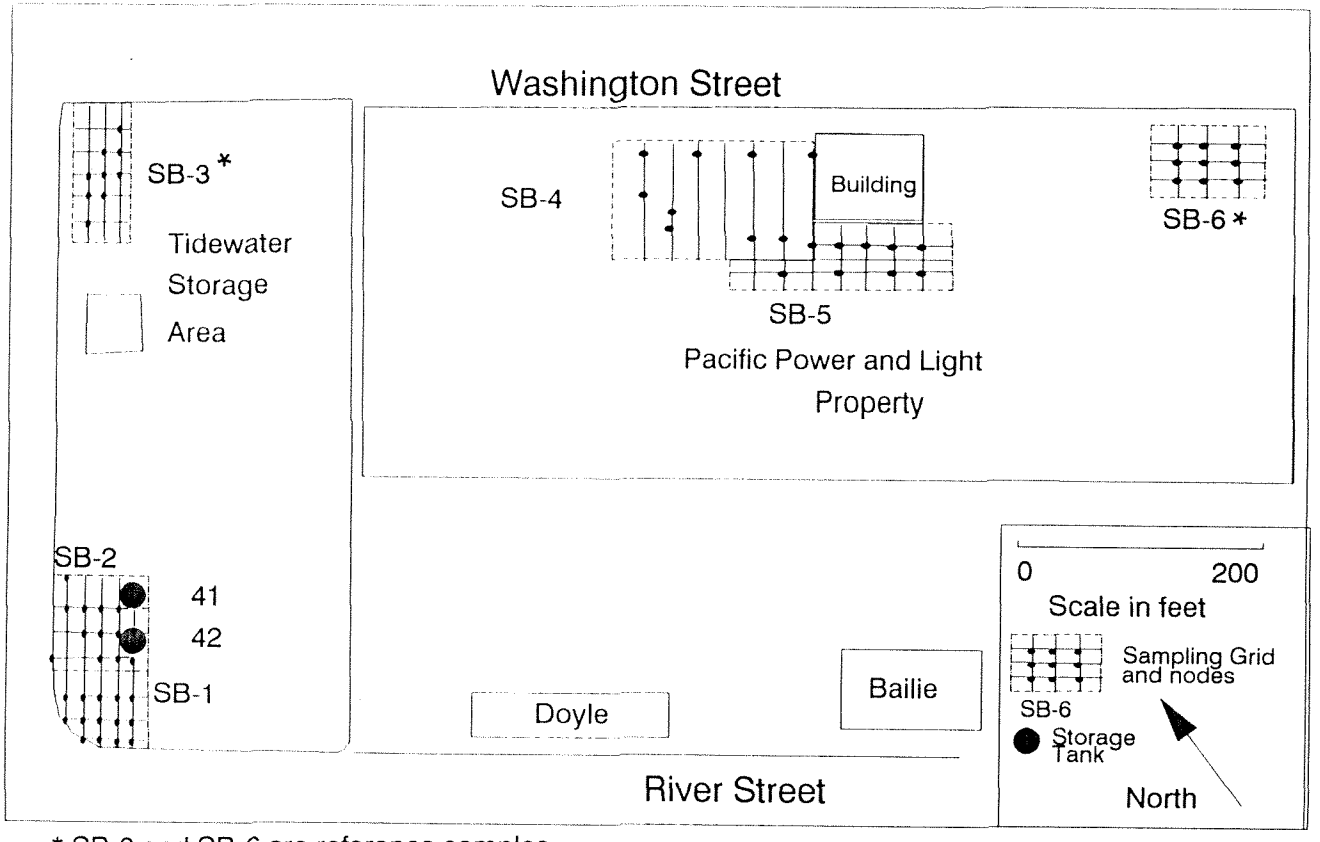


Figure 5: Soil Sample Grid Locations

Port of Pasco

February, 1989



* SB-3 and SB-6 are reference samples.

contamination. Composite sample grid locations were determined from site blueprints provided by PPL and dated 1917. Soils consisted of fine sand containing some silt and well-rounded very coarse gravel. SB-5 was a composite collected along a former rail bed. SB-4 was collected from randomly chosen grid nodes along a loading area.

All samples were collected from six to eight inches below the surface using a decontaminated stainless steel spoon. An equal amount of sediment was collected from each node and thoroughly mixed on an aluminum foil-lined tray with a stainless spatula. Volatile organic compounds (VOC) samples were collected directly into sample bottles without mixing.

Quality Assurance/Quality Control

Transfer, transport, and filter blanks were collected for ground water sample quality assurance. Transfer blanks were obtained by rinsing teflon bailers with organic free water and collecting the rinsate in sample bottles. An additional transfer blank for dissolved metals analyses was run through the pump and filter bed to ensure field decontamination procedures were adequate. A ground water duplicate sample was collected each sampling day. A soil quality assurance transfer blank was collected by rinsing decontaminated sampling equipment with organic free water and collecting the rinsate in soil sampling jars. No reference material was available for soil transport blanks. Duplicate samples were collected at each of the two sampling locations. Method blanks, matrix spikes, and matrix spike duplicates were run in the laboratory for ground water and soil samples.

Analyses

Ground water and soil samples, with the exception of Pacific Power and Light (PPL) samples, were analyzed for volatile organic compounds (VOCs), base\neutral\acids (BNAs), pesticides, polychlorinated biphenyls (PCBs), and priority pollutant metals. Soil samples obtained from PPL property were analyzed for all of the above except pesticides. All samples were analyzed at the Weyerhaeuser Analytical Laboratory for low detection limits using EPA method 625 for volatile and semi-volatile organic compounds, EPA method 608 for pesticides and PCBs, and EPA method 600/4-79-020 4.1.1 (atomic absorption) for dissolved metals.

RESULTS

Field Observations

Of the twelve wells sampled, MW-4, MW-5, MW-6, MW-12, and MW-20 contained measurable thicknesses of floating hydrocarbon product. Hydrocarbon odor was detected in MW-7, MW-13, and MW-18 although no floating product was measured. Ground water samples taken from MW-6 were yellow, viscous, and had a strong hydrocarbon odor. MW-18 was blocked by an organic mat prior to purging. Field-determined pH, temperature, and specific conductance along with purge volumes are listed in Table 1.

Table 1. Field Measurements Taken During Purging at the Port of Pasco

Monitoring Well	pH	Temperature Degrees C	Specific Conductance (umohs/cm)	Purge Volume (gallons)
MW-1	7.60	13	600	3
MW-3	7.43	14	680	3.5
MW-4	NR	14.2	750	3.5
MW-5	NR	13	600	4
MW-6	NR	10.9	1000	3
MW-7	7.06	11.9	580	3
MW-9	7.51	11.6	440	22
MW-12	NR	12.5	640	3.2
MW-13	7.23	12.5	700	5
MW-14	6.83	12.5	650	3.5
MW-18	7.29	12.9	620	2.1
MW-20	NR	12	570	3

NR: Not Recorded due to pH meter failure

Ground Water

Tables 2 through 4 list the concentrations of compounds detected in each monitoring well. MW-9 was designated as the upgradient well. Analytical results showed above background concentrations of benzene, toluene, ethyl benzene, and total xylene in nine wells. 1,2-dichloropropane, a compound found in the banned pesticide D-D* and Telone II which were stored in tanks 41 and 42, was also detected in ground water. Fluorene, naphthalene, 2-methylnaphthalene, 2-methylphenol were detected in concentrations above background in at least one monitoring well. Bis(2-ethylhexly)phthalate appears in several monitoring wells and may be the result of laboratory contamination or dissolution of the PVC monitoring wells located on-site. Dissolved priority pollutant metal analyses detected lead, copper, zinc, arsenic, and chromium levels above background concentrations. No PCBs were detected in ground water. Several volatile and semi-volatile tentatively identified compounds (TIC) were detected. These included dissolved alkanes, aromatic hydrocarbons, and chlorinated hydrocarbons. TICs and the monitoring wells they were detected in are listed in Appendix B; estimated values are available on request.

Table 2. Volatile Organic Compounds Detected in Monitoring Wells (ug/L) Where detection limits exceed concentrations, values are estimated.

Monitoring Well	Benzene	Toluene	Ethyl benzene	Total Xylene	1,2-Dichloro-propane	Acetone
MW-1	ND	ND	ND	86	13	ND
MW-3	ND	ND	ND	ND	ND	ND
MW-4	1700	1800	160	1900	ND	ND
MW-5	190	84	7	760	24	ND
MW-6	170	ND	ND	300	ND	ND
MW-7	ND	ND	3	16	5	ND
MW-9*	ND	ND	ND	ND	ND	ND
MW-12	2800	850	260	2700	ND	57
MW-13	ND	ND	30	ND	ND	ND
MW-14	71	ND	ND	ND	ND	ND
MW-18	ND	ND	ND	ND	ND	ND
MW-20	ND	ND	ND	1300	26	ND
Detection Limits	5	5	5	5	5	10

ND: Compound not detected at limit given.
* Background sample

Table 3. Semi-Volatile Organic Compounds Detected in Ground Water (ug/L)

Monitoring	Acenaphthene	Fluorene	Phenanthrene	Naphthalene	2-Methyl-naphthalene	2-Methyl-phenol	Bis(2-ethyl-hexyl)phthalate
MW-1	ND	ND	ND	ND	ND	ND	ND
MW-3	ND	ND	ND	ND	ND	ND	ND
MW-4	ND	ND	ND	29	12	ND	5
MW-5	ND	ND	ND	25	3	ND	ND
MW-6	ND	ND	ND	22	13	ND	ND
MW-7	ND	ND	ND	ND	ND	ND	ND
MW-9*	ND	ND	ND	ND	ND	ND	ND
MW-12	3	5	3	100	75	ND	ND
MW-13	ND	3	ND	ND	ND	ND	5
MW-14	ND	ND	ND	18	6	ND	2
MW-18	ND	ND	ND	ND	ND	ND	ND
MW-20	ND	ND	ND	26	11	14	19
Detection Limits	10	10	10	10	10	10	10

* Background sample

Table 4: Dissolved Metals Detected in Monitoring Wells (ug/L)

Monitoring Well	Lead	Zinc	Arsenic	Chrome	Copper
MW-1	ND	8	4	ND	5
MW-3	3	18	4	ND	10
MW-4	2	ND	17	ND	ND
MW-5	ND	ND	3	ND	ND
MW-6	2	ND	21	ND	5
MW-7	ND	26	ND	ND	5
MW-9*	ND	ND	3	ND	5
MW-12	3	ND	24	ND	6
MW-13	6	36	39	5	14
MW-14	ND	25	16	ND	ND
MW-18	ND	ND	3	ND	ND
MW-20	ND	ND	3	ND	ND
Detection Limits	2	5	2	5	5

* Background sample

Soils

Tables 5 through 7 list compounds found at each sampling grid. 1,2-dichloropropane, and the pesticides aldrin, dieldrin, 4,4'DDD, 4,4'DDE, and 4,4'DDT were detected in composite sample SB-1 obtained from fill in the tank storage area. Low concentrations of metals were detected in all sampling areas, but levels did not exceed those found in reference samples. No PCBs were detected. TICs included chlorinated hydrocarbons and are listed in Appendix B.

Table 5. Volatile and Semi-Volatile Organic Compounds in Soil Samples (ug/Kg)

Sample Site	2-Butanone	Acetone	Bis(2ethyl-hexyl)phthalate	Toluene	1,2-Dichloro propane
SB-1	ND	ND	ND	2	15
SB-2	ND	ND	390	ND	11
SB-3*	ND	ND	ND	ND	ND
SB-4	ND	ND	ND	ND	ND
SB-5	ND	18	ND	ND	ND
SB-6*	2	ND	ND	ND	ND
Detection Limits	12	6	380	5	6

* Reference samples

Table 6. Pesticides Detected in Composite Soil Samples (ug/Kg)

Sample Site	Aldrin	Dieldrin	4,4' DDE	4,4' DDD	4,4' DDT
SB-1	31.1	19	8.6	10.4	16
SB-2	ND	ND	ND	ND	13
SB-3*	ND	ND	ND	ND	9.8
SB-4	ND	ND	ND	ND	ND
SB-5	ND	ND	ND	ND	12.5
SB-6*	ND	ND	4	ND	3.5
Detection Limits	7.3	14.6	14.6	14.6	14.6

* Reference samples

Table 7. Metals Detected in Soil Samples (ug/Kg)

Site Name	Arsenic	Chromium	Copper	Nickel	Lead	Zinc
SB-1	8.50	19.20	19.30	16.30	20.80	67.80
SB-2	2.70	20.50	15.60	13.80	24.90	77.50
SB-3*	2.10	27.60	14.70	15.00	25.10	60.90
SB-4	2.80	19.20	12.20	14.40	30.40	62.60
SB-5	2.60	22.10	16.20	16.40	92.20	180.00
SB-6*	3.10	20.70	20.00	17.80	55.90	102.20
Detection Limits	0.50	1.00	1.00	5.00	0.50	1.00

* Reference samples

Quality Assurance/Quality Control

Quality control sample results were reviewed by Stuart Magoon of the Manchester Laboratory. Surrogate recoveries for VOCs, BNAs, pesticides, and PCBs were acceptable within Contract Laboratory Program limits for all ground water and soil samples with the exception of acid compound surrogate recoveries for ground water BNA analysis. Low recoveries for these compounds are thought to be the result of matrix effects and results were flagged with a "J" qualifier indicating that concentrations are estimated. Duplicate samples for both ground water and soils showed similar results for compounds detected. Method blanks contained acetone and methylene chloride in low concentrations. Low concentrations of acetone and methylene chloride were found in ground water and soil transfer blanks. These are common laboratory contaminants and were used for decontamination. Zinc was

detected in the ground water transfer blank at seven ug/L which may indicate some contamination in either the blank water or the sampling device. The metal's transport blank, run though the filter and pump only, showed no detectable contamination. Information on duplicate and blank sample analyses for ground water and soil samples along with detection limits is available on request.

DISCUSSION

Figure 6 shows the extent and apparent thickness of floating hydrocarbon product at the Port of Pasco. Comparison of apparent product thickness data collected by GeoEngineers in December and March of 1987 suggests that plume locations and extent have remained relatively stable (GeoEngineers, 1988). Two separate plumes appear to be present on-site. A larger plume in the western half of the site extends from MW-20 north to MW-22. MW-5 has the greatest apparent product thickness at 1.83 feet. The source of this plume is probably related to the bulk storage of gasoline on-site. Samples of product collected from this plume by GeoEngineers and analyzed for American Petroleum Institute gravity (equivalent to the gasoline/diesel ratio) show this plume to be a mixture ranging in composition from pure gasoline to up to 40 percent diesel (GeoEngineers, 1988).

The smaller of the two plumes is located in the southern portion of the site. MW-6 has an apparent product thickness of 0.73 feet. This smaller plume may extend to COE-1 and COE-2 with apparent product thicknesses of 0.52 and 0.79 feet, respectively (GeoEngineers, 1989). The water levels in the COE wells are approximately 15 feet below the water table beneath the site. The source of this plume is unclear but the interceptor drain at the base of the levee may be acting as a conduit from sources at the eastern end of the site. Analysis of product samples showed the smaller plume to be diesel fuel. MW-6 has an API gravity ratio of 40 percent gasoline to 60 percent diesel fuel (GeoEngineers, 1988). Product in both COE wells is pure diesel.

The sum of the product volume for both plumes is estimated to be 300,000 gallons based on a porosity value of 0.2 and no correction for capillary fringe effects. Capillary fringe effects may be important because the greatest apparent product thickness coincides with a silt lens where the capillary fringe could measure up to 14 inches (Bear, 1979). In addition, water table fluctuations caused by changing levels in McNary pool and seasonal variations increase the apparent product thickness. During the sampling period, levels in McNary pool fluctuated up to one foot during each 24 hour period as recorded at the USGS station on Clover Island. In response, the water table fluctuated up to 0.12 feet in one of five wells measured twice during the sampling period. Seasonal ground water elevation variation is about 0.5 to 1 feet (GeoEngineers, 1988). This suggests that the actual volume of product present on-site is probably less than estimated above.

Figure 7 shows concentration contours (isoplethes) for the sum of dissolved benzene, toluene, ethyl benzene, and total xylenes. Greatest concentrations of these compounds occur upgradient of the larger product plume in MW-12 and MW-4. EPA proposed drinking water standards for aromatic hydrocarbons detected at the Port of

Figure 6: Apparent Product Thickness
February, 1989
Port of Pasco

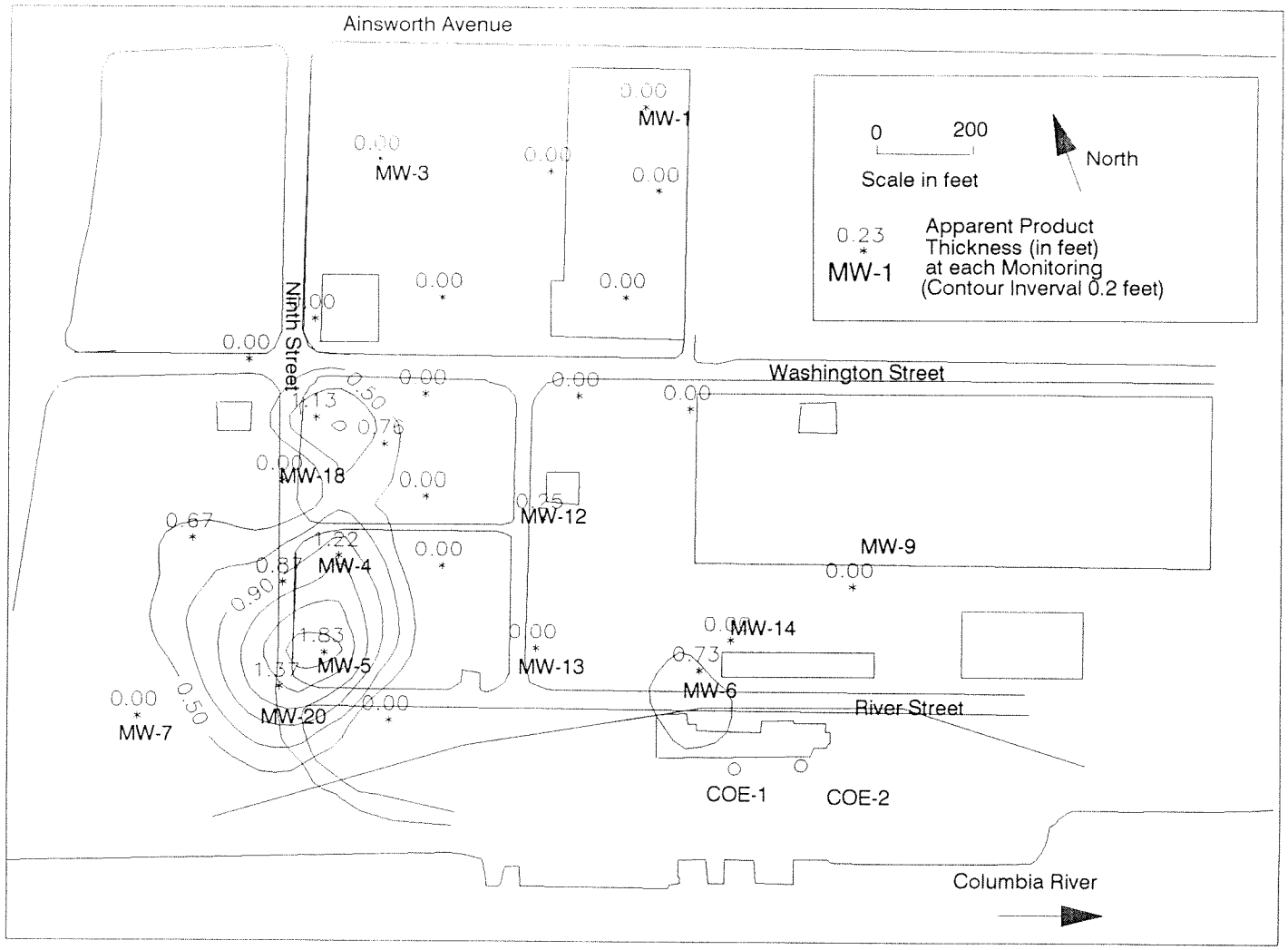
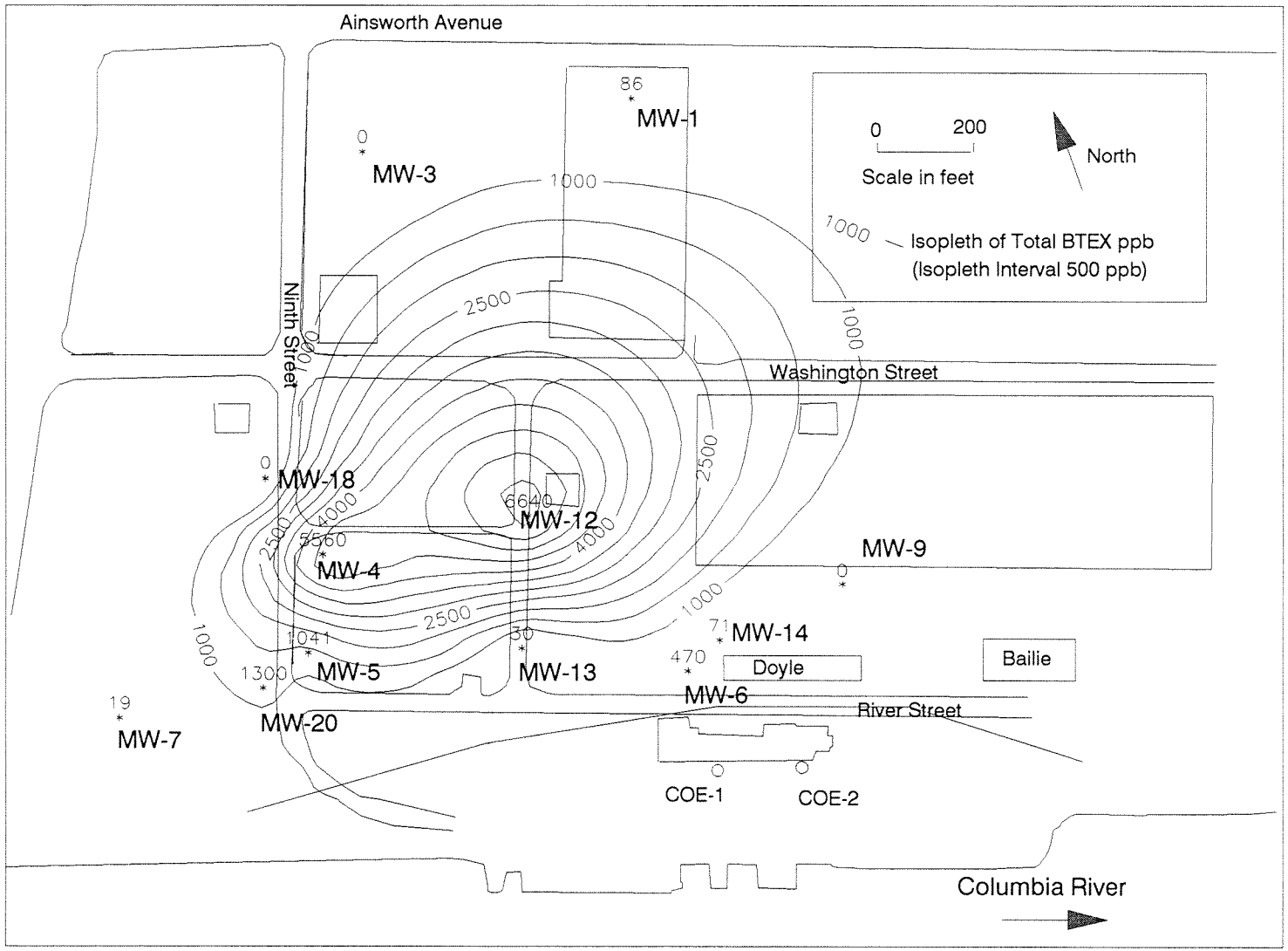


Figure 7: Isopleth Map of Dissolved Total
Benzene, Toluene, Ethyl benzene, and Xylene
February, 1989



Pasco are listed in Table 8. Benzene concentrations exceed the proposed standards in MW-4, MW-5, MW-6, MW-12, and MW-14. Tentatively identified compounds (TIC) include VOCs and BNAs associated with gasoline and diesel fuel. The highest sums of concentrations of tentatively identified compounds occur in monitoring wells containing free product.

Table 8. EPA Draft Drinking Water Standards

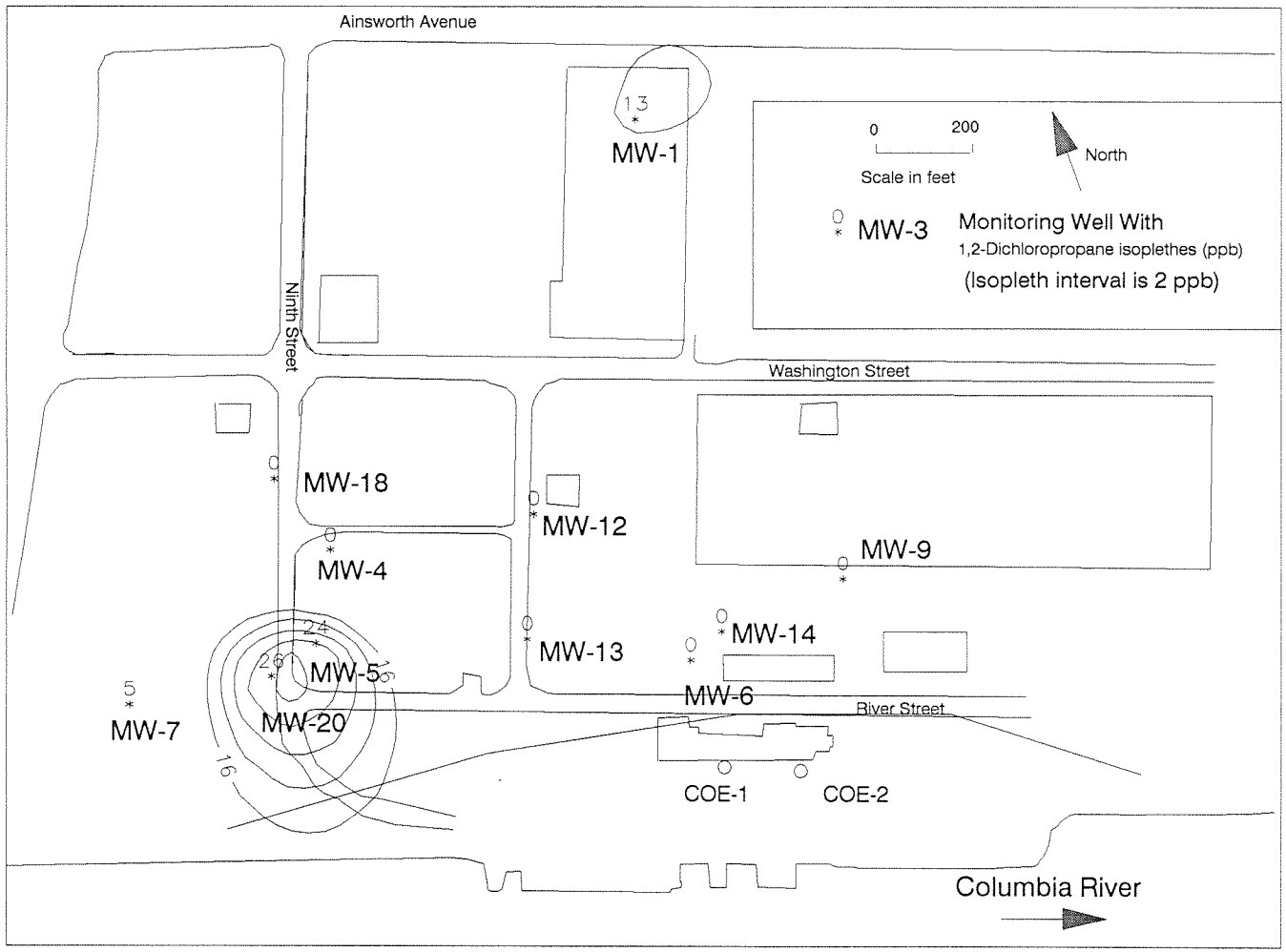
Compound	Maximum Contaminant Level ug/L	Range of Contaminants Detected this Study ug/L
Benzene	5	< 5 to 2800
Toluene	2000	< 5 to 1800
Ethly benzene	700	< 5 to 260
Xylene	10000	< 5 to 2700
1,2-Dichloropropane	5	< 5 to 26
Arsenic	30	< 2 to 39

1,2-Dichloropropane, a possible human carcinogen, was detected in four of the wells sampled. Figure 8 shows the distribution of 1,2-Dichloropropane in ground water. 1,2-Dichloropropane is a component of the banned soil fumigant D-D* and an impurity in 1,2-Dichloropropene, a component of the pesticide Telone II previously stored in tank 42. No 1,2-dichloropropene, which degrades faster than 1,2-dichloropropane, was detected. 1-Chloro-2-methyl propane and 1-chloro-3-methyl butane were tentatively identified in MW-18 and MW-12, respectively. These chlorinated compounds may be related to the product or 1,2-dichloropropane. Under the EPA proposed drinking water standards, the hydrocarbon proposed maximum contaminant level (MCL) for 1,2-dichloropropane is five ug/L, equal to the detection limit during this study. Concentrations in ground water at the Port of Pasco exceed this. The source of ground water contamination is believed to be a spill near storage tanks 41 and 42. Contaminated fill in the area of the spill may be acting as a continuing source to ground water.

Elevated levels of dissolved metals were detected in MW-3, MW-6, MW-7, MW-12, MW-13, and MW-14 (See Table 4). These wells appear to coincide with the fringe of the free product plumes. Arsenic was detected at 39 ug/L in MW-13. It was the only metal which exceeded the proposed maximum contaminant level of 30 ug/L. Arsenic has a current MCL of 50 ug/L which is not exceeded. Arsenic, along with copper, were detected in low concentrations in designated upgradient well MW-9. The source of arsenic is unknown but may be related to pesticides stored or used on-site in the past.

Soil samples were collected as composites over grids of varying size. BNA and PCB concentrations in composite soil samples did not exceed reference sample levels. Pesticides aldrin, dieldrin, and DDT and 1,2-dichloropropane were detected above reference levels, in composite soil sample SB-1, located near storage tank 41. 1,3-Dichloropropane, 1,2,3-trichloropropane, 1,3-dichloro 1-propene, 1,1,2-

Figure 8: Isopleth Map of 1,2-Dichloropropane in Ground Water
Port of Pasco
February, 1989



trichloropropene, and 1,2,3-trichloro 1-propene were tentatively identified in soil sample SB-2 located in the suspected spill area. Table 9 compares soil monitoring data on aldrin, dieldrin, and DDT from five fields near Quincy and Moses Lake, Washington, to results from this study. All pesticides detected at the Port of Pasco are in the lower part of the ranges given for Quincy and Moses Lake. Arsenic was detected above reference levels in sample SB-1. Lead and zinc were detected above reference levels in sample SB-5. Table 10 compares metals detected in this study to ranges of total amounts of metals generally found in soils worldwide and in the Western United States.

Table 9. Comparison of pesticide concentrations in soils from five fields near Quincy and Moses Lake Washington with those detected at Port of Pasco. Ranges are given where possible.

Pesticide	Quincy and Moses Lake* (ug/kg dry weight)	Port of Pasco (ug/kg dry weight)
Aldrin	(4- 140)	31.1
Dieldrin	(10- 210)	19
DDT	(20-2800)	3.5 -16

* - Stevens, *et al.*, (1970)

Table 10. Comparison of ranges (where possible) of metal concentrations detected in soils world wide and in the Western U.S. to concentrations found at the Port of Pasco (mg/kg dry weight basis).

Source	Silver	Chromium	Copper	Nickel	Lead	Zinc
Ebens and Shacklette, 1982*	0.1-76	5.5-350	1.6-120	-	1.2-100	12-170
Bohn *et al.*, 1985+	1-50	5-1000	2-100	10-1000	2-200	10-300
Port of Pasco, 1988	.002-.008	.02	.02	.015	.02-.09	.06-.18

* Data from the Western U.S
+ Data from soils world wide
- No data available

CONCLUSIONS

1. Measurements of apparent product thickness by Ecology and GeoEngineers show that the product plume has been relatively stable since 1987.

2. Dissolved aromatic and aliphatic hydrocarbons associated with the product plume are present in ground water. Benzene concentrations exceed EPA's proposed drinking water standards.

3. 1,2-Dichoropropane, chlorinated hydrocarbon Tentatively Identified Compounds, and several pesticides were detected in fill surrounding bulk storage tanks 41 and 42. 1,2-Dichloropropane is present in ground water at concentrations exceeding proposed standards.

4. Concentration of dissolved arsenic in MW-13 exceeded EPA's proposed drinking water standards. Dissolved zinc and copper were detected in ground water slightly above background levels in several wells. The source of metals is unknown.

5. No polychlorinated biphenyls were detected in soils surrounding the former Pacific Power and Light transfer substation.

RECOMMENDATIONS

1. The hydraulic properties of the contaminated aquifer should be determined prior to design of the recovery system. Two approaches should be used: a) a 24 to 48 hour aquifer test (pumping test) should be used to obtain integrated estimates of transmissivity and storage. This will require installation of a six inch test well. Water levels in several monitoring wells and COE-1 and COE-2 should be recorded during the test; and b) short-term pump tests or slug tests should be conducted at several on-site wells. The results from these tests can be used to estimate the hydraulic conductivity in wells across the site.

2. An estimate of free hydrocarbon product volume should be recalculated taking into account effects of the capillary fringe. This will provide a better estimate of treatment time and remedial effectiveness. One possibility for estimating true product thickness is a product bailout test as described by Gruszczenski (1987).

3. Use of COE dewatering wells and the interceptor drain for recovery of free product, as described by GeoEngineers (1988), should be re-evaluated. Presence of free product in the interceptor drain was documented by GeoEngineers (1987). The source of product was thought to be a buried pipeline which extended from the bulk storage area to the dock. The product was then thought to be drawn into the interceptor drain via the COE pumping wells. Since 1983 or earlier, the automatic pumps have been activated in May and June of 1987 and October of 1988 only. Pumping rates did not exceed 0.1 cubic feet per second (S.Shampine, 1988). It is possible that petroleum product is entering the interceptor drain directly from a continuing upgradient source. The source of the free product should be investigated further to ensure effective recovery and treatment.

4. The interceptor drain should be checked to determine if it is working properly.

5. Remedial alternatives for dissolved aromatic and aliphatic hydrocarbons and 1,2-dichloropropane in ground water should be evaluated. Treated ground water must be monitored during discharge to ensure effectiveness of remediation.

6. 1,2-Dichloropropane in fill surrounding storage tanks 41 and 42 may be acting as a continuing source to ground water. The contaminated soil should be removed and either treated, if possible, or disposed of. Prior to removal, the depth of soil contamination should be determined.

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Appendix A

Depth to Water Table Correction Calculations

Monitoring Well	Product Thickness (feet)	Thickness Density Corrected*	Corrected DTW (feet)	Corrected Water Table (MSL)
MW-1	0.00	0.00	7.23	336.76
MW-2	0.00	0.00	6.35	336.88
MW-3	0.00	0.00	9.83	336.32
MW-4	1.22	1.07	5.24	335.84
MW-5	1.83	1.61	5.44	335.64
MW-6	0.73	0.64	9.37	336.77
MW-7	0.00	0.00	5.74	335.08
MW-8	0.67	0.59	4.29	335.41
MW-9	0.00	0.00	5.65	337.17
MW-10A	0.00	0.00	6.56	335.99
MW-11A	0.00	0.00	6.30	336.04
MW-12	0.25	0.22	6.36	336.45
MW-13	0.00	0.00	5.02	336.40
MW-14	0.00	0.00	5.69	336.82
MW-15	DRY	DRY	DRY	DRY
MW-16	0.00	0.00	5.59	335.50
MW-17	0.76	0.67	7.70	335.98
MW-18	0.00	0.00	5.18	335.67
MW-19	0.87	0.77	4.90	335.46
MW-20	1.37	1.21	4.35	335.50
MW-21	0.00	0.00	6.39	336.13
MW-22	0.23	0.20	7.61	336.44
MW-23	1.13	0.99	6.15	335.97
MW-24	0.00	0.00	7.58	335.62
MW-25	0.00	0.00	7.31	334.80
MW-26	0.00	0.00	8.81	336.27
MW-27	0.00	0.00	7.77	336.67
MW-28	0.00	0.00	6.59	336.43
MW-29	0.00	0.00	7.68	336.89
MW-30	0.00	0.00	7.84	336.77

* Specific Gravity of Product = 0.88 (GeoEngineers, 1987).

Appendix B

Ground Water Tentatively Identified Compounds

Volatile Organic Compounds

Compounds	Monitoring Wells
Propane	
1-chloro-2-methyl	18
Butane	
2-methyl	1,4,7,12,13
2,3-dimethyl	1
2,2,3,3-trimethyl	18
1-chloro-3 methyl	12
Butene	
2-, ,2,3-dimethyl	18
Pentane	
2-methyl	20
(ACN)(DOT)	13
2,3,3-trimethyl	5,7,20
Pentene	
1-, ,2-methyl	18
Benzene	
propyl	4
1-ethyl-2-methyl	1,4,5,6,12,13,14,20
(1-methylethyl)	4,12
1,2-dimethyl (o-xylene)	18
1,2,3-trimethyl	4,5,6,12,20
1,2,4-trimethyl	4,5,14,20
1,3,5-trimethyl	7,20
Hexane	
2,3-dimethyl	5
3,3-dimethyl	12,13
Octane	
3-methyl	7
Nonane	
2,6-dimethyl	14
Decane	
2,5,9-trimethyl	14
2-methyl-propanoic acid	18
2,3-dihydro-1-met	5
o-(3-methylbutyl) Hydroxylamine	7,14
dihydrous 2H-pyran-2,6(3H)-Dione	12

CYCLO-

Propane	
propyl	1,13,20
(1-methylethyl)	5
1,1-dimethyl	4,6,12,14
1,2-dimethyl	20
Butane	
methyl	14
Pentane	
methyl	13
1,2-dimethyl	1,13
Pentene	
4,4-dimethyl	1
Hexane	
(DOT)	1,12,20
methyl	1,4,12
1,1,3-trimethyl	1,13

Semi-volatile Tentatively Identified Compounds

Compounds	Monitoring Wells
Benzene	
propyl	4
ethyl	4,5,12
(1,1-dimethyl)	12
1,2-dimethyl	
4,5,6,12.20	
1,4-dimethyl	
4,5,6,12,20	
1,2,3-trimethyl	
4,5,6,12,14	
1,2,4-trimethyl	4,5,12,20
1,3,5-trimethyl	4,6,7,20
1,2,3,4-tetramethyl	
4,5,6,12,20	
1,2,4,5-tetramethyl	5,12,14
1,2,3,5-tetramethyl	14
1-ethyl-2-methyl	4,6,14
1-ethyl-3-methyl	
4,5,6,12,20	
1-methyl-4propyl	4
4-ethyl-1,2-dimethyl	4
1-ethyl-2,3-dimethyl	5
2-ethyl-1,3-dimethyl	5
(1,1-dimethylethyl)	5
4-ethyl-1,2-dimethyl	14
1H-Indene	
2,3-dihydro	4,5,12
2,3-dihyldro-4-methyl	4,5,6,12,13,20
1-ethylidene	4,5,6,12
2,3-dihydro-5-methyl	5,12
1-one,2,3-dihydro	6
1-one,2,3-dihydro-3-methyl	6
2,3-dihydro-1,1-dimethyl	13
octahydro-2,2,4,4,7,7-hexamethyl	2
Ethanol	
2-(2-butoxyethoxy)	5,12,20
2-(2-buthoyethxy)-acetate	5,20
Ethanone	
1-methylphenyl	6
Naphthalene	
1,3-dimethyl	12
1,8-dimethyl	12
Decane	
2,3,7-trimethyl	13
3,4-dimethyl	14
1-heptanol	14
2-propyl	14
2,3,7-trimethyl Octane	13
2,7,10-trimethyl Dodecane	7,13

2,6,10,14-tetramethyl Pentadecane	7
2,6-dimethyl Undecane	7,13,14
2-cyclopentene-1-One,3,4,5-trimethyl	6
tetrahydro,1,1-dioxide Thioplene	5,20
Octacosane	5
4-methly Pentanamide	5
2-butly,1,1,3-trimethyl cyclohexane	12
Sulfur molecule (S8)	7,14

Soil Sample Tentatively Identified Compounds

Volatile Organic Compounds

1,3-dichloropropane	SB-2
1,2,3-trichloropropane	SB-2
1,3-dichloro 1-propene	SB-2
1,1,2-trichloropropene	SB-2
1,2,3-trichloro 1-propene	SB-2

Semi-volatile Organic Compounds

2-butyl-1,1,3-trimethly cyclohexane	SB-2
octahydro-2,2,4,4,7,7-hexamethyl-,trans 1h-indene	SB-2
octacosane	SB-5
4-methyl pentanamide	SB-5