2611255

ADDITIONAL SUBSURFACE PETROLEUM HYDROCARBON ASSESSMENT

BP SERVICE STATION No. 11255

19924 Pacific Highway South
SeaTac, Washington

Prepared for

BP Oil Company

W-7475-2

June, 1993

RZA AGRA, Inc.
Engineering & Environmental Services

AGRA
Earth & Environmental Group

Additional Subsurface Petroleum Hydrocarbon Assessment

BP Facility No. 11255

19924 Pacific Highway South

SeaTac, Washington 98188

Prepared for

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W-7475-2

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TABLE OF CONTENTS

W-7475-2

ADDITIONAL SUBSURFACE PETROLEUM HYDROCARBON ASSESSMENT
BP FACILITY NO. 11255
19924 PACIFIC HIGHWAY SOUTH
SEATAC, WASHINGTON

1.0 SUMMARY

The following report presents the results of our Additional Subsurface Petroleum Hydrocarbon Assessment for B.P. Facility Number 11255, located at 19924 Pacific Highway South in SeaTac, Washington. This assessment consisted of a subsurface exploration program, analytical testing of soil and groundwater samples, and a vapor extraction system (VES) feasibility study. Presented below is a brief summary of the significant findings of this assessment.

- The subsurface exploration program involved advancing four soil borings on-site, installing monitoring wells in each boring, and the collection of soil and groundwater samples for laboratory analysis.

- The subsurface conditions encountered during our exploration program indicate the site is generally underlain at shallow depths by a very dense, silty, fine-medium sand, with some gravel. The formation appeared to be interbedded with discontinuous sand, silt and gravel lenses to an approximate depth of 35 feet below the below ground surface (BGS). A very dense, silty, fine to course sand with some gravel was encountered in the borings at depths below 35 feet to the maximum extent of each boring.

- At the time of our exploration, groundwater was encountered in monitoring wells MW-6 and MW-7 at a depth of approximately 28 feet BGS. Groundwater was not encountered in monitoring wells MW-4 and MW-8. The presence of groundwater in some wells, and its absence in others, indicates that hydrogeologic conditions on-site may consist of perched groundwater in discontinuous sand lenses. Preliminary bail testing of monitoring well MW-7 indicated a low hydraulic conductivity value of 1.50×10^{-4} cm/sec

- Monitoring well MW-4, installed during our Subsurface Petroleum Hydrocarbon Evaluation (dated February 1992), was over-drilled during this assessment to a depth of approximately 45 feet to extend the screened portion of the monitoring well within the existing sand lens. Further penetration of the sand lens, it was thought, would provide the additional groundwater necessary to maintain operation of the groundwater pump and treat system. This did not prove to be the

case as the additional screen did not provide the necessary sustained flow. Due to the absence of groundwater in monitoring well MW-4, and low groundwater yield rates from monitoring wells MW-6 and MW-7, the pump and treat system was discontinued and removed from the site

- Analytical laboratory test results indicate that the soil samples selected for analysis from borings B-6, B-7 and B-8 contained gasoline range (C_7 through C_{12}) petroleum hydrocarbons at concentrations exceeding the Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method A cleanup levels.

- Analytical laboratory test results indicate that the groundwater samples collected from monitoring wells MW-6 and MW-7 contained gasoline range (C_7 through C_{12}) petroleum hydrocarbons, Benzene, Toluene, Ethylbenzene and total Xylenes (BTEX) concentrations exceeding the Method A cleanup levels.

- Vapor extraction feasibility testing results indicated an approximate radius of influence of 45 feet, with significant (1,200 ppm) recovery of petroleum hydrocarbons in the induced air flow.

This summary is presented for introductory purposes only and should be used in conjunction with the full text of this report. Our observations of the subsurface conditions, the results of laboratory analyses and the installation of the monitoring wells are documented in the text of the report. Analytical laboratory testing procedures and analytical test reports are included as Appendices to this report.

2.0 PROJECT DESCRIPTION

The purpose of this study was to attempt to more accurately define the vertical and lateral extent of the petroleum hydrocarbon plume detected in the vicinity of monitoring well MW-4. This previous assessment work was documented in the RZA AGRA report entitled "Subsurface Petroleum Hydrocarbon Evaluation", dated February 1992.

The scope of work for this assessment consisted of the following:

1). Drilling three borings (B-6 through B-8); removal, extending, and replacement of monitoring well MW-4 to a depth of approximately 45 feet. Completion of each boring as a monitoring well.

2). Collect and field screen soil samples for the presence of volatile organic vapors using an Organic Vapor Analyzer (OVA) equipped with a photolonization detector (PID).

3) Based on field screening, selecting soil samples for laboratory analysis.

4). Measuring water levels and liquid petroleum hydrocarbon (LPH) thickness, if present in each monitoring well

5) Sample groundwater from each monitoring well and submit samples for laboratory analysis

6). Perform a vapor extraction feasibility study.

7) Evaluating the data collected and preparation of this report.

This report has been prepared for the exclusive use of BP Oil Company, and their agents for specific application to this project site, in accordance with generally accepted environmental assessment practices and the constraints of our approved scope of work . No warranty, expressed or implied is made. In the event other information regarding site conditions becomes known, or if there are any changes to the conditions on the existing site or nearby properties, the conclusions of this report should be reviewed and if necessary, revised by our office to reflect updated site information

3.0 SITE CONDITIONS

The subject site is a rectangular-shaped parcel measuring approximately 150 feet by 200 feet located at 19924 Pacific Highway South on the northeast corner of the intersection of South 200th Street and Pacific Highway South in SeaTac, Washington. Topographically, the site is situated near the top of a north-south trending ridge and is fairly flat with a gentle downslope to the southeast. Geographically the site is situated in a residential/retail neighborhood, approximately one mile south of the Seattle-Tacoma International Airport, and roughly one- quarter mile southwest of Angle Lake. Surrounding properties primarily consist of residential houses to the east and west of the Pacific Highway South business corridor. Along the business corridor, the subject parcel is bounded on the north by a car rental agency, an apartment complex, storage facilities, an auto parts store and several automobile dealers. The properties south of the project site consist of commercial and retail properties including a fire station, restaurant, a dry-cleaner, a motel and several automobile dealers. The property west of the subject site, across Pacific Highway South, is occupied by a Chevron Service Station The subject site is asphalt and concrete paved with numerous perimeter landscape planters. Three east-west oriented pump islands are located along the western side of the property and two storm drains are situated along the southern edge of the property Three fiberglass underground storage tanks (USTs) are present at the site These USTs range in size from 5,000 to 20,000 gallons in capacity, and contain leaded or unleaded gasoline

3.1 Site History

RZA AGRA's involvement in the project was initiated with a Subsurface Petroleum Hydrocarbon Evaluation (W-7475) completed in February 1992. The scope of work for the Subsurface Petroleum Hydrocarbon Evaluation included the advancement of five borings, the installation of four monitoring wells in borings B-1, B-3, B-4 and B-5, the collection of soil and groundwater samples for laboratory analysis, and the measurement of groundwater elevations to determine the direction of the subsurface groundwater gradient. In addition, a sensitive receptors survey was completed for the project site. The results of the evaluation indicated liquid phase petroleum hydrocarbons (LPH) were present in monitoring well MW-4. Based on the presence of LPH, BP Oil Company elected to install a recovery system in monitoring well MW-4. Following the initial recovery of available LPH, the perched groundwater source was depleted and the system was turned off and removed.

4.0 SUBSURFACE EXPLORATION

The subsurface exploration program completed for this assessment consisted of advancing three borings (B-6, B-7, and B-8) to depths of approximately 35 to 50 feet BGS and completing each boring as a groundwater monitoring well (MW-6, MW-7, and MW-8, respectively). In addition, monitoring well MW-4 was removed, and the boring extended to a depth of 45 feet BGS. The extended boring was also completed as a monitoring well (MW-4). The borings were drilled during the week of 8 January 1992 by an exploration drilling company under subcontract to our firm and were continuously observed and logged by an experienced geologist from our firm. Each boring was advanced by a truck mounted drill rig using a 6-inch inside diameter (ID) hollow-stem auger. Prior to drilling, the drilling equipment and sampling tools were decontaminated by steam cleaning. During drilling procedures, soil samples were collected at depth intervals of approximately 5 feet and prepared for laboratory analysis. Each soil sample was screened in the field for the presence of volatile organic compounds utilizing an OVA equipped with a PID, to facilitate selecting appropriate soil samples from each boring for chemical analysis. Each boring was completed as a four inch ID PVC monitoring well. The approximate locations of the borings/monitoring wells are shown on the Site and Exploration Plan, Figure 2. Exploration and sampling procedures, subsurface logs, and monitoring well as-built diagrams are included in Appendix A.

4.1 Subsurface Soil Conditions

Geologic maps and literature describe the near surface soils in the vicinity of the subject site as glacially-derived materials characteristic of the Puget Sound region. Specifically, the subject site and vicinity have been mapped as Vashon Glacial Till, reported to be up to 50 feet thick, consisting of a compact mixture of gravel in a gray, silty, sand matrix with interspersed lenses of sand and gravel.

Our field observations during drilling procedures were consistent with published geologic information for the vicinity of the subject site Field observations indicate that the near surface soils generally consist of a dense to very dense, damp to moist, silty, fine to medium SAND with some gravel, with discontinuous sand, silt, and gravel lenses to an approximate depth of ten to twenty feet BGS. Beyond a depth of ten feet, the soil generally increases in moisture content with depth until saturated The soils observed in our explorations appears to be similar to the Vashon Glacial Till Formation described in the geologic literature

The discontinuous zones of sand and gravel encountered within the formation may act as temporary groundwater storage areas creating perched groundwater conditions.

4.2 Groundwater Conditions

Groundwater conditions were evaluated on 16 January 1992. The results of the evaluation indicated groundwater was present in all of the monitoring wells with the exception of monitoring wells MW-4 and MW-8. The depth to groundwater in monitoring wells MW-1, MW-3, MW-5, MW-6 and MW-7 ranged from 17 to 49 feet BGS. Depth to groundwater data is normally used to establish the groundwater elevations and possible groundwater gradient flow directions. However, the variable depth to groundwater measurements in the monitoring wells, and the absence of groundwater in monitoring wells MW-4 and MW-8, are further evidence that the groundwater beneath the subject site is perched within the discontinuous sand and gravel lenses encountered in the borings.

It appeared that the limited volume of perched groundwater in the vicinity of MW-4 had been depleted by the previously installed pump. Due to the lack of groundwater in monitoring well MW-4, the monitoring well was over-drilled to a depth of 45 feet in an attempt to re-establish groundwater pumping and treating. However, upon drilling to 45 feet, additional groundwater was not encountered. Due to the lack of groundwater in MW-4, the emergency response equipment was removed from the site.

Measurements of the groundwater elevations were obtained during our differential leveling program. Differential leveling involved establishing an arbitrary 100.00 foot elevation datum or control point at the southeast corner of the retail building. The differences in elevation were then measured from the top of each monitoring well PVC casing relative to the arbitrary datum. The respective water level measurements are presented in Table 1.

A bail test was conducted on MW-7 to determine the approximate hydraulic conductivity value. The results of the bail test were analyzed using the method developed by Bouwer and Rice and indicated an approximate hydraulic conductivity value of 1.50×10^{-4} cm/sec. A copy of the analysis results are presented in Appendix B

5.0 QUANTITATIVE ANALYSES

5.1 Analytical Results: Soils

Two soil samples from borings B-6, B-7 and B-8 were selected for laboratory analysis. Selected soil samples were analyzed for gasoline range (C_7 through C_{12}) petroleum hydrocarbons using Ecology test method WTPH-G, the volatile organics benzene, toluene, ethylbenzene and xylenes (BTEX) using EPA test method 8020; and total lead using EPA test method 7421. Analytical test results indicated gasoline range petroleum hydrocarbon concentrations ranging from 5.6 part per million (ppm) (B-7, S-6) to 1,300 ppm (B-8, S-6). BTEX concentrations ranged from below the method detection limit to 43 ppm (xylenes in sample B-8, S-6). Total lead concentrations ranged from 3.2 ppm (B-7, S-6) to 5.0 ppm (B-8, S-6).

One soil sample collected from a depth of 45 feet BGS, at the bottom of boring B-4 (during over-drilling of monitoring well MW-4), was selected for chemical analysis. This sample (B-4, S-105) was analyzed for gasoline range petroleum hydrocarbons using Ecology test method WTPH-G and BTEX using EPA test method 8020. The analytes were not detected in this sample at concentrations exceeding the method detection limit. This may be an indication that the on-site contamination is limited to the zone above the depth sampled.

Soil sample B-6, S-5 was split in the field and one half of the sample was labeled as duplicate sample B-11, S-2. Analysis of these samples indicated that gasoline range petroleum hydrocarbons were present in sample B-6, S-5 at a concentration of 12 ppm, and in sample B-11, S-2 at a concentration of 370 ppm. Benzene, toluene, ethylbenzene and xylenes were detected in sample B-6, S-5 at concentrations of 0.09 ppm, 0.09 ppm, none detected and 0.11 ppm respectively. Benzene, toluene, ethylbenzene, and xylenes were detected in sample B-11, S-2 at concentrations of 0.13 ppm, 2.6 ppm, 2.1 ppm and 12 ppm, respectively. Total lead was detected in soil sample B-6, S-5 at a concentration of 3.4 ppm and in sample B-11, S-2 at a concentration of 3.6 ppm. The indicated purgeable hydrocarbon and BTEX concentrations for these soil samples are likely the result of natural variations in the soil sample.

The results of analyses performed on soil samples collected during this assessment are summarized in Table 2. Complete laboratory reports are included with this report in Appendix B.

5.2 Analytical Results: Groundwater

Groundwater samples were collected from monitoring wells MW-1, MW-3, MW-5, MW-6 and MW-7 for chemical analysis. Monitoring wells MW-4 and MW-8 did not contain sufficient groundwater to allow representative samples to be collected. The collected water samples were analyzed for gasoline range petroleum hydrocarbons using Ecology test method WTPH-G, BTEX using EPA test method 8020, total lead by EPA test method 7421, and turbidity using EPA test method 180 1

Gasoline range petroleum hydrocarbons were detected in the groundwater samples collected from monitoring wells MW-6 and MW-7 at concentrations of 9,100 parts per billion (ppb) and 35,000 ppb, respectively. Gasoline range petroleum hydrocarbons were not detected in the groundwater samples collected from monitoring wells MW-1, MW-3 and MW-5 BTEX was detected in the groundwater samples collected from monitoring wells MW-6 and MW-7 at concentrations ranging from 210 ppb (toluene, MW-6) to 6,600 ppb (xylenes, MW-7). BTEX concentrations in the groundwater samples collected from monitoring wells MW-1 and MW-3 were below the detection limit of the test method used. The groundwater sample collected from monitoring well MW-5 contained benzene, toluene, and total xylenes concentrations of 5 ppb.

Analytical test results indicate that total lead was detected in the water sample collected from monitoring well MW-7 at a concentration of 8 ppb. Total lead was not detected in any of the remaining groundwater samples at concentrations above the method detection limit. Turbidity values for the samples collected from monitoring wells MW-1, MW-5 and MW-7 ranged from 2.2 nephelometer turbidity units (NTUs) to 23 NTUs.

The results of analyses performed on soil samples collected during this assessment are summarized in Table 3. Complete laboratory reports are included with this report in Appendix B.

6.0 ON-SITE CONTAINMENT OF DRILL CUTTINGS AND PURGE WATER

Soil cuttings, monitoring well development water and purge water generated from the subsurface exploration and sampling program were placed in 55-gallon Department of Transportation (DOT) approved steel containers with bolt down lids for storage onsite. Each 55- gallon drum was labeled to identify its contents, origin of the contents, and the date they were generated. The barrels were subsequently removed from the site after characterization of the contents was completed

7.0 VAPOR EXTRACTION SYSTEM (VES) FEASIBILITY STUDY

RZA AGRA Inc. conducted a test at the subject site to determine the feasibility of remediating petroleum hydrocarbon impacted soil with vapor extraction system (VES) technology Based on the results of the test, vapor extraction appears to be an effective remediation technology for use at the subject site.

7.1 Vacuum Testing

Vapor extraction testing was performed using a portable VES system consisting of a ROTRON 454 regenerative blower manifolded to either monitoring well MW-4 or MW-6. Magnehelic vacuum gauges were attached to monitoring wells MW-7, MW-8, and either MW-4 or MW-6 depending on which was used as the "extraction" well. The gauges were installed to monitor the vacuum-pressure induced in soils within and around the test zone. The results of the VES feasibility test indicated an effective radius of influence of approximately 45 feet. However, due to the variable nature of the soils encountered beneath the subject site, the estimated radius of influence determined during the test may be the result of air flow along preferential pathway in the subsurface soils Therefore, it should not be assumed that all of the soil within the radius of influence from the extraction point will be affected by a VES. A more detailed discussion of the VES feasibility test is included in Appendix C.

8.0 CONCLUSIONS

The results of this Additional Petroleum Hydrocarbon Assessment indicate that the soils and groundwater in the vicinity of the southern pump island have been impacted by petroleum hydrocarbons, and BTEX at concentrations exceeding the MTCA Method A cleanup levels. The vertical extent of the contaminants in the vicinity of monitoring well MW-4 appear to be limited in extent to depths less then 45 feet, however, the petroleum hydrocarbon plume appears to extend laterally beyond the location of the borings advanced for this assessment.

On-site subsurface soil conditions generally appear to consist of discontinuous sand lenses interbedded with glacial till, creating perched groundwater conditions. Sand lenses are extremely susceptible to petroleum hydrocarbon impact due to the higher permeability associated with sandy soils. The logs from borings B-6 and B-7 indicate a sand lens at a depth of 20 to 30 feet. Perched groundwater conditions were observed within this sand lens at a depth of 28 feet below the ground surface.

Groundwater samples collected from monitoring wells MW-1, MW-3 and MW-5 generally contained concentrations of gasoline range petroleum hydrocarbons and BTEX below the detection limits of the analysis methods used. Samples collected from monitoring wells MW-6 and MW-7 indicate the perched

groundwater has been impacted by petroleum hydrocarbons at concentrations in excess of the MTCA Method A cleanup levels. The groundwater sample collected from monitoring well MW-7 contained a total lead concentration exceeding MTCA Method A cleanup levels, which is likely due to the turbidity of the sample Preliminary hydrogeologic testing of monitoring well MW-6 indicates groundwater yield rates of less then 0.5 gallons per minute (gpm). The preliminary hydrogeologic testing of monitoring well MW-7 indicated approximate yield rates of 1 to 2 gpm

The vapor extraction system (VES) feasibility study conducted for this assessment indicated that vapor extraction is a feasible option for treatment of the petroleum hydrocarbon impacted soils identified on site. The results of the study indicated a radius of influence of approximately 45 feet and good hydrocarbon loading (1200 ppm) from the test monitoring wells.

9.0 CLOSURE

Information in this report is based on the site characterization, field observations, and the laboratory analyses accomplished for this study. The conclusions presented are professional opinions based on our interpretation of the analytical laboratory test results, as well as our experience and observations during the project field characterizations. The number, locations, and depth of explorations during the characterization programs, including the analytical testing scope, were completed within the site and proposal constraints so as to yield the information utilized to formulate our conclusions.

We appreciate this opportunity to be of continued service to you. Please contact us if you have questions regarding this report or other aspects of this project.

Respectfully submitted,
RZA AGRA Inc.,

Robert P Czaja
Project Environmental Geologist

Dave G. Cooper, P.G.
Associate

TABLE 1:
Summary of Fluid Level Measurements
BP Facility No. 11255
19924 Pacific Hwy South
SeaTac, Washington
RZA Job No. W-7475-2

Date Collected	*Elevation (TOC)	Depth to Water	Water Elevation
MW-1			
1-16-92	99.73	28.60	71.13
1-23-92	99.73	28.75	70 98
1-31-92	99.73	28 56	71 17
MW-3			
1-16-92	98.89	28.38	70 51
1-23-92	98.89	28.46	70 43
1-31-92	98.89	28.26	70 63
MW-4			
1-16-92	98.28	**	**
1-23-92	98.28	**	**
1-31-92	98.28	**	**
MW-5			
1-16-92	97.75	19.39	78.36
1-23-92	97.75	19.29	78.46
1-31-92	97.75	19.62	78.13
MW-6			
1-16-92	98.77	31.12	67.65
1-23-92	98.77	31.25	67.52
1-31-92	98.77	31.32	67 45
MW-7			
1-16-92	98.42	29.30	69 12
1-23-92	98.42	29 33	69 09
1-31-92	98.42	29.22	69 20
MW-8			
1-16-92	98.80	49.00	49.80
1-23-92	98 80	49.17	49 63
1-31-92	998 8	50.00	50 00

Notes:
Water Table Elevation = Well Elevation(TOC) - Depth to water
* = Measured from arbitrary datum of 100 feet above sea level.
TOC = Top of Casing
** = No water measured in well
All measurements made in feet

TABLE 2:
Summary of Analytical Results: Soil Samples
BP Facility No. 11255
19924 Pacific Hwy South
SeaTac, Washington
RZA AGRA Project No. W-7475-2

Boring No.	Sample #	Sample Depth(ft)	TPH	B	T	E	X	Lead
B-6	B-6,S-5	23 5	12.00	0 09	0.09	<0.05	0 11	3 40
	B-11,S-2	27 5	370.00	0 13	2.60	2.10	12.00	3 60
	B-6,S-6	27 5	170 00	0 24	1 30	0.53	3.40	3 40
B-7	B-7,S-6	27 5	5 60	0 09	<0 05	<0.05	<0.05	3.20
	B-7,S-8	36 5	230.00	0.10	0.80	0.57	3.80	3 50
B-8	B-8,S-6	27 5	1300.00	2.50	25.00	10.00	43.00	5.00
	B-8,S-10	47 5	6 70	0.08	<0.05	<0.05	<0 05	4.40
B-4	B-4, S-105	45.0	N.D.	N.D.	N D	N.D.	N.D.	N.T.
MTCA Method A Cleanup Level			*100*	*0 5*	*40*	*20*	*20*	*250*

Notes:

Test results are presented in parts per million (ppm)

TPH by Ecology Method WTPH G for gasoline

BTEX = Benzene, Toluene, Ethylbenzene, Xylene, by EPA Method 8020

Total Lead by EPA Method 7420

ND = Not Detected

N T = Not Tested

MTCA = Model Toxics Control Act Method A Cleanup Criteria

= concentrations above MTCA Method A Cleanup Criteria

TABLE 3:
Summary of Analytical Results: Groundwater
BP Facility No. 11255
19924 Pacific Hwy South
SeaTac, Washington
RZA AGRA Project No. W-7475-2

Collected: 16 January 1992

Sample #	TPH	B	T	E	X	Lead	Turbidity
MW-1	<100	<1	<1	<1	<1	<5	23.0
MW-3	<100	5.0	5.0	<1	5.0	<5	NT
MW-5	<100	<1	<1	<1	<1	<5	2 2
MW-6	9100.0	240.0	210.0	260.0	1400.0	<5	NT
MW-7	35000.0	610.0	6900.0	1000.0	6600.0	8.0	4.0
MTCA	1000 0	5 0	40.0	30.0	20.0	5.0	--

Notes:

All results are presented in parts per billion (ppb)

ND = Below laboratory method detection limit

NT = Not Tested

MTCA = Model Toxics Control Act Method A Cleanup Criteria

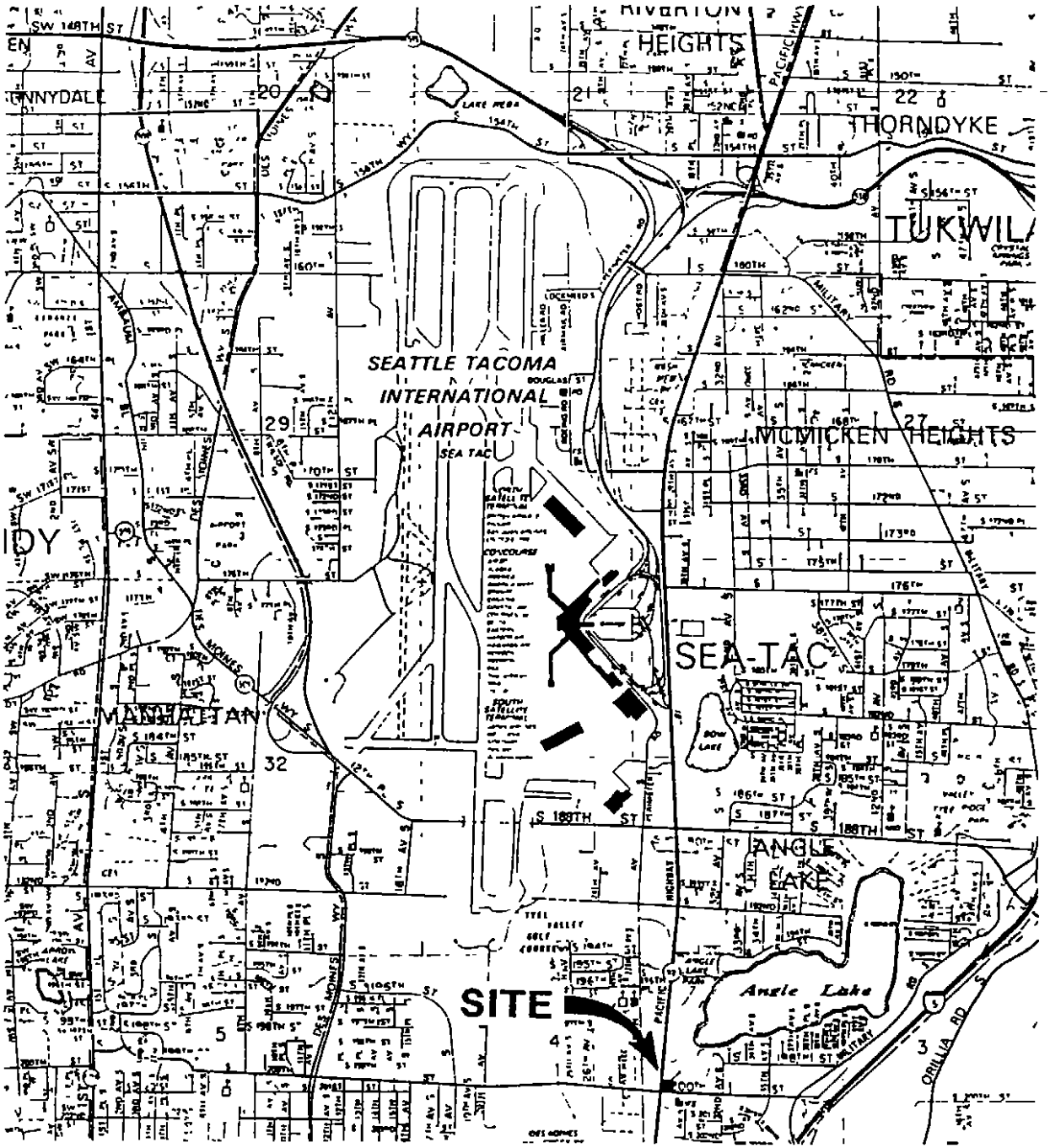
BTEX = Benzene, Toluene, Ethylbenzene, Xylene, by EPA Method 8020

TPH by Ecology Method WTPH-G, for gasoline

Total Lead by EPA Method 7421

Turbidity by EPA Method 180 1, in NTU's

= concentrations above MTCA Method A Cleanup Criteria

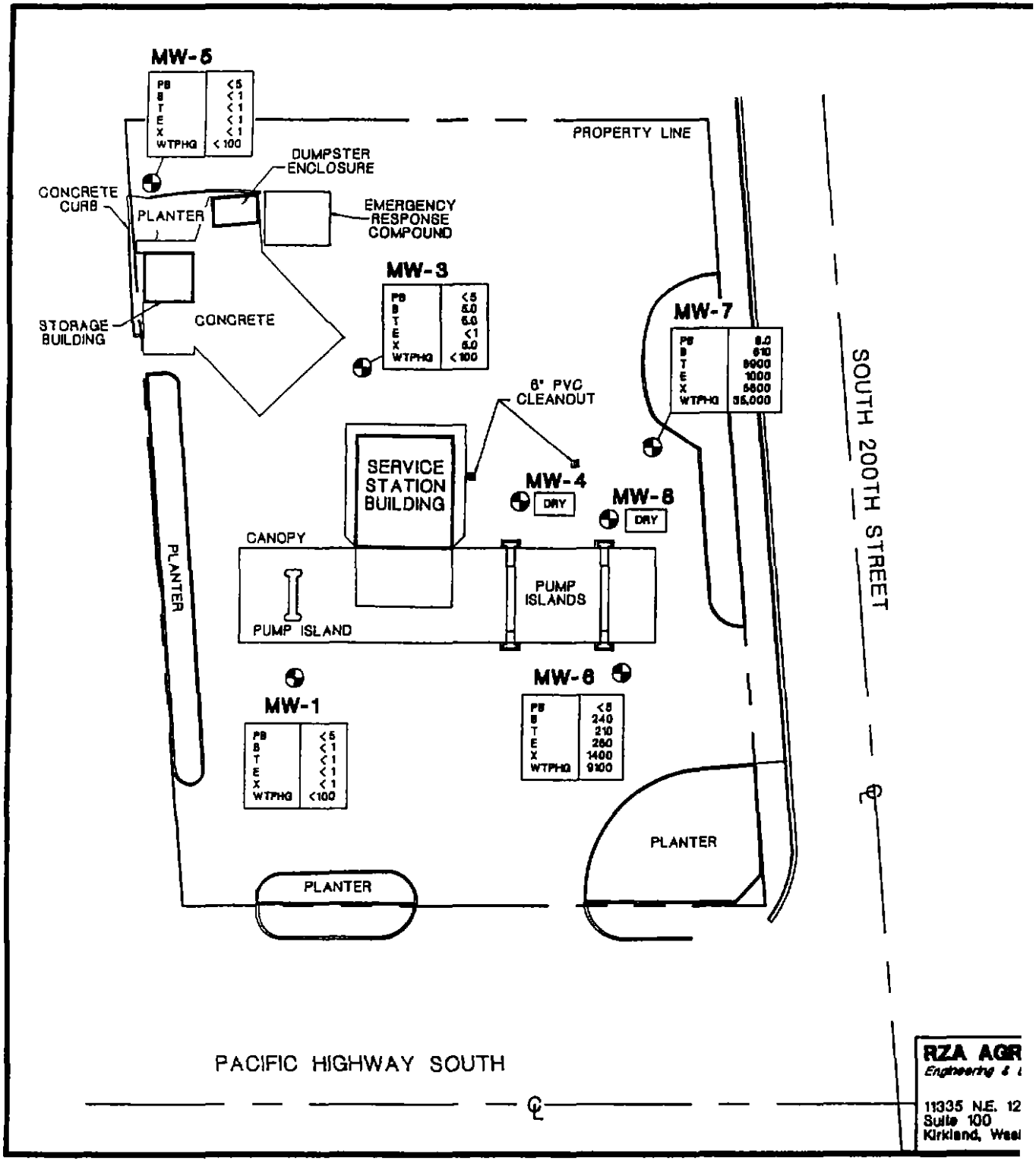


RZA-AGRA	WO W-7475-2
ENGINEERING & ENVIRONMENTAL SERVICES	DESIGN BDE
11335 N.E. 122nd Way	DRAWN MJF
Suite 100	DATE MAY 1992
Kirkland, Washington	SCALE N.T.S.
98034-6918	

BP SERVICE STATION No. 11255
SEATTLE, WASHINGTON

LOCATION MAP

FIGURE 1


MW-5
PB <5
B <1
T <1
E <1
X <1
WTPHG <100
PROPERTY LINE
DUMPSTER ENCLOSURE
CONCRETE CURB
PLANTER
EMERGENCY RESPONSE COMPOUND
MW-3
PB <5
B 8.5
T <1
E 8.0
X <1
WTPHG <100
MW-7
PB 8.0
B 610
T 9000
E 1000
X 5600
WTPHG 35,000
STORAGE BUILDING
CONCRETE
6" PVC CLEANOUT
SERVICE STATION BUILDING
MW-4
DRY
MW-8
DRY
CANOPY
PUMP ISLANDS
PUMP ISLAND
PLANTER
MW-1
PB <5
B <1
T <1
E <1
X <1
WTPHG <100
MW-6
PB <5
B 240
T 210
E 260
X 1400
WTPHG 9100
PLANTER
PLANTER
SOUTH 200TH STREET
PACIFIC HIGHWAY SOUTH
RZA AGR
Engineering &
11335 N.E. 12
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Kirkland, Wes

Appendix A

APPENDIX A
SUBSURFACE EXPLORATION PROCEDURES
W-7475-2

APPENDIX A
SUBSURFACE EXPLORATION PROCEDURES
W-7475-2

Subsurface Exploration

The borings were drilled by an exploration drilling company under subcontract to RZA AGRA, Inc The borings consisted of advancing 6-inch I.D. hollow-stem augers utilizing a truck-mounted drill rig. Each of the explorations was advanced to a depth of approximately 35 to 50 feet below the ground surface. During the drilling process samples were generally obtained at 5-foot depth intervals beginning at 2½ feet below ground surface. The explorations were logged under full-time supervision of an environmental geologist. The geologist classified the subsurface materials, kept a detailed log and maintained custody of the recovered samples.

Characterization of Soils

Disturbed representative samples were obtained using the Standard Penetration Test procedure as described in ASTM:D 1586. The test sampling method consists of driving a standard 2-inch outside diameter split barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch is recorded. The number of blows required to drive a sampler the final 12 inches is considered the standard penetration resistance ("N") or blow count. If a total of 50 blows is recorded within one 6-inch interval, the blow count is recorded as 50 blows for the actual number of inches of penetration. The blow count, or "N" value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils.

Soil Sampling Procedure

The soil samples were recovered at each interval using procedures designed to minimize the risk of cross-contamination. Prior to each boring, the drilling equipment and sampling tools were cleaned. Prior to each sampling attempt, the sampling tools were scrubbed with a stiff brush and a detergent solution consisting of Liquinox and distilled water, and then rinsed with potable water and liberal quantities of distilled water. The samples were classified in the field, immediately transferred to laboratory-treated glass jars, and tightly sealed with a Teflon-lined threaded cap Samples were stored and transported in a chilled ice chest throughout the field program

The boring logs presented in this appendix are based on the drilling action, visual inspection of the samples secured, laboratory results, and field logs. The various types of soils are indicated, as well as the depths where the soils or characteristics of the soils changed It should be noted that these changes may have

been gradual, and if the changes occurred between sample intervals, they were interpreted. Subsurface water conditions were evaluated observing the moisture condition of the samples, the free water on the sampling rods, and the installation of monitoring wells in the borings.

Field Screening

Each soil sample was screened in the field for the presence of volatile organic compounds, to facilitate selecting an appropriate soil sample for chemical analysis. The screening involved placing approximately 4 ounces of sampled soil directly into a plastic bag. The sample was then shaken vigorously for about 15 seconds and a head space reading was taken after plunging the probe of an organic vapor meter (OVM) through the sealed plastic bag. Prior to sample collection, background measurements of the air space in the plastic bags indicated non-detectable concentrations of organic vapors. Field head space analysis was performed on each sample utilizing an OVM. The highest value displayed by the OVM during the drilling program ranged from non-detectable headspace values to levels as high as 959 ppm (during the advancement of boring B-6/MW-6). However, the OVM is not capable of identifying specific compounds or their actual concentrations in the soil samples. Therefore, this method is considered only a screening tool that aids in detecting the presence of volatile organic compounds with an ionization potential less than 10.0 Ev, which includes many petroleum hydrocarbons.

Monitoring Well Construction

The monitoring wells were constructed of a section of 4-inch I D. Schedule 40 polyvinyl chloride (PVC) casing five feet long threaded flush to a 15 foot length of schedule 40, 0.01-inch slotted PVC well screen. Washed 10/20 graded sand was then allowed to surround the screened portion of the well during withdrawal of the augers. Above the screened portion of the wells, the annulus of each boring was backfilled with approximately 2 feet of granular bentonite. A bentonite/Concrete slurry, was placed above the granular bentonite to within 2 feet of the surface. At the surface, an approximately 2-foot thick cap of concrete was placed. Each of the wells was completed with a locking thermos cap, and a weatherproof monument mounted flush to surface grade The as-built drawings for each of the four monitoring wells are presented in this appendix.

Well Development Procedures

Prior to groundwater sampling, the monitoring wells were developed by hand bailing methods. Water was removed from each well, allowed to recharge and the process continued until the water entering the well was noticeably clearer of sand and silt. The well development process ensures proper seating of the annular sand pack around the well screen and removal of fines.

Groundwater Sampling Procedures

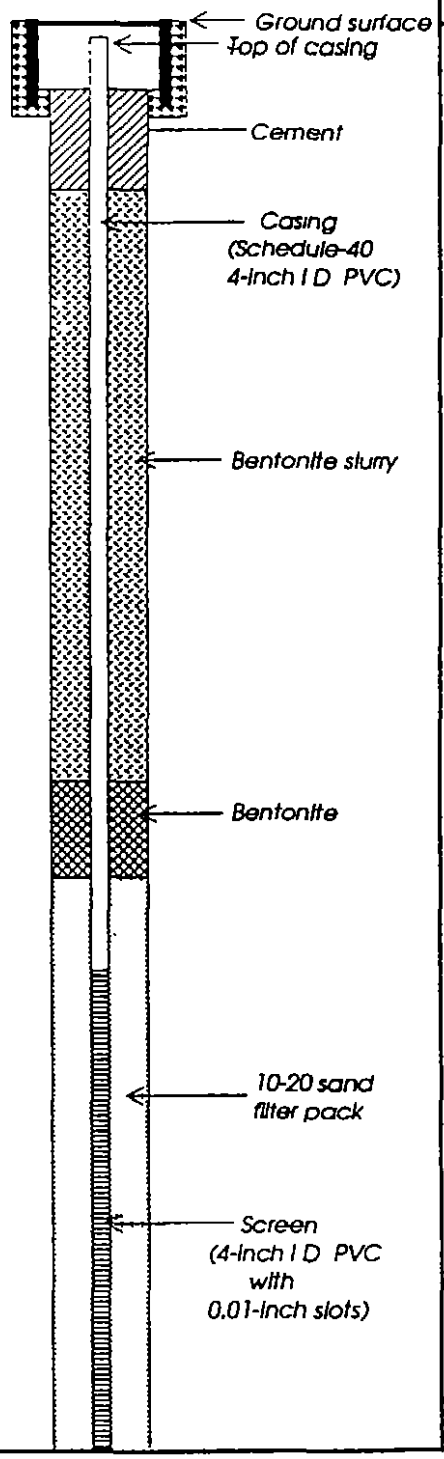
The groundwater sampling procedure for these wells consisted of evacuating 3-5 well casing volumes of water from a well using a PVC bailer cleaned prior to each well purge. Once each well was purged, a new laboratory certified disposable Teflon bailer was lowered slowly through the air/water interface, and a sample from near the water surface was retrieved from the monitoring well The water was carefully decanted into three different types of sampling containers. The first sampling consisted of filling two 40 millimeter (ml) laboratory-cleaned and dried glass vials. The vials were sealed with a Teflon-lined threaded cap, such that no air bubbles were trapped inside These samples were analyzed for dissolved BTEX by EPA method 8020; and for purgeable petroleum hydrocarbons (TPH) by Ecology Method WTPH-G. The next sampling involved filling two 500 ml plastic containers. One sample was analyzed for Turbidity by EPA Method 180.1. Approximately 2 ml of concentrated nitric acid (HNO_3) was placed in the other plastic container to bring the Ph of the water down to less than 2 and preserve the sample prior to laboratory analysis. This sample was analyzed for Total Lead by EPA Method 7421

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-4*

Elevation reference *100.00 (arbitrary)* Well completed *11 February 1992*
Ground surface elevation *99.36* Casing elevation *98.28*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER	TESTING
0	*Concrete vault interior (void)*						
	Crushed rock						
5	*Grayish brown, moist, bentonite 'MUD',, with some sand and silt present (from previous boring wall)*						
10							
15							
20	*Encountered sand pack fromprevious boring. (Drilled· 10 April 1991)*						
25							
30							



LEGEND

I 2-inch O D split-spoon sample

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started. *11 February 1992* Drilling completed. *11 February 1992* Logged by: *DAS*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-4*

Elevation reference *100.00 (arbitrary)* Well completed *11 February 1992*
Ground surface elevation *99 36* Casing elevation *98 28*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER	TESTING
30							
35	*Very dense, damp to moist, brown, silty medium to coarse SAND, with some gravel*		S-101	50/ 5"	18		
			S-102	50/ 5"	63		
40			S-103	50/ 5"	82		
			S-104	50/ 4"			
45			S-105	50/ 5"	0		8020 8015MOD
	Bottom of boring at 45.4 feet. Groundwater was not encountered at time of drilling.						
50							
55							
60							

10-20 sand filter pack

Screen (4-inch I D PVC with 0.01-inch slots)

Threaded end cap

LEGEND

- 2-inch O D split-spoon sample
- Sample not recovered
- Observed groundwater level ATD = at time of drilling

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started *11 February 1992* Drilling completed *11 February 1992* Logged by *DAS*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-6*

Elevation reference. *100.00 (arbitrary)* Well completed. *8 January 1992*
Ground surface elevation *99 67* Casing elevation *98 77*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER	TESTING
0	*3" of Asphalt*						
	Loose, damp, light to dark brown fine to medium SAND, some organics, some silt, some gravel		S-1	7	<1		
5							
	Very dense, damp, dark to light brown, fine to medium SAND, some gravel.		S-2	57	0		
10							
	Very dense, damp, brown to gray, silty, fine to medium SAND, some gravel		S-3	50/ 6"	2		
15							
			S-4	50/ 6"	28		
20							
	SANDY (LENS)						
	Very dense, moist, gray to brown, silty, fine to medium SAND Strong petroleum hydrocarbon odor, in ambiant air surrounding soil cuttings		S-5	50/ 6"	932		8015 MOD 8020 7421
25							
	Dense, wet, brown, silty, fine to medium SAND; trace gravel Strong petroleum hydrocarbon odor, in ambiant air surrounding soil cuttings		S-6	40	959	ATD	8015 MOD 8020 7421
30							

Flush-mounted steel monument
Ground surface
Top-of casing
Cement
Bentonite-Concrete slurry
Casing (Schedule-40 4-inch I.D PVC)
Bentonite slurry
10-20 sand filter pack
Screen (4-inch I D PVC with 0 01-inch slots)

LEGEND

2-inch O D split-spoon sample

Observed groundwater level (ATD = at time of drilling 0/00/00 = date observed)

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started *08 January 1992* Drilling completed *08 January 1992* Logged by *BDE*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-6*

Elevation reference *100 00 (arbitrary)* Well completed *8 January 1992*
Ground surface elevation *99 67* Casing elevation *98 77*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER	TESTING
30	*Very dense, wet, brown to gray, fine to coarse SAND, some silt*		S-7	50/4"	116	1/31/92	
35	*Very dense, saturated, brown, silty fine to coarse SAND, some gravel.*		S-8	50/5"	67		
40	*Bottom of boring at 39 feet.*						
45							
50							
55							
60							

10-20 sand filter pack

Screen (4-inch I.D. PVC with 0.01-inch slots)

Threaded end cap

LEGEND

2-inch O D split-spoon sample

Observed groundwater level (0/00/00 = date observed)

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started. *08 January 1992* Drilling completed. *08 January 1992* Logged by *BDE*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-7*

Elevation reference *100.00 (arbitrary)* Well completed *9 January 1992*
Ground surface elevation ~~*98 75*~~ Casing elevation ~~*98 42*~~

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER
0	3" of Asphalt					
	Loose, damp, brown, silty, fine to medium SAND, some gravel.		S-1	8	0	
5						
	Dense, damp, brown to gray, silty, fine to medium SAND; trace gravel.		S-2	47	0	
10						
	Very dense, damp, gray, silty, fine to medium SAND, some gravel.		S-3	50/ 6"	0	
15						
	Very dense, moist, light brown to gray, silty, fine to medium SAND, trace gravel		S-4	50/ 5 75"	32	
20						
	Very dense, moist, brown, silty, fine to medium SAND, trace gravel		S-5	50/ 5 5"	159	
25						
	Very dense, moist, brown, silty, fine to medium SAND		S-6	50/ 5 5"	56	ATD 1/31/92
30						

Flush-mounted steel monument
Ground surface
Top of casing
Cement
Bentonite-Concrete slurry
Casing (Schedule-40 4-inch I D PVC)
Bentonite slurry
10-20 sand filter pack
Screen (4-inch I D PVC with 0 01-inch slots)

TESTING

8015 MOD
8020
7421

LEGEND

2-inch O D split-spoon sample

Observed groundwater level (ATD = at time of drilling 0/00/00 = date observed)

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started. *09 January 1992* Drilling completed. *09 January 1992* Logged by *BDE*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-7*

Elevation reference *100 00 (arbitrary)* Well completed *9 January 1992*
Ground surface elevation *98 75* Casing elevation *98 42*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER	TESTING
30							
	Very dense, moist to wet, brown, silty, fine to medium SAND, some gravel		*S-7*	*50/ 2"*	*85*		
35							
	Very dense, moist to wet, brown, silty, fine to medium SAND		*S-8*	*100/ 4"*	*83*		*8015 MOD 8020 7421*
	Bottom of boring at 37 feet.						
40							
45							
50							
55							
60							

10-20 sand filter pack

Screen (4-inch I D PVC with 0.01-inch slots)

Threaded end cap

LEGEND

2-inch O.D split-spoon sample

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started. *09 January 1992* Drilling completed *09 January 1992* Logged by *BDE*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-8*

Elevation reference *100.00 (arbitrary)* Well completed. *10 January 1992*
Ground surface elevation *99 16* Casing elevation *98 80*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER
0	*3" of Asphalt*					
	Medium dense, moist, brown to gray, silty, fine to medium SAND, some gravel		S-1	18	1	
5						
	Very dense, moist, gray, silty, fine to medium SAND, some gravel		S-2	66	141	
10						
	Very dense, moist, brown to gray, silty, fine to medium SAND, trace gravel		S-3	50/ 6"	715	
15						
			S-4	50/ 5.5"	890	
20						
	Very dense, damp, brown, silty, fine to medium SAND, trace gravel		S-5	50/ 6"	202	
25						
			S-6	50/ 6"	539	
30						

Flush-mounted steel monument
Ground surface
Top of casing
Cement
Bentonite-Concrete slurry
Casing (Schedule-40 4-inch I.D. PVC)
Bentonite slurry
10-20 sand filter pack
Screen (4-inch I D PVC with 0 01-inch slots)

TESTING

8015 MOD.
8020
7421

LEGEND

2-inch O D split-spoon sample

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started *10 January 1992* Drilling completed *10 January 1992* Logged by *BDE*

PROJECT: *BP SeaTac Facility #11255* W.O. *W-7475-2* WELL NO. *MW-8*

Elevation reference *100 00 (arbitrary)* Well completed *10 January 1992*
Ground surface elevation *99.16* Casing elevation *98 80*

AS-BUILT DESIGN

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	OVM READING	GROUND WATER	TESTING
30	*Very dense, moist, gray to brown, silty fine to medium SAND, some gravel*		S-7	50/4"	630		
35	*Very dense, moist, brown, silty, fine to medium SAND, some gravel.*		S-8	50/2"	28		
40			S-9	50/4"	205		
45	*Very dense, moist to wet, brown, silty, gravelly, medium to coarse SAND.*		S-10	105/6"	42		8015 MOD 8020 7421
50	*Bottom of boring at 49.5 feet. Groundwater was not encountered at time of drilling*						
55							
60							

10-20 sand filter pack

Screen (4-inch I.D PVC with 0.01-inch slots)

Threaded end cap

LEGEND

I 2-inch O D split-spoon sample

X Sample not recovered

RZA AGRA, Inc.
Geotechnical & Environmental Group

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

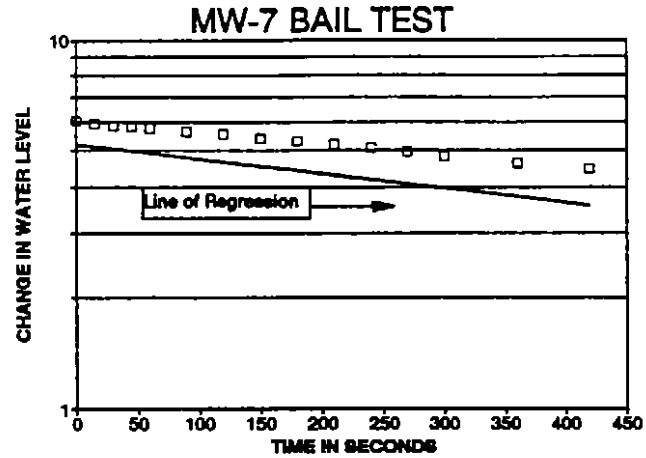
Drilling started *10 January 1992* Drilling completed *10 January 1992* Logged by *BDE*

Appendix B

APPENDIX B

GROUNDWATER BAIL TEST RESULTS

W-7475-2



TIME	DEPTH TO WATER	CHANGE IN WATER LEVEL
0	35 22	6.04
15	35.10	5.92
30	35 04	5.86
45	35 00	5 82
60	34 94	5 76
90	34 82	5.64
120	34 72	5.54
150	34 60	5.42
180	34 50	5.32
210	34 40	5.22
240	34.27	5.09
270	34 15	4.97
300	34 02	4.84
360	33.81	4.63
420	33.64	4 46
480	33.46	4.28
540	33.27	4.09
600	33.07	3.89
720	32.67	3.49
840	32.31	3.13
960	31 95	2.77
1080	31.36	2.18
1200	31 02	1.84
1500	30.26	1 08
1800	29.85	0.67
2100	29 66	0.48
2400	29.50	0.32
2700	29 40	0.22
3000	29.34	0.16
3600	29.26	0.08
4200	29.23	0.05
4800	29.21	0.03
5400	29.20	0.02
6000	29.20	0.02
7200	29.20	0.02
9000	29 19	0 01

Lw (feet)	7 61	Le/rw	18.264
rw (inches)	5	re (inches)	3.21
H (feet)	7 61	A	2.25
Le (feet)	7 61	B	0.3
ln (Re/rw)	1 17	Depth to Stabo Water	29.18

Regression Output:

Constant	1.648643
Std Err of Y Est	0.54101
R Squared	0 935895
No. of Observations	36
Degrees of Freedom	34
X Coefficient(s)	-0.0009
Std Err of Coef	4 02E-05

HYDRAULIC CONDUCTIVITY		TRANS.
IN/SEC	CM/SEC	GPD/FT
5.91E-05	1 50E-04	24

APPENDIX C

ANALYTICAL TEST RESULTS

W-7475-2

SOUND ANALYTICAL SERVICES, INC.

SPECIALIZING IN INDUSTRIAL & TOXIC WASTE ANALYSIS

4813 PACIFIC HIGHWAY EAST, TACOMA, WASHINGTON 98424 - TELEPHONE (206) 922-2310 - FAX (206) 922-5047

ANALYTICAL NARRATIVE

Client: RZA - AGRA

Date: January 28, 1992

Project: W-7475

Lab No.: 22075

Delivered by: SAS

Date Sampled: 01-08-92 and 01-09-92

Condition of Samples on Receipt:

Samples were received cold and in good condition. Chain-of-custody was in order.

EXTRACTION AND ANALYSIS DATES

Samples were analyzed for BTEX in accordance with EPA SW-846 Method 8020. Soil samples were extracted on 01-15-92. The extract was analyzed on 01-20-92.

Samples were analyzed for gasoline range hydrocarbons per WA State DOE method WTPH-G. Soil samples were extracted on 01-15-92. The extract was analyzed on 01-20-92 and reported on a dry weight basis.

Samples were analyzed for lead by ICP in accordance with EPA SW-846 Method 6010. Samples were digested on 01-15-92 and analyzed on 01-17-92.

SOUND ANALYTICAL SERVICES, INC.

SPECIALIZING IN INDUSTRIAL & TOXIC WASTE ANALYSIS

4813 PACIFIC HIGHWAY EAST, TACOMA, WASHINGTON 98424 - TELEPHONE (206)922-2310 - FAX (206)922-5047

Report To: RZA - AGRA Date: January 28, 1992

Report On: Analysis of Soil Lab No: 22075

IDENTIFICATION:

Samples received on 01-14-92
Project: W-7475 BP - SeaTac #11255

ANALYSIS:

Lab Sample No.	1	2	3	4
Client ID	B-6,S-5	B-6,S-6	B-7,S-6	B-7,S-8
Units	mg/kg	mg/kg	mg/kg	mg/kg
WTPH-G Gasoline (C_7-C_{12})	12	170	5.6	230
BTEX by 8020				
Benzene	0.088	0.24	0.090	0.095
Toluene	0.090	1.3	< 0.05	0.80
Ethyl Benzene	< 0.05	0.53	< 0.05	0.57
Xylenes	0.11	3.4	< 0.05	3.8
Total Lead	3.4	3.4	3.2	3.5
SURROGATE RECOVERIES WTPH-G / BTEX				
Trifluorotoluene %	94	87	103	95

Results are reported on a dry weight basis.

Continued . . . . .

SOUND ANALYTICAL SERVICES, INC.

SPECIALIZING IN INDUSTRIAL & TOXIC WASTE ANALYSIS

4813 PACIFIC HIGHWAY EAST, TACOMA, WASHINGTON 98424 - TELEPHONE (206)922 2310 - FAX (206)922-5047

QUALITY CONTROL REPORT

DUPLICATES

Client: RZA - AGRA
Project: W-7475
Matrix: Soil
Units: mg/kg
Date: January 28, 1992

Lab No: 22075 (1) Client ID: B-6,S-5

Parameter	Sample(S)	Duplicate(D)	RPD
WTPH-G Gasoline (C6)-(C10)	12	10	18.2
Benzene	0.088	0.090	2.2
Toluene	0.090	0.10	10.5
Ethyl Benzene	< 0.05	< 0.05	0.0
Xylenes	0.11	0.095	14.6
SURROGATE RECOVERY% WTPH-G- / BTEX Trifluorotoluene	94	117	

Lab No: 22075 (2) Client ID: B-6,S-6

Parameter	Sample(S)	Duplicate(D)	RPD
Total Lead	3.4	3.8	11.1

RPD = relative percent difference
= [(S - D) / ((S + D) / 2)] x 100

SOUND ANALYTICAL SERVICES, INC.

RZA - AGRA
Project: W-7475

Lab No. 22075
January 28, 1992

Lab Sample No.	5	6	7
Client ID	B-8, S-6	B-8,S-10	B-11,S-2
Units	mg/kg	mg/kg	mg/kg
WTPH-G Gasoline (C_7-C_{12})	1,300	6.7	370
BTEX by 8020			
Benzene	2.5	0.076	0.13
Toluene	25	< 0.05	2.6
Ethyl Benzene	10	< 0.05	2.1
Xylenes	43	< 0.05	12
Total Lead	5.0	4.4	3.6
SURROGATE RECOVERIES WTPH-G / BTEX			
Trifluorotoluene %	116	67	94

Results are reported on a dry weight basis.

SOUND ANALYTICAL SERVICES

STAN P. PALMQUIST

RZA-AGRA
Environmental & Engineering Services
11335 Northeast 122nd Way
Kirkland, Washington 98034-6918
(206) 820-4669/FAX (206) 821-3914

#22015
№ 00043

Chain of Custody Record / Analysis Request

Project Name: BP-SeaTac #11255 Job No.: W-7475
Project Manager: John Cooper Phone #: 820-4669
Sampler: Brian Evans

RZA-AGRA Sample ID	Lab Samp ID	Date Collected	Time Collected	Matrix (S=soil, W=water, A=air)	# Containers/Preservation: 40 ml VOA	1 L Glass	8 oz Glass	4 oz Glass			CHILL	W-TPH-G/BTEX	Total Lead	Hold for Further Analysis	RUSH (see below)
B-7, S-5		1-9-92		S			1				✓			✓	
B-7, S-6		"		"			1				✓	X	X	✓	
B-7, S-7		"		"				1			✓			✓	
B-7, S-8		"		"				1			✓	X	X	✓	
B-7, S-8A		"		"				1			✓			✓	
B-8, S-1		1-10-92		"			1				✓			✓	
B-8, S-2		"		"			1				✓			✓	
B-8, S-3		"		"			1				✓			✓	
B-8, S-4		"		"			1				✓			✓	
B-8, S-5		"		"			1				✓			✓	
B-8, S-6		"		"			1				✓	X	X	✓	
B-8, S-7		"		"			1				✓			✓	

RELINQUISHED BY SAMPLER	RELINQUISHED BY	RELINQUISHED BY
Signature: Brian Evans	Signature	Signature
Printed Name: Brian Evans	Printed Name	Printed Name
Firm: RZA	Firm	Firm
Date/Time: 1/14/92 9:30 AM	Date/Time	Date/Time
RECEIVED BY	**RECEIVED BY**	**RECEIVED BY**
Signature: Tom Watson	Signature	Signature.
Printed Name: TOM WATSON	Printed Name	Printed Name
Firm: SAS	Firm	Firm
Date/Time: 1/14/92 11:15 AM	Date/Time	Date/Time

LABORATORY: Sound Analytical
Total # Containers
Condition of Containers?
Condition of Seals?

Special Handling
Turnaround
- ☐ 8 hour
- ☐ 24 hour
- ☐ 5 business day
- ☒ 10 business day
- ☐ other _____ (#)business day

PURPOSE OF SAMPLING / COMMENTS

Form 100B DISTRIBUTION WHITE - return to originator, YELLOW - lab, PINK - retained by originator; GOLDENROD - to lab in advance

RZA-AGRA
Environmental & Engineering Services
11335 Northeast 122nd Way
Kirkland, Washington 98034-6918
(206) 820-4669/FAX (206) 821-3914

#2025
№ 00041

Chain of Custody Record / Analysis Request

Project Name: BP-SaTa #11255 Job No: W-7475
Project Manager: John Cooper Phone #: 820-4669
Sampler: Brian Evans

RZA-AGRA Sample ID	Lab Samp ID	Date Collected	Time Collected	Matrix (S=soil, W=water, A=air)	# Containers/Preservation: 40 ml VOA	1 L Glass	8 oz Glass				CHILL	Analysis Requested: W-TPH-G/BTEX	Total Lead	Hold for Further Analysis	RUSH (see below)
B-6, S-1		1-8-92		S			1				X			X	
B-6, S-2							1				X			X	
B-6, S-3							1				X			X	
B-6, S-4							1				X			X	
B-6, S-5							1				X	X	X	X	
B-6, S-6							1				X	X	X	X	
B-6, S-7							1				X			X	
B-6, S-8							1				X			X	
B-7, S-1		1-9-92					1				X			X	
B-7, S-2							1				X			X	
B-7, S-3							1				X			X	
B-7, S-4							1				X			X	

RELINQUISHED BY SAMPLER	RELINQUISHED BY	RELINQUISHED BY
Signature: Brian Evans	Signature:	Signature
Printed Name: Brian Evans	Printed Name	Printed Name
Firm: RZA	Firm	Firm
Date/Time: 1/14/92 9:30 AM	Date/Time	Date/Time
RECEIVED BY	**RECEIVED BY**	**RECEIVED BY**
Signature: Tom Watson	Signature	Signature:
Printed Name: TOM WATSON	Printed Name	Printed Name
Firm: SAS	Firm	Firm
Date/Time: 1/14/92 11:45A	Date/Time	Date/Time.

LABORATORY: Sound Analytical
Total # Containers
Condition of Containers?
Condition of Seals?

Special Handling
Turnaround
- ☐ 8 hour
- ☐ 24 hour
- ☐ 5 business day
- ☒ 10 business day
- ☐ other _____ (#)business day

PURPOSE OF SAMPLING / COMMENTS

Form 100B DISTRIBUTION WHITE - return to originator, YELLOW - lab, PINK - retained by originator, GOLDENROD - to lab in advance

RZA-AGRA
Environmental & Engineering Services
11335 Northeast 122nd Way
Kirkland, Washington 98034-6918
(206) 820-4669/FAX (206) 821-3914

#22075
№ 00044

Chain of Custody Record / Analysis Request

Project Name: BP-SecTac #11255 Job No.: W-7475
Project Manager: John Cooper Phone #: 820-4669
Sampler: Brian Evans

RZA-AGRA Sample ID	Lab Samp ID	Date Collected	Time Collected	Matrix (S=Soil, W=water, A=air)	# Containers/Preservation: 40 ml VOA /	1 L Glass /	8 oz Glass /	4oz Glass		CHILL	Analysis Requested: W-TPH-G / BTEX	Total Lead	Hold for Further Analysis	RUSH (see below)
B-8, S-8		1-10-92		S			✓			✓	X	X	✓	
B-8, S-10		"		S			✓			✓	X	X	✓	
B-11, S-2		"		S				1		✓	X	X	✓	

RELINQUISHED BY SAMPLER	RELINQUISHED BY	RELINQUISHED BY	LABORATORY	Special Handling
Signature: Brian Evans	Signature	Signature	Sund Analytical	Turnaround
Printed Name: Brian Evans	Printed Name	Printed Name	Total # Containers	☐ 8 hour
Firm: RZA	Firm	Firm	Condition of Containers?	☐ 24 hour
Date/Time: 7/14/92 9:30 AM	Date/Time	Date/Time	Condition of Seals?	☐ 5 business day
RECEIVED BY:	RECEIVED BY	RECEIVED BY:		☒ 10 business day
Signature: Tom Watson	Signature	Signature	PURPOSE OF SAMPLING / COMMENTS	☐ other ____ (#)business day
Printed Name: TOM WATSON	Printed Name	Printed Name		
Firm: SAS	Firm	Firm.		
Date/Time: 7/14/92 11:45A	Date/Time	Date/Time		

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NORTH CREEK ANALYTICAL

18939 120th Avenue N.E., Suite 101 • Bothell, WA 98011-2569
Phone (206) 481-9200 • FAX (206) 485-2992

RZA/AGRA	Client Project ID:	B.P. Sea-Tac, W-7475-1		
11335 NE 122nd Way, #100	Matrix:	Soil		
Kirkland, WA 98034	Analysis for:	Total Solids	Received:	Feb 12, 1992
Attention: John Cooper	First Sample #:	202-0484	Reported:	Feb 24, 1992

LABORATORY ANALYSIS FOR: Total Solids

Sample Number	Sample Description	Sample Result %
202-0484	B4-S105	91

North Creek Analytical routinely provides analytical results for soils, sediments or sludges in a wet weight "as received" basis
To attain dry weight equivalents for regulatory compliance, divide the soil result by the decimal fraction of percent solids

NORTH CREEK ANALYTICAL

Scot Cocanour
Laboratory Director

NORTH CREEK ANALYTICAL

18939 120th Avenue N.E., Suite 101 • Bothell, WA 98011-2569
Phone (206) 481-9200 • FAX (206) 485-2992

RZA/AGRA	Client Project ID:	B P. Sea-Tac, W-7475-1	Sampled.	Feb 11, 1992
11335 NE 122nd Way, #100	Matrix Descript:	Soil	Received.	Feb 12, 1992
Kirkland, WA 98034	Analysis Method:	EPA 5030/8015/8020	Analyzed.	Feb 14, 1992
Attention: John Cooper	First Sample #:	202-0484	Reported:	Feb 24, 1992

TOTAL PETROLEUM FUEL HYDROCARBONS with BTEX DISTINCTION (WTPH-G/BTEX)

Sample Number	Sample Description	Volatile Hydrocarbons mg/kg (ppm)	Benzene mg/kg (ppm)	Toluene mg/kg (ppm)	Ethyl Benzene mg/kg (ppm)	Xylenes mg/kg (ppm)	Surrogate Recovery %
202-0484	B4-S105	N.D.	N.D.	N.D.	N D.	N.D.	85
BLK021492	Method Blank	N.D.	N.D.	N D.	N.D.	N.D.	83
Detection Limits:		**1.0**	**0.050**	**0.10**	**0.10**	**0.10**	

Volatile Hydrocarbons are quantitated against a gasoline standard (nC5 - nC12) Surrogate recovery reported is for Bromofluorobenzene.
Analytes reported as N.D. were not present above the stated limit of detection

NORTH CREEK ANALYTICAL

Scot Cocanour
Laboratory Director

NORTH CREEK ANALYTICAL

18939 120th Avenue N.E., Suite 101 • Bothell, WA 98011-2569
Phone (206) 481-9200 • FAX (206) 485-2992

RZA/AGRA	Client Project ID: B.P. Sea-Tac, W-7475-1	Analyst	R. Lister
11335 NE 122nd Way, #100	Method : EPA 5030/8020		S. Stowell
Kirkland, WA 98034	Sample Matrix : Soil		
Attention John Cooper	Units . mg/kg	Analyzed:	Feb 14, 1992
	QC Sample #. 202-0436	Reported:	Feb 24, 1992

QUALITY CONTROL DATA REPORT

ANALYTE	Benzene	Toluene	Ethyl benzene	Xylenes
Sample Conc.:	N.D	N.D	N.D.	N.D.
Spike Conc. Added:	0.50	0.50	0.50	1.50
Conc. Matrix Spike:	0.33	0.35	0.41	1.16
Matrix Spike % Recovery:	66	70	82	77
Conc. Matrix Spike Dup.:	0.35	0.37	0.45	1.26
Matrix Spike Duplicate % Recovery:	70	74	90	84
Relative % Difference:	5.9	5 6	9.3	8.3

NORTH CREEK ANALYTICAL

Scot Cocanour
Laboratory Director

% Recovery	Conc. of M.S. - Conc. of Sample / Spike Conc. Added	x 100
Relative % Difference	Conc. of M S - Conc. of M S D / (Conc of M S + Conc of M.S D) / 2	x 100

RZA-AGRA

Environmental & Engineering Services
11335 Northeast 122nd Way
Kirkland, Washington 98034-6918
(206) 820-4669/FAX (206) 821-3914

Chain of Custody Record / Analysis Request

No 10086

Project Name: B.P. Section Job No: W-7475-1
Project Manager: Todd Cleveland Phone #: 820-4669
Sampler: Dave St. John

RZA-AGRA Sample ID	Lab Samp ID	Date Collected	Time Collected	Matrix (S=soil, W=water, A=air)	# Containers/Preservation: 40 ml VOA /	1 L Glass /	8 oz Glass /	4 oz Glass			CHILL	BTEX by EPA 8020 Soil / EPA 602 Water	WTPH-G	BTEX / WTPH-G	WTPH-HCID	WTPH-D	TPH by EPA 8015 Mod.	WTPH-418.1 Modified	TPH by EPA 418.1	LEAD EPA 6010 7420 7421 Soil Total / Dissolved EPA 7421 Water	TOTAL METALS	TCLP EPA 1311	PCBs EPA 8080 Soil EPA 608 Water	VOCs EPA 8010 8020 Soil EPA 601 602 Water	GC/MS EPA 8240 Volatiles	GC/MS EPA 8270 Semi-volatiles			Hold for Further Analysis	RUSH (see below)
B4 S101		2/11	4pm	S																										
B4 S102																														
B4 S103														X	3	note	below													
B4 S105	2020489																													

RELINQUISHED BY SAMPLER	RELINQUISHED BY	RELINQUISHED BY
Signature:	Signature	Signature
Printed Name: David St. John	Printed Name	Printed Name
Firm: RZA AGRA	Firm	Firm
Date/Time: 2-12-92 10:15 am	Date/Time	Date/Time
RECEIVED BY	**RECEIVED BY**	**RECEIVED BY**
Signature:	Signature	Signature: Dina Heine
Printed Name	Printed Name	Printed Name: D. HEINE
Firm	Firm	Firm: NCA
Date/Time: NA 2/13/92	Date/Time	Date/Time: 2/12/92 1015

LABORATORY: North Creek.
Total # Containers:
Condition of Containers?
Condition of Seals?

Special Handling
Turnaround
- ☐ 8 hour
- ☐ 24 hour
- ☐ 5 business day
- ☒ 10 business day
- ☐ other _____ (#)business day

PURPOSE OF SAMPLING / COMMENTS
If sample B4-S105 is too small please run B4-S103 instead for the above specified analysis.

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SOUND ANALYTICAL SERVICES, INC.

SPECIALIZING IN INDUSTRIAL & TOXIC WASTE ANALYSIS

4813 PACIFIC HIGHWAY EAST, TACOMA, WASHINGTON 98424 TELEPHONE (206)922 2310 - FAX (206)922 5047

Report To: RZA - AGRA

Date: January 29, 1992
Revised: February 10, 1992

Report On: Analysis of Water

Lab No: 22170

IDENTIFICATION:
Samples received on 01-17-92
Project: W-7475-2 BP SeaTac #11255

ANALYSIS:

Lab Sample No.	1	2	3	4
Client ID	MW-1	MW-5	MW-7	MW-10
WTPH-G Gasoline (C_7-C_{12}) mg/l	< 0.1	< 0.1	35	< 0.1
BTEX by 8020				
Benzene, mg/l	< 0.001	< 0.001	0.61	< 0.001
Toluene, mg/l	< 0.001	< 0.001	6.9	< 0.001
Ethyl Benzene, mg/l	< 0.001	< 0.001	1.0	< 0.001
Xylenes, mg/l	< 0.001	< 0.001	6.6	< 0.001
Total Lead, (GFAA) mg/l	< 0.005	< 0.005	0.008	NT
Turbidity, NTU	23.0	2.2	4.0	NT
SURROGATE RECOVERIES WTPH-G / BTEX Trifluorotoluene %	67	61	71	59

NT = Not Tested

Continued . . .

SOUND ANALYTICAL SERVICES, INC.

RZA - AGRA
Project: W-7475-2

Lab No. 22170
January 29, 1992
Revised: February 10, 1992

Lab Sample No.	5	6
Client ID	MW-3	MW-6
WTPH-G Gasoline (C_7-C_{12}) mg/l	< 0.1	9.1
BTEX by 8020 Benzene, mg/l Toluene, mg/l Ethyl Benzene, mg/l Xylenes, mg/l	 0.005 0.005 < 0.001 0.005	 0.24 0.21 0.26 1.4
Total Lead (GFAA), mg/l	< 0.005	< 0.005
SURROGATE RECOVERIES WTPH-G / BTEX Trifluorotoluene %	 84	 88

SOUND ANALYTICAL SERVICES

STAN P. PALMQUIST

RZA-AGRA
Environmental & Engineering Services
11335 Northeast 122nd Way
Kirkland, Washington 98034-6918
(206) 820-4669/FAX (206) 821-3914

#2270
№ 00047

Chain of Custody Record / Analysis Request

Project Name: BP-SeaTac #11255 Job No.: W-7475-2
Project Manager: John Cooper Phone #: 820-4669
Sampler: Brian Evans

RZA-AGRA Sample ID	Lab Samp ID	Date Collected	Time Collected	Matrix (S=soil, W=water, A=air)	# Containers/Preservation: 40 ml VOA	1 L Glass	8 oz Glass	500 mL		CHILL	Analysis Requested: W-TPH-G/BTEX	Total Lead	Turbidity	Hold for Further Analysis	RUSH (see below)
MW-1		1-16		W	2			2			XXX	XX	XX		
MW-5		1-16		W	2			2			XXX	XX	XX		
MW-7		1-16		W	2			2			XXX	X	XX		
MW-10		1-16		W	2						XXX				

RELINQUISHED BY SAMPLER	RELINQUISHED BY	RELINQUISHED BY
Signature: Brian Evans	Signature: Tom Marshall	Signature: Tom Watson
Printed Name: Brian Evans	Printed Name: TOM MARSHALL	Printed Name: TOM WATSON
Firm: RZA-AGRA	Firm: RZA-AGRA	Firm: SAS
Date/Time: 1/17/91 8:40	Date/Time: 1/17/92 1130AM	Date/Time: 1/17/92 1:00 pm
RECEIVED BY	RECEIVED BY	RECEIVED BY
Signature: Kelly David	Signature: Tom Watson	Signature: Mary Curtiss
Printed Name: KELLY DAVID	Printed Name: TOM WATSON	Printed Name: Mary Curtiss
Firm: RZA-AGRA	Firm: SAS	Firm: SAS
Date/Time: 1/17/92 840	Date/Time: 1/17/92 11:30A	Date/Time: 1/17/92 1pm

LABORATORY: Sound Analytical
Total # Containers
Condition of Containers?
Condition of Seals?

Special Handling
Turnaround
- ☐ 8 hour
- ☐ 24 hour
- ☐ 5 business day
- ☒ 10 business day
- ☐ other _____ (#)business day

PURPOSE OF SAMPLING / COMMENTS
Total lead not preserved in field
MTCA - detection limits

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PAGE ____ OF ____

RZA-AGRA
Environmental & Engineering Services
11335 Northeast 122nd Way
Kirkland, Washington 98034-6918
(206) 820-4669/FAX (206) 821-3914

#2940
№ 00048

Chain of Custody Record / Analysis Request

Project Name: BP-SeaTac #11255 Job No: W-7475-2
Project Manager: John Cooper Phone #: 820-4669
Sampler: Brian Evans

RZA-AGRA Sample ID	Lab Samp ID	Date Collected	Time Collected	Matrix (S=soil, W=water, A=air)	# Containers/Preservation: 40 ml VOA	1 L Glass	8 oz Glass	500 ml		CHILL	Analysis Requested: W-TPH-G/BTEX	Total Lead	Hold for Further Analysis	RUSH (see below)
MW-3		1-17-92		W	2			2		✓	X	X	✓	
MW-7(6)		1-17-92		W	2			2		✓	X	X	✓	

RELINQUISHED BY SAMPLER	RELINQUISHED BY	RELINQUISHED BY	LABORATORY	Special Handling
Signature: Brian Evans	Signature: Kelly David	Signature: Tom Watson	Sound Analytical	Turnaround: ☐ 8 hour ☐ 24 hour ☐ 5 business day ☒ 10 business day ☐ other ____ (#)business day
Printed Name: Brian Evans	Printed Name: Kelly David	Printed Name: TOM WATSON	Total # Containers:	
Firm: RZA	Firm: RZA-AGRA	Firm: SAS	Condition of Containers?	
Date/Time: 1/20/92 7:00 AM.	Date/Time: 1/20/92 10 YOA	Date/Time: 1/20/92 12:25	Condition of Seals?	
RECEIVED BY	**RECEIVED BY**	**RECEIVED BY**	**PURPOSE OF SAMPLING / COMMENTS**	
Signature: Kelly David	Signature: Tom Watson	Signature: Mary Curtiss	Total Lead Samples not preserved! Normal Turnaround. To be analyzed with samples sent to lab on 1-17-92.	
Printed Name: KELLY DAVID	Printed Name: TOM WATSON	Printed Name: Mary Curtiss		
Firm: RZA AGRA	Firm: SAS	Firm: SAS		
Date/Time: 1/20/92 7:00A.	Date/Time: 1/20/92 10:50 AM	Date/Time: 1/20/92 12:25		

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APPENDIX D

VES TESTING METHODS

W-7475-2

APPENDIX D

INTRODUCTION

RZA AGRA, Inc (RZA AGRA) conducted a vapor extraction feasibility test March 20, 1992 at BP Service Station #11255 located at 19924 Pacific Highway South SeaTac, Washington (Figure 1) Testing was conducted to determine if air-flow could be induced in soils above the groundwater table, and in the proximity of the vadose zone, by applying a vacuum to existing monitoring wells From this test, data was collected for analysis to calculate the estimated radius of influence which can be expected in the on site soils. Following is a summary of activities during the test period and the results of data reductions.

Vapor extraction soil venting has been shown to be a very effective remediation technology in both environmental literature and RZA AGRA's own experience. Soil venting or vapor extraction is the process by which a vacuum is induced in impacted soils at/or immediately above the groundwater table, using an above-ground high volume regenerative blower, manifolded to a well point or perforated pipe installed into the vadose zone. The pressure differential induces air circulation through the soil toward the area of lowest pressure. Volatile hydrocarbon molecules are mobilized in the induced circulation pattern and expelled to the open air or vapor collection system through the blower

The orientation of the vapor extraction points have a direct impact on the effectiveness of the system. A vacuum applied to a vertical extraction point will produce a radially distributed zone of low pressure. If the soils are relatively "loose", the area of influence can become large until the system reaches equilibrium, or the adjacent wells "short-circuit" each other. For soils which are less permeable, horizontal placement of the perforated piping in trenches may prove to be much more effective. Horizontal placement is preferable if the vertical extent of the contamination is known, and seasonal groundwater levels have been determined.

Vertical extraction points, as used in this feasibility test, must have screened intervals in the well casing above the groundwater level If the groundwater levels rise above the screened interval, the well becomes "shorted." "Shorting" can also occur when significant vacuum is present in the well and lifts the groundwater in the well casing and occludes the screened portion of the well. Horizontal venting can be placed in relatively shallow trenches (2-6 foot deep) and constructed with site specific parameters. The advantage of the horizontal configuration is that the screened portion of the VES can be located within the contaminated soils and a larger area of soil can be influenced by a single trench

PROCEDURES

The test was run using a ROTRON 454 regenerative blower alternately manifolded to extraction wells MW-4 and MW-6 and attaching Magnehelic vacuum gauges to the remaining wells heads to monitor pressure changes at each well point

The portable VES system incorporates a moisture "drop-out" tank with fresh air bleeder valve to allow fluid vapors to condense, as well as ease the load on the blower. The fresh air bleed was used in this test to control the loading of the blower. The loading was stepped from lowest to highest vacuum in four stages. Stepping the system produced vacuum pressures ranging from 5-inches H_2O minimum, to 50 inches H_20 maximum The expansion of the subsurface low pressure field was monitored against time with data collected from all well points and VES system in consistent units

The Modified Jacob's form of analysis was used to examine the vapor flow characteristics of the contaminated soils and to estimate the radius of influence. The results of this analysis indicate a non-homogeneity in flow paths between wells. This can be explained by the variable soil stratigraphy encountered on the site, or differences in the screened intervals among the monitoring wells. These factors, However, these factors do not appear to have the potential to diminish the practicality of a soil venting system.

RESULTS

During the test (2.5-hour duration) all monitored wells displayed response to the vacuum applied at the extraction points. Pressure meters placed at the various monitoring points indicated vacuums ranging from about 0.5 to 3.2-inches of H_2O. For example MW-7, which is approximately 62 feet from MW-6, showed an induced vacuum pressure of 2.8-inches of H_2O when 48-inches H_20 of vacuum was applied at MW-6.

An OVA was used to monitor the efficiency of the system in collecting contaminant vapors from within the effective radius of the impacted soil. Total organic vapor readings of up to 1200 ppm were measured at the blower exhaust during the test. Based on the data collected, the area of influence for the VES system is approximately 45 feet.

The intrinsic permeability of the soil at the test location was determined to be 61.7 ee^{-8} cm^2 but should be considered to be in a range of 50 to 150 ee^{-8} cm^2 or 50 to 150 Darcy (1 Darcy = 1 ee^{-8} cm^2). This range should be considered to be approximate for a native soil-backfill mixture. The intrinsic permeability will vary with the character of the soil at the site. The permeability of native soils would be expected to be lower than

imported backfill material.

CONCLUSIONS

Based on an analysis of the data collected during this VES feasibility test, this technology could be successfully utilized to at least partially remediate soils underlying the subject site which have been affected by petroleum hydrocarbons. However, due to the variable nature of the soils encountered beneath the subject site, the estimated radius of influence determined during the test may be the result of air flow along preferential pathway in the subsurface soils. Therefore, it should not be assumed that all of the soil within the radius of influence from the extraction point will be affected by a VES.