FINAL
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
FOR
JIM'S BP
BATTLE GROUND, WASHINGTON

Submitted to:

Washington Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504

Submitted by:

Science Applications International Corporation
626 Columbia Street N.W., Suite 1-C
Olympia, Washington 98501

Ecology Contract C000890006
Work Assignment No. SAIC 24
SAIC Project No. 01-0817-00-0462-000

July 1, 1992

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION AND OBJECTIVES

1.1 PURPOSE AND OBJECTIVE OF REMEDIAL INVESTIGATION

This remedial investigation report describes the field activities, methods and rationale used to determine the extent of contamination at the Jim's BP site and to assist in the determination of the most feasible remedial option for treating contaminated soils and ground water. In accordance with WAC 173-340 of the Model Toxics Control Act, the selected remedial option must be protective of human health and the environment; be in compliance with local, state and federal laws; and to the extent possible, comprise a permanent solution.

The Model Toxics Control Act (MTCA) as specified in WAC 173-340 provides regulations pertaining to releases from underground storage tanks (WAC 173-340-405). Detailed in that section are interim actions, reporting requirements, and site characterization requirements. Specified in paragraph seven (7) are the cleanup standards appropriate for UST owners or UST operators and the requirements for the selection of cleanup standards. UST cleanup actions must meet the cleanup standards specified in WAC 173-340-700 through 173-340-750. Section 173-340-710 indicates that any person conducting a cleanup action must identify all applicable federal and state laws and relevant and appropriate requirements. There is a wide range of Applicable or Relevant and Appropriate Requirements (ARARs) which address cleanup standards through federal and state laws of environmental quality criteria. For this investigation, the ARARs are limited to MTCA cleanup standards as determined by Method A. Method A compliance cleanup standards incorporate existing numerical standards for all indicator hazardous substances in all media of concern. The Method A cleanup levels associated with this site can be found in Section 4.4 and 4.5 of this report.

The data collection effort during the remedial investigation (RI) was designed to provide a basis for determining subsequent site management options and associated costs addressed in the Feasibility Study (FS). This was accomplished by performing a soil gas survey, obtaining and analyzing soil samples from multiple soil borings, installing and sampling ground water monitoring wells, and conducting aquifer characterization tests. A detailed description of each individual field activity can be found in Sections 3.0 (SAIC 1992). The FS is presented as a complete, stand-alone document under the same cover as the RI.

1.2 PROJECT LOCATION AND SITE LAYOUT

The Jim's BP site is located in the NW1/4 NW1/4 of Section 2 of T3N R2E in Clark County, Washington. The site is within the community of Battle Ground which is approximately 10 miles north-northeast of Vancouver, Washington (Figure 1-1). The site is a small service station, within the business district of Battle Ground, that dispenses gasoline from three underground storage tanks (USTs). The station is located on the corner of Main Street and Parkway Avenue. It is bordered

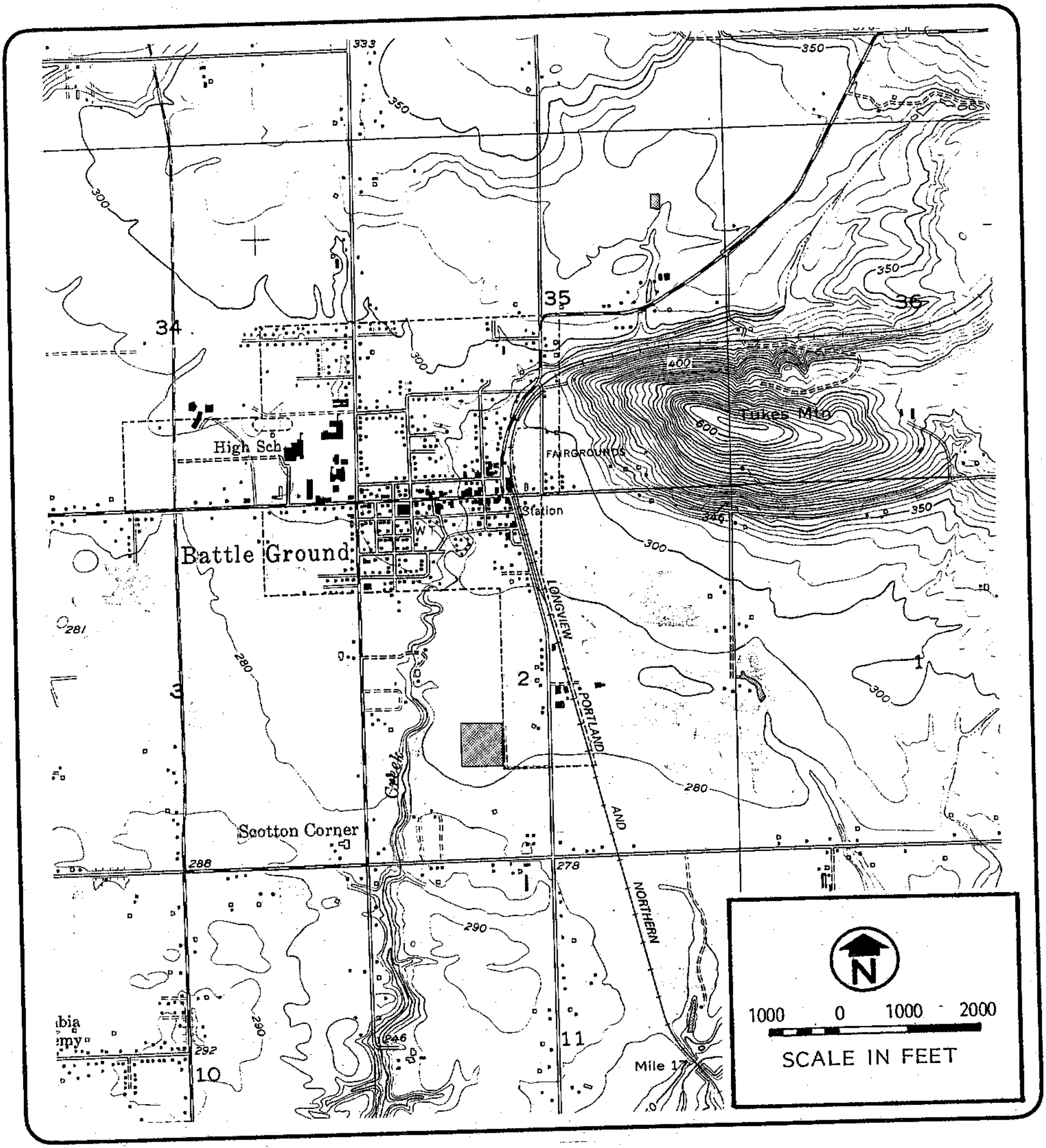


Figure 1-1

SITE LOCATION MAP
JIM'S BP
BATTLEGROUND, WASHINGTON

on two sides by commercial businesses and opposite the site is an auto parts store. The nearest private residence is located immediately behind the Jim's BP lot to the south. Residents of the city of Battle Ground have a municipal water supply with the water obtained from four city wells, two of which are located approximately seven blocks west of the site (SAIC, 1992). A site map of Jim's BP is presented in Figure 1-2.

1.3 SITE HISTORY

During excavation of a 6,000 gallon UST at Jim's BP station in February 1991, it was observed by the contractor conducting the tank removal (Northwest Construction) that a release of gasoline had occurred. The tank also failed a tightness test. Both soils and ground water were observed to have been impacted by the release and subsequently, both media were sampled for possible petroleum contamination. Samples were collected and submitted to the analytical laboratory on two separate occasions. It is clear that the samples were collected from within the excavated area(s). In both instances, however, the exact spatial distribution (lateral and vertical) of the sampling locations in relation to the UST's is unclear.

A summary of the analytical results available from the samples collected during excavation is presented in Table 1-1. The first sampling event, conducted in February 1991, resulted in the collection of two soil samples and one ground water sample which were obtained from the bottom of the excavation. Only the soil sample results were forwarded to Washington State Department of Ecology (Ecology). One of the two soil samples contained a TPH concentration of 900 mg/kg, which is well above the MTCA Method A cleanup level of 100 mg/kg. A new tank was installed in the excavation sometime in June 1991. A second set of samples were collected during another excavation event. During the second excavation, soil was removed eastward starting from the previous excavation and ending at the property line. The complete extent of the excavation is shown in Figure 1-2. Three soil and two ground water samples were collected and analyzed from the second excavation. These results are also provided in Table 1-1.

The results of the second sampling event indicated that contaminants were found in soil and ground water well above the MTCA standards. The compounds exceeding MTCA soil standards included benzene and total xylenes (at 2.70 and 99.2 mg/kg, respectively) in Sample 53-2. Benzene (742 μg/L), toluene (314 μg/L), and total xylenes (1,230 μg/L) exceeded ground water cleanup standards in Sample 513-5 (SAIC 1992).

Approximately 100 to 140 cubic yards of soil were removed during the two excavations. The soils were stockpiled on plastic behind the station. The stockpiled soils were removed from Jim's BP property and were deposited onto the property of Mr. Don Boespflug, located at 6816 N.E. 219th Street in Battle Ground. From the stockpiled soils at Mr. Boespflug's property, Ecology personnel collected four soil samples at a depth of 6-8 inches. The samples locations were distributed randomly across the pile and TPH was detected in all samples. The concentrations ranged from 80 to 500 mg/kg (P. Martin, Personal Communication, 1/14/92). Three of the four samples had concentrations in excess of their respective MTCA standards.

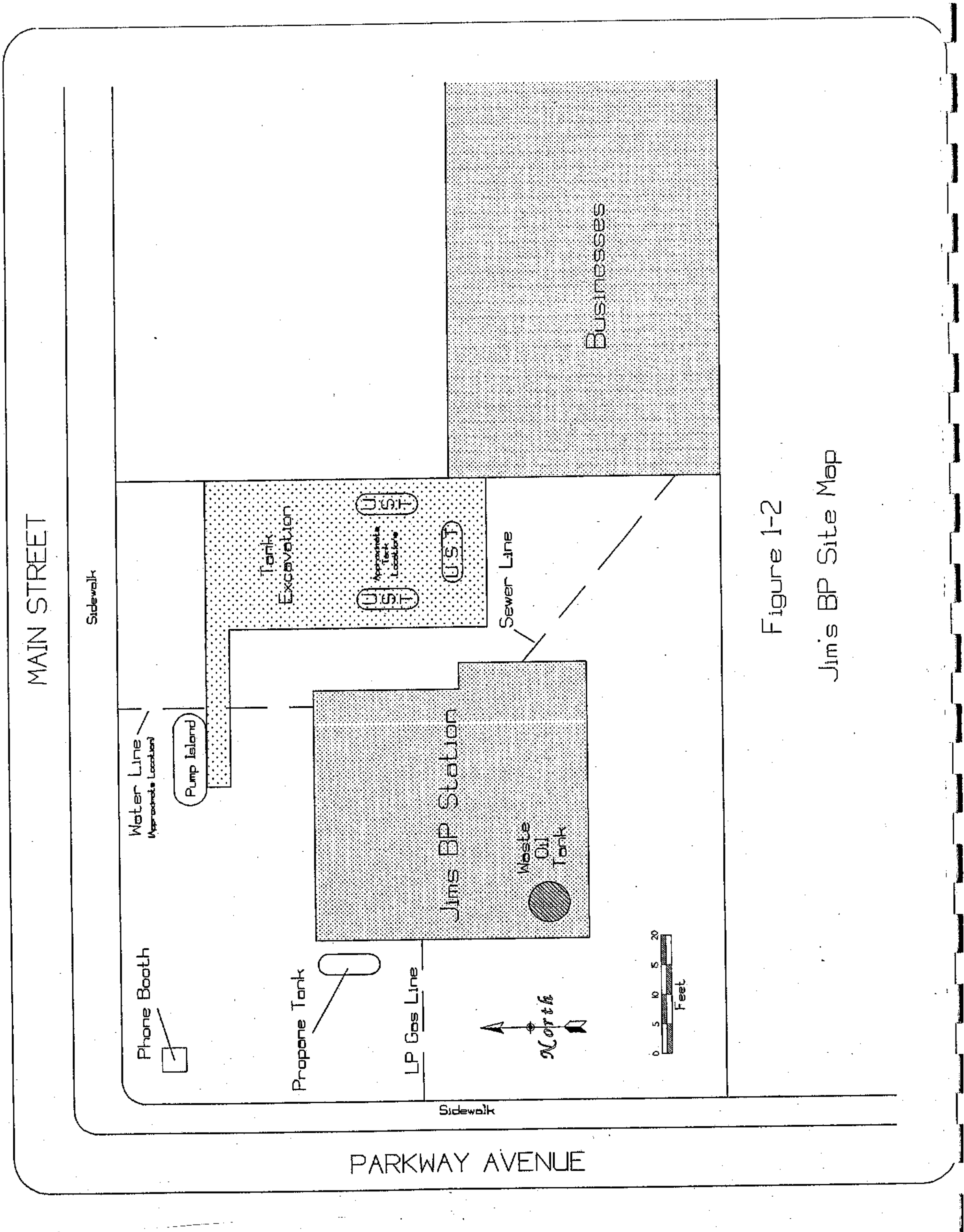


Figure 1-2
Jim's BP Site Map

Table 1-1

SUMMARY OF PREVIOUS ANALYTICAL RESULTS FROM EXCAVATION SAMPLING

HAZARDOUS SUBSTANCE	SAMPLE #	1	2	53-1	53-2	53-3	MTCA Method A
	DATE	2-91	2-91	5-91	5-91	5-91	Cleanup levels
SOIL (mg/kg)							
TPH-Diesel		NA	NA	20	ND	ND	200
TPH-Gasoline		900	10 U	ND	30	10	100
TPH-Oil		NA	NA	ND	ND	60	
Benzene		NA	NA	0.14	2.70	ND	0.5
Toluene		NA	NA	0.17	27.6	ND	40.0
Ethylbenzene		NA	NA	1.25	14.9	0.38	20.0
Total Xylenes		NA	NA	6.03	99.2	1.60	20.0

HAZARDOUS SUBSTANCE	SAMPLE #	513-4	513-5	MTCA Method A
	DATE	5-91	5-91	Cleanup levels
GROUND WATER (μg/L)				
TPH-Gasoline		1,340	ND	1000
Benzene		ND	742	5.0
Toluene		ND	314	40.0
Ethylbenzene		ND	ND	30.0
Total Xylenes		ND	1,230	20.0

ND = Not Detected
U = The analyte concentration is less than applicable listed reporting limit.

NOTE: Shaded areas indicate concentrations which exceed the MTCA Method A cleanup level.

Previous undocumented releases of petroleum products may have also occurred. In 1985, customers complained about water in the gasoline. In response to those complaints, the current owner replaced a tank. During the replacement, the backhoe fell into the excavation and struck one of the tanks and tilted it (P. Martin, Personal Communication, 1991). It is unknown if this caused a release of product.

Two other petroleum releases have occurred in the downtown area of Battle Ground. A spill (reportedly unleaded gasoline, and perhaps diesel fuel, which was also detected in the sample) occurred at the Cenex station, located approximately 200 feet northeast of Jim's BP. Reportedly, releases of product occurred in the 1980s and a tightness test in January 1990 may have helped to compromise the integrity of a tank (Chen Northern, 1991 and Ecology, 1991). Several blocks west of Jim's BP, a petroleum release from gasoline USTs was also reported at the Battle Ground High School (BGHS). Soil contamination was discovered upon the decommissioning of several USTs during February and March 1990 (SRH, 1991). Preliminary indications are that the Jim's BP site is not downgradient of BGHS. These indicate that it is very unlikely that the petroleum release at the BGHS site would have contributed contaminants to ground water in the vicinity of Jim's BP.

2.0 ENVIRONMENTAL SETTING

2.1 REGIONAL PHYSIOGRAPHY

Battle Ground is located west of the Cascade Mountains approximately 75 miles inland from the Pacific Ocean and 10 miles north northeast of Vancouver, Washington. West and south of the city, the terrain is relatively level to slightly rolling. The foothills of the Cascades begin a short distance east of the city. Within a distance of 25 miles, the Cascades reach elevations of 4,000 to 5,000 feet. The more level areas are devoted to agriculture, while foothills and higher ridges are covered with timber. The climate is predominantly a mid-latitude, west coast marine type. Summers are characterized by pleasant temperatures, (typically 70-90°F and little precipitation. During July and August, it is not unusual for 2 to 3 weeks to pass without measurable rainfall. During the fall and winter season, a prevailing southwesterly flow of warm moist air from over the ocean results in a rainy season beginning about October, reaching a peak in midwinter and decreasing in the spring. Battle Ground receives an annual rainfall of about 40 inches per year (Phillips, 1960).

2.2 REGIONAL GEOLOGY

Clark County lies in the long structural basin (Willamette-Puget trough) between the Coast Ranges on the west and the parallel Cascade Range on the east. The Columbia River, which is the major trunk stream of the Pacific Northwest, cuts through both mountain systems and crosses the trough to empty into the Pacific Ocean to the west. Clark County is bounded on the south and west by the Columbia River and is drained by streams tributary to that river (Mundorff, 1964).

The western and more thickly populated half of the county consists of a series of nearly flat plains and benches rising steplike from the level of the Columbia River. These range in elevation from only a few feet to about 800 feet above sea level. The eastern half of the county consists of foothills along the western slope of the Cascade Range. The boundary between these two distinctly different physiographic units trends roughly 20° west of north from Washougal and passes a few miles east of Battle Ground (Mundorff, 1964).

The younger (Pliocene to Recent) unconsolidated materials were deposited chiefly by streams in the basin formed by downwarping of the older rocks. However, some lake deposits and glacial drift also are included. Of primary interest within these deposits because of its regional water uses, is the Troutdale Formation. The oldest unit of this group, the lower member of the Troutdale formation of Pliocene age, consists chiefly of clay, silt and fine sand but includes lenses of coarser sand and, rarely, gravel. The maximum known thickness of the lower member of the Troutdale formation is about 600 feet. This unit is not a good aquifer in this area because most of the strata are fine grained (Mundorff, 1964).

The upper member of the Troutdale formation consists almost entirely of lightly to moderately cemented gravel, of which the most striking feature is the presence of a considerable percentage of quartzite pebbles. The average thickness of the upper member of the Troutdale may originally have been 300 to 400 feet. The member crops out over considerable areas in the county (including the Battle Ground area) and, where conditions of topography and exposure are optimum, has been very deeply weathered. It is suggested that the upper member of the Troutdale formation may prove to be of early Pleistocene age. This member is one of the best aquifers in the county; more drilled wells have been completed in this unit than in any other and most irrigation supplies are obtained from it. The best aquifers are the cleaner, uncemented or only lightly cemented sand and gravel layers below the weathered zone (Mundorff, 1964).

Glacial drift, including till, glaciofluvial outwash, and deposits of glacial lakes or ponds, blanket much of the area north and northeast of Battle Ground. The glacial drift was deposited by or derived from a broad thick lobe of ice (probably more than 15 miles wide at places and more than 1,000 feet thick) which extended into the area from the Mount St. Helens-Mount Adams area. Gravel, sand, silt, and clay were deposited as a great deltaic fan of the Columbia River downstream from the mouth of the gorge near Washougal. These deposits commonly lie directly on the upper member of the Troutdale formation, but at a few places lie on other rocks. The coarser phases of these deltaic deposits are extremely permeable and yield large quantities of water. Many domestic and a number of irrigation supplies are obtained from them, although much of the rural part of the county is underlain by the finer grained phases (Mundorff, 1964).

2.3 REGIONAL HYDROGEOLOGY

The occurrence of ground water in various parts of Clark County is directly related to the character of the rock and to landforms.

There are two important aquifers in the area: (a) the Pleistocene alluvial deposits which are utilized for most domestic and some irrigation supplies; and (b) as previously mentioned, the upper member of the Troutdale formation, which is utilized for most irrigation and municipal supplies. The Pleistocene alluvial deposits in general form a blanket, from a few feet to about 200 feet thick. However, where they are thickest and most permeable, ground water drains out readily and the water table generally is far below the surface, so that these deposits are saturated only near the base. Where the deposits are thin or are finer grained and therefore less permeable, perched or semiperched ground water is obtained from lenses of coarser grained material (Mundorff, 1964).
The upper member of the Troutdale is the formation that supplies potable water for the city of Battle Ground, as is shown by the well logs for the municipal wells (Appendix A). Municipal wells for Battle Ground are screened at depths of approximately 95 feet BLS or greater.

If local and regional ground water flows in a direction following topography, ground water flow would be to the southwest. Many of the wells are completed in cemented or lightly cemented gravelly, sandy silts. In general, regional ground water flow follows the topography. If this is the case in the vicinity of Battle Ground, regional ground water flow would be to the southwest.

2.4 GROUND WATER USE

Ground water within a one-mile radius of the Jim's BP site is used as drinking water by the City of Battle Ground, as well as, a number of private domestic water users. Table 2-1 summarizes well installations and ground water use data within a one-mile radius of the Jim's BP site. The data presented in Table 2-1 was taken from well logs on file at the Department of Ecology's Southwest Regional Office. The well logs of the wells shown in Table 2-1 may be found in Appendix A.

Review of Table 2-1 shows a total of 5 municipal wells which serve an approximate population of 4,000 (current population of Battle Ground listed at City Hall is 4,044). Additionally, 31 private domestic use wells are on record at the Department of Ecology's Southwest Regional Office for the given geographic area. No irrigation wells are listed within the one-miles area of Jim's BP, although it is likely that some of the surrounding rural areas use ground water for irrigation and watering of livestock. Of all the drinking water supply wells given in Table 2-1 (municipal and domestic), all wells have screened or perforated intervals, or in the absence of a screen, a completion depth, of at least 40 feet BLS.

Table 2-1

SUMMARY OF WELL LOGS WITHIN A ONE-MILE RADIUS OF JIM'S BP

WELL LOCATION				DATE DRILLED	USE	TOTAL DEPTH OF WELL (feet BLS)	STATIC WATER LEVEL (feet BTC)	SCREENED INTERVAL (feet BTC)
Quarter	Section	Township	Range					
NW 1/4 NE 1/4	2	3N	2E	4-20-72	Domestic	116	57	None
NW 1/4 SE 1/4	2	3N	2E	12-26-79	Domestic	98	54	None
NE 1/4 NW 1/4	2	3N	2E	7-3-84	Domestic	207	75	None
NE 1/4 NW 1/4	2	3N	2E	8-8-89	Domestic	95	69	None
SW 1/4 NW 1/4	3	3N	2E	9-27-50	Unknown	177	47	65-120
SE 1/4 NE 1/4	3	3N	2E	4-25-52	Unknown	Unknown	40	Unknown
NW 1/4 NE 1/4	3	3N	2E	3-30-54	Municipal	144	Unknown	Unknown
NW 1/4 NE 1/4	3	3N	2E	9-15-54	Municipal	152	54	Unknown
SE 1/4 SE 1/4	3	3N	2E	8-17-67	Municipal (Meadow Glade)	110	53	100-110
NE 1/4 SE 1/4	3	3N	2E	6-25-76	Municipal	180	62	105-135
NE 1/4 SE 1/4	3	3N	2E	8-22-75	Municipal	140	60	105-135
NW 1/4 NW 1/4	34	4N	2E	7-11-74	Domestic	99	65	None
NE 1/4 SW 1/4	34	4N	2E	10-25-84	Domestic	115	63	None
SE 1/4 NE 1/4	34	4N	2E	7-14-89	Domestic	161	74	113-161[1]
SE 1/4 NE 1/4	34	4N	2E	3-1-90	School	170	73	160-170
SE 1/4 NE 1/4	34	4N	2E	3-7-90	School	163	77	153-163
NE 1/4 NE 1/4	34	4N	2E	1-25-91	Domestic	122	97	117-122[1]
SE 1/4 SE 1/4	34	4N	2E	2-14-91	Monitoring	50	32	30-50
SE 1/4 SE 1/4	34	4N	2E	2-14-91	Monitoring	50	32	30-50
SE 1/4 SE 1/4	34	4N	2E	6-17-91	Monitoring	42	Unknown	8.5-38.5
SE 1/4 SE 1/4	34	4N	2E	6-18-91	Monitoring	39	28	9-39
SE 1/4 SE 1/4	34	4N	2E	6-18-91	Monitoring	39	Unknown	8-39
NE 1/4 NE 1/4	34	4N	2E	10-28-91	Domestic	115	85	None
NE 1/4 NE 1/4	34	4N	2E	2-21-92	Domestic	130	92	None
NE 1/4 NE 1/4	34	4N	2E	4-28-92	Domestic	138	95	None

1 Perforated, not screened.
2 Deepened well listed immediately above entry.
BLS = Below land surface
BTC = Below top of casing

NOTE: This table excludes information pertaining to the wells installed as part of this RI. That data is presented elsewhere.

Table 2-1

SUMMARY OF WELL LOGS WITHIN A ONE-MILE RADIUS OF JIM'S BP

WELL LOCATION				DATE DRILLED	USE	TOTAL DEPTH OF WELL (feet BLS)	STATIC WATER LEVEL (feet BTC)	SCREENED INTERVAL (feet BTC)
Quarter	Section	Township	Range					
NE 1/4 NW 1/4	35	4N	2E	6-21-74	Domestic	115	45	50-75[1]
SE 1/4 SE 1/4 NE 1/4	35	4N	2E	8-5-75	Domestic	58	18	None
NW 1/4 NW 1/4	35	4N	2E	7-11-77	Domestic	99	80	None
NW 1/4 NW 1/4	35	4N	2E	3-21-78	Domestic	75	42	None
NW 1/4 NW 1/4	35	4N	2E	3-30-78	Domestic	152	105	None
NW 1/4 NW 1/4	35	4N	2E	3-31-78	Domestic	77	42	None
NW 1/4 NW 1/4	35	4N	2E	4-4-78	Domestic	82	41	None
NW 1/4 NW 1/4 NW 1/4	35	4N	2E	6-28-79	Domestic	77	51	None
NW 1/4 NW 1/4	35	4N	2E	7-19-79	Domestic	80	53	None
NW 1/4 NW 1/4	35	4N	2E	11-7-79	Domestic	137	96	None
NE 1/4 SE 1/4	35	4N	2E	6-4-80	Domestic	548	245	498-548[1]
NE 1/4 NW 1/4	35	4N	2E	11-4-80	Domestic	82	62	62-82[1]
NW 1/4 NW 1/4	35	4N	2E	4-15-81	Domestic	120	Unknown	None
NE 1/4 NW 1/4	35	4N	2E	8-26-82	Domestic	104	65	84-104[1]
NE 1/4 NW 1/4	35	4N	2E	3-18-83	Domestic	67	30	None
NE 1/4 NW 1/4	35	4N	2E	6-20-83	Domestic	445	170	320-335[1] 420-430[1]
NW 1/4 NW 1/4	35	4N	2E	7-25-86	Domestic	132	107	None
SE 1/4 SE 1/4	35	4N	2E	7-20-89	Domestic	250	59	244-250
NW 1/4 NE 1/4	35	4N	2E	9-29-89	Domestic	263	82	400-412
SE 1/4 SE 1/4	35	4N	2E	9-5-90	Domestic[2]	417	140	160-180 243-263
SW 1/4 NE 1/4	35	4N	2E	9-28-90	Domestic	367	218	362-365
SW 1/4 SW 1/4	35	4N	2E	5-22-91	Monitoring	8	4.7	3-8
SW 1/4 SW 1/4	35	4N	2E	5-23-91	Monitoring	8	4.5	3-8

[1] Perforated, not screened.
[2] Deepened well listed immediately above entry.
BLS = Below land surface
BTC = Below top of casing

NOTE: This table excludes information pertaining to the wells installed as part of this RI. That data is presented elsewhere.

3.0 FIELD METHODS

3.1 INTRODUCTION

Activities performed at the Jim's BP site followed the guidelines specified in the Project Work Plan and the "Quality Assurance Project Plan" (QAPP). Prior to the commencement of field activities, a number of logistical problems were overcome. These logistical problems are mentioned here to facilitate planning if further remedial action is required at the site. Utility clearances had to be obtained prior to any drilling to prevent damage to underground lines and subsequent interruption of service. The Clark County Utility Coordinating Council was notified approximately 10 days prior to the commencement of field work. They contacted the various utility companies (telephone, gas, cable, electric, water, Battle Ground Public Works, etc.) and informed them of the drilling location(s). Each company was then responsible for marking any buried utilities by painting on the asphalt lots of Jim's BP Service Station. Important underground utilities at this site (shown in Figure 1-2) include:

- A sewer lateral line extending from the restrooms/garage door southeast to the corner of the property
- Above ground utility and telephone lines along the street sides of the property (may present problems for extension of a drill rig mast if drilling on the periphery of the site)
- Underground storage tanks (USTs) for gasoline storage and associated piping to the pump islands (this is clearly marked at the site by new concrete surfaces as the USTs and delivery system were recently replaced)
- Water line extending along the edge of the property bordering Main Street with a connection located east of the pump islands running south to the building
- Gas line on the west side of the building extending to Park Avenue
- Underground waste oil tank near the southwest corner of the building

Field activities for this phase of the RI/FS included:

- Soil Gas Survey - Conducted March 23-27, 1992; collected 31 samples from 31 sampling locations and analyzed for BTEX
- Borehole Installation - Conducted March 30 - April 2, 1992; drilled 4 boreholes and collected 9 soil samples (including a field duplicate); samples analyzed for BTEX, TPH, and lead
- Monitoring Well Installation - Conducted March 30 - April 2, 1992; completed each borehole as a monitoring well (4 monitoring wells total) with total depths between 19.5 and 33 feet BLS

- Developed Monitoring Wells - Conducted April 6-8, 1992
- Ground Water Sampling - Conducted April 6-8, 1992; collected 5 ground water samples (including a field duplicate) from the four wells; sample analysis for BTEX, lead, and TPH (diesel and gasoline fractions)
- Aquifer Characterization - Conducted slug tests of each well April 6-8, 1992
- Surveyed Monitoring Well Locations - Conducted April 9, 1992

The field methods used to accomplish the above tasks are described in the following sections.

3.2 SOIL GAS SURVEY

The methods used to collect and analyze soil gas samples are summarized below. More detailed information about the soil gas survey can be found in Appendix B.

Assembly of the soil gas sampling probe was accomplished by feeding teflon tubing through the stainless steel extension rod and attaching to the retractable stainless steel probe tip. The tip was then screwed on to the extension rod. Holes were drilled in the asphalt lot using a rotary hammer. The sampling apparatus was then driven to the appropriate sampling depth using a manual hammer probe driver. A manual jack was then attached to the extension and used to raise the sampling apparatus a few inches to retract the probe tip and expose the screened slots of the tip for gas collection. The teflon tubing at the top of the extension pole was then attached to a vacuum box, and the electric pump was activated. The system was allowed to operate for approximately 20-30 seconds to purge the sampling apparatus. This prevents (1) sample dilution with "dead air volume" in the system, and (2) sample contamination due to contaminants in the system. After purging, a tedlar bag was attached to the end of the teflon tubing inside the vacuum box. The motor was turned on, creating a vacuum external to the bag causing soil gas to flow into the tedlar bag. Approximately 750 to 1000 mL of sample was collected in the bag. The bag number, date, time, and sample location were noted in the field log book.

Soil gas samples were analyzed by gas chromatography (GC) using a micro argon ionization detector. The portable GC was powered by electrical cords extending from inside the service station to the van where the GC was located. The GC was operated using a portable computer (IBM compatible) which also digitally recorded all sample analyses, chromatograms, and operating parameters. At one point during the investigation, the battery supplying power to portions of the GC lost its charge. This resulted in a 24-hour delay as the GC was shipped off site for repairs and returned. Upon receipt, the GC was checked and calibrated, QA/QC samples run for calibration verification, and environmental samples analyzed.

Obtaining soil gas samples was made difficult by the fine gravel deposits underneath the site, and by the depth of the water table. The shallow soils underlying Jim's BP are very fine silty clays as described in Section 2.2. This adversely impacts soil gas sample collection in two ways. First, the screen or slots of the soil gas tip can become clogged during advancement and subsequent retraction of the soil gas sampling apparatus into the soil column. Additionally, the tightness of the formation does not lend itself to the transport of a vapor phase in any direction. Thus obtaining sufficient volumes of soil gas was sometimes difficult. Secondly, in some areas, water was encountered at very shallow depths. In these instances, the soil gas probe was raised using the manual jack to a point where soil gas could be collected (in some instances approximately 1 foot BLS). Under these conditions the sampling procedure can be unreliable as air can travel from the surface around the edges of the sampling apparatus and down to the soil gas probe tip. This dilution of true soil gas with ambient air cannot be measured or corrected. Under these conditions, samples with undetectable results are questionable and perhaps negatively biased (i.e. biased low). However, most of the samples wee collected at a sufficient depth, such that ambient air interference was a cause for concern.

Soil gas results are discussed in Section 4.1 and Appendix B.

3.3 BOREHOLE AND MONITORING WELL INSTALLATIONS

The borehole and monitoring well installation program was conducted after the soil gas survey was completed. Soil gas results discussed in Section 4.1 were used to guide the placement of boreholes. A total of four monitoring wells were installed. The monitoring well locations have been selected to accomplish two objectives. The first objective is to determine if all contaminated soil above MTCA Method A cleanup levels was removed during previous excavations. The second is to evaluate the lateral and vertical extent of potential ground water contamination. It was assumed that the ground water flow direction was south-southwest based on the UST investigation conducted at the Jim's BP site.

3.3.1 Borehole Installation

Soil Sampling Service, Inc. performed all drilling and well installation tasks with oversight by SAIC field personnel. The boreholes were drilled using a 10-inch outer diameter, hollow stem auger drilling rig. All equipment that contacted any soil (e.g. hollow stem auger flights, split spoons, drill plugs) were decontaminated prior to the start of drilling at any borehole. The boreholes were all started in EPA Level C personal protective gear (air-purifying respirator with organic/HEPA cartridges, tyvek, gloves, chemical resistant boots, hard hat, safety glasses, ear protection). Air monitoring was performed using an HNu PI-101 and a Mine Safety Appliances Combustible Gas Indicator (CGI) meter at the time the asphalt was broken and at every sampling interval thereafter. After 3 feet of drilling with no measurable levels of organic vapors (and noncombustible atmospheres), personal levels of protection were downgraded to EPA Level D at the direction of the site Health and Safety Officer.

Boreholes were advanced to the appropriate sampling depth (e.g. 3 feet) when drilling was stopped. A stainless steel split spoon was then attached to the drill rod and lowered into the borehole. The split spoon was driven below the level of the auger flight using a 140 pound hammer with a 30 inch drop height. The number of blows required to drive the split spoon for four, six-inch intervals was recorded. In this fashion, the split spoon always collected sample ahead of the auger flights to prevent contamination, obtain representative samples, and minimize slough in the sampling apparatus. After retrieving the split spoon, the borehole was monitored for released vapors with the CGI and HNu. The split spoon was carried to the sample classification station where the Field Geologist tested the sample for organic vapors upon opening of the split spoon. In addition, the percent recovery of sample material in the spoon was recorded (excluding slough when possible). Sample material was placed in appropriate sampling containers and in a plastic baggie which was sealed. The sample containers were labeled and put in a cooler with ice. The baggie was then screened after several minutes using the HNu to detect any volatile organic compounds that may have been release and "concentrated" in the baggie. This screening was conducted for several qualitative purposes including: ensuring health and safety conditions had not changed, for identification and submittal of "heavily contaminated samples" for laboratory analysis, and to characterize subsurface conditions. The split spoon was then carried to the decontamination area for cleaning as described below.

The drilling company then repeated the process of drilling (five foot sampling intervals) with SAIC personnel performing the air monitoring tasks, soil sampling and classification, and split spoon decontamination. This procedure was followed until water was detected in the borehole. At this point, drilling was discontinued and the water level allowed to stabilize for a few minutes. The water level was then measured using an electronic water level sounder and the depth to water (feet BLS) was noted. Drilling and sampling continued in 5 foot intervals for approximately 10 additional feet below the top of the water column. All soil cuttings were placed in plastic lined, steel, 55-gallon drums which were sealed and labeled stating the contents, the origin of the cuttings, the date, and a point of contact at the Department of Ecology for inquiries. All drums were moved via a drum dolly to the southeast area of the Jim's BP lot and covered with plastic pending sample results and subsequent removal by the Department of Ecology.

Decontamination of sampling equipment followed strict protocols to ensure cross contamination of samples as a result of contaminated equipment did not occur. Contaminated (suspected contaminated) items were placed in the decontamination area. The equipment was placed in the primary wash bucket (alconox/water solution) and scrubbed using a nylon bristle brush to remove the majority of soil particles. The equipment was then transferred to the secondary decontamination bucket (distilled water) and scrubbed with a nylon bristle brush to remove the alconox solution and any remaining particles not removed by the previous step. The equipment was then rinsed with distilled water and placed in the third decontamination bucket. Within this bucket the equipment was rinsed with methanol followed by hexane to remove any organic contaminants that may have adhered onto the rough surfaces of the sampling equipment. Finally, the equipment was rinsed with reagent grade distilled/deionized water to remove any remaining solvents. Decontamination of heavy equipment (e.g. auger flights) was accomplished using a portable steam cleaner. The contaminated equipment was placed on blocks over a large trough to collect decontamination water. The equipment was then sprayed thoroughly with a steam cleaner to remove contaminant particles and volatilize any organic contaminants adhering to the surface. The decontaminated equipment was then placed on a clean sheet of plastic or on the service truck for transport to the next borehole.

3.3.2 Monitoring Well Installation and Development

Monitoring wells were installed using factory cleaned casing and materials (inspected prior to installation). A one foot section of blank Schedule 40 PVC was attached to the bottom of the screen (Schedule 40 PVC, 4" diameter, 10' long section, 0.020 - inch slot size). The screen was lowered partially into the borehole and a section of PVC riser pipe was screwed onto the top of the well screen. The unit was then lowered further into the borehole until the unit touched the bottom of the borehole. Once the well sump, screen, and casing were in place, the annular space around the screen was backfilled with 10-20 silica sand until at least 3 feet of sand was contained in the annular space above the top of the well screen. A bentonite pellet seal was then installed to prevent surficial contaminant migration to the lower depths (and subsequently into the well). The seal was installed by pouring bentonite pellets into the annular space for at least a thickness of 2 feet. Water was then added (if necessary) to the annular space to hydrate the bentonite. The seal was continued upward using bentonite chips until approximately 1.5 feet below land surface. At this point additional water was added to hydrate the bentonite. After sufficient time had elapsed for hydration, concrete was mixed in buckets and poured over the hydrated bentonite to create the surface seal around the top of the well casing and to anchor the flush grade monument. The monument was leveled and sealed with concrete around the edges to ensure no cracks were present between the concrete seal and the surrounding asphalt.

Monitoring wells were developed using a centrifugal pump fitted with disposable tubing. At the time of development, the tubing was lowered to near the bottom of the well. The static water level and total depth of each well was measured prior to development. From these values, the water volume required for well development or purging was calculated. To contain development water, 55-gallon drums were placed near the well and water was pumped directly into the drums. Because the formation in which the monitoring wells were installed is not highly permeable, each well was pumped dry and allowed to recharge to remove enough water to ensure proper development and purging. After each well volume, pH, temperature, and specific conductivity were measured to characterize ground water quality and ensure that water representative of the formation had been drawn into the well. The well was considered to be fully developed when pH, conductivity, and turbidity measurements stabilized. The well was allowed to stabilize overnight prior to sampling to ensure successful development.

3.4 GROUND WATER SAMPLING

Ground water samples were obtained within 24 hours of successful well development. Prior to sampling, the wells were purged of standing water using a disposable teflon-lined bailer suspended by nylon rope. Purge water was containerized in unlined, 55-gallon, bung-top steel drums. Because of the close proximity of well development and sampling (i.e. less than 24 hours), purging was required. Chemical monitoring for pH, temperature, and specific conductivity was performed to ensure a representative sample was collected.

Ground water samples were collected by lowering a disposable bailer into the water column in the well, allowing the single check valve to close, and raising the bailer to the surface. A teflon bottom emptying device was attached to the bottom of the bailer which allowed controlled pouring of the sample into the sample jars. At each location, the volatile organic analysis (VOA) vials were filled first to prevent loss of volatile contaminants; lead and TPH bottles were then filled using multiple bails of water if necessary. At the time of sampling, the sample number, time, and date were noted in the field log book. The samples were placed in a cooler with ice for temporary storage until shipment.

3.5 SAMPLE CUSTODY AND SHIPMENT

As samples were collected (soil and ground water), the sample locations, time of collection, sample number, depths, and any chemical characteristics (e.g. HNu reading) were noted in the field log book. The samples were placed in coolers with ice and stored until the end of the work day. At that time, SAIC field personnel completed chain of custody forms, repacked the samples in coolers with ice and vermiculite, and stored the samples overnight in locked storage. On the following morning, a representative of NET Pacific Laboratories, the subcontracted analytical laboratory, came to the Jim's BP site, inspected the samples for damage, and completed the chain of custody thus relinquishing SAIC from custody of the samples. The samples were then delivered directly to NET Pacific laboratories where they were logged into their data management system.

3.6 SLUG TESTING

Slug tests were performed in order to estimate the hydraulic conductivity of the materials in which the monitoring wells are screened. Water levels were displaced by inserting a surge block which consisted of a length of PVC tubing sealed at both ends and suspended by nylon rope. A slug test may be performed by inserting the volume into the well and raising the water level within the well (falling head) or by removing the slug and lowering the water level (rising head). In theory the hydraulic conductivity determined by either method will be the same.

Timed water level displacement measurements were recorded using a automated datalogger manufactured by Thor International. This datalogger was equipped with a fifteen psi pressure transducer and programmed to measure the water level in the well being tested every ten seconds. Data was collected during the insertion and removal of the block, primarily to provide additional information in case of malfunction. Data was collected during the falling head test until a 100 percent recovery was achieved (within the resolution of the data logger) and until a 95 percent recovery had occurred on the rising head test.

APPENDIX A

WELL LOGS FOR WELLS LOCATED WITHIN A ONE MILE RADIUS OF JIM'S BP SERVICE STATION

4.0 REMEDIAL INVESTIGATION RESULTS

Each field activity was performed to obtain specific data to help guide other field activities, more fully characterize the nature and extent of contamination at Jim's BP, and to provide information to facilitate the identification of feasible remedial alternatives and to exclude remedial measures from consideration. The results of the field activities are described below as they pertain to the above objectives.

4.1 SOIL GAS SURVEY

To help guide the placement of soil borings and monitoring wells, a soil gas survey was performed. A total of 31 samples were analyzed from 27 sampling locations. Samples were initially collected from 31 locations as shown in Figure 4-1, however due to analytical difficulties, samples from 4 locations were not analyzed. A summary of contaminant detections is presented in Table 4-1 (the results for all samples are presented in Appendix B).

Ethylbenzene and total xylenes were not detected in any of the soil gas samples. Benzene was detected in 2 samples, while toluene was detected in 5 samples (3 of the detections are from soil gas location SG#4 due to duplicate analyses). All detections occurred in soil gas sampling locations 4, 7, 8, or 13. The highest detection was 1 ppb of benzene.

Although very low detections of volatile organic compounds occurred during the soil gas survey and subsurface conditions were not ideal, the survey was deemed to be representative of subsurface conditions. The water table was quite high in several locations which resulted in sampling depths of 1 foot BLS. This increased the possibility of sample dilution due to ambient air travelling down the probe installation hole. In addition, due to perched water (or a high water table), soils were moist to wet which was not conducive to vapor generation and transport. Thirdly, the formation materials, silty clays, were dense and compacted further reducing the likelihood of vapor generation and transport.

4.2 LOCAL GEOLOGY AND HYDROGEOLOGY

Information pertaining to the local geology and hydrogeology in the vicinity of Jim's BP was obtained primarily from the borehole installation program conducted during the RI. Initial local geologic and hydrogeologic information was obtained from two previous UST investigations in the area, which were previously summarized in the Jim's BP project work plans (SAIC, 1992). One of these investigations was conducted 400 feet northeast of Jim's BP at the former Cenex station. The lithology encountered and observations with respect to the site stratigraphy are summarized below.

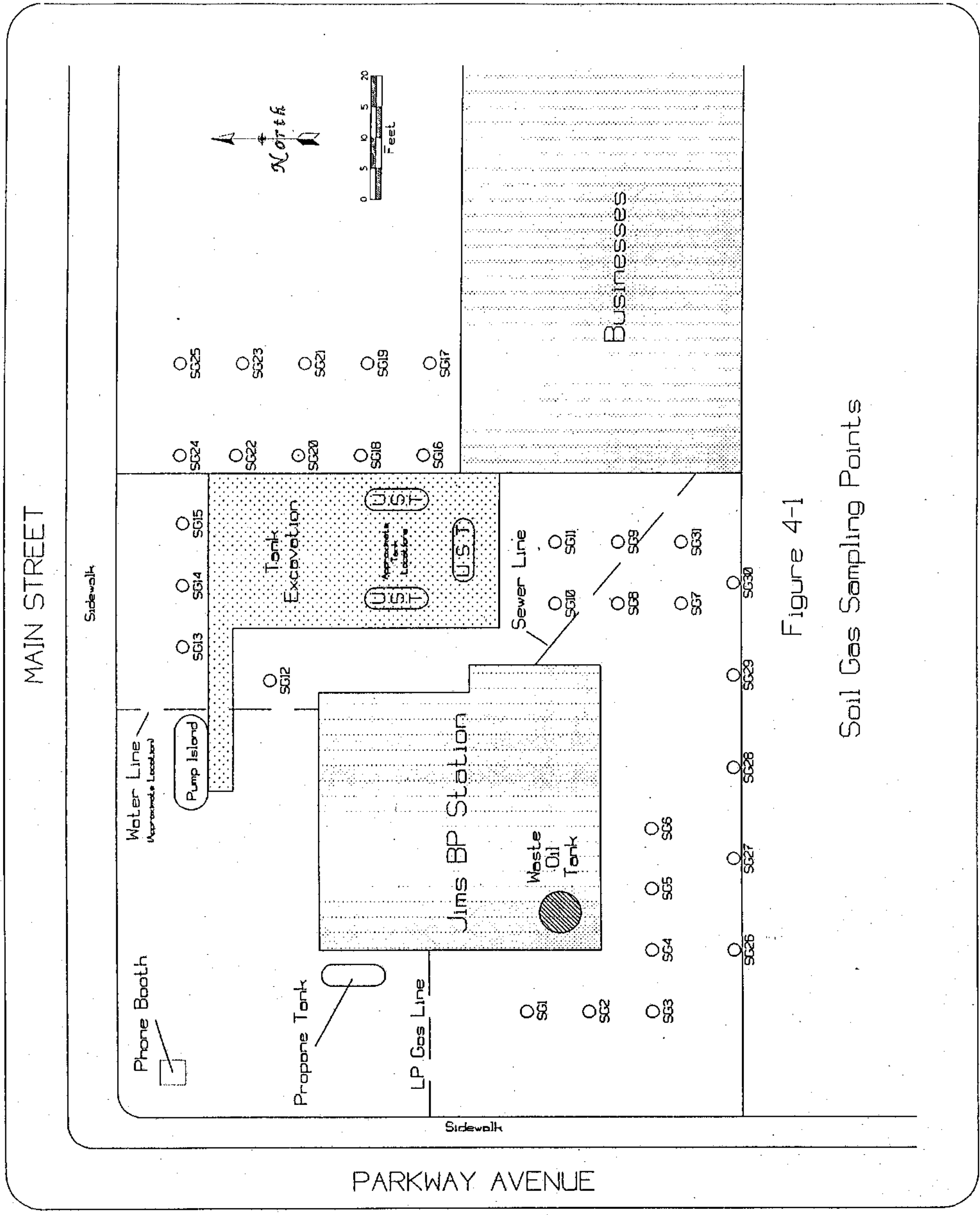


Figure 4-1

Soil Gas Sampling Points

Table 4-1

SOIL GAS SURVEY
Summary of Contaminant Detections

SAMPLE ID	DEPTH	CONTAMINANT CONCENTRATION (ppb)				Total No. of Unknown Compounds Detected
		Benzene	Toluene	Ethylbenzene	Total Xylenes	
SG#1	1'	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#4	1'4"	0.1 U	0.1[1]	0.5 U	0.9 U	5
SG#4 A.D.	1'4"	0.1 U	0.1[1]	0.5 U	0.9 U	5
SG#4 F.D.	1'4"	0.1 U	0.04[1]	0.5 U	0.9 U	1
SG#5	1'6"	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#6	3'	0.1 U	0.3 U	0.5 U	0.9 U	3
SG#7	2'10"	0.1 U	0.1[1]	0.5 U	0.9 U	3
SG#8	3'	1.0	0.3 U	0.5 U	0.9 U	3
SG#9	2'6"	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#13	3'	0.2	0.6	0.5 U	0.9 U	4
SG#14	1'	0.1 U	0.3 U	0.5 U	0.9 U	8
SG#18	2'8"	0.1 U	0.3 U	0.5 U	0.9 U	4
SG#19	3'	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#20	3'	0.1 U	0.3 U	0.5 U	0.9 U	1

A.D.= Analytical duplicate
F.D.= Field duplicate
[1] Value is estimated
U = Compound undetected at concentration shown

NOTE: Shaded values indicate detections above the Practical Quantitation Limit (PQL)

4.2.1 Local Geology

A total of four boreholes were installed in the immediate vicinity of Jim's BP in order to evaluate the subsurface geology. Borehole installation was conducted as described in Section 3.3.1. Soil in each borehole was sampled at 5-foot intervals to provide lithologic descriptions of the soil column and to screen the samples for possible submittal to the analytical laboratory. The borehole logs of each of the four soil borings are presented in Appendix C. In general, very fine-grained sediments were encountered during borehole installation, and gravel was present as the borings progressed in depth.

The subsurface geology at Jim's BP consists of silty clays probably indicative of the regional deltaic fan depositional environment discussed in Section 2.2.1. The initial 10 to 15 feet BLS in all four boreholes consisted of dense silty clay with little or no coarse material. Below this, for an additional depth of 5 to 10 feet was a dense silty clay which sporadically contained sand, banding (either due to oxidation or slightly different colored clay), and in some cases small pebbles or gravel. Below this, in all four boreholes at depths ranging from 18 to 22 feet BLS, a very dense, compacted silty clay with gravel was present. During the installation of MW-1, which was drilled to a total depth of 33 feet, this unit was present from roughly 18 to 33 feet BLS. This material typically required more than 50 blows with the down-hole hammer to obtain a minimal recovery in the split spoon. This unit was encountered during the Cenex investigations at similar depths. No coarse-grained, moderately to highly permeable sediments were encountered during the drilling program.

4.2.2 Local Hydrogeology

To characterize the ground water conditions at Jim's BP, the four boreholes were completed as monitoring wells. Of the six possible well locations specified in the project work plans, monitoring wells were installed at locations 1, 3, 5, and 6 as shown in Figure 4-2. Construction details such as elevation with respect to mean sea level, completion depths, screened intervals, and annular space backfilling and sealing materials are presented in Appendix D. The four wells at Jim's BP were installed in the younger (Pliocene and Recent) unconsolidated materials that were deposited as part of a deltaic fan of the Columbia river, or possibly in the weathered, upper member of the Troutdale Formation (as evidenced by the gravel present at greater depth).

Static water levels were measured on four separate occasions and are presented in Table 4-2. The first measurements for each well represent the depth to water encountered during drilling. There is a substantial difference in the static water levels between two sets of monitoring wells. Monitoring wells MW-1 and MW-3 show a much greater depth to water than MW-5 and MW-6. It is believed that this is due to a ground water mounding effect centered near the northern end of the UST pit at Jim's BP. The mound is probably centered near the north end of the pit because three USTs present in the southern portion of the pit will displace much of the water in this end of the pit. Measurement of two stand-pipes previously installed in the UST pit had higher static water levels than monitoring wells MW-5 and MW-6. The groundwater mounding effect is possible because the backfilled material in the UST pit has a much higher permeability than the surrounding soil, which would allow ground water to drain into the pit at a much faster rate than it would drain out.

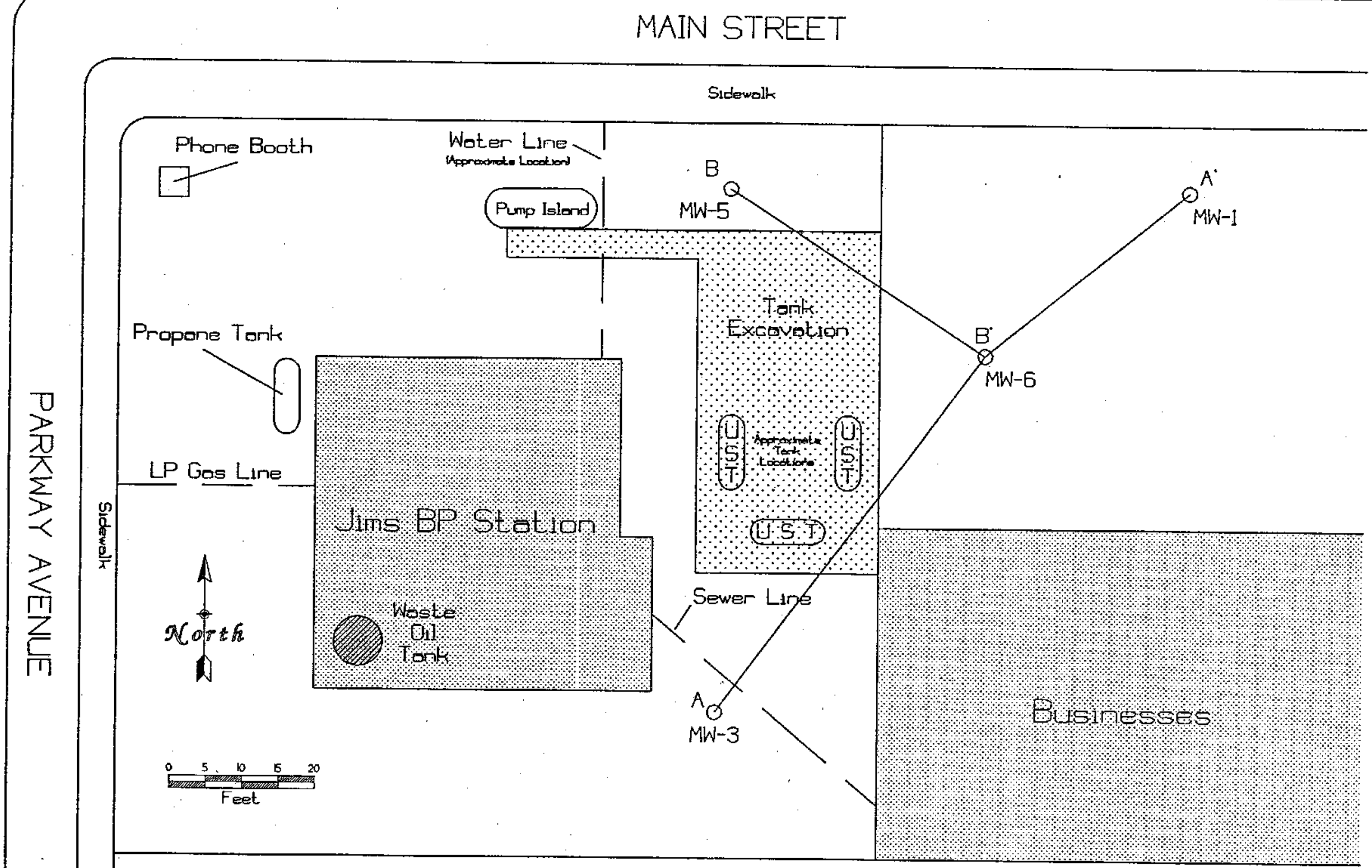


Figure 4-2

Locations of Monitoring Wells
and Stratigraphic Cross Sections

Table 4-2

STATIC WATER LEVELS (feet, MSL)

DATE		MW-1	MW-3	MW-5	MW-6
	Monitoring Well No.	MW-1	MW-3	MW-5	MW-6
	Completed Depth	268.81	268.85	271.26	271.49
	Top of Casing	291.31	292.95	291.76	291.19
3/31-4/1/92*		278.31	278.95	282.26	282.19
4/6/92		275.76	273.55	285.16	285.69
4/7/92		275.76	273.55	283.56	285.64
4/8/92		275.76	272.60	283.46	285.39
5/12/92		273.59	272.28	283.16	282.12
Hydraulic Conductivity Estimates K (cm/sec)[1]		8E-5	7E-4	4E-4	3E-4

* Depth at which water was encountered during drilling.

1 Hydraulic conductivities determined from slug test, see Appendix E.

The ground water mounding effect observed at Jim's BP has made it difficult to interpret the ground water gradient and flow direction. Therefore, it is only possible to provide a qualitative discussion of these hydraulic parameters. The static water level in MW-1 is approximately one foot lower than in MW-3. Therefore, it appears that ground water is flowing away (north to northeast) from the excavation. However, an additional monitoring well which is not influenced by the ground water mound is necessary in order to provide an estimated flow direction. It is suspected that ground water levels in monitoring wells MW-1 and MW-3 are more similar to those in MW-5 and MW-6 during the wet season. This observation is based on the presence of contaminants in a soil sample collected at 10 feet BLS in MW-1. It is believed that these compounds are present due to downgradient flow of contaminated ground water and that the contamination is due to residual ground water left behind in the pore spaces of the silty clay as the ground water level dropped during the onset of the dry season.

It is also difficult to speculate on the extent of the water-bearing zone encountered in MW-1 and MW-3. The relatively low permeability of the silty clay allows for the formation of a perched zone(s), whose areal continuity can be difficult to establish. Water is present at a similar depth in the Cenex excavation. Cross-sections of the site stratigraphy and static water levels are presented in Figure 4-3. From the cross-section, it is observed that the static ground water level is within the compacted silty clay layer containing cemented gravel. This layer, based on the slug tests conducted in each of the monitoring wells, has a horizontal conductivity range of 8×10^{-5} to 7×10^{-4} cm/second. It was observed during well development that continuous pumping of these wells was not possible. Typically, vertical hydraulic conductivities are several orders of magnitude lower than the horizontal values. These values indicate a relatively low permeability layer(s) underlie the Jim's BP site. This low permeability unit does not transmit water easily in either the horizontal or vertical direction. Hydraulic conductivities for the slug tests conducted in all monitoring wells are presented in Table 4-2.

4.3 QUALITY ASSURANCE AND QUALITY CONTROL

Throughout all sampling activities, a variety of quality control samples were collected for chemical analysis to monitor the effectiveness of procedures undertaken to maximize sample integrity. Quality control samples were collected to monitor both field operations (i.e. the quality of the methods used in producing representative samples of similar quality with little or no cross-contamination) and laboratory operations (i.e. precision, accuracy, and minimization of laboratory-induced sample contamination during chemical analysis). For the soil gas survey, both areas of quality control were measured in the field since analysis of the samples occurred in the field rather than at an offsite laboratory.

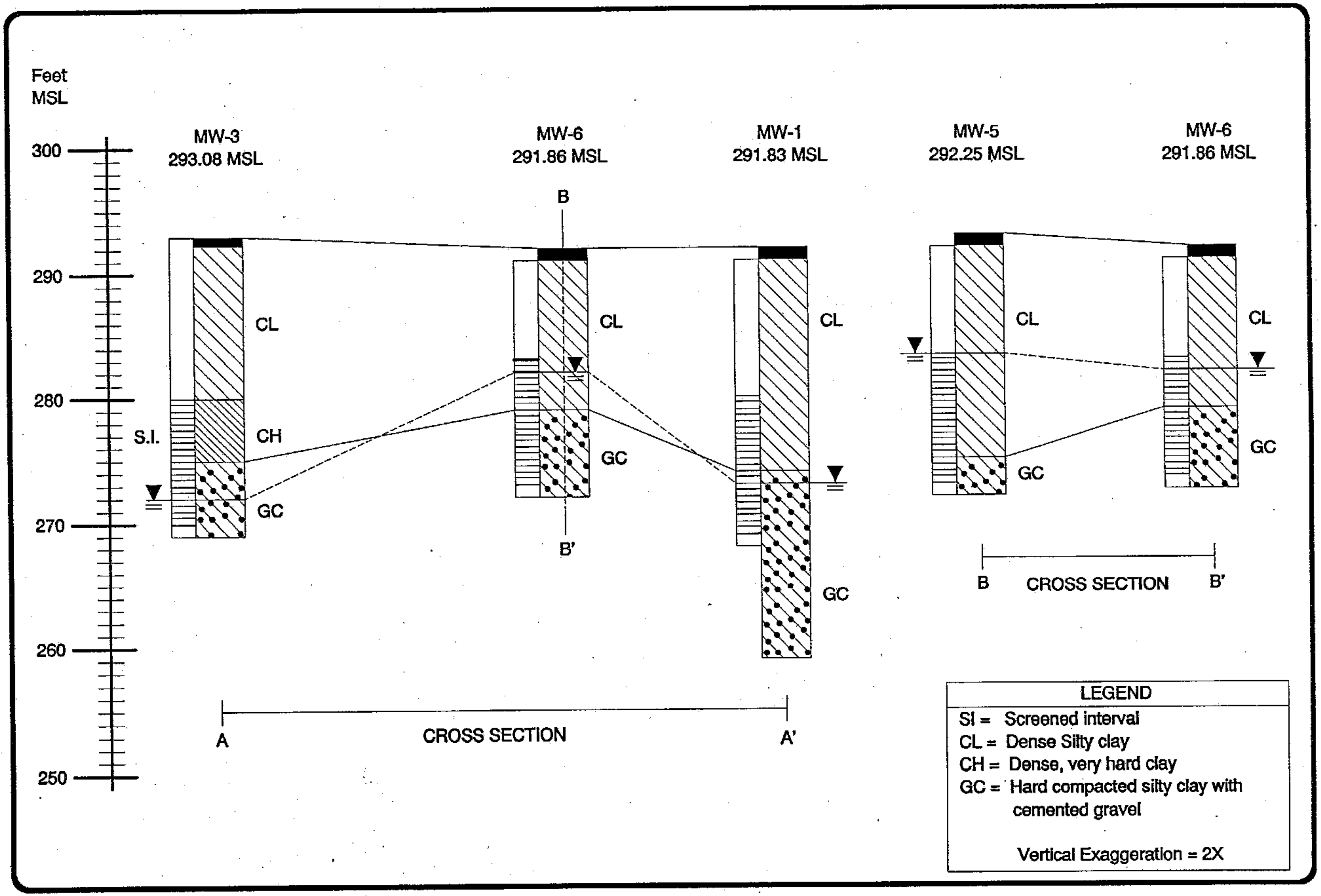


Figure 4-3

STRATIGRAPHIC CROSS SECTIONS

4.3.1 Soil Gas Survey Quality Control

QA/QC samples for the soil gas survey included instrument calibration and calibration check samples, argon blanks, field blanks, analytical duplicates, and field duplicates.

Analytical QA/QC

The GC was calibrated on a daily basis, prior to sample analysis, using gas standards. Calibration checks were performed immediately after calibration, after every five samples as a continuing calibration verification, and at the end of the day. The percent recovery of the calibration check samples had to be within 70-130 percent of the true value. If the calibration check was out of this range, then the check sample was reanalyzed, and if still out of the recovery limits, the system was recalibrated.

In addition to the calibrations and calibration verifications, GC blanks (argon blanks) were analyzed following the analysis of a high concentration standard or environmental sample to ensure contaminants were not being carried over to the next sample analysis. No argon blanks showed any detectable concentrations of any compounds. As a further QA/QC check on system performance, an analytical duplicate was performed. Both the sample and the analytical duplicate showed concentrations of toluene below practical quantitation limits, but above instrument detection limits (IDL); as such, the results must be qualified as estimates. However, the relative percent difference (RPD) of the low detections was only 17.1 percent.

Soil Gas Survey Field QA/QC

A field duplicate was collected at SG#4 and analyzed. The original sample and the duplicate did not have contaminants above practical quantitation limits, but did contain concentrations of toluene that were estimated (i.e. just above the IDL). The RPD of these two samples was 62 percent. Field blanks were collected every day to ensure that sampling procedures and equipment were not resulting in sample cross-contamination. No field blanks contained detectable concentrations of any compounds. More information concerning QA/QC for the soil gas survey can be found in Appendix B.

4.3.2 QA/QC for Field Activities

Field quality control samples included: trip blanks, equipment blanks, field blanks, and field duplicates. The number of environmental samples, associated QA/QC samples, and chemical analyses are presented in Table 4-3. QA/QC samples were collected at a frequency of greater than 10 percent. Each type of field QA/QC is discussed in the following sections.

Trip Blanks

Trip blanks are prepared by pouring laboratory grade water into two 40-ml VOA vials at the laboratory. The vials are placed in the sample shipping cooler that will contain the samples for the

Table 4-3

SUMMARY OF FIELD SAMPLING ACTIVITY

Media/Analyte	Analytical Method	Environmental Samples	Field Duplicates	Field Blanks	Equipment Rinse	Trip Blank
SOIL						
TPH	WTPH-G	8	1	1	1	
BETX	SW5030/8020	8	1	1	1	1
Lead	SW5030/7421	8	1	1	1	
GROUND WATER						
TPH	WTPH-G	4	1	1	1	
TPH	WTPH-D	4	1	1	1	
BETX	SW5030/8020	4	1	1	1	1
Lead	SW5030/7421	4	1	1	1	

entire day. The trip blanks then accompany the samples collected during the same work day, are manifested and packaged with the environmental samples, and shipped to the laboratory with the samples for analysis. During the Jim's BP investigation, trip blanks received by the analytical laboratory contained air bubbles which invalidate the use of the vials for VOA (or in this case, BTEX) analysis. The problem was identified by field personnel, however, the problem could not be rectified in time to transport new trip blank samples with the soil samples. At the time of ground water sampling, valid trip blank samples were obtained, however the field personnel marked "VOA" for the type of analysis rather than "BTEX" which the laboratory was contracted to perform. The laboratory failed to notify field personnel of the error for clarification before the sample holding time expired. Thus the trip blank associated with the ground water samples was not analyzed.

Equipment Blanks

Equipment blank samples were collected by pouring laboratory-grade water over decontaminated equipment (e.g., split spoon and a new factory-sealed teflon bailer). These samples are designed to monitor the effectiveness of decontamination procedures or to ensure that disposable equipment (such as a teflon bailer) is received from the factory free of contamination. Equipment blank samples were submitted for the same analysis as the environmental samples. The analytical results for all equipment blank samples are presented in Table 4-4. No contaminants were detected in any of the equipment blank samples, indicating that sample contamination from improper decontamination procedures did not bias the analytical results with respect to the environmental samples.

Field Blanks

Field blank samples were prepared by pouring laboratory grade water directly into sample containers while in the support or contaminant reduction zone. Field operations were ongoing at the times when the field blanks were collected. Analytical results of the field blank samples, shown in Table 4-4, showed no contaminants were detected in any field blank samples. This supports the conclusion that ambient conditions did not bias the analytical results with respect to the environmental samples.

Field Duplicate Samples

Field duplicate samples are designed to measure the representativeness and reproducability of field sampling activities. Two field duplicate samples were collected, one during soil sampling and one during ground water sampling. A summary of the field duplicate sample results is presented in Table 4-5. The soil duplicate sample was collected from the same split spoon as the environmental sample. However, to prevent loss of volatile constituents, the sample was not homogenized when placing sample material in sampling jars. The sample material for lead analysis was homogenized as loss of contaminant was not expected due to mixing. This is also reflected in Table 4-5 as a greater RPD exists for the volatile constituents than for lead (excluding the nondetectable value). Additionally, the low contaminant levels skew the RPD high as a 1 ppb difference in the sample results becomes significant when the calculations are performed. Overall, the differences shown are relatively low, sampling procedures did not bias the analytical results with respect to the environmental samples.

Table 4-4

QUALITY CONTROL SAMPLE RESULTS (μg/L)

HAZARDOUS SUBSTANCE	Quality Control Sample	EQUIPMENT RINSE	FIELD BLANK	FIELD BLANK	EQUIPMENT RINSE	TRIP BLANK
	Date	4-02-92	4-02-92	4-08-92	4-08-92	4-08-92
Benzene		0.5 U	0.5 U	4U	4U	NA
Ethylbenzene		0.5 U	0.5 U	4U	4U	NA
Toluene		.002 U	.002 U	4U	4U	NA
Xylenes		0.5 U	0.5 U	4U	4U	NA
Lead		0.5 U	0.5 U	2U	2U	NA
Total Petroleum Hydrocarbons- Diesel		250U	250U	250U	250U	NA
Total Petroleum Hydrocarbons- Gas		250U	250U	250U	250U	NA

U- The analyte concentration is less than applicable listed reporting limit.
NA-Trip blank exceeded holding time and was not analyzed.

Table 4-5

SUMMARY OF FIELD DUPLICATE ANALYTICAL RESULTS

LOCATION	SAMPLE ID (Duplicate ID)	DETECTED COMPOUNDS	CONCENTRATION ($\mu g/kg$) (Duplicate Concentration)	PRECISION AS RPD (%)
Monitoring Well #5 (soil)	SB-5-2 (SB-5-2D)	Toluene	7 (S)	33.3
		Total Xylenes	45 (11)	121.4
		Lead	9 (8)	11.8
Monitoring Well #1 (water)	MW-1 (MW-1Dup)	Benzene	7 (7)	0
		Ethylbenzene	4 (4)	0
		Xylenes	6 (5)	18.2
		Lead	3 (2U)	40.0*

* Calculated assuming duplicate value is the reporting limit (i.e. 2 $\mu g/kg$)
U- Compound undetected at concentration shown

4.3.3 Laboratory Quality Control

Laboratory quality control programs include comparison of environmental samples to established holding times, measurement of quality control samples including matrix spike/matrix spike duplicates, surrogate spikes, method blanks, and analytical duplicate samples. A brief description of quality control methods and the results is presented below. Laboratory QA/QC data is presented in Appendix F with the analytical results.

All samples were analyzed within allowable holding times as stated in the Project Work Plan (SAIC, 1992). One trip blank sample was sent to the laboratory and as previously discussed, due to a documentation error on the chain of custody form, the holding time expired before the problem was recognized and the sample analyzed. As shown in the chain of custody forms in Appendix F, the laboratory attested to the acceptability of the samples by inspecting the sample cooler and releasing SAIC of sample custody by signing the chain of custody.

Precision

Precision refers to the reproducability of results among replicate measurements of a single analyte. Two matrix spike and matrix spike duplicate samples (MS/MSD) of each media (total of four MS/MSD samples) were analyzed by the laboratory to determine precision. The results of these analyses is presented in Table 4-6. The precision limits for the project were met for all samples for all analytes with the exception of TPH-diesel in water. The control limit was 15% RPD, and the MS/MSD sample run for TPH-diesel returned an RPD of 17 percent. However, diesel fuel measured as total petroleum hydrocarbons was not detected in any of the water samples. Therefore, qualification of TPH-diesel results in terms of precision is not necessary.

Accuracy

Accuracy refers to the degree of difference of a measured value to the true value. Accuracy may be expressed as the percent recovery of an analyte that has been added (spiked) to an environmental sample at a known concentration prior to analysis. Two MS/MSD samples were analyzed for each media (water and soil) for BTEX. Only one MS/MSD was run for lead in soil and water, and one for TPH-diesel in water. The results of these analysis is summarized in Table 4-7. All of the data was within quality control limits specified in the QAPP. Therefore, none of the analytical data for the environmental sample results must be qualified relative to the accuracy of analysis.

Method Blanks

Method blank samples are analyzed by the laboratory to ensure that sample handling, extraction procedures, and measurement procedures are not resulting in cross contamination of samples. At least one method blank was analyzed along with each group of samples received by the laboratory. No contaminants were detected in any of the method blanks. Therefore, the analytical results of environmental samples do not have to be qualified with respect to cross contamination of samples while undergoing analysis at the laboratory.

Table 4-6

MATRIX SPIKE / MATRIX SPIKE DUPLICATE PRECISION

COMPOUND	RPD (%) RANGE	RPD UNIT[1]	DATA ACCEPTANCE
WATER SAMPLES			
Benzene	2.0-3.1	22	Yes
Toluene	3.0	22	Yes
Ethylbenzene	2.0-4.2	22	Yes
Xylene	2.0-3.1	22	Yes
TPH-Gas	<1.0-2.9	15	Yes
TPH-Diesel	17	15	Yes[2]
Lead	3.2	15	Yes
SOIL SAMPLES			
Benzene	2.5	22	Yes
Toluene	1.1	22	Yes
Ethylbenzene	2.2-2.3	22	Yes
Xylene	1.1	22	Yes
TPH-Gas	2.5	15	Yes
Lead	<1	15	Yes

[1] QA/QC limits were obtained from USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition, SW-846; Washington Department of Ecology, Guidance for Remediation of Releases from Underground Storage Tanks, Appendix L, Total Petroleum Hydrocarbons Analysis for Soil and Groundwater, October 1991.

[2] Data accepted although the precision limits were exceeded because no ground water samples contained detectable amounts of diesel fuel measures as total petroleum hydrocarbons.

Table 4-7

MATRIX SPIKE RECOVERIES

COMPOUND	NO. OF MS/MSD ANALYSES	SPIKE % RECOVERY RANGE	ACCEPTABLE RANGE[1]	DATA ACCEPTANCE
WATER SAMPLES				
Benzene	2	95-101	60-140	Yes
Toluene	2	98-103	60-140	Yes
Ethylbenzene	2	94-101	60-140	Yes
Xylene	2	96-101	60-140	Yes
TPH-Gas	2	102-105	50-150	Yes
TPH-Diesel	1	66-78	50-150	Yes
Lead	1	101-104	75-125	Yes
SOIL SAMPLES				
Benzene	2	80-82	60-140	Yes
Toluene	2	91-92	60-140	Yes
Ethylbenzene	2	86-88	60-140	Yes
Xylene	2	88-89	60-140	Yes
TPH-Gas	2	80-82	50-150	Yes
Lead	1	84-85	75-125	Yes

1 QA/QC limits were obtained from USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition, SW-846; Washington Department of Ecology, Guidance for Remediation of Releases from Underground Storage Tanks, Appendix L, Total Petroleum Hydrocarbons Analysis for Soil and Groundwater, October 1991.

Completeness

Completeness is expressed as the percentage of valid samples obtained for a given sample set. For the RI phase of the investigation, 9 soil samples and 9 water samples (including QA/QC samples) were submitted for analysis. All sample data was accepted giving a 100 percent completeness rate for the project.

4.4 SOIL SAMPLING RESULTS

During the drilling of all boreholes, soil samples were collected using a stainless steel split spoon. As previously shown in Table 4-3, eight environmental soil samples were collected during the investigation and analyzed for BTEX, TPH (gasoline fraction), and total lead. The results of these analyses are presented in Table 4-8. Laboratory data are presented in Appendix F.

For this phase of the RI, lead results in soil are difficult to interpret because no background soil samples were collected to form a basis of comparison for lead in soils. The range of lead values (4.3-11 mg/kg) are below the MTCA Method A Cleanup criteria of 250 mg/kg by more than an order of magnitude. Whether these low concentrations of lead are comparable to background or are slightly elevated cannot be determined with presently available data.

Gasoline, measured as total petroleum hydrocarbons, was detected in only one soil sample, from location MW-6 over a depth of 3-4.5 feet BLS. This corresponds to the area of heaviest contamination during previous remedial activities [the release reportedly occurred from the eastern tank - closest to the MW-6 location (see Figure 4-2)]. The concentration of TPH-gasoline in the sample was 31 mg/kg, approximately one third the MTCA Method A Cleanup criteria of 100 mg/kg.

Because some components of gasoline are not soluble in water, and the specific gravity of gasoline (0.729 at 15°C) is less than that of water (1.0), the detection at a depth of 3-4.5 feet BLS, above the buried depths of the tanks (approximately 12 feet), is a reasonable finding (API, 1989). Assuming soil vapor transport is not the primary mechanism for gasoline migration in the subsurface, the most likely transport mechanism would be "floating" on a rising water table and subsequent deposition to soil. This would also imply the water table reaches elevations of approximately 3 feet BLS at the Jim's BP site (which was noted during the soil gas survey). However, once liquid hydrocarbons are in the unsaturated zone, the migration tendency would be downward due to the influence of gravity. Thus two scenarios are present for migration of TPH. First, the water table is fairly constant underneath the Jim's BP site. In this scenario the water table would impede vertical migration of liquid phase hydrocarbon contamination and thereby promote horizontal spreading. The second (more likely) scenario would be a fluctuating water table. Under these conditions, the liquid phase hydrocarbons would alternatively rise on the water table and fall as the water table drops (due to gravitational influences in the unsaturated zone). Here vertical migration is enhanced over horizontal migration, however the vertical extent of contamination would be limited to the vertical extent of fluctuations in the water table (API, 1989). The exact nature of plume migration and subsequent soil

Table 4-8

SOIL SAMPLE RESULTS (mg/kg)

HAZARDOUS SUBSTANCE		SB1-3	SB3-3	SB3-4	SB5-2	SB5-2-DUP	SB5-3	SB6-1	SB6-2	SB6-4	MTCA CLEANUP LEVEL (mg/kg)
	Depth (ft. BLS)	13-14.5	13-14.5	18-19.5	8-11	8-11	13-14.5	3-4.5	8-9.5	18-19.5	
	Date	3-31-92	3-31-92	3-31-92	4-1-92	4-1-92	4-1-92	4-1-92	4-1-92	4-1-92	
Benzene		.004 U	.004 U	.004 U	.004 U	.004 U	.004 U	.01	.004 U	.004 U	0.5
Ethylbenzene		.007	.006	.004 U	.004 U	.004 U	.004 U	.22	.004 U	.004 U	20.0
Toluene		.035	.032	.004 U	.007	.005	.009	.007	.005	.005	40.0
Xylenes		.041	.034	.004 U	.045	.011	.023	.17	.010	.017	20.0
Lead		5.7	7.4	4.3	9	8	7	10	11	11	250.0
Total Petroleum Hydrocarbons- Gas		5U	5U	5U	5U	5U	5U	31	5U	5U	100.0

U- The analyte concentration is less than applicable listed reporting limit.

contamination resulting from soil particle wetting by liquid phase hydrocarbons is unknown. However, because soil contamination is slight, the potential for contaminant migration as a "plume" is unlikely.

Review of Table 4-8 shows BTEX compounds to be present at very low levels (well below MTCA Method A Cleanup Levels) throughout the soils underlying Jim's BP. Benzene, was only detected at MW-6 at a depth of 3-4.5 feet. The detection of benzene was at levels over an order of magnitude below MTCA Method A Cleanup criteria. The other BTEX components, ethylbenzene, toluene, and xylenes, were detected more frequently (at more locations and more depth ranges). This is consistent with their higher solubilities and a fluctuating ground water table. All the detections were at least an order of magnitude below the MTCA Method A Cleanup criteria, and in many cases, the detections were two orders of magnitude less than the cleanup level. Review of the results does not reveal any apparent trends of contaminant migration (other than the highest concentrations of BTEX were generally found at MW-6). The contamination seems to be dispersed at low concentrations relatively uniformly throughout the depths studied in this RI.

4.5 GROUND WATER SAMPLING RESULTS

A total of five ground water samples (including 1 field duplicate) were collected from the four monitoring wells installed as part of this RI. Samples were analyzed for BTEX, total lead, TPH-gasoline, and TPH-diesel. The results of the ground water sampling are presented in Table 4-9, and are shown in Figure 4.4. Laboratory data may be found in Appendix F.

Lead was detected in samples from 3 locations, MW-1, MW-5, and MW-6. However, only in MW-6 did the lead concentration (6 ppb) exceed the MTCA Method A Cleanup criteria of 5 ppb. Lead levels were found in highest concentration in the soils at this location, as were most of the BTEX constituents. This well also appears to be the most highly contaminated with constituents in the ground water.

Ground water samples were analyzed for total petroleum hydrocarbons (gasoline and diesel fractions). No detections occurred for the diesel fraction in any of the ground water samples. Gasoline, measured as TPH, was found in the two wells closest to the former excavation area (MW-5 and MW-6). Sample concentrations were 1,000 and 1,500 μg/L respectively, both of which are concentrations at or above the MTCA Method A Cleanup Level of 1,000 μg/L. This corresponds well with documented spill areas (and subsequent remedial actions), with the highest levels of soil contamination, and with the static water levels presented in Table 4-2. BTEX compounds were detected in the samples of ground water at all of the monitoring wells except MW-3. Monitoring wells 5 and 6 had the highest concentrations of BTEX compounds with benzene, ethylbenzene, and xylenes all detected in concentrations above MTCA Method A Cleanup criteria. Toluene was not detected in concentrations above cleanup levels in any of the wells. Benzene was also detected above cleanup criteria in MW-1.

Table 4-9

GROUND WATER SAMPLE RESULTS (μg/L)

HAZARDOUS SUBSTANCE	MONITORING WELL NUMBER	MW-1	MW-1-DUP	MW-3	MW-5	MW-6	MTCA CLEANUP LEVEL (μg/L)
	Date	4-8-92	4-8-92	4-8-92	4-8-92	4-8-92	
Benzene		7	7	0.5 U	72	220	5.0
Ethylbenzene		4	4	0.5 U	53	98	30.0
Toluene		0.5 U	0.5 U	0.5 U	7	2	40.0
Xylenes		6	5	0.5 U	110	59	20.0
Lead		3	2U	4	2U	6	5.0
Total Petroleum Hydrocarbons-Diesel		250U	250U	250U	250U	250U	1,000
Total Petroleum Hydrocarbons-Gas		250U	250U	250U	1000	1500	1,000

U- The analyte concentration is less than applicable listed reporting limit.
The shaded areas indicate the values that equal or exceed MTCA Method A cleanup level

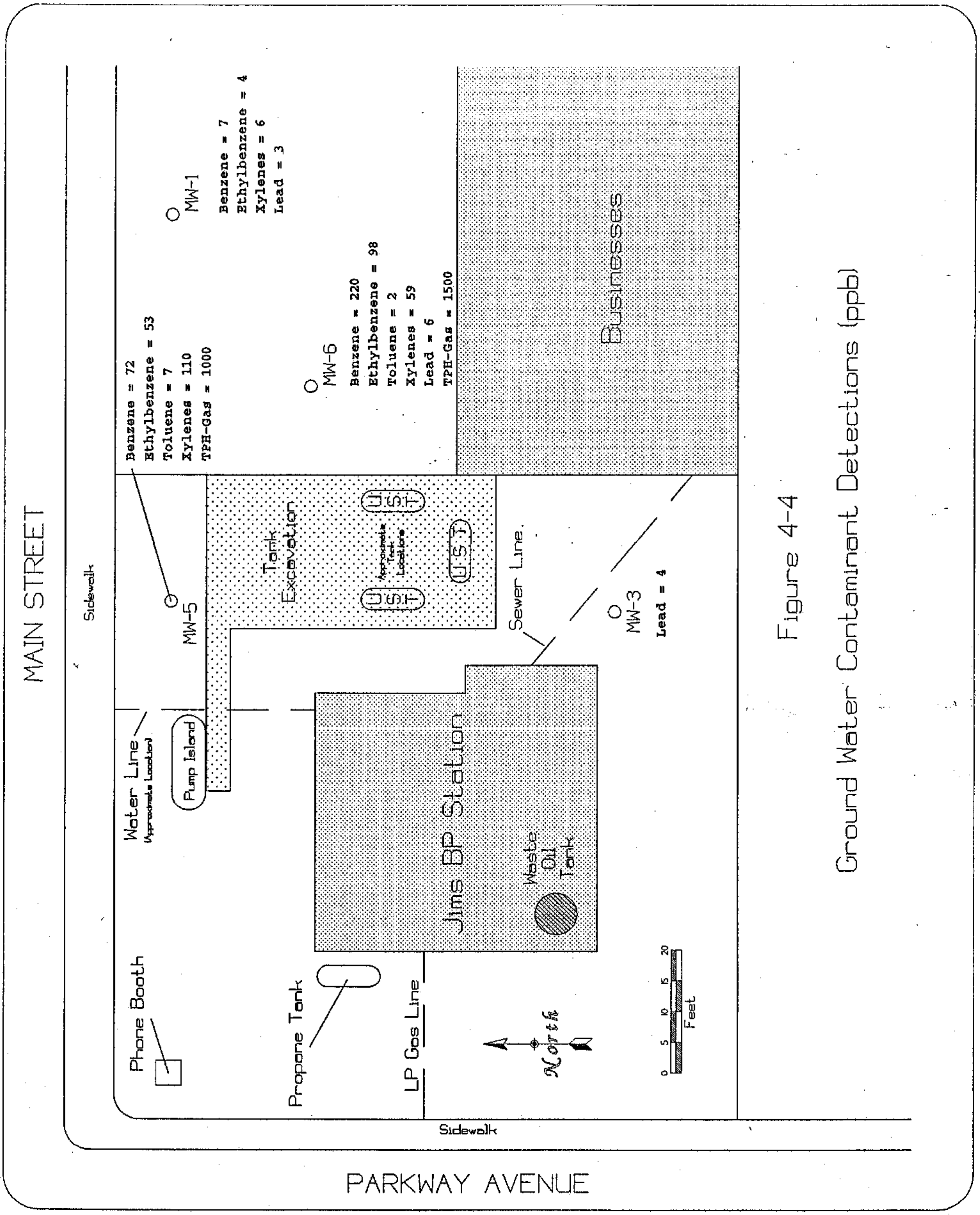


Figure 4-4

Ground Water Contaminant Detections (ppb)

The solubilities of benzene (1,800 mg/L), toluene (540 mg/L), ethylbenzene (150 mg/L), and xylene (200 mg/L) in water (Dept. of Ecology, 1992), as components of gasoline, may migrate as a dissolved phase in ground water by either advective or dispersive processes. Advective process transport chemical contaminants by the movement of ground water (API, 1989). Slug tests showed the formation materials underlying the Jim's BP site to be of low permeability which would tend to impede ground water flow. Thus migration of BTEX with ground water would tend to be a fairly slow process at the Jim's BP site.

Hydrodynamic dispersive forces tend to dilute contaminant concentrations within a dissolved hydrocarbon plume. Dispersion can occur through two processes, chemical diffusion and mechanical mixing. Chemical diffusion occurs in areas of very low hydraulic conductivity and very low flow rates resulting in a radial dispersion of chemical contaminants away from a source (API, 1989). Because mounding effects near the excavation area may create hydraulic head differentials large enough to induce some ground water flow, chemical diffusion is probably of little significance at this site. Mechanical mixing processes, caused by movement of ground water (either laterally or vertically)is probably of more significance as a transport process than chemical diffusion. As shown in Table 4-2, static water levels may show a gradient to the northeast (refer to monitoring wells 1 and 3, which are drilled and screened at nearly the same elevations with respect to mean sea level). Field studies have shown chemical dispersion to be greatest along the direction of ground water flow, primarily due to mechanical mixing (API, 1989). BTEX compounds were not detected in MW-3 (apparently upgradient), were highest in MW-6 (original contaminant source area), and just detectable in MW-1 (apparently downgradient). Thus it appears a very small ground water plume may be defined by these three wells. This plume suggests that the ground water flow path is to the northeast (toward the CENEX excavation) and the edge of the plume terminates in the vicinity of MW-1. The full extent of the plume perpendicular to the projected ground water flow pattern cannot be accurately determined with currently available data.

5.0 CONCLUSIONS

Based on the results of this RI, the following conclusions have been reached regarding the physical and chemical setting of petroleum hydrocarbon contamination in the subsurface at Jim's BP Service Station in Battle Ground:

(1) Contaminants remaining in the subsurface soils at the site are below MTCA Method A Cleanup criteria. This indicates that previous remedial measures taken (soil excavation in the vicinity of the current USTs) removed the most heavily contaminated soils.

(2) Residual soil contamination at the site is heaviest along the fringes of the previous excavation (as indicated by soil sampling results of MW-5 and MW-6). Soil contamination by petroleum hydrocarbons (TPH-gasoline) appears to be higher in the unsaturated zone. Low concentrations of BTEX compounds were detected in soil samples at depths down to 20 feet BLS presumably due to transport processes of dissolved species in ground water.

(3) The remaining subsurface soil contamination is partitioning into the vapor phase and into ground water as indicated by detections of contaminants in both the gaseous and aqueous phases. The rate of partitioning and the maximum contaminant levels expected in each phase could not be determined with presently available data.

(4) Although the soil gas survey data confirmed the correct placement of monitoring wells, soil gas concentrations do not indicate the presence of significant contamination. This, in conjunction with observations during drilling and soil sampling results supports: a) soil contamination is not extensive both in terms of concentration and areal extent, and b) formation materials (primarily silty clays) are not conducive to the vapor phase generation or transport of contaminants.

(5) Ground water at the site is currently contaminated above MTCA Method A Cleanup criteria for benzene, ethylbenzene, xylenes, TPH-gasoline, and lead at one or more sampling locations.

(6) The areal extent of ground water contamination has not been fully characterized. However, sampling data indicate heaviest ground water contamination near the current USTs with lower concentrations downgradient at MW-1. The spatial boundaries of the ground water plume cannot be completely defined with currently available data.

(7) It is not known if contaminated ground water represents residual contamination from the spill prior to remedial excavation, or if the current levels of soil contamination are high enough to constitute a continuing source of contamination to ground water.

(8) Review of static water levels in MW-1 and MW-3, in conjunction with chemical data of the ground water, appears to indicate the ground water flow direction is to the northeast (at the depths investigated during this RI). The effect of ground water mounding observed in the vicinity of the UST pit has not been determined with respect to ground water flow direction and contaminant distribution.

(9) During well development and slug testing, field personnel noted slow recovery rates of the wells and that continuous pumping of ground water from the wells did not appear feasible.

(10) Chemical contamination under the Jim's BP property and the immediately adjacent lot to the east (MW-6, MW-1) does not appear to be influenced by contamination from the Cenex site located northeast of Jim's BP.

(11) Data from borehole logs, observations during drilling, sampling results, and the chemical characteristics of the contamination present, and other geological reports for Clark County indicate that further vertical migration of significant contamination into the Troutdale Formation is unlikely. Additionally, well logs for the surrounding area (one mile radius from the site) indicate drinking water is obtained at depths of at least 40 feet BLS and more often at depths of greater than 50 feet BLS. It is unlikely that contaminants present at this site, at current concentrations and without a continuing source of contamination, will introduce contaminants at concentrations above the MTCA Method A Cleanup Levels into the ground water used to supply drinking water for Battle Ground.

6.0 REFERENCES

American Petroleum Institute, 1989. "A Guide to the Assessment and Remediation of Underground Petroleum Releases," API Publication 1628, Second Edition, April 1989.

Chen-Northern, Inc., March 1991. Report of Phase II Environmental Assessment to Cenex Farm and Home.

Freeze, R.A., and Cherry, J.A., 1979. Ground water. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Phillips, E.L. 1961. Climatological Summary, Battle Ground, Washington. U.S. Department of Commerce, Weather Bureau. Seattle, Washington.

Science Applications International Corporation., February 1992. Final Project Workplan, Remedial Investigation/Feasibility Study of Jim's BP, Battle Ground, Washington.

SRH Environmental Management, September 1991. Subsurface Hydrocarbon Investigation, Battle Ground School District.

SRH Environmental Management, February 22, 1991a. File letter to Patricia Martin, Department of Ecology Southwest Regional Office, regarding Battle Ground School District LUST Investigation Synopsis.

U.S. Environmental Protection Agency, 1986. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, 3rd Edition. Washington D.C.: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency, 1988. Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses.

U.S. Environmental Protection Agency, 1988. Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses.

U.S. Environmental Protection Agency, June 1990. Assessing UST Corrective Action Technologies: Site Assessment and Selection of Unsaturated Zone Treatment Technologies. EPA/600/2-90/011. Risk Reduction Engineering Laboratory, Office of Research and Development.

U.S. Environmental Protection Agency, June 1990. Assessing UST Corrective Action Technologies: Early Screening of Clean-up Technologies for the Saturated Zone. EPA/600/2-90/027. Risk Reduction Engineering Laboratory, Office of Research and Development.

Washington Department of Ecology, 1992. Toxicology database for Use in Washington Ranking Method Scoring, January, 1992.

Washington Department of Ecology. 1990. Cleanup Standards Amendments to Model Toxics Control Act Cleanup Regulation. March 9, 1990.

Washington Department of Ecology. October 1991. Guidance for Remediation of Releases From Underground Storage Tanks, Appendix L.

Washing Department of Ecology. February 13, 1991. File Record of Telephone Conversation Between Patricia Martin, Ecology Southwest Regional Office, and Daryl Becker, N.W. Construction.

Mundorff, M.J., 1964. "Geology and Ground water Conditions of Clark County, Washington, with a Description of a Major Alluvial Aquifer Along the Columbia River." Geological Survey Water Supply Paper 1600.

File Original and First Copy with the Division of Water Management
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

DSHS

Application No. ....
Permit No. ....

(1) **OWNER:** Name Roy Bishop Address ....

(2) **LOCATION OF WELL:** County Clark — NW ¼ NE ¼ Sec. 32 T. 3 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 117 ft. Depth of completed well 116 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from 0 ft. to 113 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 45 ft.
Material used in seal Bentonite & Cuttings
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) **PUMP:** Manufacturer's Name ....
Type: .... H.P. ....

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... .... ft.
Static level 57 ft. below top of well Date 4/20/72
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 15 gal./min. with 32 ft. drawdown after 2 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown rockey soil	0	1
Brown rockey clay	1	18
Grey sand & water	18	38
Brown sandy clay	38	78
Brown sandy clay w/seams of sand and water	78	91
Cemented gravel	91	111
Partly cemented gravel & water	111	117

Recommend setting pump between 100 and 110 feet

Work started 4/17, 19 72. Completed 4/20, 19 72

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Zent Drilling, Inc. (Person, firm, or corporation) (Type or print)

Address 9906 N.E. 67th Street, Vancouver, Wn.

[Signed] Marlin Zent (Well Driller)

License No. 223-02-3275 Date 4/21, 19 72

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 5-69)—5-69.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Don Coffield Address

(2) LOCATION OF WELL: County Clark — NW ¼ SE ¼ Sec 2 T 3 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 98 ft. Depth of completed well 98 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from plus 6 in ft. to 93-4 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type ..... Model No.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal bentonite & drill cuttings
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ..... H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 54 ft. below top of well Date 12/26/79
Artesian pressure ..... lbs. per square inch Date
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 20 gal./min. with 36 ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
gravel clay brown	0	2
clay gravel brown	2	19
sandy clay gray	19	68
sand gravel gray	68	88
sand gravel water gray	88	97
sand gravel gray	97	98

1980

Work started 12/21/79, 19..... Completed 12/26/79

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Zent Drilling, Inc. (Person, firm, or corporation) (Type or print)

Address 7310 St. Johns Vancouver, Wash. 9866

[Signed] [signature] (Well Driller)

License No. 223-02-28500 Date 1/2/80, 19.....

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Dale Lubbers / Roy Blace Address Mail 5700 Franklin Vancouver, Wa. 98663

(2) LOCATION OF WELL: County Clark NE ¼ NW ¼ Sec. 2 T. 3 N., R. ~~3~~ 2E W.M.
Bearing and distance from section or subdivision corner Site: Lot# 12 Spring Brook Estates

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 207 ft. Depth of completed well 207 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 183'6" ft.
Threaded ☐ PVC 4 " Diam. from 167 ft. to 207 ft.
Welded ☒ ....” Diam. from .... ft. to .... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Saw
SIZE of perforations 1/16 in. by 8 in.
36 perforations from 187 ft. to 207 ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 183 ft.
Material used in seal Bentonite & fill
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 75 ft. below top of well Date 7-3-84
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 12 gal./min. with 50 ft. drawdown after 1 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	2
Reddish brown clay	2	25
Broken rock brown clay	25	48
Grey rock	48	67
Red clay decomposed rock	67	80
Broken rock 4 GPM	80	100
Decomposed rock	100	120
Brown clay	120	155
Grey rock	155	166
Brown rock	166	175
Red rock soft	175	180
Broken grey rock, water	180	200
Grey rock	200	207

RECEIVED
JUL 20 1984
Department of Ecology
Southwest Regional Office

Work started July 2, 19 84. Completed July 3, 19 84

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co. Inc. (Person, firm, or corporation) (Type or print)
Address 6711 NE. 58th Ave. Vancouver, Wa. 98661
0006 Ron Aspaas
[Signed] Ron Aspaas (Well Driller)
License No. C-51 Date July 5, 19 84
223-02HA-NS-ED-*377NT

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 030672

Water Right Permit No.

(1) OWNER: Name Gordy Jolma Construction Address 20409 NE 72nd Ave., BattleGroun

(2) LOCATION OF WELL: County Clark NE ¼ NW¼ Sec 2 T 3N N., R2E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) 9701 NE 138 Court

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 95 feet. Depth of completed well 95 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 94 ft.
Welded [ ] " Diam. from ft. to ft.
Liner installed [ ]
Threaded [ ] " Diam. from ft. to ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 69 ft. below top of well Date 8-8-89
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 13 gal./min. with stem set at 90 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil and subsoil with scattered gravel	0	3
Cobbles and gravel	3	15
Gravel, fine with brown clay	15	47
Clay; tan, sticky	47	54
Clay, sandy, brown	54	73
Gravel, brown and black, partially cemented with brown sand	73	90
Gravel, brown and black, loose waterbearing with brown sand andsilt	90	95

Work started 8-7-89 19. Completed 8-8-, 19 89

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Ritola Well Drilling 14214 NE 202nd Avenue (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address Brush Prairie, WA 98606

(Signed) R W Ledingis III (WELL DRILLER) License No. 1294

Contractor's Registration No. RITOLWD251MM Date 8-9-, 19 89

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG

Date September 23, 1950 No. Appli. #1276 Permit #1187

Record by Floyd Wickersham

Source well driller's record

Location: State of WASHINGTON

County Clark

Area

Map

SW ¼ NW ¼ sec 3 T 3 N., R. 2 E.

Drilling Co.

Address

Method of Drilling drilled Date Sept. 27 1950

Owner Clarence A. Remy

Address Battle Ground, Washington

Land surface, datum ft. above / below

Diagram of Section

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Top soil	6	6
	Yellow clay	15	21
	Blue clay & gravel	12	33
	Yellow clay & boulders	29	62
	Cemented gravel	60	122
	Sand & gravel	25	147
	Blue clay	30	177
Pump Test:			
	Dim: 177' x 8"		
	SWL: 47'		
	Dd: 88' Yield: 200 g.p.m. (permit)		
	Casing: 8" 177 one casing		
	Shoe: sets at 179 - 7' of open hole at bottom in blue clay		
	Perfor: 4 cuts per ft. 1½ x 3/8 from 65 to 120'		

Turn up

over Sheet of sheets

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Appl. 2338
Cert. 1151-A

Date May 20, 1952

Record by R. M. Wade & Co.

Source Driller's Record

Location: State of WASHINGTON

County Clark

Area

Map

SE¼ NE¼ sec. 3 T. 3 N., R. 2 E.

DIAGRAM OF SECTION

Drilling Co. R. M. Wade & So.

Address Seattle, Wash.

Method of Drilling Date April 25 1952

Owner James H. Babcock

Address Route 2 Box 340; Battle Ground

Land surface, datum ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	No information		
	Pump Test:		
	Dim: 103' x 8" Drilled		
	SWL: 40'		
	DD: No information		
	Yield: 175 g.p.m.		
	Casing: Cased to 103'		
	Perforations:		
	No information		

Turn up Sheet of sheets

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Appli. / #3661
Permit #3537

Date March 30, 1954

Record by Haakon I. Bottner

Source Well driller's record

Location: State of WASHINGTON

County Clark

Area

Map

NW ¼ NE ¼ sec. 3 T. 3 N., R. 2 E.

DIAGRAM OF SECTION (3)

Drilling Co. Haakon I. Bottner

Address Portland 16, Oregon

Method of Drilling drilled Date Mar. 30 1954

Owner TOWN OF BATTLE GROUND

Address Battle Ground, Wash.

Land surface, datum ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Silt loan topsoil	5	5
	Medium size gravel	6	11
	Gravel & large boulders	21	32
	Yellow sand-clay	20	52
	Cemented gravel	15	67
	Water bearing gravel	3	70
	Cemented gravel	22	92
	Water bearing medium gravel	3	95
	Water bearing yellow sand	2	97
	Water bearing coarse sand-gravel	20	117
	Water bearing medium black sand	2	119
	Water bearing loose medium gravel	16	135
	Water bearing loose coarse gravel	3	138
	Water bearing medium black sand	5	142
	Yellow clay	7	144
Pump	Test:		

Turn up (Over) Sheet of sheets

Well no. 3

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Appli. #3661
Permit #3537

Date Sept. 15, 1954
Record by H. Bottner
Source Well driller's record

Location: State of WASHINGTON
County Clark
Area
Map
NW ¼ NE ¼ sec. 3 T. 3 N., R. 2 E.

DIAGRAM OF SECTION (3)

Drilling Co. H. Bottner
Address Portland, Wash.
Method of Drilling drilled Date 19
Owner TOWN OF BATTLE GROUND
Address Battle Ground, Wash.
Land surface, datum ft. above / below

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	Thickness (feet)	Depth (feet)
	Clay loam topsoil	2	2
	Brown clay & gravel	13	15
	Boulders & clay	10	25
	Gravel & brown sand clay	20	45
	Brown sand clay, some gravel	22	67
	Gravelly sand clay, show of water	3	70
	Sandy gravel	35	105
	Coarse sand & gravel, water bearing	7	112
	Coarse black sand & gravel, water bearing	30	142
	Blue clay	10	152
Pump	Test:		
	Dim: 144' x 12"		
	SWL: 54'		
	Dd: 52'		
	Yield: 400 gpm		

Turn up (Over) Sheet of sheets

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG No. Appli. 3785 Cert. 2284

Date September 15, 1954

Record by H. Bottner

Source Driller's record

Location: State of WASHINGTON

County Clark

Area

Map

NW ¼ NE ¼ sec. 3 T. 3 N., R. 2 E.

Diagram of Section

File number 3N/2E-3B2

Drilling Co. H. Bottner

Address 11544 NE Glisan, Portland 16, Ore.

Method of Drilling drilled Date not given 19

Owner Town of Battle Ground

Address Battle Ground, Wash.

Land surface, datum ft. above/below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Clay loam topsoil	2	2
	Brown clay and gravel	13	15
	Boulders and clay	10	25
	Gravel and brown sand clay	20	45
	Brown sand clay, some gravl	22	67
	Gravelly sand clay, show of water	3	70
	Sandy gravel	35	105
	Coarse sand and gravel water bearing	7	112
	Coarse black sand and gravel, water bearing	30	142
	Blue clay	10	152
Pump	test:		
	Dim: 12" x 144'		

Turn up Sheet of sheets

Appl. 8827
Per. 9492

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

File number: 3/2E-3R

WELL LOG

Record by: Driller
Source: Driller's record

Location: State of WASHINGTON
County: Clark
Area:
Map:
SE ¼ SE ¼ sec. 3 T. 3 N., R. 2 E.

Diagram of Section

Drilling Co. O. J. Norris - Water Well Drilling
Address 4411 N.E. 59th Avenue, Vancouver, Wash.
Method of Drilling Cable Date Aug. 17, 1967
Owner ~~Measow~~ Meadow Glade Water Ass'n
Address Rt. 2, Box 285, Battle Ground, Wash.
Land surface, datum ..... ft. above/below
SWL: 53 Date August 9, 1967 Dims.: 8" x 110'

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	From (feet)	To (feet)
	Municipal supply		
	clay, brown, sandy	0	7
	sand gray & silt with clay binder	7	28
	snad, gravel & Boulders with gray clay binder	28	73
	sand & gravel with clay binder	73	91
	water bearing sand & gravel	91	110
	Casing: 8" from 0' to 100'		
	Screen: Johnson stainless steel Model 25		
	8 slot size 25 from 100' to 110;		
	Surface seal: Bentonite & cement - to 30'		
	Pump test: 138 gpm with 42' DD after 4 hrs.		
	Recovery data: :00 - 82', :01 - 59'6"		
	:15 - 55'7", :30 - 54'7", :45 - 54'1"		
	1:00 - 53'11", 1:15' - 53'8"; 1:30 - 53'6"		
	2:00 - 53"		

Turn up

Sheet ..... of ..... sheets

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G2-23122
Permit No. G2-23122P

(1) **OWNER:** Name Town of Battle Ground Address P.O. Box 233 Battle Ground, WA.

(2) **LOCATION OF WELL:** County Clark NE ¼ SE ¼ Sec 3 T. 3 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 5
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 12 inches.
Drilled 180 ft. Depth of completed well 141 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 16" Diam. from 0 ft. to 43 ft.
Threaded ☐ 12" Diam. from 0 ft. to 105 ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless steel Model No.
Diam. 10" Slot size 60 from 105 ft. to 135 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☒ No ☐ Size of gravel: #6 mesh
Gravel placed from 0 ft. to 141 ft.

Surface seal: Yes ☒ No ☐ To what depth? 43 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 61'7" ft. below top of well Date 8-22-75
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Hansen Drilling
Yield: 100 gal./min. with 30 ft. drawdown after 24 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
+1 M	79'7"	4	69'11"	30	63'2"
2 M	74'5"	5	68'9"	1 Hr.	62'4"
3	71'9"	10	65'10"	3 Hr.	62'0"

Date of test 8-22-75
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 53 F Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	7
Brown clay	7	16
Brown clay w/gravels & boulders	16	20
Brown clay, sand, gravel & boulders	20	33
Brown sandy clay	33	36
Grey & brown clay, gravel & boulders	36	47
Brown sand	47	48
Cemented sand & gravel	48	100
Loose sand & gravel. Water	100	135
Brown clay & gravel	135	140
Blue-green clay	140	154
Brown-green clay	154	160
Grey clay	160	180

This test hole was drilled... starting September 30,1974... NO Permit had been issued...work was not completed on the production well until 1975

Work started 9-30, 19 74. Completed 6-25, 19 75

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co., Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE 58th Ave., Vancouver, WA.

[Signed] 0098 Gerald Desmet (Well Driller) KM Hansen

C51
License No. 223 02 1155 Date Sept. 2, 19 75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G2-23122
Permit No. G2-23122

(1) **OWNER:** Name Town of Battle Ground Address P.O. Box 233 Battle Ground, WA.

(2) **LOCATION OF WELL:** County Clark — NE ¼ SE ¼ Sec. 3 T. 3 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 6
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 12 inches.
Drilled 140 ft. Depth of completed well 140 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 16" Diam. from 0 ft. to 42 ft.
Threaded ☐ 12" Diam. from 0 ft. to 105 ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless steel Model No.
Diam. 10" Slot size 60 from 105 ft. to 135 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☒ No ☐ Size of gravel: #6 mesh
Gravel placed from 0 ft. to 140 ft.

Surface seal: Yes ☒ No ☐ To what depth? 42 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 59'8" ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Hansen Drilling
Yield: 77 gal./min. with 34'5" ft. drawdown after 24 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
1 M	77'10"	6	65'7"	30	60'11"
4	68'4"	8	64'7"	1 Hr.	59'11"
5	66'9"	10	63'6"	3 Hr.	59'9"

Date of test 8-22-75
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	6
Brown clay	6	13
Brown clay, gravel & boulders	13	25
Brown clay, sand, gravel & boulders	25	34
Grey-brown clay, gravel & boulders	34	53
Cemented sand & gravel w/ layers of sand	53	94
Loose sand & gravel	94	136
Blue clay	136	140

Work started 7-8, 1975. Completed 8-22, 197[illegible]

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co., Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE 58th Ave., Vancouver, [illegible]

[Signed] 0098 Gerald Desmet (Well Driller) KM Hansen
C51
License No. 223 02 1155 Date Sept. 2, 19[illegible]

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name ~~XXXX~~ James Paul Dove Address Rt. 3 Box 110 Battle Ground

(2) LOCATION OF WELL: County Clark NW ¼ SW ¼ Sec. 34 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 99 ft. Depth of completed well 99 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 99 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 65 ft. below top of well Date 7-11-74
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 40 gal./min. with 20 ft. drawdown after 1 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
brown soil	0	3
light brown clay	3	12
cemented boulders	12	20
light cemented sand	20	23
light cemented gravel	23	29
clay w/cobbles	29	48
sandy clay brown	48	52
cemented sand, gravel, green	52	60
sand & water	60	61
soft cemented sand, green & gravel H	61	83
cemented sand, gravel	83	87
water, sand, gravel	87	91
sand, gravel, brown	91	95
course sand, gravel, water	95	99

Work started 7-9, 19 74 Completed 7-11, 19 74

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co., Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE 58th Ave. Vancouver

0175 A. L. Harrington

[Signed] Al Harrington (Well Driller) By Km Hansen

051

License No. 223 02 1155 Date July 18, 19 74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

Schlermeister

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name OLIVER SCHREINEISTER Address 11902 NE 228TH X BATTLE GROUND WA

(2) LOCATION OF WELL: County CLARK — NE ¼ SW ¼ Sec. 34 T. 4 N., R. 2E W.M.
Bearing and distance from section or subdivision corner WELL SITE 11902 NE 228TH ST.

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 118 ft. Depth of completed well 115 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 115 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ "" Diam. from "" ft. to "" ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal BENTONITE & SLURRY
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level ..... ft.
Static level 63 ft. below top of well Date 10/25/84
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
AIR ~~Bailer~~ test 35 + gal./min. with MAX ft. drawdown after 2 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
CLAY BROWN	0	14
BOULDER & CLAY	14	28
GRAVEL & CLAY BROWN	28	44
CLAY BROWN	44	48
GRAVEL & CLAY	48	70
SAND BROWN DRY	70	81
GRAVEL LARGE	81	90
GRAVEL CEMENTED	90	104
GRAVB & SAND WATER BR	104	117

RECEIVED DEC 12 1984 SW REGIONAL OFFICE

Work started 10/23/1984 Completed 10/25/1984

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CHRISTENSEN WELL DRILLING (Person, firm, or corporation) (Type or print)
Address 12809 NE 25TH AVE VANC. WN.
[Signed] C G Christensen (Well Driller)
License No. 0068 Date 10/25/1984

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 035664

Water Right Permit No.

(1) OWNER: Name City of Battle Ground Address P.O. Box 37 Battle Ground, Wa. 98604

(2) LOCATION OF WELL: County Clark SE ¼ NE ¼ Sec. 34 T. 4 N., R. 2E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [XX] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned [ ] New well [XX] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [XX] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 518 feet. Depth of completed well 161 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 8 " Diam. from + 2 ft. to 116 ft.
Welded [XX] 6 " Diam. from 113 ft. to 161 ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [XX] No [ ]
Type of perforator used Torch
SIZE of perforations 3/16 in. by 6 in.
264 perforations from 113 ft. to 161 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [XX]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [XX] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [XX] No [ ] To what depth? 35 ft.
Material used in seal Bentonite &hole plug
Did any strata contain unusable water? Yes [ ] No [XX]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 74 ft. below top of well Date 7-14-89
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: 37 gal./min. with 29 ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [XX]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top soil	0	2
Sandy clay water, leaking from	2	9
creek	9	11
Lt. Brown clay	11	17
Broken rock brown clay	17	35
Grey rock broken	35	42
Gravel & cobbles	42	51
Silty sand & gravel	51	68
Sand brown clay & gravel	68	79
Mucky sand brown, wet, some gravel	79	113
Sand & gravel 8010 GPM blew		
Sand & gravel partly cemented	113	128
belw 15 GPM @ 117'	128	145
Gravel sand	145	153
Sand & gravel cemented layers	153	158
Looser sand & gravel blew 60 GPM	158	165
Gravel lt. brown clay	165	170
Sandy blue clay	170	185
Grey clay	185	205
Brown & red clay	205	230
Brown sandstone & brown clay		
Green & blue shale & soft brown	230	245
rock	245	265
Grey shaley rock w/grey clay seams	265	285
Brown rock	285	373
Grey rock	373	378
Fractured rock brown & grey	378	459
Grey rock hard	459	491
Grey rock soft	491	518
Fractured grey rock		

Work started 6-13-89, 19. Completed 7-14-89, 19.

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Hansen Drilling Co. Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 6711 NE 58th Ave. Vancouver, Wa. 9866
(Signed) [signature] (WELL DRILLER) License No. 0006
Contractor's Registration No. HANSED*377NT Date July 20, 1989, 19.

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 063110

Water Right Permit No. ____

(1) **OWNER:** Name Island Mechanical--BG School Address PO Box 17264, Portland, OR, 97217

(2) **LOCATION OF WELL:** County Clark SE ¼ NE ¼ Sec 34 T. 4N N., R. 2E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) 800 N Sixth, Battle Ground Elementary School

(3) **PROPOSED USE:** ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☒

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ____
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 173 feet. Depth of completed well 170 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6 " Diam. from 0 ft. to 159 ft.
Welded ☒ 4.5 PVC " Diam. from 158 ft. to 160 ft.
Liner installed ☒
Threaded ☐ ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type stainless steel Model No. ____
Diam. 6 Slot size 30 from 160 ft. to 165 ft.
Diam. ____ Slot size 25 from 165 ft. to 170 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 50 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) **PUMP:** Manufacturer's Name ____
Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ____ ft.
Static level 73 ft. below top of well Date 3-1-90
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 18 gal./min. with 2 ft. drawdown after 1 hrs.
Airtest 60 gal./min. with stem set at 170 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil and subsoil	0	3
Clay, brown, sticky	3	19
Clay, brown, with broken rock	19	56
Broken rock with gray clay	56	75
Gravel, brown and black, partially cemented with cobbles	75	115
Gravel, brown and black, partially cemented, waterbearing with brown sand and silt	115	125
Gravel, brown and black, loose, waterbearing	125	172
Clay, tan	172	173

Work started 2-28-90, 19__. Completed 3-1-90, 19__

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief.

NAME Ritola Well Drilling 14214 NE 202nd Avenue (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address Brush Prairie, WA 98606

(Signed) Charles L. Ritola (WELL DRILLER) License No. 1501

Contractor's Registration No. RITOLWD251MM Date 3-8-90, 19__

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 063109

Water Right Permit No. ____

(1) **OWNER:** Name Island Mechanical-Battle Ground School Address P.O. Box 17264, Portland, OR 97217

(2) **LOCATION OF WELL:** County Clark SE ¼ NE ¼ Sec. 34 T. 4N N., R. 2E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) 800 North Sixth, Battl e Ground

(3) **PROPOSED USE:** ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ____
Abandoned ☐ New well [X] Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary [X] Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 163 feet. Depth of completed well 163 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6 " Diam. from 0 ft. to 152 ft.
Welded [X] / Liner installed [X] 4.5 PVC Diam. from 151 ft. to 153 ft.
Threaded ☐ ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [X] No ☐
Manufacturer's Name Cook
Type stainless steel Model No. ____
Diam. 6 Slot size 70 from 153 ft. to 163 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No ☐ To what depth? 56 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes ☐ No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) **PUMP:** Manufacturer's Name ____
Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ____ ft.
Static level 77 ft. below top of well Date 3-7-90
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No [X] If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 18 gal./min. with 1 ft. drawdown after 1 hrs.
Airtest 73 gal./min. with stem set at 140 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No [X]

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil and subsoil	0	2
Clay, brown, sticky	2	10
Clay, brown, with broken rock	10	54
Broken rock with gray clay	54	77
Gravel, brown and black, partially cemented with cobbles	77	100
Gravel, brown and black, loose with brown sand and red silt	100	163

Work started 3-5-90, 19 . Completed 3-7-90, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Ritola Well Drilling 14214 NE 202nd Avenue
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address Brush Prairie, WA 98606

(Signed) [signature] (WELL DRILLER) License No. 1597

Contractor's Registration No. RITOLWD251MM Date 3-8-90, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1220-

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 065663
Water Right Permit No. ___________
Page 1 of 1

(1) OWNER: Name Loren Seppanen   Address 23606 NE Worthington Road Yacolt WA 98675

(2) LOCATION OF WELL: County Clark   NE 1/4 NE 1/4 Sec 34 T 4 N R 2 EM

(2a) STREET ADDRESS OF WELL (or nearest address) 237th West off 132nd Avenue WA

(3) PROPOSED USE: DOMESTIC   Owner Well ID 1

(4) Type of work: NEW WELL
Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 129 feet. Depth of completed well 122 ft.

(6) CONSTRUCTION DETAILS:
Casing instld: 6 " Diam. from 0 ft. to 121 ft.
Welded X 4"cls200" Diam. from 107 ft. to 127 ft.
Liner _ ________" Diam. from _____ ft. to _____ ft.
Threaded _

Perforations: Yes X No _
Type of perforator used DRILL
Size of perforations 1/4 in. by 4 in.
22 perforations from 117 ft. to 122 in.
__________ perforations from ________ ft. to ________ in.
__________ perforations from ________ ft. to ________ in.

Screens: Yes _ No X
Manufacturer's Name ____________________
Type ____________________ Model No ___________
Diam _______ Slot size ______ from ______ ft. to ______ ft.
Diam _______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes _ No X Size of gravel ______________
Gravel placed from _____________ ft. to _____________ ft.

Surface seal: Yes X No _ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes _ No X
Type of water? ______________ Depth of strata __________
Method of sealing strata off ____________________

(7) PUMP: Manufacturer's Name ____________________
Type ____________________ H.P. _______

(8) WATER LEVELS: Surface elev above mean sea level _______ ft.
Static level 97 ft. below top of well Date 01/25/91
Artesian pressure ______ lbs. per sq. in. Date
Artesian pressure is controlled by ____________________

(9) WELL TESTS: Pump test made? ___ By whom? _______________
Yield _______ gal./min. with ___ ft. drawdown after ___ hrs
Yield _______ gal./min. with ___ ft. drawdown after ___ hrs
Yield _______ gal./min. with ___ ft. drawdown after ___ hrs
Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.

Date of test
Bailer test _______ gal/min with ____ ft. drawdown after ____ hr
Airtest 15 gal/min with stem set at 120 ft. for 1 hrs
Artesian flow _______ gal/min Date
Temperature of water ______ Was chemical analysis made? YES

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Topsoil, brown, soft	0	1
Subsoil, clay, tan, soft	1	19
Rock, broken, brown, clay	19	35
Gravel and cobbles	35	50
Clay, blue gray, medium	50	83
Gravel, with some tan sand	83	124
Gravel, with some sand, waterbearing	124	129

Hardness - 1.5 to 2
PH - 8
Iron - trace

Work Started 01/25/91   Completed 01/25/91

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.
Name RITOLA WELL DRILLING
Address 14214 NE 202nd Avenue Brush Prairie WA 98606

(Signed) ____________________ License No 1878
(Well Driller)

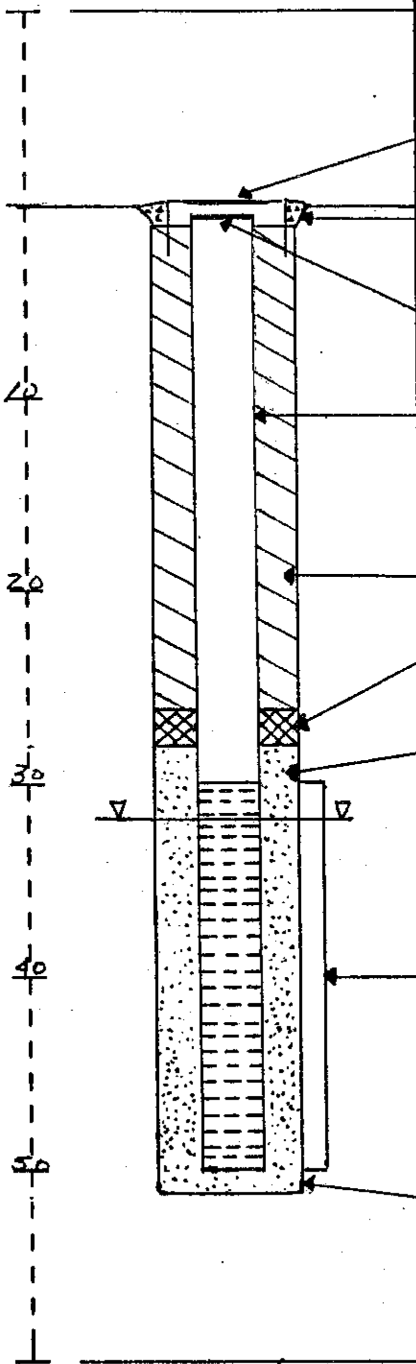
Contractor's Registration No. RITOLWD251MM   Date 01/25/91

12 MAR 91 2 26

RESOURCE PROTECTION WELL REPORT

START CARD NO. 063658

PROJECT NAME: BATTLE GROUND SCHOOL DISTRICT
COUNTY: CLARK
WELL IDENTIFICATION NO. B-4 MW-2
LOCATION: SE 1/4 SE 1/4 Sec 34 Twn 4N R 2E
DRILLING METHOD: Dual Wall Percussion hammer AP-1000
STREET ADDRESS OF WELL: 204 West Main ST Battleground, WA
DRILLER: DERRY LOWNER
FIRM: LAYNE ENVIRONMENTAL SERVICES
WATER LEVEL ELEVATION: 33'
SIGNATURE: [signature]
GROUND SURFACE ELEVATION: 280
CONSULTING FIRM: SRH ENVIROMENTAL MANAGEMENT
INSTALLED: 2-14-91
REPRESENTATIVE: MIKE GREENE
DEVELOPED: 2-19-91

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	Flush mounted Christy box	
	Concrete surface seal	MOTTLED Brown, gray and black; pebbly, silty, sandy clay
	Locking expansion plug w/ lock	
	4" Sch 40 TFI PVC blank	Remant sedimentary structures
	Cement/bentonite annular seal	
	Bentonite Plug 26'-28'	
	Filter pack 28' to 51 Colorado Silica Sand 10-20	Less clay, more sand
	Potentiometric surface	
	Screened interval 30'-50' 4" Sch 40 .020 factory slotted TFI PVC with threaded bottom cap	DRY, medium brown, silty pebbly, fine to course sand
		Wet, medium brown, clayey fine to course sandy gravel w/ pebbles & cobbles Very tight
	51' Total Depth Borehole diameter 9"	NOTE: WATER encountered @ 45' rose to 33' after 24 hrs.

SCALE: 1" = 10'

PAGE 1 OF 1

ECY 050-12 (Rev. 11/89)

12 MAR 91

RESOURCE PROTECTION WELL REPORT

START CARD NO. 063658

PROJECT NAME: Battleground School District

WELL IDENTIFICATION NO. B-5 MW-3

DRILLING METHOD: Dual Wall Percussion hammer AP-1000

DRILLER: Jerry Lodder

FIRM: Layne Enviromental Services

SIGNATURE:

CONSULTING FIRM: SAH Enviromental Management

REPRESENTATIVE: Mike Greene

COUNTY: Clark

LOCATION: SE ¼ SE ¼ Sec 34 Twn 4N R 2E

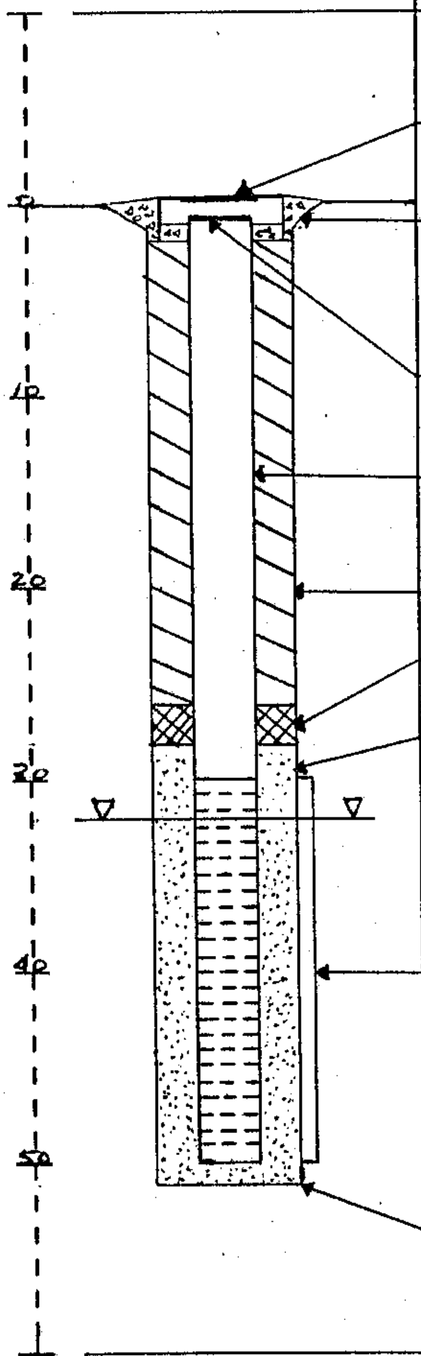
STREET ADDRESS OF WELL: 204 West Main ST Battle Ground WA

WATER LEVEL ELEVATION: 32.5'

GROUND SURFACE ELEVATION: 280

INSTALLED: 2-14-91

DEVELOPED: 2-19-91

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	Flush mounted Christy box Concrete surface seal Locking expansion plug w/ lock 4" Sch 40 TFI PVC blank Cement/bentonite annular seal Bentonite Plug 26-28' Filter pack 28'-51' Colorado Silica Sand 10-20 Potentiometric surface Screened Interval 30'-50' 4" Sch 40 .020 factory slotted TFI PVC w/ bottom cap Bore hole diameter 9" 51' Total depth	0–30: mottled brown, gray + black; pebbly, sandy, silty clay 30–40: mottled brown, gray + black; clayey, silty, fine to course sandy, pebble gravel 40–51: mottled brown, gray + black; silty, fine to course sandy pebble gravel Note: water encountered @ 40' rose to 32.5' after several hours.

SCALE: 1" = 10'

PAGE 1 OF 1

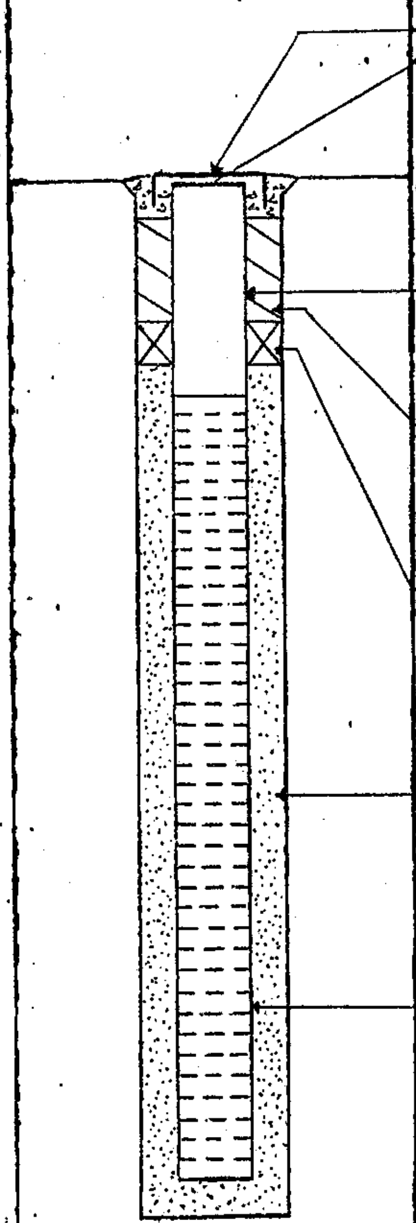
ECY 050-12 (Rev. 11/89)

RESOURCE PROTECTION WELL REPORT

START CARD NO. 044765

PROJECT NAME: BATTLEGROUND SCHOOL DISTRICT
WELL IDENTIFICATION NO. MW-5
DRILLING METHOD: Dual Wall Percussion Hammer
DRILLER: BILL JESKEY
FIRM: Layne Environmental Services, Inc.
SIGNATURE: Bill Jeskey
CONSULTING FIRM: SRH GROUP
REPRESENTATIVE: WESS GREENWOOD

COUNTY: Clark
LOCATION: SE 1/4 SE 1/4 Sec 34 Twn 4N R 2E
STREET ADDRESS OF WELL: 204 West Main ST. BATTLEGROUND, WA
WATER LEVEL ELEVATION:
GROUND SURFACE ELEVATION: 280'
INSTALLED: 6-17-91
DEVELOPED: 6-25-91

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	Flush Mounted Monument Expansion plug with lock Concrete Surface Seal 0 to 2 ft Well csg 0 to 8.5 ft 4" SCH 40 TFJ PVC Annular Sealant 2 to 4.5 ft Cement/Bentonite Seal 4.5 to 6.5 ft 1/4" Bentonite pellets Filter Pack 6.5 to 42 ft 10-20 Colorado Silica Sand Screened Interval 8.5 to 38.5 ft 4" SCH 40 TFJ PVC 020 Factory Slotted	0-2 Asphalt + crushed rock (Fill) 2-8 Silty clay, reddish brown 8-12 Clay, reddish gray-gray 12-16 Sandy clay w/gravel reddish brown-brown 16-42 Sandy gravel, reddish brown, medium sand w/poorly sorted well rounded gravels.
Total Depth 42 ft Hole Diameter 9 in		

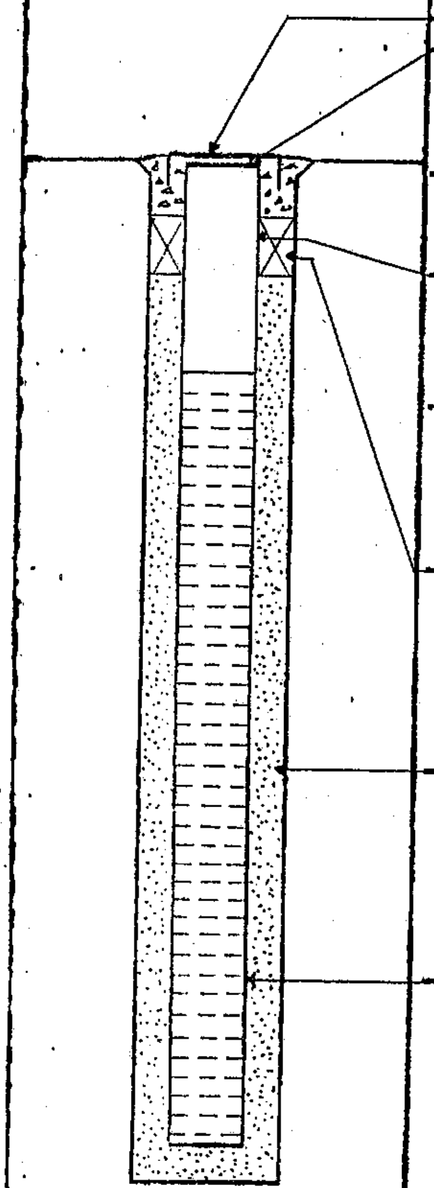
Layne Environmental Services, Inc.

RESOURCE PROTECTION WELL REPORT

START CARD NO. 044763

PROJECT NAME: Battleground School District
WELL IDENTIFICATION NO. MW-1
DRILLING METHOD: Dual Wall Percussion hammer
DRILLER: Bill Jeskey
FIRM: Layne Environmental Services, Inc.
SIGNATURE: [signature]
CONSULTING FIRM: SRH Group
REPRESENTATIVE: Wes Greenwood

COUNTY: Clark
LOCATION: SE 1/4 SE 1/4 Sec 34 Twn 4N R 2E
STREET ADDRESS OF WELL: 204 West Main St Battleground, WA
WATER LEVEL ELEVATION: 28'
GROUND SURFACE ELEVATION: 280'
INSTALLED: 6-18-91
DEVELOPED: 6-25-91

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	-Flush Mounted Monument -Expansion plug with lock -Concrete Surface Seal 0 to 4 ft -Well csg 0 to 9 ft 4" SCH 40 TFJ PVC -Annular Sealant ___ to ___ ft -Seal 4 to 6 ft Bentonite pellets -Filter Pack 6 to 39 ft 10-20 Colorado Silica Sand -Screened Interval 9 to 39 ft 4" SCH 40 TFJ PVC 020 Factory Slotted	0-18 Reddish brown/brown medium sand, Concrete debris (Fill) 18-30 Sandy gravel, reddish brown, well rounded, poorly sorted, medium grained sand - hydrocarbon background odor 30-39 Sandy gravel w/clay Reddish brown. med. grained Sand Well rounded poorly sorted gravel
Total Depth 39 ft Hole Diameter 9 in		

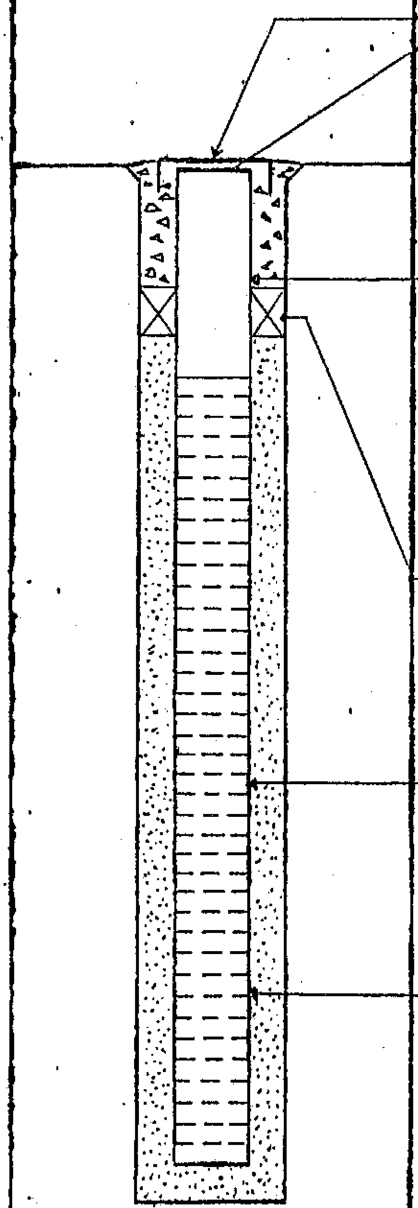
Layne Environmental Services, Inc.

RESOURCE PROTECTION WELL REPORT

START CARD NO. C44763

PROJECT NAME: Battleground School District
WELL IDENTIFICATION NO. MW-6
DRILLING METHOD: Dual Wall Percussion hammer
DRILLER: Bill Jeskey
FIRM: Layne Environmental Services, Inc.
SIGNATURE: Bill Jeskey
CONSULTING FIRM: SRH Group
REPRESENTATIVE: Wes Greenwood

COUNTY: Clark
LOCATION: SE 1/4 SE 1/4 Sec 31 Twn 4N R 2E
STREET ADDRESS OF WELL: 204 West Main St Battleground, WA
WATER LEVEL ELEVATION:
GROUND SURFACE ELEVATION: 280'
INSTALLED: 6-18-91
DEVELOPED: 6-25-91

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	-Flush Mounted Monument -Expansion plug with lock -Concrete Surface Seal 0 to 4 ft -Well csg 0 to 8 ft 4" SCH 40 TFJ PVC -Annular Sealant ___ to ___ ft -Seal 4 to 6 ft 1/4" Bentonite pellets -Filter Pack 6 to 38 ft 10-20 Colorado Silica Sand -Screened Interval 8 to 39 ft 4" SCH 40 TFJ PVC 020 Factory Slotted	0-5 Silt, brown-reddish brown 5-10 Silty clay w/gravel reddish brown. 10-14 Clay, reddish gray-gray 14-39 Sandy gravel, reddish brown, med. sand w/well rounded poorly sorted gravel
Total Depth 39 ft Hole Diameter 9 in		

Layne Environmental Services, Inc.

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 045296
Water Right Permit No. ____________
Page 1 of 1

(1) OWNER: Name Loren Seppanen — Address 23606 NE Worthington Road Yacolt WA 98675
(2) LOCATION OF WELL: County Clark — NE 1/4 NE 1/4 Sec 34 T 4 N R 2 EM
(2a) STREET ADDRESS OF WELL (or nearest address) approx 237 West off 132nd Avenue

(3) PROPOSED USE: DOMESTIC Owner Well ID 3
(4) Type of work: NEW WELL
Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 115 feet. Depth of completed well 115 ft.

(6) CONSTRUCTION DETAILS:
Casing instld: 6 " Diam. from 0 ft. to 115 ft.
Welded X ______ " Diam. from _____ ft. to _____ ft.
Liner _ ______ " Diam. from _____ ft. to _____ ft.
Threaded _

Perforations: Yes _ No X
Type of perforator used ____________
Size of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ in.
______ perforations from ______ ft. to ______ in.
______ perforations from ______ ft. to ______ in.

Screens: Yes _ No X
Manufacturer's Name ____________
Type ____________ Model No ______
Diam ______ Slot size _____ from _____ ft. to _____ ft.
Diam ______ Slot size _____ from _____ ft. to _____ ft.

Gravel packed: Yes _ No X Size of gravel ____________
Gravel placed from ____________ ft. to ____________ ft.

Surface seal: Yes X No _ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes _ No X
Type of water? ____________ Depth of strata ______
Method of sealing strata off ____________

(7) PUMP: Manufacturer's Name ____________
Type ____________ H.P. ______

(8) WATER LEVELS: Surface elev above mean sea level ______ ft.
Static level 85 ft. below top of well Date 10/28/91
Artesian pressure ______ lbs. per sq. in. Date
Artesian pressure is controlled by ____________

(9) WELL TESTS: Pump test made? ___ By whom? ____________
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.

Date of test
Bailer test ______ gal/min with ____ ft. drawdown after ____ hr
Airtest 12 gal/min with stem set at 107 ft. for 1 hrs
Artesian flow ______ gal/min Date
Temperature of water ______ Was chemical analysis made? YES

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Topsoil and subsoil	0	10
Broken lava rock, tan clay and boulders	10	24
Gravel, brown and black with broken rock, boulders and cobbles	24	34
Gravel, brown and black, with brown sand, silt and clay	34	70
Clay, tan, sandy, soft	70	76
Gravel, brown and black, cemented with gray sand	76	95
Gravel, brown and black, partially cemented with gray sand	95	108
Gravel, brown and black, loose with gray sand waterbearing	108	115

Iron - .5 ppm or less
Hardness - 5 gpg
P.H. - 7.5

Work Started 10/24/91 Completed 10/28/91

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.
Name RITOLA WELL DRILLING
Address 14214 NE 202nd Avenue Brush Prairie WA 98606
(Signed) [signature] (Well Driller) License No 1501
Contractor's Registration No. RITOLWD251MM Date 10/29/91
Based on form ECY 050 1-20 (10/87) -1329- by Speed Systems Corp

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 045317
Water Right Permit No. ______
Page 1 of 1

(1) OWNER: Name Loren Seppanen Address 23606 NE Worthington Road Yacolt WA 98675
(2) LOCATION OF WELL: County Clark NE 1/4 NE 1/4 Sec 34 T 4 N R 2 EM
(2a) STREET ADDRESS OF WELL (or nearest address) approx 237 West off 132nd Avenue Battle Ground WA 98604

(3) PROPOSED USE: DOMESTIC Owner Well ID 4
(4) Type of work: NEW WELL
Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 132 feet. Depth of completed well 130 ft.

(6) CONSTRUCTION DETAILS:
Casing instld: 6 " Diam. from 0 ft. to 130 ft.
Welded X ______ " Diam. from ____ ft. to ____ ft.
Liner _ ______ " Diam. from ____ ft. to ____ ft.
Threaded _

Perforations: Yes _ No X
Type of perforator used ______
Size of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ in.
______ perforations from ______ ft. to ______ in.
______ perforations from ______ ft. to ______ in.

Screens: Yes _ No X
Manufacturer's Name ______
Type ______ Model No ______
Diam ______ Slot size ______ from ______ ft. to ______ ft.
Diam ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes _ No X Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes X No _ To what depth? 36 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes _ No X
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type ______ H.P. ______

(8) WATER LEVELS: Surface elev above mean sea level ______ ft.
Static level 92 ft. below top of well Date 02/20/92
Artesian pressure ______ lbs. per sq. in. Date
Artesian pressure is controlled by ______

(9) WELL TESTS: Pump test made? ___ By whom? ______
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.

Date of test
Bailer test ______ gal/min with ____ ft. drawdown after ____ hr
Airtest 15 gal/min with stem set at 118 ft. for 1 hrs
Artesian flow ______ gal/min Date
Temperature of water ______ Was chemical analysis made? YES

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Topsoil and subsoil	0	7
Clay, brown, sticky	7	15
Broken lava rock, boulders and brown clay binder	15	51
Brown clay	51	54
Gray clay	54	61
Clay, brown sandy with some gravel	61	66
Sand, brown with tan clay, waterbearing	66	75
Clay, gray, sticky	75	81
Gravel, black and brown, partially cemented with tan clay	81	100
Gravel, black and brown, cemented	100	121
Sand, gray, fine gravel, waterbearing	121	125
Gravel, cemented	125	128
Gray, sand and gravel, waterbearing	128	132
Iron - .5 ppm or less		
Hardness - 4 gpg		
P.H. - 7.5		

Work Started 02/19/92 Completed 02/21/92

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.
Name RITOLA WELL DRILLING
Address 14214 NE 202nd Avenue Brush Prairie WA 98606
(Signed) ______ License No 1501
(Well Driller)
Contractor's Registration No. RITOLWD251MM Date 02/24/92
Based on form ECY 050 1-20 (10/87) -1329- by Speed Systems Corp.

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 203706
Water Right Permit No. ________
Page 1 of 1

(1) OWNER: Name Loren Seppanen Address 23606 NE Worthington Road Yacolt WA 98675
(2) LOCATION OF WELL: County Clark NE 1/4 NE 1/4 Sec 34 T 4 N R 2E EM
(2a) STREET ADDRESS OF WELL (or nearest address) Subdivisio aprx 237th Street West off 132 Avenue 1st left lot

(3) PROPOSED USE: DOMESTIC Owner Well ID 7
(4) Type of work: NEW WELL
Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 139 feet. Depth of completed well 138 ft.

(6) CONSTRUCTION DETAILS:
Casing instld: 6 " Diam. from 0 ft. to 138 ft.
Welded X ____ " Diam. from ____ ft. to ____ ft.
Liner _ ____ " Diam. from ____ ft. to ____ ft.
Threaded _

Perforations: Yes _ No X
Type of perforator used ________
Size of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ in.
____ perforations from ____ ft. to ____ in.
____ perforations from ____ ft. to ____ in.

Screens: Yes _ No X
Manufacturer's Name ________
Type ________ Model No ____
Diam ____ Slot size ____ from ____ ft. to ____ ft.
Diam ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes _ No X Size of gravel ________
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes X No _ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes _ No X
Type of water? ____ Depth of strata ____
Method of sealing strata off ________

(7) PUMP: Manufacturer's Name ________
Type ________ H.P. ____

(8) WATER LEVELS: Surface elev above mean sea level ____ ft.
Static level 95 ft. below top of well Date 04/27/92
Artesian pressure ____ lbs. per sq. in. Date
Artesian pressure is controlled by ________

(9) WELL TESTS: Pump test made? ___ By whom? ________
Yield ____ gal./min. with ___ ft. drawdown after ___ hrs
Yield ____ gal./min. with ___ ft. drawdown after ___ hrs
Yield ____ gal./min. with ___ ft. drawdown after ___ hrs
Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.

Date of test
Bailer test ____ gal/min with ____ ft. drawdown after ____ hr
Airtest 22 gal/min with stem set at 130 ft. for 1 hrs
Artesian flow ____ gal/min Date
Temperature of water ____ Was chemical analysis made? YES

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Topsoil and subsoil	0	22
Cobbles and brown clay	22	25
Boulders, cobbles and brown clay	25	38
Broken lava rock and brown clay	38	54
Clay, rusty red	54	58
Clay, gray and blue, sticky	58	68
Sandy, gray clay and gravel	68	84
Gravel, brown and black, partially cemented	84	105
Gravel, brown and black with cobbles and brown silt	105	122
Gravel, brown and black, partially cemented waterbearing with seams of brown medium to fine sand	122	139
Iron - .5 ppm or less		
Hardness - 4 gpg		
P.H. - 7.5		

Work Started 04/27/92 Completed 04/28/92

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reporte above are true to my best knowledge and belief.
Name RITOLA WELL DRILLING
Address 14214 NE 202nd Avenue Brush Prairie WA 98606
(Signed) [signature] License No 1501
(Well Driller)
Contractor's Registration No. RITOLWD251MM Date 04/30/92
Based on form ECY 050 1-20 (10/87) -1329- by Speed Systems Corp

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Ron Sieigman Address Rt1 Box 462H - Battleground, Wash

(2) LOCATION OF WELL: County Clark — ¼ NW ¼ Sec 35 T 4 N., R 2E W.M.
NE NW-

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) DIMENSIONS: Diameter of well 10 inches.
Drilled 23 ft. Depth of completed well 115 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 23 ft.
Threaded ☐ 5" Diam. from 15 ft. to 75 ft.
Welded ☑ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☑ No ☐
Type of perforator used Torch
SIZE of perforations ¼ in. by 3 in.
.... perforations from 50 ft. to 75 ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☑ No ☐ Size of gravel: ....
Gravel placed from 100 ft. to 115 ft.

Surface seal: Yes ☑ No ☐ To what depth? 23 ft.
Material used in seal ....
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 45 ft. below top of well Date 6-21-74
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top Soil	0	2
Clay Yellow	2	5
Bolders	5	15
Basalt Gray	15	35
Fractured Basalt Black	35	50
Sandy Shale	50	100
Sandy Clay	100	115

Work started ...., 19.... Completed ...., 19....

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME SWIFT WATER WELL DRILLING INC (Person, firm, or corporation) (Type or print)

Address 4215 W. 6th Ptld, ORE 97204

[Signed] Russell Smith (Well Driller)

License No. [illegible] Date 6-21, 1974

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Bertha Wolf   Address 4X1 Box 437 Battle Ground, Wash

(2) LOCATION OF WELL: County Clark   SE¼ SE¼ NE¼ Sec 35 T 4 N., R 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 58 ft. Depth of completed well 58 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 2 ft. to 47½ ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☐ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☑
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☑ No ☐ To what depth? 19 ft.
Material used in seal.....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 18 ft. below top of well Date.....
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?.....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test 10 gal./min. with 30 ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Top Soil	0	1
Clay, Tan, gummy	1	13
Gravel, Clay, Tan	13	14
Clay, Tan	14	16
Basalt, Black & Brown, broken Weathered	16	17
Clay, Tan	17	21
Gravel, Black - Clay, Tan	21	31
Clay, Tan	31	35
Gravel	35	36
Clay, Tan - Gravel fine Hard formation	36	45
Clay blue - Gravel, fine	45	48
Gravel, fine - with Clay water bearing	48	52
Clay, Light blue	52	53
Claystone, blue	53	58

Work started 8/2 1975 Completed 8/5 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Ritola Well Drilling (Person, firm, or corporation) (Type or print)
Address 14314 NE 202nd Ave Brush Prairie Wash.

[Signed] David Ritola (Well Driller)

License No. 0423 Date 8/5, 197

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Dale Lang Address ....

(2) LOCATION OF WELL: County Clark NW ¼ NW ¼ Sec 35 T. 4 N., R. 2 E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 110 ft. Depth of completed well 99 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 99 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 50 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name ..... H.P. .....
Type: .....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 400 ft.
Static level 80 ft. below top of well Date 7/11/77
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Air Flow test 15 gal./min. with 19 ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil	0	1
Gray Basalt	1	33
Sand, Gravel + Boulders	33	110
Blue Clay	110	

RECEIVED JUL 1 8 1977 DEPARTMENT OF ECOLOGY SOUTHWEST REGIONAL OFFICE

Work started 7/8/77, 19..... Completed 7/11, 19...

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report true to the best of my knowledge and belief.

NAME H + L Const. (Person, firm, or corporation) (Type or print)

Address 24022 NE 29th Ave Ridgefield

[Signed] Tom Leonard (Well Driller)

License No. 275 Date 7/11, 19.....

(USE ADDITIONAL SHEETS IF NECESSARY)

#1 Hanson

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Randy Hanson Address 13219 NE 238th ST

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec 35 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 75 ft. Depth of completed well 75 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from +1 ft. to 75 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 30 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P.....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 700 ft.
Static level 42 ft. below top of well Date Mar 22 78
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?.....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

~~Date~~ air flow of test
~~Bailer~~ test 21 gal./min. with 33 ft. drawdown after 1 hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil & Boulders	0	10
Gray Basalt	10	30
Gravels	30	75

Work started 21 Mar, 19 78 Completed 22 Mar, 19 78

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME K&L Construction, Inc. (Person, firm, or corporation) (Type or print)

Address 24022 NE 29th Ave.

[Signed] Kenneth H Webber (Well Driller)

License No 0672 Date 3-22, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

H [illegible] Hanson

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) **OWNER:** Name Randy Hanson Address [illegible] NE 338th St.

(2) **LOCATION OF WELL:** County Clark — NW ¼ NW ¼ Sec 35 T 4 N., R 2E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 152 ft. Depth of completed well 152 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from +1 ft. to 152 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) **PUMP:** Manufacturer's Name ......
Type: ...... H.P. ......

(8) **WATER LEVELS:** Land-surface elevation above mean sea level .... 500 ft.
Static level 105 ft. below top of well Date Mar 30 78
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ......
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
~~Bailer test~~ air flow 10 gal./min. with 47 ft. drawdown after 1 hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil	0	1
Brown Clay & Boulders	1	6
Gray Basalt	6	35
Gravels	35	77
Brown Clay	77	97
Gravels	97	157

RECEIVED
APR 7 1978
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 29 Mar, 1978 Completed 30 Mar, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME K & L Construction, Inc. Kenneth H [illegible]
(Person, firm, or corporation) (Type or print)

Address 24022 NE 29th Ave. Ridgefield, WA

[Signed] Kenneth H [illegible]
(Well Driller)

License No. 0672 Date 3-30, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

#3 Hanson

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Randy Hanson Address NE 238th St.

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec. 35 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 77 ft. Depth of completed well 77 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from +3 ft. to 77 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.......
Type...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?...... Depth of strata......
Method of sealing strata off......

(7) PUMP: Manufacturer's Name......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 500 ft.
Static level 42 ft. below top of well Date 3/31/78
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

air Blow
~~Date~~ of test 1
~~Bailer~~ test 8 gal./min. with 35 ft. drawdown after 1 hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil	0	1
Brown Clay	1	4
Gray Basalt	4	35
Gravels	35	77

RECEIVED
APR 7 1978
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 3/30, 1978 Completed 3/31, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME K & L Construction, Inc. (Person, firm, or corporation) (Type or print)

Address 24022 NE 29th Ave. Ridgefield, WA

[Signed] Kenneth H. Walker (Well Driller)

License No. 0672 Date 3-31-78, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

4 Hanson

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Randy Hanson Address NE 238th St.

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec 35 T 4 N., R 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 82 ft. Depth of completed well 82 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from +3 ft. to 82 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 36 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 500 ft.
Static level 41 ft. below top of well Date April 4, 77
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
~~Bailer~~ air blow test 8 gal./min. with 41 ft. drawdown after 1 hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil	0	1
Brown Clay	1	4
Boulders	4	36
Gravels	36	82

RECEIVED
APR 7 1978
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 30 Mar., 1978 Completed April 4, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME K & L Construction, Inc. (Person, firm, or corporation) (Type or print)

Address 24022 NE 29th Ave. Ridgefield, WA

[Signed] Kenneth H. [signature] (Well Driller)

License No. 0672 Date 4-4, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) **OWNER:** Name Randy Hanson Address 13313 NE 238th St Battle Ground, Wa

(2) **LOCATION OF WELL:** County Clark NW¼ - NW ¼ NW ¼ Sec 35 T. 4 N., R 2E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 79 ft. Depth of completed well 77 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from 0 ft. to [redacted] 75 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☑ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☑
Type of perforator used..........
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name..........
Type.......... Model No..........
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ....
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water?...... Depth of strata......
Method of sealing strata off......

(7) **PUMP:** Manufacturer's Name.......... H.P......
Type: ....

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... ft.
Static level [redacted]51 ft. below top of well Date 6/28/79
Artesian pressure ...... lbs. per square inch Date......
Artesian water is controlled by...... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
Airlift 16 Gpm at 70 ft after 1 hour
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test...... gal./min. with...... ft. drawdown after...... hrs.
Artesian flow...... g.p.m. Date......
Temperature of water...... Was a chemical analysis made? Yes ☑ No ☐
Iron Less Than .5ppm
PH 7.5
Hardness 3gpg

(10) **WELL LOG:**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Topsoil	0	1
Clay, Brown with Lava boulders	1	7
Basalt, gray	7	43
Lava Cobbles & gravel with Brown Clay	43	49
Lava gravel, Loose Waterbearing	49	50
Lava Cobbles & gravel with Brown Clay binder	50	74
Lava gravel, Loose Water bearing	74	76
Lava gravel with Brown Clay binder	76	78

RECEIVED
AUG 8 1979
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 6/27, 1979. Completed 6/28, 197[illegible]

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report true to the best of my knowledge and belief.

NAME RITOLA WELL DRILLING (Person, firm, or corporation) (Type or print)
Address 14214 N.E. 202nd Ave. - Ph. 892-4764 Brush Prairie, Wash. 98606

[Signed] David Ritola (Well Driller)

License No. 423 Date 6/29, 197[illegible]

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Ken Cobb Address 23601 N.E. 132nd. Ave. Battle Ground, Wa.

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec 35 T 4 N., R 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 90 ft. Depth of completed well 80 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 80 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 30 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level ..... ft.
Static level 53 ft. below top of well Date 7-19-79
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test 18 gal./min. with 12 ft. drawdown after 2 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top Soil	0	1'
Clay, Brown	1'	9'
Rock, Grey; Volcanic	9'	51'
Gravel, Sand Brown;	51'	90'
Loose Water-Bering		

RECEIVED
AUG 13 1979
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 7-5, 1979 Completed 7-19, 1979

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME NORRIS DRILLING & PUMP CO., INC. (Person, firm, or corporation) (Type or print)

Address 11026 St. Johns Blvd. Vanc. Wa. 98665

[Signed] Randy V. Anderson (Well Driller)

License No. 0770 Date 7-20, 1979

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Shainin & Associates Inc Mail Address P.O. Box 485 Burlington, Washington 98233

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec 35 T 4 N., R 2 W.M.
Bearing and distance from section or subdivision corner For: Sacred Hearts Catholic Church - 23505 NE. 132nd Ave.

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 137 ft. Depth of completed well 137 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 138'4" ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used..........
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name..........
Type.......... Model No..........
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 48 ft.
Material used in seal Bentonite& Clean fill
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?.......... Depth of strata..........
Method of sealing strata off..........

(7) PUMP: Manufacturer's Name..........
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 96 ft. below top of well Date 11-7-79
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by.......... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?..........
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 20 gal./min. with 10 ft. drawdown after 1 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	4
Brown clay & rocks	4	10
Grey rock	10	23
Broken rock & clay	23	48
Gravel	48	65
Nucky sand	65	73
Brown clay	73	85
Sand & gravel	85	130
Cemented sand & gravel , water	130	137

RECEIVED
DEC 13 1979
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started November 1 19 79 Completed November 7 19 79

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co. Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE. 58th Ave. Vancouver, Washington 9

0006 Ron Aspaas

[Signed] Ron Aspaas (Well Driller) KM Hansen

License No. C-51 Date November 8, 19 79

223-02HA-NS-ED-*377NT

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G2-25807
Permit No. ....

(1) OWNER: Name Don Roberts — Mail Address 917 NW.139th St.Vancouver,Washington 98665

(2) LOCATION OF WELL: County Clark — NE ¼ SE ¼ Sec. 35 T. 4 N., R. 2 W.M.

Bearing and distance from section or subdivision corner 830'N & 425'W of SE Corner of Sec 35

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 548 ft. Depth of completed well 548 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from 0 ft. to 99'4" ft.
Threaded ☐ 6" Diam. from 0 ft. to 548'4" ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Torch
SIZE of perforations 1/4 in. by 10 in.
77 perforations from 498 ft. to 548'4" ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 0 - 35 ~~75~~ - 99 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P.....

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 245 ft. below top of well Date 6-24-80
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?.....
Yield: gal./min. with ft. drawdown after hrs.
" to be tested by owner with his own "
" " pump " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
BLOWING test 30 gal./min. with ..... ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Dirt & rocks	0	3
Broken rock, brown clay	3	19
~~Brown & grey rock w/broken layers~~	19	50
Grey rock fractured	50	78
Blue green shale	78	120
Brown & grey rock	120	185
Grey rock	185	260
Green & grey shale	260	375
Grey rock w/thin layers of claystone	375	470
Grey rock fractured	470	548

RECEIVED
JUL 17 1980
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started June 4, 1980. Completed June 24, 1980

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co. Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE. 58th Ave.Vancouver,Washington 986

0006 Ron Aspaas
[Signed] Ron Aspaas (Well Driller) KM Hansen

License No. C-51 Date June 25, 1980

223-02HA-NS-ED-*377NT

RWS 8-19-81

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Steve Dunning Mail Address P.O. Box 821 BattleGround, Washington98604

(2) LOCATION OF WELL: County Clark NE ¼ NW ¼ Sec. 35 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner Site: 14105 NE. 239th St.

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 82 ft.. Depth of completed well 82 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 59'4" ft.
Threaded ☐ PVC 4½" Diam. from 52 ft. to 82 ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Saw
SIZE of perforations 1/8 in. by 14 in.
25 perforations from 62 ft. to 82 ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Stabilized Size of gravel: Pea
Gravel placed from 60 ft. to 82 ft.

Surface seal: Yes ☒ No ☐ To what depth? 60 ft.
Material used in seal Bentonite & fill
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 62 ft. below top of well Date 11-4-80
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?.....
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test.....
Bailer test 10 gal./min. with 2 ft. drawdown after 1 hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	3
Brown clay	3	8
Grey rock	8	42
Broken rock some brown clay	42	75
Broken rock & gravel water	75	82

RECEIVED
DEC - 5 1980
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started November 4, 19 80 Completed November 4, 19 80

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co. Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE. 58th Ave. Vancouver, Washington98...

0006 Ron Aspaas

[Signed] Ron Aspaas KM Hansen (Well Driller)

License No. C-51 Date November 6, 19 80

223-02HA-NS-ED-*377NT

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Randy Hanson Address 23619 NE 132nd Ave Battle Ground

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec 35 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 121 ft. Depth of completed well 120 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 120 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☐ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☑
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☑ No ☐ To what depth? 30 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P.....

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level ..... ft. below top of well Date.....
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?.....
Yield: gal./min. with ft. drawdown after hrs.
Airlift 10 Gpm for 1 hour at 118 ft
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test..... gal./min. with ..... ft. drawdown after..... hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☑ No ☐
Iron .5ppm
Hardness 7 GPG
pH 7

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Topsoil	0	2
Clay, brown with lava boulders	2	10
Basalt, gray	10	22
Lava rock broken with tan clay	22	24
Basalt, gray	24	30
Clay, red with	30	42
Clay, brown with lava boulders + cobbles	42	45
Same with lava gravel	45	55
Clay, tan with brown gravel	55	68
Clay, white	68	80
Clay, blue	80	92
Gravel, black + brown with brown clay	92	107
Gravel, black + brown with tan sand + water	107	121

RECEIVED
APR 29 1981
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 4/14, 1981. Completed 4/15, 1981

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME RITOLA WELL DRILLING (Person, firm, or corporation) (Type or print)
14214 N.E. 202nd Ave. - Ph. 892-4764
Address Brush Prairie, Wash. 98606

[Signed] David Ritola (Well Driller)

License No. 423 Date 4/16, 1981

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Ray Simonson — Mail Address 27434 NE. 155th Ave.Battle Ground,Was.9860

(2) LOCATION OF WELL: County Clark — NE ¼ NW ¼ Sec. 35 T. 4 N., R. 2 W.M.
Bearing and distance from section or subdivision corner — Site: 14103 NE. 240th St.Battle Ground

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 110 ft. Depth of completed well 104 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 78'6 ft.
Threaded ☐ PVC 4½" Diam. from 64 ft. to 104 ft.
Welded ☒ ..." Diam. from ... ft. to ... ft.

Perforations: Yes ☒ No ☐
Type of perforator used TXXXXX Saw
SIZE of perforations 1/8 in. by 12 in.
24 perforations from 84 ft. to 104 ft.
... perforations from ... ft. to ... ft.
... perforations from ... ft. to ... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ...
Type ... Model No. ...
Diam. ... Slot size ... from ... ft. to ... ft.
Diam. ... Slot size ... from ... ft. to ... ft.

Gravel packed: Yes ☐ No ☐ Backfill Size of gravel: Pea
Gravel placed from 65 ft. to 104 ft.

Surface seal: Yes ☒ No ☐ To what depth? 65 ft.
Material used in seal Bentonite & fill
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ... Depth of strata ...
Method of sealing strata off ...

(7) PUMP: Manufacturer's Name ...
Type: ... H.P. ...

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 65 ft. below top of well Date 8-26-82
Artesian pressure ... lbs. per square inch Date ...
Artesian water is controlled by ... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ...
Yield: ... gal./min. with ... ft. drawdown after ... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ...
Bailer test 20 gal./min. with 2 ft. drawdown after 1 hrs.
Artesian flow ... g.p.m. Date ...
Temperature of water ... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	7
Grey rock	7	45
Broken rock, gravel & clay	45	90
Gravel, water	90	104
Blue clay	104	110

RECEIVED
NOV 12 1982
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started August 25, 1982. Completed August 26, 1982

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co. Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE. 58th Ave.Vancouver,Washington

[Signed] 0006 Ron Aspaas Ron Aspaas (Well Driller)

License No. C-51 Date August 27, 1982

223-02HA-NS-ED-*377NT

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Steve Dunning Mail Address P.O. Box 821 Battle Ground, Wa. 98604

(2) LOCATION OF WELL: County Clark — NE ¼ NW ¼ Sec 35 T 4 N., R 2 W.M.

Bearing and distance from section or subdivision corner Ste: 14009 NE. 240th St. Battle Ground, Wa.

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 67 ft. Depth of completed well 67 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 63'10 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 38 ft.
Material used in seal Bentonite & fill
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 30 ft. below top of well Date 3-18-83
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test 20 gal./min. with 0 ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	5
Brown clay	5	13
Broken rock	13	38
Broken rock & gravel water	38	67

RECEIVED
APR 21 1983
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started March 17, 19 83. Completed March 18, 19 83

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Hansen Drilling Co. Inc. (Person, firm, or corporation) (Type or print)

Address 6711 NE. 58th Ave. Vancouver, Washington986
0006 Ron Aspaas

[Signed] Ron Aspaas (Well Driller) PJB Bookker

License No. C-51 Date March 21, 19 83

223-02HA-NS-ED-*377NT

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Ron Steigman Address 23602 NE 142nd Ave Battle Ground, wa

(2) LOCATION OF WELL: County Clark — NE ¼ NW ¼ Sec 35 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 475 ft. Depth of completed well 445 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 340 ft.
Threaded ☐ 4" pvc " Diam. from 310 ft. to 445 ft.
Welded ☑ " Diam. from ft. to ft.

4" Check Valve at 410'

Perforations: Yes ☑ No ☐
Type of perforator used Rotary & drill for liner
SIZE of perforations 1/8 in. by 1 1/4 in.
420 perforations from 320 ft. to 335 ft.
32 hole ~~perforations~~ from 420 ft. to 430 ft.
perforations from ft. to ft.

2 Shale Traps 335, 337'

Screens: Yes ☐ No ☑
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 170 ft. below top of well Date 6/20/83
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 18 gal./min. with 110 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☑

Water at 423-427
Hardness 1 gpg
PH 9

RECEIVED
JUL 18 1983
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Topsoil & subsoil brown	0	6
Basalt, gray	6	14
Lava! Cobbles boulders & gravel with light brown clay	14	26
Clay, light brown	26	34
" , white	34	40
boulders & cobbles, water bearing	40	46
Clay, tan, silty	46	50
" , blue & brown, sticky	50	65
" , blue "	65	82
" , tan & gray "	82	95
" , gray "	95	130
" , Dark gray, slightly sandy	130	138
" , light gray sticky	138	152
" , brown "	152	155
" gray "	155	188
" , Dark gray, sandy	188	202
" , gray, with wood	202	230
" , gray	230	253
" , blue with coarse grained sand	253	264
" , Clay light brown, sticky	264	266
Sand, multi-colored	266	267
Clay, brown, sticky	267	282
" , light brown	282	296
" , gray with fine clay gravel	296	303
" , tan, sticky	303	320
Sand, coarse cemented	320	323
Shale, tan with fine silty sand	323	333
Pumice sand, gray & water	333	335
Shale, gray	335	357
Sandstone, gray (shale)	357	423
~~Sand~~ Shale, gray & brown & water	423	427
Sandstone, shale gray & brown	427	448
Shale, red	448	465
" , gray	465	475

Work started 6/9 1983 Completed 6/20 1983

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME RITOLA WELL DRILLING (Person, firm, or corporation) (Type or print)
Address 14214 N.E. 202nd Ave. - Ph. 892-4784 Brush Prairie, Wash. 98606

[Signed] David Ritola (Well Driller)

License No. 423 Date 6/22, 1983

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) OWNER: Name Raineer Financial Service Address 23619 NE 132nd Ave., Battle Ground, WA

(2) LOCATION OF WELL: County Clark — NW ¼ NW ¼ Sec. 35 T. 4 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 132 ft. Depth of completed well 132 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 132 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 75 ft.
Material used in seal Bentonite & Puddling Clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name Sta-Rite
Type: submersible H.P. 3/4

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 106'-10" ft. below top of well Date 7/25/86
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Warren
Yield: 12 gal./min. with 2'-11" ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
Zero	109'- 9"				
6 min	106'-10"				
20 Sec					

Date of test 7/25/86
Bailer test..... gal./min. with..... ft. drawdown after..... hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil & broken rocks	0	2'
Clay, brown, with scattered boulders	2'	4'
Rock, gray	4'	29'
Fractured brown rock with brown clay seams	29'	70'
Clay, brown	70'	95'
Sand, brown, gravel, cemented	95'	128'
Sand, brown & gravel, water bearing	128'	132'

RECEIVED SEP 26 '86 DEPARTMENT OF ECOLOGY

Work started 7/17 19 86 Completed 7/25 19 86

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME NORRIS DRILLING & PUMP CO., INC. (Person, firm, or corporation) (Type or print)
11026 N.E. St. Johns Road
Address Vancouver, Washington 98686

[Signed] Bert O. Warren (Well Driller)

License No. 1422 Date August 1 19 86

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 03@749

Water Right Permit No.

(1) OWNER: Name Ray Bloomquist Address 24214 NE 219th ST, BattleGround

(2) LOCATION OF WELL: County Clark SE ¼ SE ¼ Sec 35 T. 4N N., R 2E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Approx. 22500 NE 142nd Ave, BattleGround, WA 9860

(3) PROPOSED USE: [X] Domestic [ ] Industrial [ ] Municipal [ ] Irrigation [ ] Test Well [ ] Other [ ] DeWater

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Bored [ ] Cable [ ] Driven [ ] Rotary [X] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 250 feet. Depth of completed well 250 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 56 ft.
Welded [ ] PVC4.5 " Diam. from 20 ft. to 250 ft.
Liner installed [X] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [X] No [X]
Type of perforator used XXXXX ¼ blade
SIZE of perforations 1/4 XXXX in. by 4 in.
30 perforations from 244 ft. to 250 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [XX] No [ ] To what depth? 56' ft.
Material used in seal Cement grout - Bentonite
Did any strata contain unusable water? Yes [ ] No [XX]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 59 ft. below top of well Date XXXXXX 7-20-89
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 5 gal./min. with stem set at 245 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil, brown	0	3
Clay; brown	4	27
Clay; gray	28	50
Rock; soft, gray	50	58
Rock; soft, brown	59	88
Rock; hard, basalt, black	88	100
Rock; hard, black	101	119
Rock, soft, red	120	125
Rock, medium, red and black	126	132
Rock, medium, black	133	144
Rock, hard, basalt	145	150
waterbearing 3GPM		
Rock, medium hard, basalt	151	168
Rock; medium, gray	169	174
Rock; medium, gray	175	190
Rock; hard, gray	191	207
Rock; hard, black	208	215
little more water - 215		
Rock, hard, black	216	225
Rock, medium black	226	250
little more water - 250		

Work started 7-15-89, 19. Completed 7-20-89, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Ritola Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 14214 NE 202nd Avenue ~~Brush Prairie, WA 98606~~
(Signed) RW Redings (WELL DRILLER) License No. 1294
Contractor's Registration No. RITOLWD251MM XXXXXXXXXX Date 7-26-89, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 020547

Water Right Permit No. ______

(1) OWNER: Name LARRY & DOLLY JONES Address MAIL RT 1 BOX 460 A AMBOY WA 98601

(2) LOCATION OF WELL: County CLARK — NW ¼ NE ¼ Sec 35 T. 5 N., R. 2 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) NE HIDDEN VALLEY RD.

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 263 feet. Depth of completed well 263 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 49'6" ft.
Welded [X] 6" Diam. from +1 ft. to 48'6" ft.
Liner installed [X] 4½" Diam. from 43 ft. to 263' ft.
Threaded [ ]

Perforations: Yes [X] No [ ]
Type of perforator used ______
SIZE of perforations 3/16 in. by 6" in.
45 perforations from 160 ft. to 180 ft.
45 perforations from 243 ft. to 263 ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [ ] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 48'6" ft.
Material used in seal CEMENT & BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 81'6" ft. below top of well Date 9/29/89
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 5 gal./min. with stem set at 260 ft. for 4 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
10" HOLE	0	48'6"
CLAY & BOULDERS	0	42'
BASALT HARD BLACK	42	112
ROCK SOFT PURPLE.	112	125
BLUE SHALE SOFT	125	150
BROKEN BLACK MED WATER BRG.	150	163
BASALT HARD.	163	180
BLUE SHALE SOFT	180	192
BROKEN ROCK SOFT-MED.	192	205
RED DECOMPOSED	205	221
BROKEN ROCK SOFT, BLACK	221	263

Work started 9/27, 1989 Completed 9/29, 1989

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME CHRISTENSEN WELL DRILLING (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 12809 NE 25TH AVE VANC, WA 98686
(Signed) C G Christensen (WELL DRILLER) License No. 0068
Contractor's Registration No. CHRISWD110QM [redacted] Date 9/29, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 066002
Water Right Permit No. ___________
Page 1 of 1

(1) OWNER: Name Ray Bloomquist Address 24214 NE 219th Street Battle Ground WA 98604

(2) LOCATION OF WELL: County Clark SE 1/4 SE 1/4 Sec 35 T 4 N R 2 EM

(2a) STREET ADDRESS OF WELL (or nearest address) Aprx 22500 NE 142nd Avenue Battle Ground WA 98604

(3) PROPOSED USE: DOMESTIC Owner Well ID 2

(4) Type of work: DEEPENED

Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 423 feet. Depth of completed well 417 ft.

(6) CONSTRUCTION DETAILS:

Casing instld: 4"PVC " Diam. from 0 ft. to 417 ft.

Welded _ ________" Diam. from _____ ft. to _____ ft.

Liner _ ________" Diam. from _____ ft. to _____ ft.

Threaded _

Perforations: Yes X No _

Type of perforator used SAW CUT

Size of perforations 4 in. by 1/4 in.

36 perforations from 400 ft. to 412 in.

__________ perforations from ________ ft. to _______ in.

__________ perforations from ________ ft. to _______ in.

Screens: Yes _ No X

Manufacturer's Name ____________________________________

Type ____________________________ Model No ___________

Diam _______ Slot size ______ from ______ ft. to ______ ft.

Diam _______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes _ No X Size of gravel ______________

Gravel placed from _____________ ft. to _____________ ft.

Surface seal: Yes X No _ To what depth? ____________ ft.

Material used in seal BENTONITE

Did any strata contain unusable water? Yes _ No X

Type of water? ______________ Depth of strata __________

Method of sealing strata off ______________________________

(7) PUMP: Manufacturer's Name ______________________________

Type ________________________________ H.P. _______

(8) WATER LEVELS: Surface elev above mean sea level _______ ft.

Static level 140 ft. below top of well Date 09/05/90

Artesian pressure ______ lbs. per sq. in. Date

Artesian pressure is controlled by ______________________

(9) WELL TESTS: Pump test made? ___ By whom? _______________

Yield _______ gal./min. with ___ ft. drawdown after ___ hrs

Yield _______ gal./min. with ___ ft. drawdown after ___ hrs

Yield _______ gal./min. with ___ ft. drawdown after ___ hrs

Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.

Date of test

Bailer test _______ gal/min with ____ ft. drawdown after ____ hr

Airtest 4 gal/min with stem set at 415 ft. for 1 hrs

Artesian flow _______ gal/min Date

Temperature of water ______ Was chemical analysis made? NO

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Rock, blue gray, medium hard	_____	197
Rock, gray, medium hard	197	248
Rock, gray, soft	248	360
Rock, gray, soft	360	423

Work Started 08/31/90 Completed 09/05/90

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Name RITOLA WELL DRILLING

Address 14214 NE 202nd Avenue Brush Prairie WA 98606

(Signed) William Ritola License No 1482

(Well Driller)

Contractor's Registration No. RITOLWD251MM Date 09/13/90

Based on form ECY 050 1-20 (10/87) -1329- by Speed Systems Corp.

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 066009
Water Right Permit No. ___________

(1) OWNER: Name Joe and Julie Zamboldi   Address 7809 NE 149th Avenue Vancouver WA 98682
(2) LOCATION OF WELL: County Clark   SW 1/4 NE 1/4 Sec 35 T 4 N R 3 EM
(2a) STREET ADDRESS OF WELL (or nearest address) SW Corner of Kaskillah Drive WA

(3) PROPOSED USE: DOMESTIC   Owner Well ID 1
(4) Type of work: NEW WELL
Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 580 feet. Depth of completed well 367 ft.

(6) CONSTRUCTION DETAILS:
Casing instld: 6 " Diam. from 0 ft. to 19 ft.
Welded X 4"cls200" Diam. from 7 ft. to 367 ft.
Liner _ ________" Diam. from _____ ft. to _____ ft.
Threaded _

Perforations: Yes X No _
Type of perforator used SAW CUT
Size of perforations 1/4 in. by 4 in.
24 perforations from 362 ft. to 365 in.
__________ perforations from ________ ft. to _______ in.
__________ perforations from ________ ft. to _______ in.

Screens: Yes _ No X
Manufacturer's Name ___________________________________
Type ____________________________ Model No ___________
Diam ______ Slot size ______ from ______ ft. to ______ ft.
Diam ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes _ No X Size of gravel _____________
Gravel placed from ____________ ft. to ____________ ft.

Surface seal: Yes X No _ To what depth? 19 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes _ No X
Type of water? ______________ Depth of strata _________
Method of sealing strata off ___________________________

(7) PUMP: Manufacturer's Name ______________________________
Type ______________________________ H.P. _______

(8) WATER LEVELS: Surface elev above mean sea level _______ ft.
Static level 218 ft. below top of well Date 11/29/90
Artesian pressure ______ lbs. per sq. in. Date
Artesian pressure is controlled by ____________________

(9) WELL TESTS: Pump test made? ___ By whom? _______________
Yield _______ gal./min. with ___ ft. drawdown after ___ hrs
Yield _______ gal./min. with ___ ft. drawdown after ___ hrs
Yield _______ gal./min. with ___ ft. drawdown after ___ hrs
Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.
_________	_________	_________	_________	_________	_________
_________	_________	_________	_________	_________	_________
_________	_________	_________	_________	_________	_________

Date of test
Bailer test _______ gal/min with ____ ft. drawdown after ____ hr
Airtest 3 gal/min with stem set at 320 ft. for 1 hrs
Artesian flow _______ gal/min Date
Temperature of water ______ Was chemical analysis made? NO

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Topsoil, brown, soft	0	1
Subsoil, tan, medium	1	6
Rock, brown, medium hard	6	25
Rock, brown, medium hard, very broken	25	30
Rock, gray and brown, medium hard	30	32
Rock, brown with brown shale, medium soft	32	36
Rock, gray, hard	36	40
Rock, gray and brown, some white shale, medium hard	40	50
Rock, multi-colored, hard, fractured, very hard	50	53
Rock, brown, some gray, fractured, very hard	53	88
Rock, gray, very hard	88	90
Rock, brown and gray, very hard	90	93
Rock, brown, very hard	93	96
Rock, shale, brown, medium	96	110
Rock, gray, medium hard	118	123
Rock, gray with brown, shale, medium hard	123	130
Rock, gray with gray shale, medium	130	143
Shale, brown, gray, soft	143	158
Rock, gray, with white quartz, medium hard	158	185
Rock, brown and gray, medium hard	185	195
Shale, brown, soft	195	203
Rock, brown, medium hard	203	209
Rock, gray, medium hard	209	293
Rock, gray and brown, medium hard	293	301
Rock, gray, hard	301	305
Rock, gray, fractured, hard	305	334
Rock, brown, fractured, hard	334	340
Rock, gray, hard	340	355
Rock, tan, brown, red, soft	355	360
Rock, gray, medium hard	360	402
Shale, black and brown, hard	402	410
Rock, gray, medium hard	410	488
Shale, red, soft	488	492
Rock, red and brown and gray, medium	492	494
Rock, gray with gray shale, medium hard	494	535
Rock, gray and brown, hard	535	555

Work Started 09/26/90   Completed 09/28/90

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.
Name RITOLA WELL DRILLING
Address 14214 NE 202nd Avenue Brush Prairie WA 98606

(Signed) ______________________________ License No 1482
(Well Driller)
Contractor's Registration No. RITOLWD251MM   Date 10/03/90
Based on form ECY 050 1-20 (10/87) -1329- by Speed Systems Corp.

File: Orig. & First Copy - Dept of Ecology
Second Copy - Owner; Third Copy - Driller

WATER WELL REPORT
State of Washington

Start Card No. 066009
Water Right Permit No. ___________

(1) OWNER: Name Joe and Julie Zamboldi   Address 7809 NE 149th Avenue Vancouver WA 98682

(2) LOCATION OF WELL: County Clark   SW 1/4 NE 1/4 Sec 35 T 4 N R 3 EM

(2a) STREET ADDRESS OF WELL (or nearest address) SW Corner of Kaskillah Drive WA

(3) PROPOSED USE: DOMESTIC   Owner Well ID 1

(4) Type of work: NEW WELL
Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 580 feet. Depth of completed well 367 ft.

(6) CONSTRUCTION DETAILS:
Casing instld: 6 " Diam. from 0 ft. to 19 ft.
Welded X 4"cls200" Diam. from 7 ft. to 367 ft.
Liner _ _______" Diam. from _____ ft. to _____ ft.
Threaded _

Perforations: Yes X No _
Type of perforator used SAW CUT
Size of perforations 1/4 in. by 4 in.
24 perforations from 362 ft. to 365 in.
__________ perforations from ________ ft. to _______ in.
__________ perforations from ________ ft. to _______ in.

Screens: Yes _ No X
Manufacturer's Name ______________________________
Type ____________________________ Model No __________
Diam ______ Slot size _____ from _____ ft. to _____ ft.
Diam ______ Slot size _____ from _____ ft. to _____ ft.

Gravel packed: Yes _ No X Size of gravel ____________
Gravel placed from ____________ ft. to ____________ ft.

Surface seal: Yes X No _ To what depth? 19 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes _ No X
Type of water? _____________ Depth of strata _________
Method of sealing strata off ________________________

(7) PUMP: Manufacturer's Name ________________________
Type ____________________________ H.P. ______

(8) WATER LEVELS: Surface elev above mean sea level _______ ft.
Static level 218 ft. below top of well Date 11/29/90
Artesian pressure _____ lbs. per sq. in. Date
Artesian pressure is controlled by ___________________

(9) WELL TESTS: Pump test made? ___ By whom? ______________
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Yield ______ gal./min. with ___ ft. drawdown after ___ hrs
Recovery data:

Time	Wtr. Lvl.	Time	Wtr. Lvl.	Time	Wtr. Lvl.

Date of test
Bailer test ______ gal/min with ____ ft. drawdown after ____ hr
Airtest 3 gal/min with stem set at 320 ft. for 1 hrs
Artesian flow _______ gal/min Date
Temperature of water _____ Was chemical analysis made? NO

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Material	From	To
Shale, brown, soft	555	560
Rock, gray, hard	560	580
Backfilled to 367 with bentonite and sand		
Test drilling from 367 to 580		

Work Started 09/26/90   Completed 09/28/90

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Name RITOLA WELL DRILLING
Address 14214 NE 202nd Avenue Brush Prairie WA 98606

(Signed) [signature] License No 1482
(Well Driller)

Contractor's Registration No. RITOLWD251MM   Date 10/03/90

Based on form ECY 050 1-20 (10/87) -1329- by Speed Systems Corp.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 033880

Water Right Permit No.

(1) OWNER: Name Cenex Address 310 E. "A" st. Battle Ground, WA 98604

(2) LOCATION OF WELL: County Clark SW ¼ SW ¼ Sec. ~~34~~ 35 T. ~~3~~ 4N N., R. 2E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Same as Owner

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☑ Monitor Well

(4) TYPE OF WORK: Owner's number of well (if more than one) DH-1

Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☑ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ~~DH-1~~ 2 inches.
Drilled 10 feet. Depth of completed well 8 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ___ " Diam. from ___ ft. to ___ ft.
Welded ☐ ___ " Diam. from ___ ft. to ___ ft.
Liner installed ☐
Threaded ☑ 2 " Diam. from 0 ft. to 3 ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Ardvark
Type PVC sch. #40 Model No.
Diam. 2" Slot size .020 from 3 ft. to 8 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☑ No ☐ Size of gravel 8-12 Silica Sand
Gravel placed from 2 ft. to 10 ft.

Surface seal: Yes ☑ No ☐ To what depth? 2 ft.
Material used in seal Enviroplug Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

(7) PUMP: Manufacturer's Name ___
Type: ___ H.P. ___

(8) WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 4.7 ft. below top of well Date 5-22-91
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ___
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water ___ Was a chemical analysis made? Yes ☑ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
~~Top Soil~~ Top Soil	0'	2'
Silty clay-Brown - Very Moist	2'	10'

Work started 5-22-91, 19. Completed 5-22-91, 19.

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Chen-Northern Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2214 N. 4th Pasco WA 99301
(Signed) Russell A. Vance (WELL DRILLER) License No. 1574
Contractor's Registration No. ___ Date 6-6-91, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 033881

Water Right Permit No. ____

(1) OWNER: Name Cenex Address 310 E. "A" st. Battle Ground, WA 9860

(2) LOCATION OF WELL: County Clark SW ¼ SW ¼ Sec. 35 T. 4N N., R. 2E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Same as Owner

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☑ Monitor Well

(4) TYPE OF WORK: Owner's number of well (if more than one) DH-2
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☑ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 2 inches.
Drilled 10 feet. Depth of completed well 8 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: ____ " Diam. from ____ ft. to ____ ft.
Welded ☐ ____ " Diam. from ____ ft. to ____ ft.
Liner installed ☐
Threaded ☑ 2 " Diam. from 0 ft. to 3 ft.

Perforations: Yes ☐ No ☑
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Ardvark
Type PVC sch. #40 Model No. ____
Diam. 2" Slot size .020 from 3 ft. to 8 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☑ No ☐ Size of gravel 8-12 Silica Sand
Gravel placed from 2 ft. to 10 ft.

Surface seal: Yes ☑ No ☐ To what depth? 2 ft.
Material used in seal Enviroplug Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 4.5 ft. below top of well Date 5-23-91
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☑ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0'	1.5'
Silty Clay - Brown - Very Moist	1.5'	10'

Work started 5-23-91, 19. Completed 5-23-91, 19.

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Chen-Northern Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2214 N. 4th Pasco, WA 99301
(Signed) Russell A. Vance (WELL DRILLER) License No. 1574
Contractor's Registration No. ____ Date 6-6-91, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

APPENDIX B

SOIL GAS SURVEY

MEMORANDUM

Date: April 30, 1992

To: Brett Freier

From: Rusty Sims

Subject: Soil Gas Data Report Results from a Survey Conducted at Jim's British Petroleum Gas Station (March 23-27, 1992).

Reference: Washington Dept. of Ecology Contract Number: C0089006
SAIC Project Number: 01-0892-00-0462-000

Enclosed please find the following:

I. SOIL GAS SURVEY RESULTS

The soil gas data generated for this report should be treated as semi-quantitative only. The soil gas instrumentation used is for "screening" purposes only and is intended to provide an indication of the nature and extent of contamination. The data presented below are not intended to be quantitative.

A. A tabular summary of all soil gas results (hard copy and diskette) for the compounds: benzene, toluene, ethylbenzene and total xylenes (as p,m and o) is presented in Appendix-A. Additionally, any unknown compounds detected are listed in the last column of the tabular summary under the header "Total No. Unknown Compounds Detected. All data are reported to two (2) significant figures in units of parts per billion by volume (ppbv), which represents the compound concentration on a volume basis ($\mu l/m^3$), at ambient temperature and pressure. Data reported in ppbv may be converted to micrograms per liter of air ($\mu g/l$) using the universal gas law formula (Nebergall et.al., 1963):

$$PV = NRT$$

Data presented in tabular summary are reported with the following qualifiers:

Qualifier	Definition
F.B.#	Field Blank along with its proper consecutive number (#)

A.D. Analytical Duplicate

F.D. Field Duplicate

U Value is below the calculated IDL value and is defined using the following operation:

Instrument Detection Limit (IDL) = the mean value of the individual IDLs obtained from three (3) separate daily runs. Each daily run consisted of seven (7) separate analyses of a standard, containing the compounds of interest. The standard deviation (S.D) of the results obtained (in ppbv), from the seven analyses, was multiplied by three (3). The resultant value was and IDL, for one (1) day's analyses.

(value) Value is below the calculated IDL, but was able to be measured by the instrument (GC). Value is not quanitifiable and should be treated as a broad estimate only.

II. SAMPLING METHODS AND ANALYSIS PROCEDURE

Samples were collected and analyzed using the procedure described in SAIC SOPs 8017 through 8020. In general, all samples were collected and analyzed as described in the following paragraphs.

- Sampling required the use of a probe extension (three feet in length), retractable probe tip, teflon tubing, probe driver and jack. The probe extension, probe tip and teflon tubing were assembled. The sampling assembly was then installed to the desired depth, using a manual probe driver (hammer type). Next, the jack was attached to the probe assembly and lifted approximately three inches (to avoid clogging the probe tip with soil). The teflon tubing was then connected to the sample port, on a vacuum box, and the electric pump motor was turned on. The soil gas to be collected was then purged through the collection system for approximately 20 seconds (500 ml volume) before a tedlar bag was connected to the system for sample collection. The sample purging before collection is necessary to avoid: (1) sample dilution due to dead volume in the system and (2) sample contamination due to contaminants in the system. Next, a sample was collected by connecting the teflon tubing (at the sample port on the vacuum box) to a tedlar bag, which was placed in the vacuum box. The top of the vacuum box was closed and the pump motor was turned on. Approximately 750 ml of sample was collected in a 1000 ml tedlar bag. The bag number was recorded in a log book along with the date, time, initials of sampler and sample location.

- Samples were analyzed by gas chromatography (GC) using a micro argon ionization detector (MAID). Analysis was conducted by pre-concentration of a 17.5 ml aliquot of soil gas onto an absorptive trap followed by heating of the trap and transfer of the volatile organic compounds into the GC detector.

III. QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) procedures implemented during this task consisted of analysis of argon bag blanks, field blanks, analytical duplicates, field duplicates, and calibration standards as required by the technical procedures. Results for each type of QC analysis are desribed in the following section.

A. Argon Bag Blanks

Argon bag blanks (GC system blanks) were analyzed daily and following the analysis of a high concentration standard or sample to determine the presence of target compounds in the analytical system. No argon bag blank showed any detectable concentration of any compounds.

B. Field Blanks

Field blanks were collected at various locations and sampled once for each day field samples were collected and analyzed. (Note: There is no field blank for samples collected and analyzed on 3/27/92. A field blank was collected, however, power was lost to the field gas chromatograph before the field blank was analyzed. Historically, field blank contamination, when using the present system has not been a problem.) The field blank samples were analyzed to insure that the sampling equipment and procedures were free of contamination. Field blanks were collected in the same manner as the samples except that the probes were not driven into the soil but were set up to collect ambient air only at ground level. No field blanks gave detectable concentrations of any compounds.

C. Analytical Duplicates

Analytical duplicate samples were analyzed at a frequency of one duplicate per thirty analyses performed. These duplicates were usually run (if possible) after a sample with a positive hit of a target compound (in order to have some measure of statistical analytical precision).

D. Field Duplicates

Field duplicates were analyzed at a frequency of one duplicate per thirty samples collected. These duplicates were usually sampled (if possible) at a location where it was most likely that a positive hit for target compounds would be measured.

E. Calibration Standards

The gas chromatograph was calibrated with gas standards on a daily basis. Calibration checks were also conducted to determine instrument performance and stability. The calibration standard source was from Scott Specialty Gases. Appendix-B presents a list of the calibration gas compounds used and their respective concentrations. As required by the technical procedure, standard verification checks (% recoveries of initial and continuing standard verification checks) were not to differ from the true standard concentration by 70-130% of the true value. When calibration checks exceeded the recovery limit requirement, the calibration check standard was reanalyzed. If the check failed a second time, the instrument was recalibrated with fresh standards and instrument maintenance performed, if deemed necessary by the project field chemist. Calibration checks were performed with the following analytical scheme and frequency: (1) at the beginning of an analytical run (after calibration but before analyzing the first field sample), as an initial calibration verification (ICV); (2) after every five field samples, as a continuing calibration verifcation (CCV) and (3) at the end of an analytical run, as a CCV.

IV. SAMPLE MEASUREMENT

Sample results were determined in the following manner. All calibrations were performed using a mixed calibration gas containing a known concentration of each of the compounds of interest. Calibrations and subsequent sample concentration calculations were based on a single point calibration. Before calibrating the GC, a compound calibration library was established, using the computer software sample analysis program.

Initially, the compound names and their respective concentration (ppbv) were entered by hand into the sample analysis program, in the order of column elution, beginning with the compound which elutes first and ending with the compound which elutes last. Next, a 17.5 ml aliquot of mixed calibration standard was collected onto the GC absorptive trap. The trap was heated and the individual compounds were measured by the MAID, in the order in which they eluted. The unit of measurement for each compound is the area count within each compound peak. At this point, the calibration library is established and contains the following information: (1) The name and elution order of each compound, (2) the compound retention time [the time, measured in seconds, before a compound desorbs from the column and is measured by the detector], (3) the concentration (ppbv) for each compound in the calibration standard and (4) the area count within the peak of each compound measured.

Once a calibration library was established, the GC was ready to analyze samples. All sample calibration libraries were established using the Scott Speciality Gases mixed calibration gas given in Appendix-B. Samples were analyzed and concentrations calculated using the following procedure. Initially an aliquot of sample gas (equal in volume to the calibration gas aliquot) was collected and measured in the same manner as the calibration standard. The retention time and area count for each compound was measured. The retention time for each compound (in the sample) was matched against the calibration compound retention times established in the library. Any compound retention time, measured in a sample, which was equal to a compound retention time contained in the calibration library ($\pm$4%) was identified by the name of the compound (it most closely matched) in the calibration library. Subsequent calculation of an identified compound contained in a sample was calculated using the formula:

$$C = \frac{SCAC}{CCRF}$$

where:

C	= compound concentration (ppbv) in sample
SCAC	= sample compound area count
CCRF	= calibration compound response factor

$$CCRF = \frac{\text{area count of calibration compound}}{\text{concentration (ppbv) of calibration compound.}}$$

V. DATA VALIDATION

All analytical results were validated by review of the raw chromatographic data using the following procedure:

- Data were reviewed to ensure that positive sample results exhibited GC relative retention times within 4% of the most recent standard calibration check. Compounds outside the 4% retention time window were labeled as unknowns.

- The tabular summary table was reviewed against the chromatograms to ensure that results were transcribed correctly.

- Sample data were reviewed with respect to the results obtained from the daily analysis of blanks (argon bag and field). Any sample data affected by compound contamination measured in the associated field and/or argon bag blank were presented with a "B" qualifier.

APPENDIX-A

JIM'S B/P GAS STATION, BATTLEGROUND, WASHINGTON (MARCH, 1992)
ECOLOGY CONTRACT: C0089006
SOIL GAS CONCENTRATIONS: ALL COMPOUNDS
(VALUES ARE REPORTED IN PARTS PER BILLION, PPB, BY VOLUME)

JIM'S B/P GAS STATION, BATTLEGROUND, WASHINGTON (MARCH,1992) ECOLOGY CONTRACT: C0089006

SOIL GAS CONCENTRATIONS: ALL COMPOUNDS (VALUES ARE REPORTED IN PARTS PER BILLION, PPB, BY VOLUME)

Table Sequence	Sample I.D.	Smpl. Date (Col/Anal)	Smpl. Col Time	Bag Number	Depth	Ambient Temp.(C)	Total No. Known Plus Unknown Compounds Detected	Benzene	Toluene	Ethyl Benzene	Total Xylenes	Total No. Unknown Compounds Detected
1	F.B.#1	3/23/92	1616	3	N/A	15.6	0	43U	67U	120U	200U	0
2	S.G.#1	3/24/92	0947	11	1'	19.4	1	43U	67U	120U	200U	1
3	S.G.#2	3/24/92	0958	5	3'	19.4	0	43U	67U	120U	200U	0
4	S.G.#3	3/24/92	0740	7	6"	17.2	0	43U	67U	120U	200U	0
5	F.B.#2	3/24/92	0836	6	N/A	17.8	0	43U	67U	120U	200U	0
6	S.G.#4	3/24/92	0846	8	1'4"	17.8	6	43U	67U(19)	120U	200U	5
7	S.G.#4A.D.	3/24/92	0846	8	1'4"	17.8	6	43U	67U(16)	120U	200U	5
8	S.G.#4F.D.	3/24/92	0849	9	1'4"	18.9	2	43U	67U(10)	120U	200U	1
9	S.G.#5	3/24/92	0906	10	1'6"	20.0	1	43U	67U	120U	200U	1
10	S.G.#6	3/24/92	0931	15	3'	19.4	3	43U	67U	120U	200U	3
11	S.G.#7	3/24/92	1118	4	2'10"	18.3	4	43U	67U(13)	120U	200U	3
12	S.G.#8	3/24/92	1155	3	3'	20.0	4	300	67U	120U	200U	3
13	S.G.#9	3/24/92	1210	13	2'6"	17.8	1	43U	67U	120U	200U	1
14	S.G.#10	3/24/92	1221	14	2'6"	17.8	0	43U	67U	120U	200U	0
15	S.G.#11	3/24/92	1234	17	2'3"	17.8	0	43U	67U	120U	200U	0
16	S.G.#12	3/27/92	0820	4	3'	15.6	0	43U	67U	120U	200U	0
17	S.G.#13	3/27/92	0803	10	3'	15.6	6	61	160	120U	200U	4
18	S.G.#14	3/27/92	0749	6	1'	16.1	8	43U	67U	120U	200U	8
19	S.G.#15	3/24/92	1445	12	2'10"	18.3	0	43U	67U	120U	200U	0
20	S.G.#16	3/27/92	1101	16	2'6"	13.3	0	43U	67U	120U	200U	0
21	S.G.#17	3/27/92	0725	15	2'	17.8	0	43U	67U	120U	200U	0
22	S.G.#18	3/27/92	0900	8	2'8"	18.3	4	43U	67U	120U	200U	4
23	S.G.#19	3/27/92	0928	11	3'	17.8	1	43U	67U	120U	200U	1
24	S.G.#20	3/27/92	0935	14	3'	15.6	1	43U	67U	120U	200U	1
25	S.G.#22	3/27/92	1005	12	2'6"	12.2	0	43U	67U	120U	200U	0
26	S.G.#23	3/27/92	1018	17	3'	12.2	0	43U	67U	120U	200U	0
27	S.G.#24	3/27/92	1032	13	2'6"	12.2	0	43U	67U	120U	200U	0
28	S.G.#25	3/27/92	1044	20	1'6"	10.0	0	43U	67U	120U	200U	0
29	S.G.#26	3/27/92	1303	19	3'	8.9	0	43U	67U	120U	200U	0
30	S.G.#27	3/27/92	1328	22	2'8"	8.9	0	43U	67U	120U	200U	0
31	S.G.#29	3/27/92	1348	21	2'8"	8.9	0	43U	67U	120U	200U	0

APPENDIX-B

CALIBRATION GAS SOURCE AND COMPOUND CONCENTRATIONS

Calibration Source : Scott Specialty Gases
Certification Data : 3/13/92
Scott Project No. : 02-18668
Cylinder No. : Scotty IV, 6 component mix (0204B7000324)
Lot No. : 2-27-92-1

Component	Concentration (ppbv)
Benzene	927
Toluene	903
Ethylbenzene	976
P-xylene	1070
M-xylene	960
O-xylene	974

APPENDIX C

BOREHOLE LOGS

SAIC	BOREHOLE LOG	Borehole Number: MW-1	Page 1 Of 3 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Brett Freier
Date Started: 3/30/92
Depth Water First Encountered (BLS): 13 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 3/31/92
Completion Depth: 33 feet

Sampling: Sample No.	Blow Count	Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
					A		Asphalt	
			2.5					
SB 1-1	8 8 10	6			CL		Dense silty clay, compacts well. Isolated areas of oxidation. Brown in color.	
			5.0					
			7.5					
SB 1-2	6 12 20	Full			CL		Dense silty clay. compacts well. Has areas of oxidation. Brown in color.	
			10.0					
			12.5				▼	
SB 1-3	5 12 20	Full			CL		Dense silty clay with 15-20% sand. Bands of other grey silty clay. Areas of oxidation.	
			15.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-1	Page 2 Of 3 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Brett Freier
Date Started: 3/30/92
Depth Water First Encountered (BLS): 13 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 3/31/92
Completion Depth: 33 feet

Sampling: Sample No.	Sampling: Blow Count	Sampling: Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
			17.5					
SB 1-4	25 50 over 4	10			GC		Cemented silty clay with 30% sand and pebbles to 1/4" in diameter. Dark reddish brown in color.	
None	60	6	20.0					
			22.5					
SB 1-5	40 50 over 4	3			GC		Sandy silty clay with pebbles 1/8" to 1/2" in diameter inter-mixed with cemented gravelly clay. Dark brown in color.	
			25.0				Note: Hole drilled to 33 feet. Drilling through hard cemented gravelly clay. No recovery during sampling. Hole backfilled with sand to 25 feet then bentonite seal to 22 feet prior to installing the well.	
			27.5					
	50+	0						
			30.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-1	Page 3 Of 3 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Brett Freier
Date Started: 3/30/92
Depth Water First Encountered (BLS): 13 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 3/31/92
Completion Depth: 33 feet

Sampling								
Sample No.	Blow Count	Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
			32.5		GC			
			35.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-3

Field Book No.: 1

Project Number: 01-0817-00-0462-000	Project Name: Jim's BP
Borehole Location: Battle Ground, WA	Drilling Company: Soil Sampling Service
Drilling Personnel: Mel Pederson	Drill Rig Type/Number:Mobile B-61/04
Drilling Method: Hollow Stem Auger	Bit Type/Size: Auger/10" - OD
Sampling Methods: Split Spoon	Hammer Wt: 140 lbs Drop: 30"
Field Geologist: Brett Freier	Assistant: Pete Christian
Date Started: 3/31/92	Date Completed: 3/31/92
Depth Water First Encountered (BLS): 14 feet	Completion Depth: 24 feet

Sampling: Sample No.	Blow Count	Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
					A		Asphalt	
			2.5					
SB 3-1	11 10 11	Full	5.0		CL	0	Dense silty clay; little or no sand. Compacts well. Has areas of oxidation. Olive brown in color.	
			7.5					
SB 3-2	11 10 11	Full			CL	0	Moist silty clay. No sand. Compacts well. Olive brown in color. Bands of oxidation present.	
			10.0					
			12.5					
SB 3-3	4 8 15	Full			CH	0	Dense very hard clay that holds shape. High plasticity. No areas of oxidation. Olive brown in color.	
							▼ (water level)	
			15.0					

BOREHOLE LOG

SAIC	BOREHOLE LOG	Borehole Number: MW-3	Page 2 Of 2 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Brett Freier
Date Started: 3/31/92
Depth Water First Encountered (BLS): 14 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" - OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 3/31/92
Completion Depth: 24 feet

Sampling: Sample No.	Blow Count	Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
			17.5					
SB 3-4	20 24 38	Full			GC	0	Silty clay with 10-15% sand and small pebbles to 1/4", compacts but crumbles under pressure. Reddish brown in color.	
			20.0					
			22.5					
SB 3-5	28 50 over 5	11			GC		Hard compacted silty clay. Sand about 30%. Very hard with signs of oxidation. Dark reddish brown in color.	
			25.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-5	Page 1 Of 2 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Gerald Tousley
Date Started: 4/1/92
Depth Water First Encountered (BLS): 9.5 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" - OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 4/1/92
Completion Depth: 20.5 feet

Sample No.	Blow Count	Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
			2.5					
SB 5-1	1 1 3	Full			CL	1	Dense silty clay, little or no sand. Compacts well, but crumbles under pressure. Dark reddish brown with bands of oxidation.	OVA of baggy sample - .06 ppm.
			5.0			3 BZ-0		
			7.5					
SB 5-2	4 8 11	Full			CL		Silty clay with little or no sand. Compacts well. Spotted areas of oxidation. Dark yellowish brown color.	Dry
							▼ Water	Sample SB 5-2 and SB 5-2 (Dup) were composited together.
SB 5-2 (Dup)	4 7 10	Full	10.0					
			12.5					Wet. OVA of baggy sample - .03 ppm.
SB 5-3	5 7 12	Full			CL		Hard cemented. Silty clay with sand. Spotted areas of oxidation. Olive brown color.	OVA of baggy sample - .01 pm.
			15.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-5	Page 2 Of 2 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Gerald Tousley
Date Started: 4/1/92
Depth Water First Encountered (BLS): 9.5 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" - OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 4/1/92
Completion Depth: 20.5 feet

Sampling: Sample No.	Sampling: Blow Count	Sampling: Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
								At 15.5 drillers remarked they hit something hard.
			17.5					
SB 5-4	28 50 over 5"	12"			GC		Compacted cemented gravelly, silty, with clay, sand. Strong brown.	
			20.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-6	Page 1 Of 2 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Gerald Tousley
Date Started: 4/1/92
Depth Water First Encountered (BLS): 9 feet

Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" - OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 4/1/92
Completion Depth: 20 feet

Sampling: Sample No.	Sampling: Blow Count	Sampling: Recovery (In)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
					A		Asphalt	
			2.5					
SB 6-1	5 6 11	14"			CL	123-Hole 11-BZ	Silty clay with small percentage of sand. Isolated areas of oxidation. Dark yellowish brown.	OVA of baggy sample - .5 ppm.
			5.0					
			7.5					
SB 6-2	5 6 8	Full			CL	0	Silty clay with little or no sand. Areas of oxidation. Dark brown color. ▼ Water	
			10.0					
			12.5					
SB 6-3	6 10 28	Full			GC	0	Hard cemented silty clay with 5-10% sand. Areas of oxidation present. Dark yellowish brown. Some areas are grey in color.	
			15.0					

SAIC	BOREHOLE LOG	Borehole Number: MW-6	Page 2 Of 2 Field Book No.: 1

Project Number: 01-0817-00-0462-000
Borehole Location: Battle Ground, WA
Drilling Personnel: Mel Pederson
Drilling Method: Hollow Stem Auger
Sampling Methods: Split Spoon
Field Geologist: Gerald Tousley
Date Started: 4/1/92
Depth Water First Encountered (BLS): 9 feet

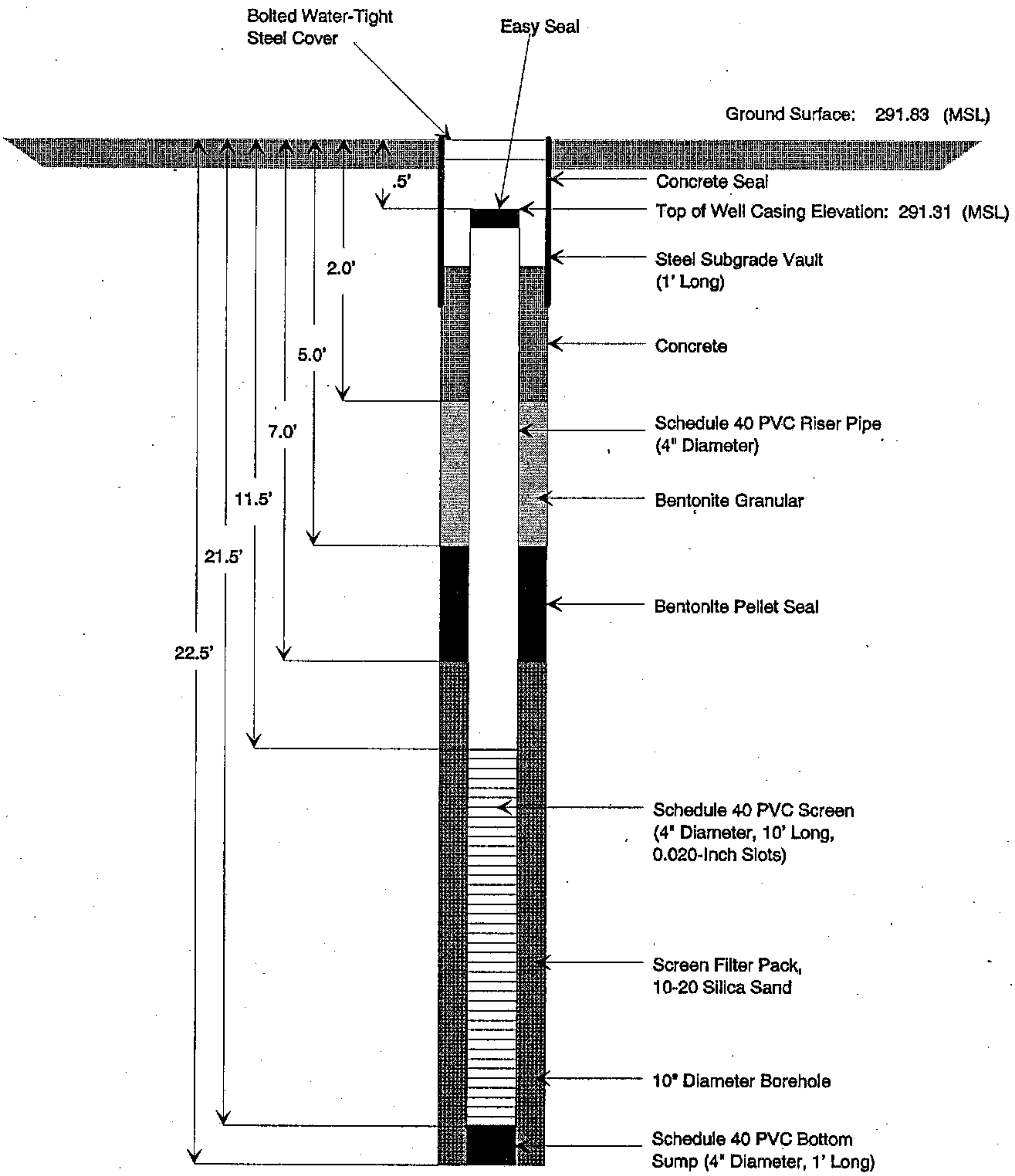
Project Name: Jim's BP
Drilling Company: Soil Sampling Service
Drill Rig Type/Number: Mobile B-61/04
Bit Type/Size: Auger/10" - OD
Hammer Wt: 140 lbs Drop: 30"
Assistant: Pete Christian
Date Completed: 4/1/92
Completion Depth: 20 feet

Sampling: Sample No.	Sampling: Blow Count	Sampling: Recovery (in)	Depth (Feet BLS)	Soil Graph	USCS Symbol	Organic Vapor (PPM)	Lithologic Description	Remarks
			17.5		GC			
SB 6-4	38 40 50	Full	20.0		GC	0	Hard, cemented gravelly, silty clay with 5-10% sand. Areas of oxidation present. Dark yellowish brown. Some banding of grey silty clays.	

APPENDIX D

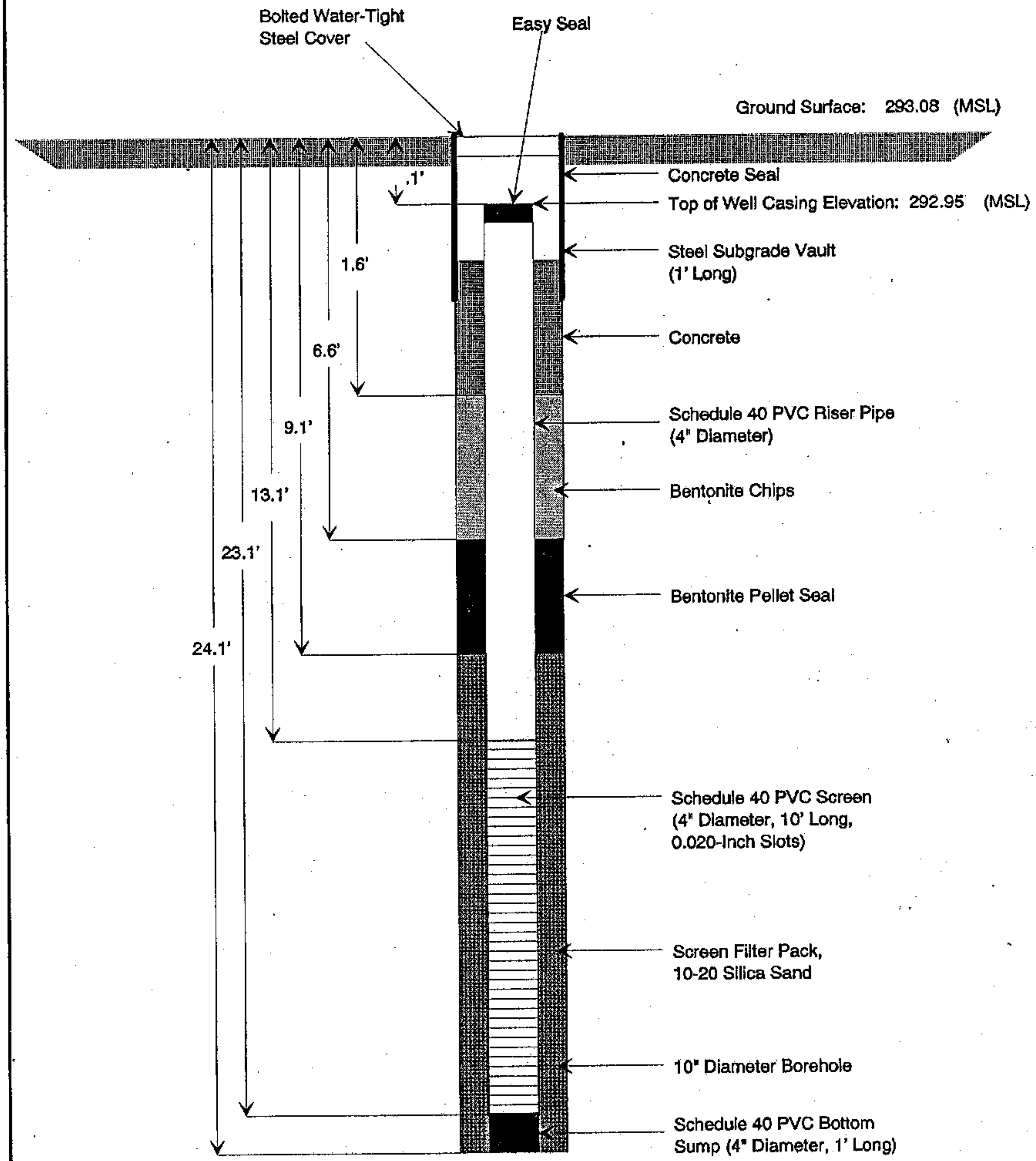
MONITORING WELL INSTALLATION DIAGRAMS

	MONITORING WELL INSTALLATION DIAGRAM	Monitoring Well No. MW-1



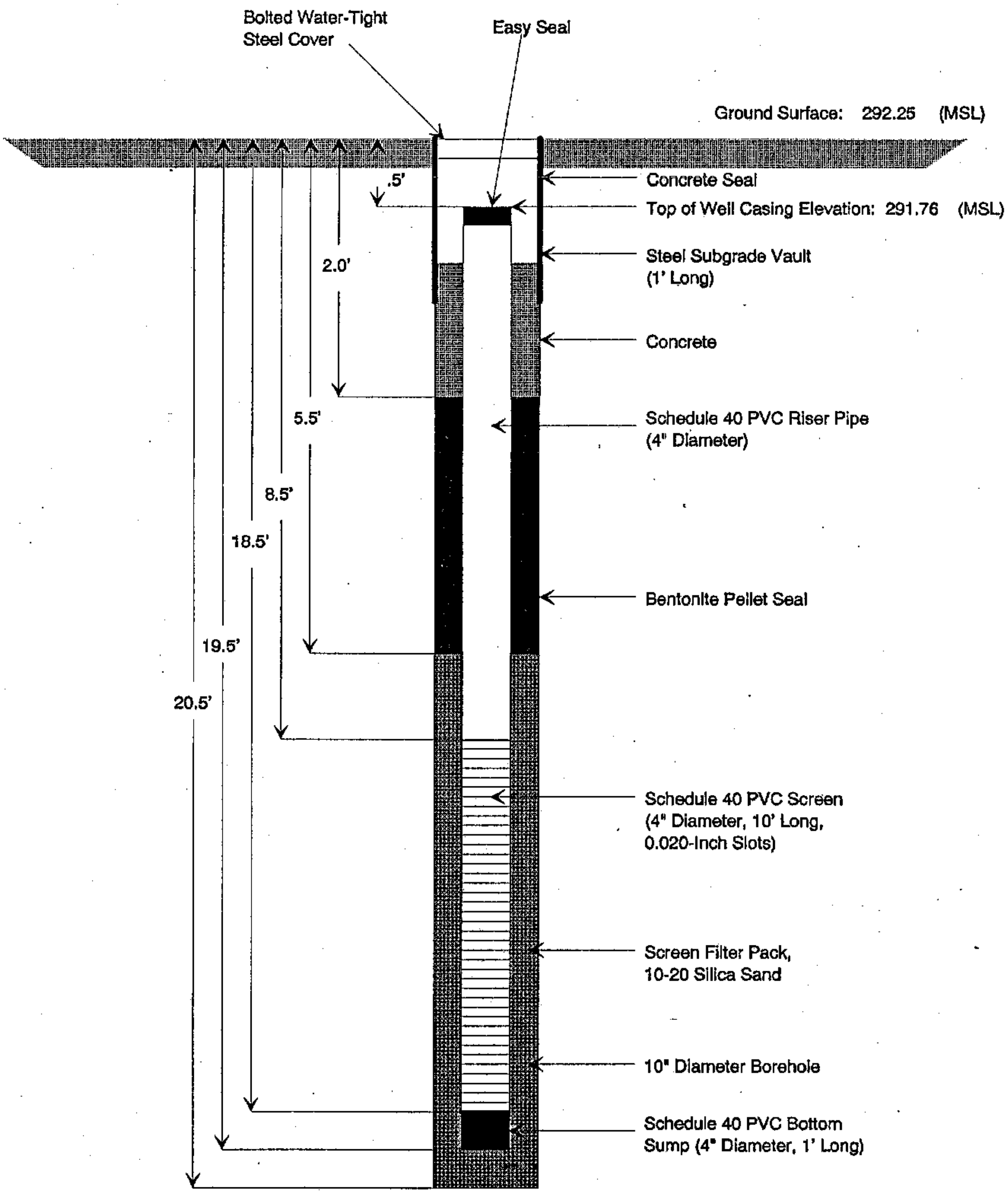
Not to Scale

SAIC	MONITORING WELL INSTALLATION DIAGRAM	Monitoring Well No. MW-3



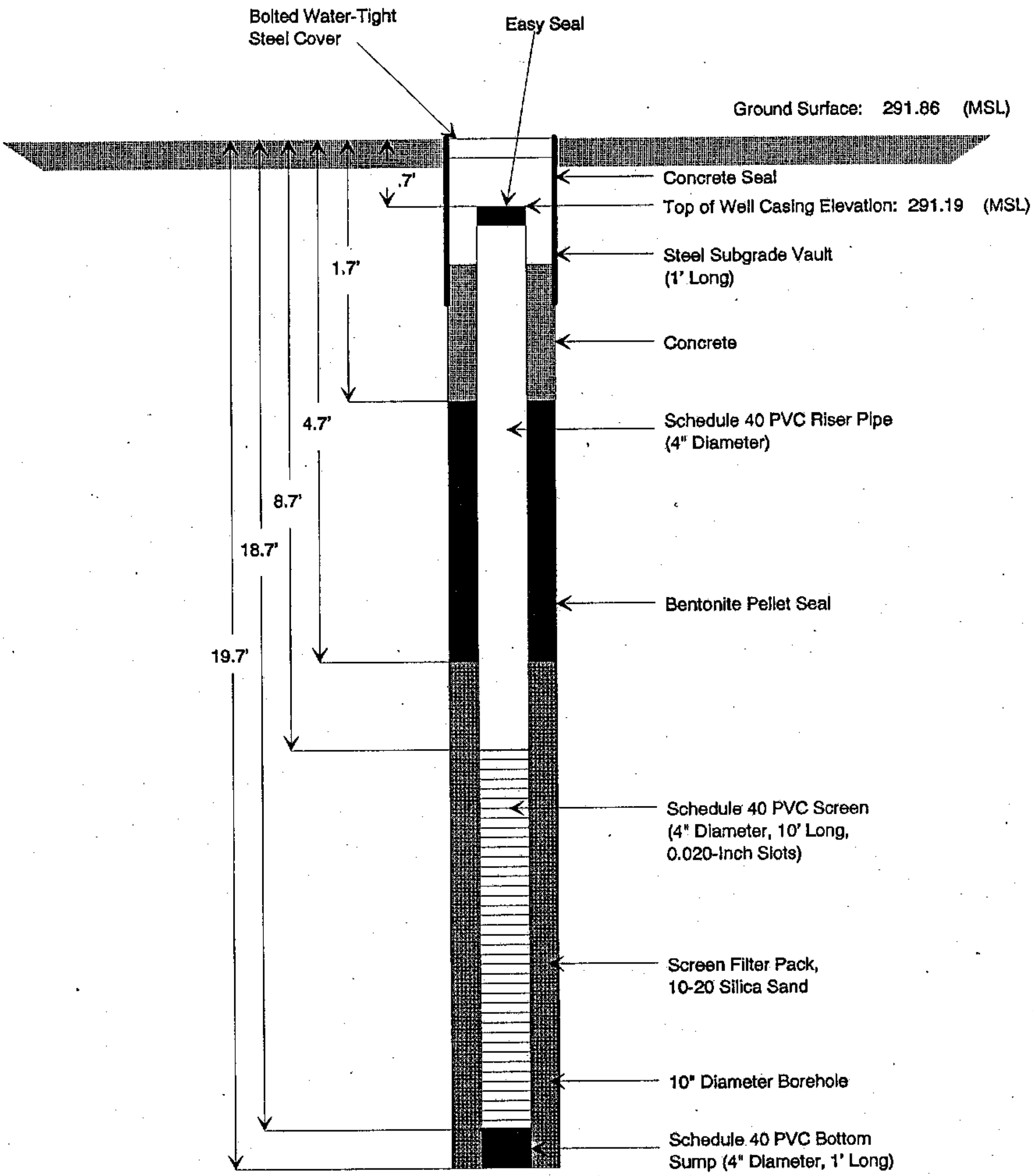
Not to Scale

SAIC	MONITORING WELL INSTALLATION DIAGRAM	Monitoring Well No. MW-5



Not to Scale

	MONITORING WELL INSTALLATION DIAGRAM	Monitoring Well No.
SAIC		MW-6



Not to Scale

APPENDIX E

SLUG TEST RESULTS

As described in Section 3.6, slug tests were performed on each monitoring well at Jim's BOP to better characterize subsurface conditions. To determine which method of analysis should be applied to slug test data, the most important consideration is the aquifer and well construction geometry. Different methods of analysis are designed for different well constructions, such as existence of gravel packs and confining layers. The analysis presented by Bower and Rice involves the instantaneous lowering (or raising) of the water level in a well, where the inflow into (or outflow out of) the well at any particular value of displacement can be calculated by a modified version of the Thiem equation:

$$Q=\frac{2\pi KLy}{\ln(R_e/r_w)}$$

where Q is the flow into the well, K is the hydraulic conductivity of the aquifer, L is the height of the screen, y is the displacement of the water level within the well, R_e is the effective radius over which y is dissipated, and r_w is the radius of the gravel pack.
A second equation that expresses the relation between flow into a well and the resulting rise in water level in the well is:

$$\frac{dy}{dt}=-\frac{Q}{\pi_c^2}$$

where dy/dt is the rate of rise of the water level within the well, and πr_c^2 is the cross-sectional area of the well. These equations can be combined to form:

$$\frac{1}{y}dy=-\frac{2KL}{r_c^2\ln(R_e/r_w)}dt$$

and then integrated to form:

$$\ln y=-\frac{2KLt}{r_c^2\ln(R_e/r_w)}+constant$$

which can be evaluated between the limits y_o at t=0 and y_t at t, and solved for K yielding:

$$K=\frac{r_c^2\ln(R_e/r_w)}{2L}\frac{1}{t}\ln\frac{y_o}{y_t}$$

Values of R_e (the effective radius of the well) were determined by Bower and Rice by application of an analog resistance network; from which they derived some dimensionless coefficients, and generated type curves for determining R_e from well construction dimensions.

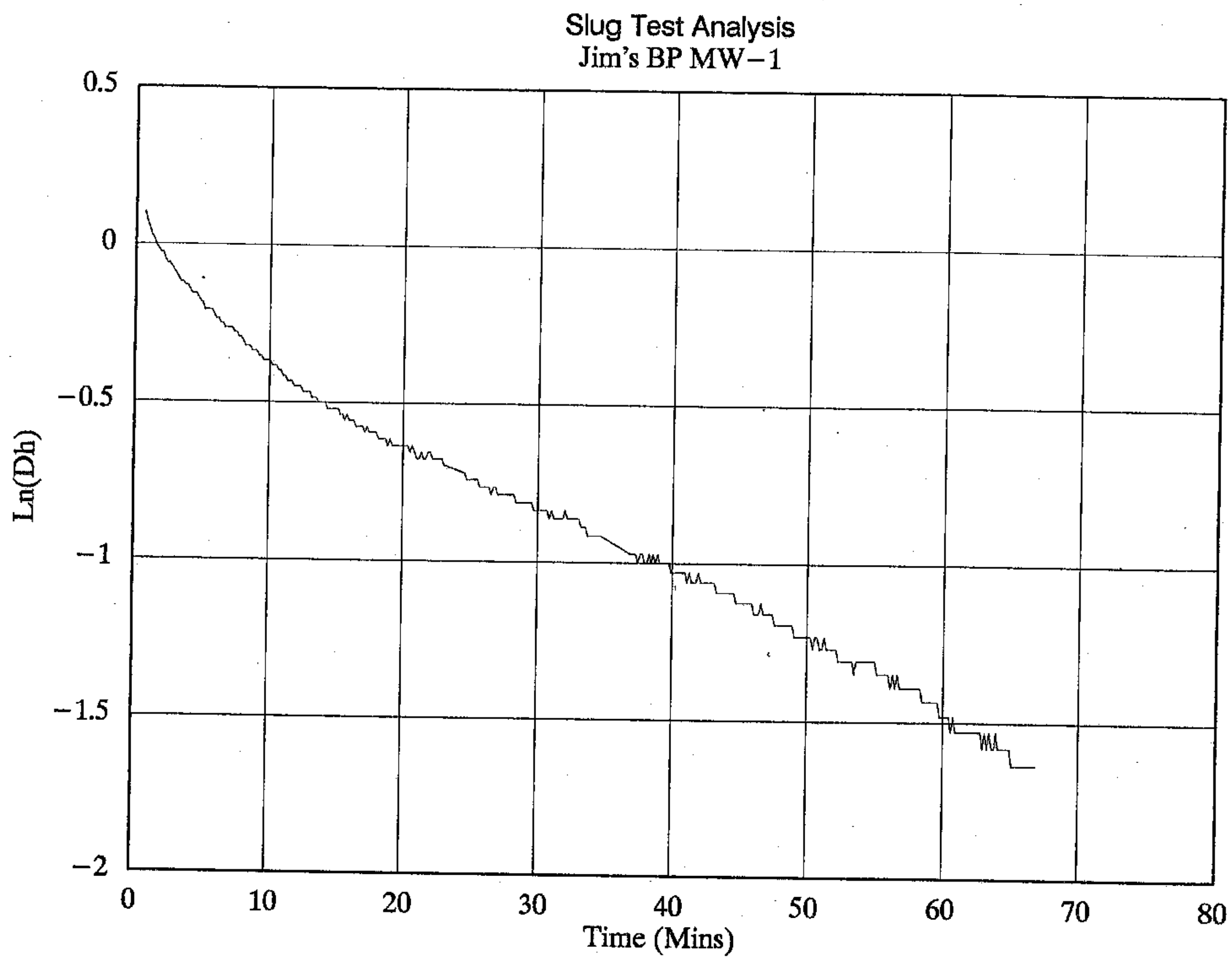
Since the piezometric surface intercepts the well screen in the wells at Jim's BP, the radius of the casing (r_c) which is used to derive the Q into the well in the above equations must be modified to reflect the flow into or out of the gravel pack. The r_c value was calculated by the following equation:

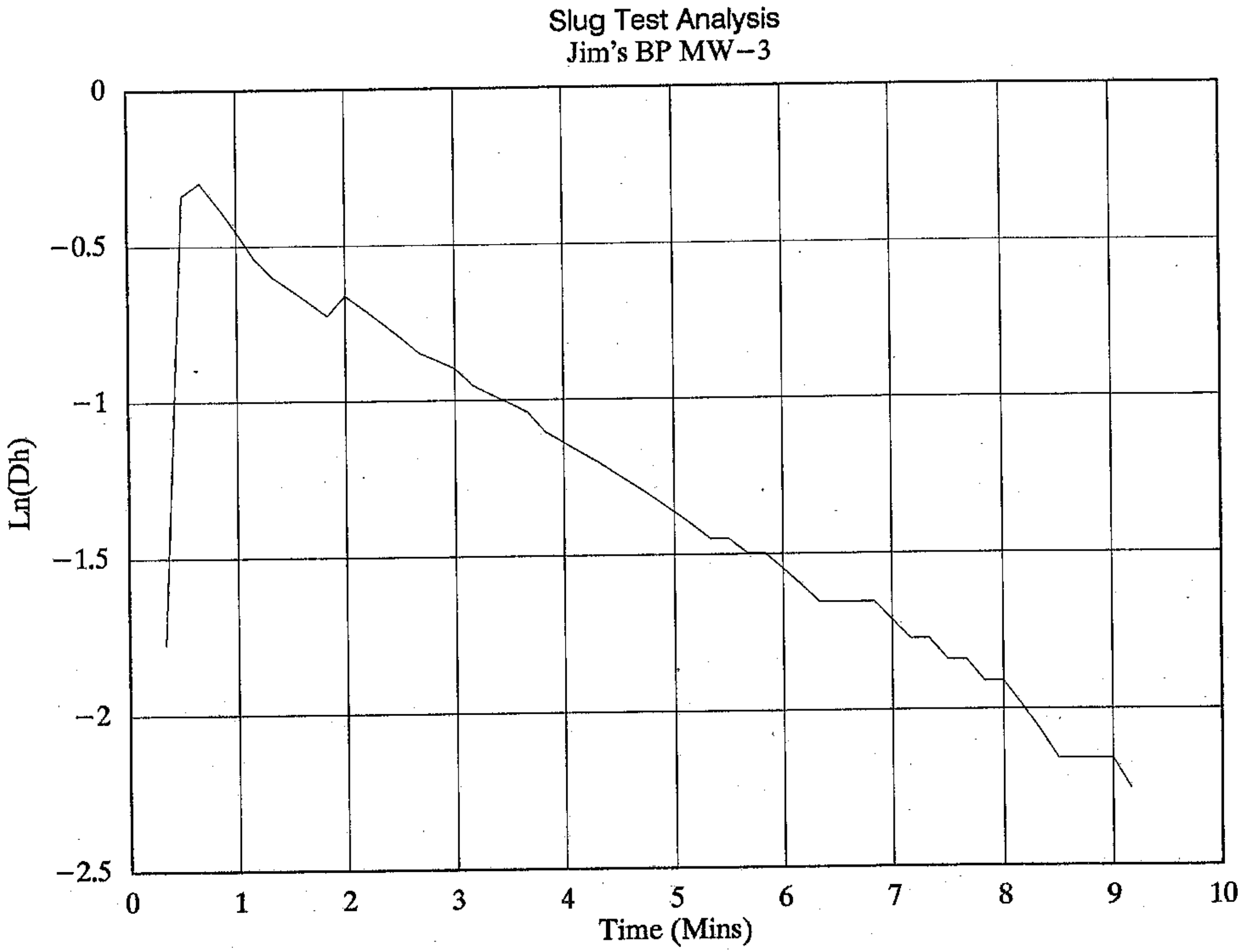
$$r_c=\sqrt{(r_a^2-r_b^2)n+r_b^2}$$

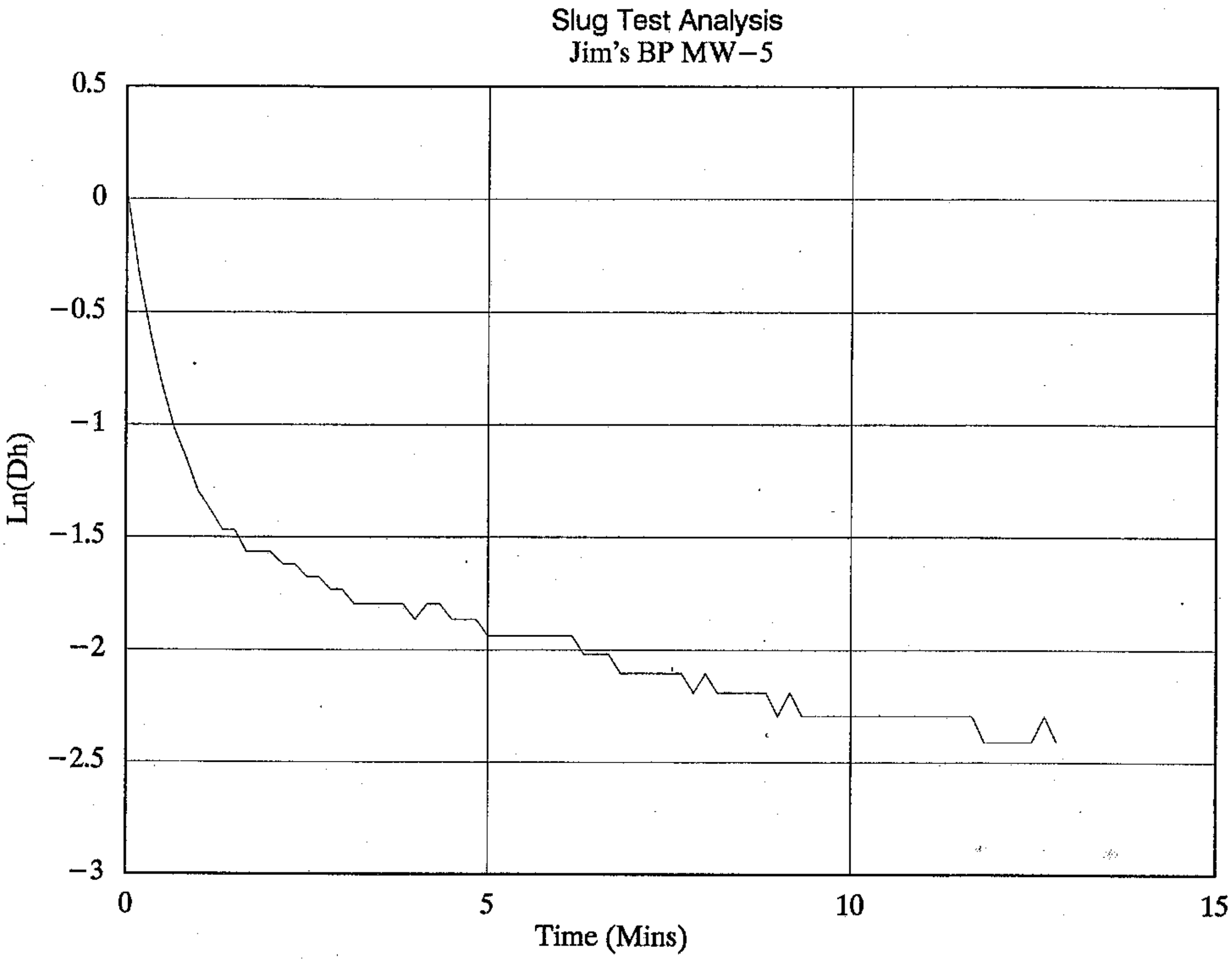
where r_a is the radius of the gravel pack, r_b is the radius of the well casing or screen, and n is the porosity of the gravel pack.

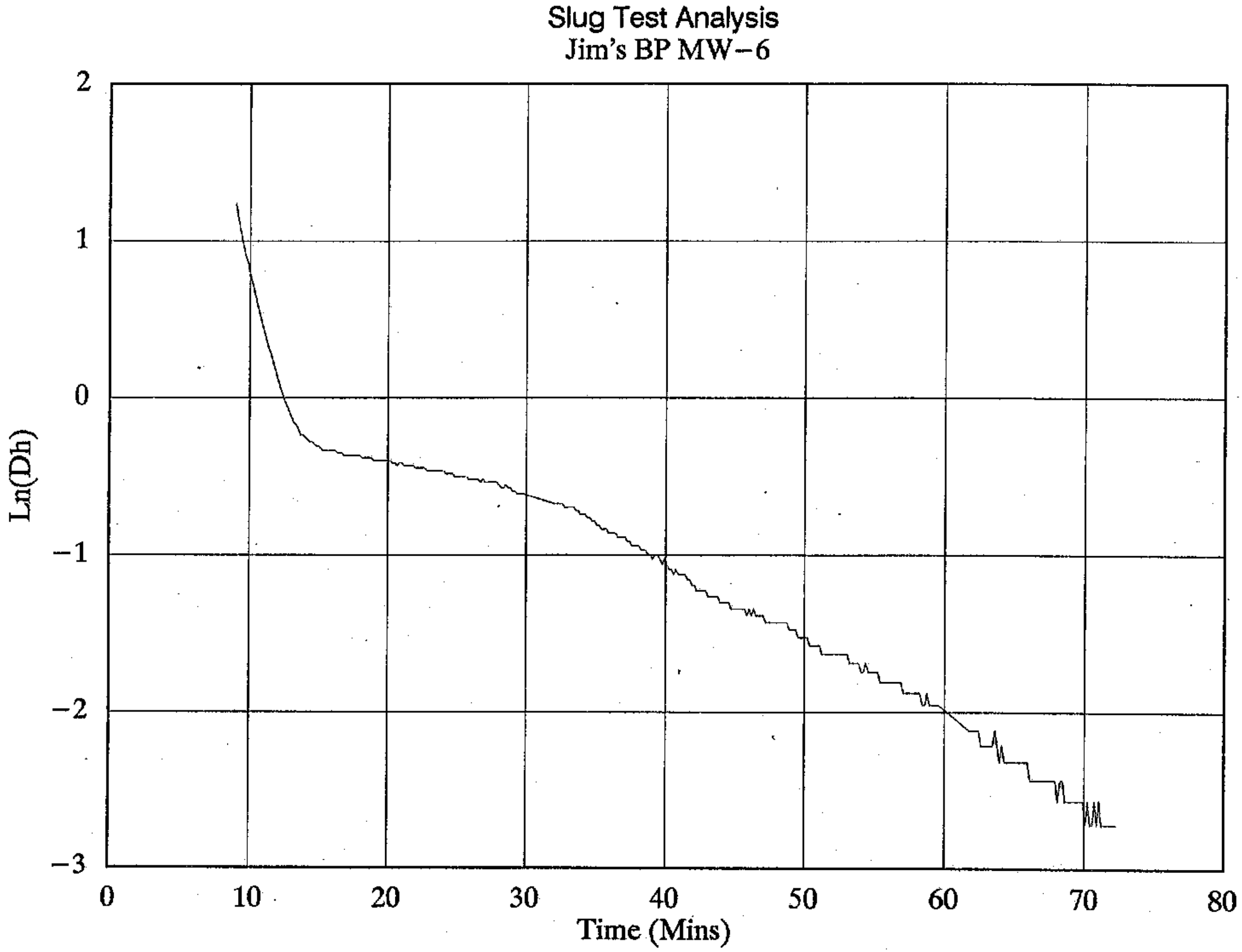
Plotting the water level displacement on a logarithmic scale versus time, the resulting graph should form a straight line. A point is taken near the end of the straight line portion of the data and the time and residual displacement are recorded. Time and displacement data from the selected point are used in conjunction with the initial displacement and well dimensions to calculate the hydraulic conductivity of the aquifer.

Water level displacement was measured using automated data collection equipment manufactured by Thor international. The data was then downloaded to an IBM personal computer,and using commercially available software, the hydraulic conductivities were determined from the generated plots.


Slug Test Analysis
Jim's BP MW−1
0.5
0
−0.5
−1
−1.5
−2
Ln(Dh)
0
10
20
30
40
50
60
70
80
Time (Mins)


Slug Test Analysis
Jim's BP MW−3
0
−0.5
−1
−1.5
−2
−2.5
Ln(Dh)
0
1
2
3
4
5
6
7
8
9
10
Time (Mins)


Slug Test Analysis
Jim's BP MW−5
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
Ln(Dh)
0
5
10
15
Time (Mins)



Slug Test Analysis
Jim's BP MW-6
Ln(Dh)
2
1
0
-1
-2
-3
0
10
20
30
40
50
60
70
80
Time (Mins)

APPPENDIX F

ANALYTICAL RESULTS

NATIONAL ENVIRONMENTAL TESTING, INC.

NET Pacific, Inc.
Suite 260
17400 SW Upper Boones Ferry Rd.
Portland, OR 97224
Tel: (503) 624-5449
Fax: (503) 639-6889

RECEIVED
MAY 04 1992
SAIC
BOTHELL, WA

Brett Freier
SAIC
18706 North Creek Parkway, Suite 110
Bothell, WA 98011

Date: 29-Apr-92
NET Client Acct No: P100
NET Pacific Log No: 1847
Rec'd: 01-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA

Dear Mr. Freier:

Sample analysis in support of the project referenced above has been completed and results are presented on following pages. All soil samples have been reported in a dry weight basis. Please refer to the enclosed "Key to Abbreviations" for definition of terms. Should you have questions regarding procedures or results please feel welcome to contact Client Services.

Approved by:

Kent Patton
Portland Division Manager

Enclosure(s)

NET

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1847
Date: 29-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA
Contact: Brett Freier
Matrix: Soil

Sampled: 31-Mar-92
Received: 01-Apr-92
Extracted: 03-Apr-92
Analyzed: 06-Apr-92

METHOD: 8020 AROMATIC VOLATILES
METHOD: WTPH-GAS

Sample ID and Lab Results

Parameter	Report Limit	1847.01 SB1-3	1847.02 SB3-3	1847.03 SB3-4	Units
Dilution Factor:		1	1	1	
Benzene	4	ND	ND	ND	ug/Kg
Toluene	4	35	32	ND	ug/Kg
Ethylbenzene	4	7	6	ND	ug/Kg
Xylenes, total	4	41	34	ND	ug/Kg
TPH-Gas	5	ND	ND	ND	mg/Kg
Surrogate Recovery					
Bromofluorobenzene		94%	99%	71%	
aaa-TFT		96%	94%	95%	

METHOD: Lead EPA 7421
Reporting Limit: 0.2 mg/Kg

Extracted: 07-Apr-92
Analyzed: 09-Apr-92

Sample Number	Sample I.D.	Lead Results	Units
1847.01	SB1-3	5.7	mg/Kg
1847.02	SB3-3	7.4	mg/Kg
1847.03	SB3-4	4.3	mg/Kg

NET

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1847
Date: 29-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA
Contact: Brett Freier
Matrix: Soil

Sampled: 31-Mar-92
Received: 01-Apr-92

Sample I.D. and Lab Results

Parameter	Report Limit	1847.01 SB1-3	1847.02 SB3-3	1847.03 SB3-4	Units
Percent Solids 160.3	0.1	75	76	74	%

QUALITY CONTROL DATA

Parameter	Reporting Limits	Units	Cal Verf Stand % Recovery	Blank Data	1850.05 Spike % Recovery	1850.05 Dup Spike % Recovery	RPD
Benzene	4	ug/Kg	97	ND	82	80	2.5
Toluene	4	ug/Kg	103	ND	91	92	1.1
Ethylbenzene	4	ug/Kg	102	ND	86	88	2.3
Xylene	4	ug/Kg	105	ND	88	89	1.1
TPH-Gas	5	mg/Kg	98	ND	82	80	2.5

QUALITY CONTROL DATA

Parameter	Reporting Limits	Units	Cal Verf Stand % Recovery	Blank Data	Spike % Recovery	Duplicate Spike % Recovery	RPD
Lead	0.2	mg/Kg	105	ND	84	85	<1

NET

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1877
Date: 13-Apr-92

Project: 01-0817-00-0462-001
Location: Jim's BP, Battle Ground
Contact: Brett Freier
Matrix: Water

Sampled: 08-Apr-92
Received: 08-Apr-92
Extracted: 09-Apr-92
Analyzed: 09-Apr-92

METHOD: TPH-Diesel 8015m
Reporting Limit: 250 ug/L
Volume Extracted: 500 mL

Units: ug/L

Sample Number	Sample I.D.	Dilution Factor	TPH-Diesel Results	o-terphenyl Surrogate Recovery	Control Limits
1877.01	F.B.	1	ND	99%	50%-150%
1877.03	MW-1-1	1	ND*	87%	50%-150%
1877.04	MW-1-1-Dup.	1	ND*	95%	50%-150%
1877.05	MW-5-5	1	ND*	87%	50%-150%
1877.06	MW-6-6	1	ND*	105%	50%-150%
1877.07	E.R.	1	ND	111%	50%-150%
1877.08	MW-3-3	1	ND	102%	50%-150%

* Contains Gasoline

QUALITY CONTROL DATA

Parameter	Reporting Limits	Units	Cal Verf Stand % Recovery	Blank Data	MW-1 Spike % Recovery	MW-1 Dup. Spike % Recovery	RPD
TPH-Diesel	250	ug/L	98	ND	66	78	17

T847. P100

SAIC 18706 North Creek Parkway, Suite 110
Bothell, Washington 98011
206/485-5800 • FAX: 485-5566

MASTER SAMPLE LOG AND CHAIN OF CUSTODY RECORD

Project No.: 01-0817-00-016-00 Project Mgr.: Rett Frewe
Project Name: JiLL's BP RI/FS
Project Location: Battle Ground, WA
Client Name: Dept of Ecology

Shipment No.:
Shipping Container No.:
Custody Seal No.:
Date Shipped:
Carrier:
Shipper:
Shipper Bill No.:

Sampling Location	Sample Number	Sample Depth	Sample Matrix	Sampling Date	Sampling Time	Sample Collector(s)	WTPH-G	BTEX	LEAD SW7241	2 oz Glass Jar (TPH, BTEX)	4 oz Glass Jar (Pb)	Comments
SB1-3	3	13-14.5'	Soil	3/31/92	1405	FREIER	X	X	X	1	1	[illegible]
SB3-3	3	13-14.5'	Soil	3/31/92	1425	FREIER	X	X	X	1	1	[illegible] 1
SB3-4	4	13-14.5'	Soil	3/31/92	1435	FREIER	X	X	X	1	1	

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Matthew P. Hayes	Signature: Douglas M Hunt	Signature:	Signature:
Date/Time: 4/1/92 0800	Date/Time: 4/1/92 09:04	Date/Time:	Date/Time:
Affiliation: SAIC	Affiliation: NET - PORTLAND.	Affiliation:	Affiliation:

• White: Lab Returns to Originator Upon Receipt of Samples; • Canary: Lab Retains; • Pink: Lab Returns to Project Manager with Final Report; • Goldenrod: Retained by Sampler

NET

NET Pacific, Inc.

KEY TO ABBREVIATIONS AND METHOD REFERENCES

< : Less than; When appearing in results column indicate analyte not detected at the value following. This datum supersedes the listed Reporting Limit.

* : Reporting Limits are a function of the dilution factor for any given sample. To obtain the actual reporting limits for this sample, multiply the stated Reporting Limits by the dilution factor (but do not multiply reported values).

ICVS : Initial Calibration Verification Standard (External Standard).

mean : Average; sum of measurements divided by number of measurements.

mg/Kg (ppm) : Concentration in units of milligrams of analyte per kilogram of sample, wet-weight basis (parts per million).

mL/L/hr : Milliliters per liter per hour.

MPN/100 mL : Most probable number of bacteria per one hundred milliliters of sample.

N/A : Not applicable.

NA : Not analyzed.

ND : Not detected; the analyte concentration is less than applicable listed reporting limit.

NTU : Nephelometric turbidity units.

RPD : Relative percent difference, 100 [Value 1 - Value 2]/mean value.

SNA : Standard not available.

ug/Kg (ppb) : Concentration in units of micrograms of analyte per kilogram of sample, wet-weight basis (parts per billion).

umhos/cm : Micromhos per centimeter.

Method References

Methods 100 through 493: see "Methods for Chemical Analysis of Water & Wastes", U.S. EPA, 600/4-79-020, rev 1983.

Methods 601 through 625: see "Guidelines Establishing Test Procedures for the Analysis of Pollutants" U.S. EPA, 40 CFR, Part 136, rev. 1988.

Methods 1000 through 9999: see "Test Methods for Evaluation solid Waste", U.S. EPA SW-846, 3rd edition, 1986.

SM: see "Standard Methods for the Examination of Water & Wastewater", 16th Edition, APHA, 1985.

NATIONAL
ENVIRONMENTAL
TESTING, INC.®

NET Pacific, Inc.
Suite 260
17400 SW Upper Boones Ferry Rd.
Portland, OR 97224
Tel: (503) 624-5449
Fax: (503) 639-6889

RECEIVED
MAY 04 1992
SAIC
BOTHELL WA

Brett Freier
SAIC
18706 North Creek Parkway, Suite 110
Bothell, WA 98011

Date: 29-Apr-92
NET Client Acct No: P100
NET Pacific Log No: 1850
Rec'd: 02-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA

Dear Mr. Freier:

Sample analysis in support of the project referenced above has been completed and results are presented on following pages. All soil samples have been reported on a dry weight basis. Please refer to the enclosed "Key to Abbreviations" for definition of terms. Should you have questions regarding procedures or results, please feel welcome to contact Client Services.

Approved by:

Kent Patton
Portland Division Manager

Enclosure(s)

NET Pacific, Inc.

Client:	SAIC	NET Log:	1850
Address:	Bothell, WA	Date:	29-Apr-92

Project:	01-0817-00-0462-009	Sampled:	01-Apr-92
Location:	Battle Ground, WA	Received:	02-Apr-92
Contact:	Brett Freier	Analyzed:	06-Apr-92
Matrix:	Soil		

METHOD: 8020 AROMATIC VOLATILES
METHOD: WTPH-GAS

Sample ID and Lab Results

Parameter	Report Limit	1850.01 SB-6 (1)	1850.02 SB-6 (2)	1850.03 SB-6 (4)	Units
Dilution Factor:		5	1	1	
Benzene	4	52	ND	ND	ug/Kg
Toluene	4	34	5	5	ug/Kg
Ethylbenzene	4	1,100	ND	ND	ug/Kg
Xylenes, total	4	850	10	17	ug/Kg
TPH-Gas	5	31	ND	ND	mg/Kg
Surrogate Recovery					
Bromofluorobenzene		81%	87%	77%	
aaa-TFT		95%	95%	96%	

Sample ID and Lab Results

Parameter	Report Limit	1850.04 SB-5 (2)	1850.05 SB-5(2D)	1850.06 SB-5 (3)	Units
Dilution Factor:		1	1	1	
Benzene	4	ND	ND	ND	ug/Kg
Toluene	4	7	5	9	ug/Kg
Ethylbenzene	4	ND	ND	ND	ug/Kg
Xylenes, total	4	45	11	23	ug/Kg
TPH-Gas	5	ND	ND	ND	mg/Kg
Surrogate Recovery					
Bromofluorobenzene		92%	94%	74%	
aaa-TFT		96%	95%	98%	

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1850
Date: 29-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA
Contact: Brett Freier
Matrix: Soil

Sampled: 01-Apr-92
Received: 02-Apr-92
Extracted: 03-Apr-92
Analyzed: 06-Apr-92

METHOD: Lead EPA 7421
Reporting Limit: 0.2 mg/Kg

Sample Number	Sample I.D.	Date Analyzed	Lead Results*	Units
1850.01	SB-6 (1)	04-Apr-92	10	mg/Kg
1850.02	SB-6 (2)	04-Apr-92	11	mg/Kg
1850.03	SB-6 (4)	04-Apr-92	11	mg/Kg
1850.04	SB-5 (2)	04-Apr-92	9	mg/Kg
1850.05	SB-5 (2D)	04-Apr-92	8	mg/Kg
1850.06	SB-5 (3)	04-Apr-92	7	mg/Kg

* Dry Weight

NET

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1850
Date: 29-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA
Contact: Brett Freier
Matrix: Water

Sampled: 02-Apr-92
Received: 02-Apr-92
Analyzed: 11-Apr-92

METHOD: 8020 AROMATIC VOLATILES
METHOD: 8015m TPH-GAS

Sample ID and Lab Results

Parameter	Report Limit	1850.07 ER	1850.08 FB	Units
Dilution Factor:		1	1	
Benzene	0.5	ND	ND	ug/L
Toluene	0.5	ND	ND	ug/L
Ethylbenzene	0.5	ND	ND	ug/L
Xylenes, total	0.5	ND	ND	ug/L
TPH-Gas	250	ND	ND	ug/L
Surrogate Recovery				
aaa-TFT		100%	99%	

METHOD: Lead EPA 7421
Reporting Limit: 0.002 mg/L

Analyzed: 02-Apr-92

Sample Number	Sample I.D.	Lead Results	Units
1850.07	ER	ND	mg/L
1850.08	FB	ND	mg/L

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1850
Date: 29-Apr-92

Project: 01-0817-00-0462-009
Location: Battle Ground, WA
Contact: Brett Freier

QUALITY CONTROL DATA - WATER

Parameter	Reporting Limits	Units	Cal Verf Stand % Recovery	Blank Data	Spike % Recovery	Duplicate Spike % Recovery	RPD
Benzene	0.5	ug/L	90	ND	95	98	3.1
Toluene	0.5	ug/L	96	ND	98	101	3.0
Ethylbenzene	0.5	ug/L	97	ND	94	98	4.2
Xylene	0.5	ug/L	99	ND	96	99	3.1
TPH-Gas	250	ug/L	101	ND	102	103	<1.0

QUALITY CONTROL DATA - SOIL

Parameter	Reporting Limits	Units	Cal Verf Stand % Recovery	Blank Data	SB-5 MS	SB-5 MSD	RPD
Benzene	4	ug/Kg	97	ND	82	80	2.5
Toluene	4	ug/Kg	103	ND	91	92	1.1
Ethylbenzene	4	ug/Kg	102	ND	86	88	2.2
Xylene	4	ug/Kg	105	ND	88	89	1.1
TPH-Gas	5	mg/Kg	98	ND	82	80	2.5

J 1877 P100

SAIC

18706 North Creek Parkway, Suite 110
Bothell, Washington 98011
206/485-5800 • FAX: 485-5566

MASTER SAMPLE LOG AND CHAIN OF CUSTODY RECORD

Project No.: 01-0817-00-0462-001 Project Mgr.: Brett Freier
Project Name: Jims BP RI/FS
Project Location: Battle Ground, Washington
Client Name: Dept of Ecology

Shipment No.:
Shipping Container No.:
Custody Seal No.:
Date Shipped:
Carrier:
Shipper:
Shipper Bill No.:

Sampling Location	Sample Number	Sample Depth	Sample Matrix	Sampling Date	Sampling Time	Sample Collector(s)	WTPH-G	WTPH-D	BTEX	LEAD SW7241	VOA	1 Liter Glass (Diesel)-HCL	1 Plastic 236 ml (Pb) HNO3	40 ml Glass (TPH-G, BTEX) HCL	Comments
	FB040892	–	Water	4-8-92	13:40	Tousley	X	X	X	X		1	1	4	
	TB040892	–	water	4-8-92	9:00	Tousley					X			1	
MW-1	1	–	Water	4-8-92	1225	Tousley	X	X	X	X		1	1	4	
MW-1	1-Dup	–	water	4-8-92	12:25	Tousley	X	X	X	X		1	1	4	
MW-5	5	–	water	4-8-92	13:15	Tousley	X	X	X	X		1	1	4	
MW-6	6	–	water	4-8-92	13:35	Tousley	X	X	X	X		1	1	4	
	ER040892	–	water	4-8-92	12:15	Tousley	X	X	X	X		1	1	2	Only two VOA bottles sent.
MW-3	3	–	water	4-8-92	11:50	Tousley	X	X	X	X		1	1	4	

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Harold L. Tousley	Signature: Douglas M Hunt	Signature:	Signature:
Date/Time: 40892 2:20	Date/Time: 2:25 pm 40892	Date/Time:	Date/Time:
Affiliation: SAIC	Affiliation: NET	Affiliation:	Affiliation:

• White: Lab Returns to Originator Upon Receipt of Samples; • Canary: Lab Retains; • Pink: Lab Returns to Project Manager with Final Report; • Goldenrod: Retained by Sampler

NET Pacific, Inc.

KEY TO ABBREVIATIONS AND METHOD REFERENCES

<	:	Less than; When appearing in results column indicate analyte not detected at the value following. This datum supersedes the listed Reporting Limit.
*	:	Reporting Limits are a function of the dilution factor for any given sample. To obtain the actual reporting limits for this sample, multiply the stated Reporting Limits by the dilution factor (but do not multiply reported values).
ICVS	:	Initial Calibration Verification Standard (External Standard).
mean	:	Average; sum of measurements divided by number of measurements.
mg/Kg (ppm)	:	Concentration in units of milligrams of analyte per kilogram of sample, wet-weight basis (parts per million).
mL/L/hr	:	Milliliters per liter per hour.
MPN/100 mL	:	Most probable number of bacteria per one hundred milliliters of sample.
N/A	:	Not applicable.
NA	:	Not analyzed.
ND	:	Not detected; the analyte concentration is less than applicable listed reporting limit.
NTU	:	Nephelometric turbidity units.
RPD	:	Relative percent difference, 100 [Value 1 - Value 2]/mean value.
SNA	:	Standard not available.
ug/Kg (ppb)	:	Concentration in units of micrograms of analyte per kilogram of sample, wet-weight basis (parts per billion).
umhos/cm	:	Micromhos per centimeter.

Method References

Methods 100 through 493: see "Methods for Chemical Analysis of Water & Wastes", U.S. EPA, 600/4-79-020, rev 1983.

Methods 601 through 625: see "Guidelines Establishing Test Procedures for the Analysis of Pollutants" U.S. EPA, 40 CFR, Part 136, rev. 1988.

Methods 1000 through 9999: see "Test Methods for Evaluation solid Waste", U.S. EPA SW-846, 3rd edition, 1986.

SM: see "Standard Methods for the Examination of Water & Wastewater", 16th Edition, APHA, 1985.

NATIONAL ENVIRONMENTAL TESTING, INC.

NET Pacific, Inc.
Suite 260
17400 SW Upper Boones Ferry Rd.
Portland, OR 97224
Tel: (503) 624-5449
Fax: (503) 639-6889

Brett Freier
SAIC
18706 North Creek Parkway, Suite 110
Bothell, WA 98011

Date: 08-May-92
NET Client Acct No: P100
NET Pacific Log No: 1877
Rec'd: 08-Apr-92

Project: 01-0817-00-0462-001
Location: Jim's BP, Battle Ground

Dear Mr. Freier:

Sample analysis in support of the project referenced above has been completed and results are presented on following pages. Please refer to the enclosed "Key to Abbreviations" for definition of terms. Should you have questions regarding procedures or results, please feel welcome to contact Client Services.

Approved by:

Kent Patton
Portland Division Manager

Enclosure(s)

NATIONAL ENVIRONMENTAL TESTING, INC.

NET Pacific, Inc.
Suite 260
17400 SW Upper Boones Ferry Rd.
Portland, OR 97224

Tel: (503) 624-5449
Fax: (503) 639-6889

Brett Freier
SAIC
18706 North Creek Parkway, Suite 110
Bothell, WA 98011

5-14-92

Project: 01-0817-00-0462-001
Location: Jim's BP, Battle Ground, WA.
NET Log: 1877.P100

Dear Mr. Freier:

Eight samples were submitted from Jim's BP for analysis on 4-8-92. These samples were assigned NET Log number 1877.P100. Sample TB040892 was marked for "VOA" analysis. The sample login personnel did not understand the analysis designation and believed that "VOA" described the sample container and that no tests were requested. Failure by login to contact the client and obtain clarification allowed the holding time on this sample to expire before the lab was informed by Mr. Hays that BTEX and WTPH-G were requested on sample TB040892. Therefore, no data is reportable for this sample number. I apologize for this laboratory oversight. A corrective action program has been initiated by the NET Portland Division and a copy of this letter will be included in Portland's corrective/preventive file.

Sincerely,

Kent Patton
Portland Division Manager

c.c. Matt Hays-SAIC Olympia

NET Pacific, Inc.

Client:	SAIC	NET Log:	1877
Address:	Bothell, WA	Date:	08-May-92

Project:	01-0817-00-0462-001	Sampled:	08-Apr-92
Location:	Jim's BP, Battle Ground	Received:	08-Apr-92
Contact:	Brett Freier	Analyzed:	14-Apr-92
Matrix:	Water		

METHOD: 8020 AROMATIC VOLATILES
METHOD: 8015m TPH-GAS

Sample ID and Lab Results
Units: ug/L

Parameter	Report Limit	1877.01 F.B.	1877.03 MW-1-1	1877.04 MW-1-1-D	1877.05 MW-5-5
Dilution Factor:		1	1	1	1
Benzene	0.5	ND	7	7	72
Toluene	0.5	ND	ND	ND	7
Ethylbenzene	0.5	ND	4	4	53
Xylenes, total	0.5	ND	6	5	110
TPH-Gas	250	ND	ND	ND	1,000
Surrogate Recovery					
aaa-TFT		100%	102%	100%	99%

Parameter	Report Limit	1877.06 MW-6-6	1877.07 E.R.	1877.08 MW-3-3	Units
Dilution Factor:		1	1	1	
Benzene	0.5	220	ND	ND	ug/L
Toluene	0.5	2	ND	ND	ug/L
Ethylbenzene	0.5	98	ND	ND	ug/L
Xylenes, total	0.5	59	ND	ND	ug/L
TPH-Gas	250	1,500	ND	ND	ug/L
Surrogate Recovery					
aaa-TFT		110%	99%	99%	

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1877
Date: 08-May-92

Project: 01-0817-00-0462-001
Location: Jim's BP, Battle Ground
Contact: Brett Freier
Matrix: Water

Sampled: 08-Apr-92
Received: 08-Apr-92
Extracted: 09-Apr-92
Analyzed: 09-Apr-92

METHOD: TPH-Diesel 8015m
Reporting Limit: 250 ug/L
Volume Extracted: 500 mL

Units: ug/L

Sample Number	Sample I.D.	Dilution Factor	TPH-Diesel Results	o-terphenyl Surrogate Recovery	Control Limits
1877.01	F.B.	1	ND	99%	50%-150%
1877.03	MW-1-1	1	ND*	87%	50%-150%
1877.04	MW-1-1-Dup.	1	ND*	95%	50%-150%
1877.05	MW-5-5	1	ND*	87%	50%-150%
1877.06	MW-6-6	1	ND*	105%	50%-150%
1877.07	E.R.	1	ND	111%	50%-150%
1877.08	MW-3-3	1	ND	102%	50%-150%

* Contains Gasoline

NET Pacific, Inc.

Client:	SAIC	NET Log:	1877
Address:	Bothell, WA	Date:	08-May-92

Project:	01-0817-00-0462-001	Sampled:	08-Apr-92
Location:	Jim's BP, Battle Ground	Received:	08-Apr-92
Contact:	Brett Freier	Analyzed:	20-Apr-92
Matrix:	Water		

METHOD: Lead EPA 7421
Reporting Limit: 0.002 mg/L

Sample Number	Sample I.D.	Lead Results	Units
1877.01	F.B.	ND	mg/L
1877.03	MW-1-1	0.003	mg/L
1877.04	MW-1-1-Dup.	ND	mg/L
1877.05	MW-5-5	ND	mg/L
1877.06	MW-6-6	0.006	mg/L
1877.07	E.R.	ND	mg/L
1877.08	MW-3-3	0.004	mg/L

NET Pacific, Inc.

Client: SAIC
Address: Bothell, WA

NET Log: 1877
Date: 08-May-92

Project: 01-0817-00-0462-001
Location: Jim's BP, Battle Ground
Contact: Brett Freier

QUALITY CONTROL DATA

Parameter	Reporting Limits	Units	Cal Verf Stand % Recovery	Blank Data	Spike % Recovery	Duplicate Spike % Recovery	RPD
Benzene	0.5	ug/L	90	ND	101	99	2.0
Toluene	0.5	ug/L	96	ND	103	100	3.0
Ethylbenzene	0.5	ug/L	98	ND	101	99	2.0
Xylene	0.5	ug/L	100	ND	101	99	2.0
TPH-Gas	250	ug/L	101	ND	105	102	2.9
TPH-Diesel	250	ug/L	98	ND	66	78	17
Lead	0.002	mg/L	105	ND	101	104	3.2

1877P100

SAIC

18706 North Creek Parkway, Suite 110
Bothell, Washington 98011
206/485-5800 • FAX: 485-5566

MASTER SAMPLE LOG AND CHAIN OF CUSTODY RECORD

Project No.: 01-0817-00-0962-001 Project Mgr.: Brett Fraser
Project Name: Jim, BP RI/FS
Project Location: Battle Ground, Washington
Client Name: Dept of Ecology

Shipment No.:
Shipping Container No.:
Custody Seal No.:
Date Shipped:
Carrier:
Shipper:
Shipper Bill No.:

Sampling Location	Sample Number	Sample Depth	Sample Matrix	Sampling Date	Sampling Time	Sample Collector(s)	WTPH-G	WTPH-D	BTEX	LEAD SW 7241	VOA	1 L Amber Glass (Diesel)-HCL	1 Plastic 236 ml (Pb) HNO3	40 ml Glass (TPH-G, BTEX) HCL	Comments
	150410892	–	Water	4-8-92	13:10	Towsley	X	X	X	X		1	1	4	
	TB010892	–	water	4-8-92	9:00	Towsley					X			1	
MW-1	1	–	water	4-8-92	1225	Towsley	X	X	X	X		1	1	4	
MW-1	1-Dup	–	water	4-8-92	1225	Towsley	X	X	X	X		1	1	4	
MW-5	5	–	water	4-8-92	1345	Towsley	X	X	X	X		1	1	4	
MW-6	6	–	water	4-8-92	13:35	Towsley	X	X	X	X		1	1	1	
	ER010892	–	water	4-8-92	12:15	Towsley	X	X	X	X		1	1	2	Only two VOA bottles sent.
MW-3	3	–	water	4-8-92	11:50	Towsley	X	X	X	X		1	1	4	

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Harold H. Towsley	Signature: Douglas M Hunt	Signature:	Signature:
Date/Time: 4/8/92 2:20	Date/Time: 2:35 PM 4/8/92	Date/Time:	Date/Time:
Affiliation: SAIC	Affiliation: NET	Affiliation:	Affiliation:

White: Lab Returns Original with Receipt of Samples; • Canary: Lab Retains; • Pink: Lab Returns to Project Manager with Final Report; • Goldenrod: Retained by Sampler

NET Pacific, Inc.

KEY TO ABBREVIATIONS AND METHOD REFERENCES

: Less than; When appearing in results column indicate analyte not detected at the value following. This datum supersedes the listed Reporting Limit.

: Reporting Limits are a function of the dilution factor for any given sample. To obtain the actual reporting limits for this sample, multiply the stated Reporting Limits by the dilution factor (but do not multiply reported values).

VS : Initial Calibration Verification Standard (External Standard).

an : Average; sum of measurements divided by number of measurements.

/Kg (ppm) : Concentration in units of milligrams of analyte per kilogram of sample, wet-weight basis (parts per million).

/L/hr : Milliliters per liter per hour.

N/100 mL : Most probable number of bacteria per one hundred milliliters of sample.

A : Not applicable.

: Not analyzed.

: Not detected; the analyte concentration is less than applicable listed reporting limit.

U : Nephelometric turbidity units.

D : Relative percent difference, 100 [Value 1 - Value 2]/mean value.

A : Standard not available.

/Kg (ppb) : Concentration in units of micrograms of analyte per kilogram of sample, wet-weight basis (parts per billion).

hos/cm : Micromhos per centimeter.

<u>thod References</u>

<u>Methods 100 through 493</u>: see "Methods for Chemical Analysis of Water & Wastes", U.S. EPA, 600/4-79-020, rev 1983.

<u>Methods 601 through 625</u>: see "Guidelines Establishing Test Procedures for the Analysis of Pollutants" U.S. EPA, 40 CFR, Part 136, rev. 1988.

<u>Methods 1000 through 9999</u>: see "Test Methods for Evaluation solid Waste", U.S. EPA SW-846, 3rd edition, 1986.

<u>SM</u>: see "Standard Methods for the Examination of Water & Wastewater", 16th Edition, APHA, 1985.

Columbia Inspection, Inc.

U.S. CUSTOMS APPROVED COMMERCIAL
GAUGER AND LABORATORY
TANK CALIBRATIONS

Offices:

Portland, OR	(503) 286-9464
Seattle, WA	(206) 522-7490
Pacheco, CA	(415) 671-4814
San Pedro, CA	(213) 833-1557

Fed. I.D. 93-0746019

NORTHWEST CONSTRUCTION
30903 NE 152nd Avenue
Battle Ground, WA 98604

ATTN: Darryl Becker

Februaary 15, 1991

INVOICE NO. 191254

Feb. 14	For Services Rendered:		
	ANALYSIS OF THE GROUND WATER SAMPLE		
	Description: 2 VOA Dup		
	Date Submitted: February 8, 1991		
	CI Lab Number: 91193		
	TEST:		
	BETX .... 1 @ $100.00/each	$100.00	
	Your total cost:		$100.00
	THANK YOU FOR DOING BUSINESS WITH CI.		
	TOTAL AMOUNT DUE (Terms: Net 15 days)		$100.00

Please state invoice numbers and remit to:

COPY

COLUMBIA INSPECTION, INC.
P.O. Box 83569, St. Johns Station

Columbia Inspection, Inc.

U.S. CUSTOMS APPROVED COMMERCIAL
GAUGER AND LABORATORY
TANK CALIBRATIONS

Offices:

Portland, OR (503) 286-9464
Seattle, WA (206) 522-7490
Pacheco, CA (415) 671-4814
San Pedro, CA (213) 833-1557

Fed. I.D. 93-0746019

NORTHWEST CONSTRUCTION
30903 NE 152nd Avenue
Battle Ground, WA 98604

ATTN: Darryl Becker

February 15, 1991

INVOICE NO. 191252

Feb. 12	For Services Rendered:		
	ANALYSIS OF THE SOIL SAMPLES		
	Marked: #1 - 2/7/91 BPN #2 - 2/7/91 BPS		
	Date Submitted: February 8, 1991		
	CI Lab Numbers: #1 - 91189-1 #2 - 91189-2		
	<u>TESTS</u>:		
	Total Petroleum Hydrocarbons .... 2 @ $40.00/each	$80.00	
	Your total cost:		$80.00
	THANK YOU FOR DOING BUSINESS WITH CI.		
	TOTAL AMOUNT DUE (Terms: Net 15 days)		$80.00

COPY

Please state invoice numbers and remit to:

COLUMBIA INSPECTION, INC.
P.O. Box 83569 St. Johns Station

CERTIFICATE OF ANALYSIS

SAMPLE DESIGNATED BY CLIENT AS:	Soils
CLIENT:	NW Construction
MARKED:	#1 2-7-91 BPN #2 2-7-91 BPS
DATE SUBMITTED:	February 8, 1991
LAB NUMBER:	91189 1 & 2

REPORT DATE February 12, 1991 REPORT NO. 191252

ANALYSIS OF THE SOIL SAMPLES

TESTS:	#1	#2
Total Petroleum Hydrocarbons mg/Kg (EPA Modified 418.1)	900	N.D. *

* None Detected (Detection limit 10 mg/Kg)

Reviewed by: Diana Wojno
Diana Wojno- Chemist

COPY

Columbia Inspection, Inc.
7133 N. Lombard St., P.O. Box 83569
Portland, Oregon 97283 503-286-9464

Columbia Inspection, Inc.

Client: N.W.Construction

Client Sample No: None   Lab Sample No.: 91193-1

Lab Receipt Date: 02/08/91   Report Date:02/14/91

Matrix: Ground Water

ORGANIC ANALYSIS DATA

Method: EPA 8020

Aromatic Volatile Organics; Identified And Measured

	Parameter	Result	Detection Limit
		------mg/L-(ppm)-----	
1.	Benzene	20.0	0.0003
2.	Chlorobenzene	ND	0.0005
3.	1,2-Dichlorobenzene	ND	0.0005
4.	1,3-Dichlorobenzene	ND	0.0005
5.	1,4-Dichlorobenzene	ND	0.0005
6.	Ethyl Benzene	1.18	0.0003
7.	Toluene	11.7	0.0003
8.	m&p-Xylene	6.01	0.0003
9.	o-Xylene	2.29	0.0003

DRAFT

FEASIBILITY STUDY
FOR
JIM'S BP
BATTLE GROUND, WASHINGTON

Submitted to:

Washington Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504

Submitted by:

Science Applications International Corporation
626 Columbia Street N.W., Suite 1-C
Olympia, Washington 98501

Ecology Contract C00890006
Work Assignment No. SAIC 24
SAIC Project No. 01-0817-00-0462-000

June 1, 1992

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

This report is part of a Remedial Investigation/Feasibility Study (RI/FS) being conducted for the Washington Department of Ecology at the Jim's BP site in Battle Ground, Washington. This report represents the feasibility study of the RI/FS effort. The remedial investigation was completed by SAIC and the RI report precedes this report (1992). Provided in this report is a summary of available information concerning the contamination at Jim's BP, an evaluation of the data to determine whether and where remedial actions are necessary, proposed appropriate remedial action objectives and cleanup goals where needed, and a range of remedial action alternatives that would be capable of achieving these objectives and goals. This FS also presents comparative evaluations of the proposed alternatives in accordance with methodology and performance criteria specified by CERCLA.

This report is based in large part upon the results of the RI conducted by SAIC in March and April 1992. The SAIC RI report includes the results of soil gas, soil, and ground water sampling efforts and presents a summary of the extent and significance of the contamination.

1.2 REGULATORY BASIS

The Model Toxics Control Act (MTCA) as specified in WAC 173-340 provides regulations pertaining to releases from underground storage tanks (UST) (WAC 173-340-450). Detailed in that section are interim actions, reporting requirements, and state remedial investigation and feasibility study requirements. The requirements of the RI/FS are stipulated in several paragraphs in WAC 173-340-350. Of primary importance with respect to the FS process is the selection of cleanup technologies. WAC 173-340-360 paragraph (4), indicates that cleanup technologies shall be considered in order of descending preference:

- Reuse or recycling
- Destruction or detoxification
- Separation or volume reduction followed by use or reuse, recycling, destruction, detoxification of the residual hazardous substances
- Immobilization of hazardous substances
- Onsite or offsite disposal at an engineered facility designed to minimize the future release of hazardous substances and in accordance with applicable state and federal laws
- Isolation or containment with attendant engineering controls
- Institutional controls and monitoring

Specified in paragraph (7) are the cleanup standards appropriate for UST owners or UST operators and the requirements for the selection of cleanup standards. UST cleanup actions must meet the cleanup standards specified in WAC 173-340-700 through 173-340-750. Section 173-340-710 indicates that any person conducting a cleanup action must identify all applicable federal and state laws and relevant and appropriate requirements (ARARs). There is a wide range of ARARs which address cleanup standards through federal and state laws or environmental quality criteria. For this investigation, the ARARs are limited to MTCA cleanup standards as determined by Method A.

1.3 SITE BACKGROUND

Jim's BP service station is located in southwest Washington and within the business district of Battle Ground. The community of Battle Ground is situated approximately 10 miles north-northeast of Vancouver, Washington (Figure 1-1). The site is a small service station which dispenses gasoline from three USTs. The station is situated on the corner of Main Street and Parkway Avenue. It is bordered on two sides by commercial businesses and opposite the site is the public library. The nearest private residence is located immediately behind the Jim's BP lot. Residents of the city of Battle Ground obtain potable water from four municipal wells, two of which are located approximately seven blocks west of the site. A site map is presented in Figure 1-2.

During excavation of a 6,000 gallon UST at Jim's BP station in February 1991, it was observed by the contractor conducting the tank removal (N.W. Construction) that a release of gasoline had occurred. The tank also failed a tightness test. Both soil and ground water were observed to have been impacted by the release and subsequently, both media were sampled for possible petroleum contamination. Samples were collected and submitted to the analytical laboratory on two separate occasions. The results of the second sampling event indicated that contaminants were found in soil and groundwater well above the MTCA standards. The compounds exceeding MTCA soil standards included benzene (2.7 mg/Kg) and total xylenes (99.2 mg/kg) in sample 53-2. Benzene, toluene, and total xylenes groundwater cleanup standards were exceeded in sample 513-5 with concentrations of 742, 314, and 1,230 μg/L, respectively. A more complete discussion of the history of site investigations and the findings were summarized in the RI report. The results of the SAIC RI findings with respect to soil and groundwater contamination are summarized in Section 2.0 of this FS.

1.4 FEASIBILITY STUDY METHODOLOGY

In general, this document follows guidance outlined in the EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under Cercla (1988). Content is similar and the guidance document has been followed to the extent possible. Due to the limited amount of data gathered during the RI, the scope of this document is limited in comparison with an FS conducted under the CERCLA process. For this FS, a three-step process was used as follows:

- Develop remedial action objectives (RAOs) which appear to be necessary for protection of human health considering the nature of contamination at Jim's BP. The RAOs are developed using the MTCA Method A cleanup levels, which stipulate maximum levels of allowable contamination.

- Identify technologies for each general response action that can address the RAOs for each medium. Screen the technology types to eliminate those which are clearly ineffective or impractical for the site by considering technical implementability alone. Other factors such as performance, effectiveness, or cost are not considered in this screening step.

- Evaluate the range of remedial alternatives in detail. This detailed analysis must cover nine evaluation criteria specified by CERCLA. These criteria are:

  - Overall protection of human health and the environment.
  - Compliance with applicable or relevant and appropriate requirements (ARARs), in this case MTCA Method A cleanup levels.

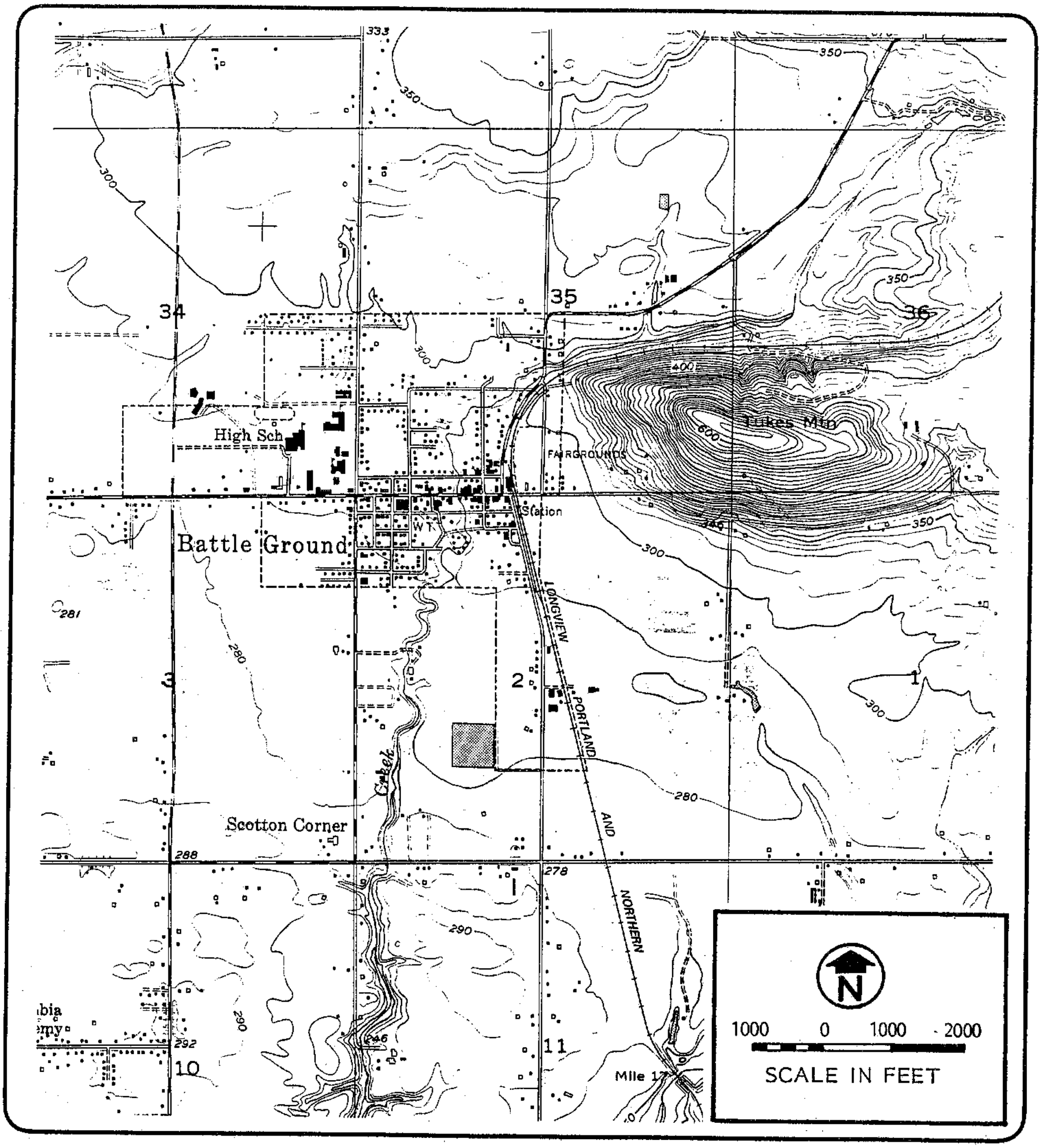


Figure 1-1

REGIONAL SITE LOCATION MAP
JIM'S BP
BATTLE GROUND, WASHINGTON

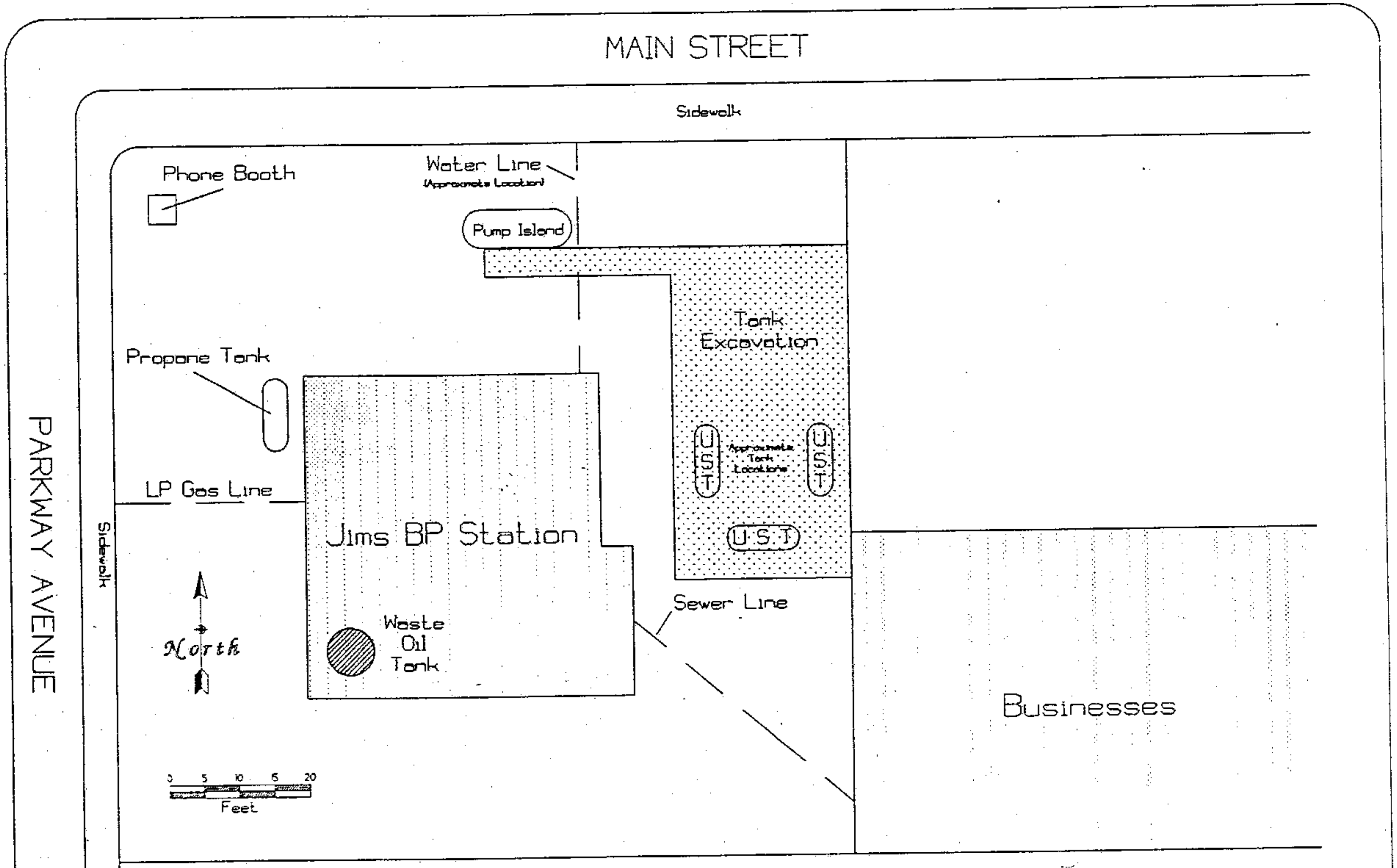


Figure 1-2

Jim's BP Site Map

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility and volume through treatment
- Short-term effectiveness
- Implementability, both technical and administrative
- Cost, including capital, operation, and maintenance
- State acceptance (preferences)
- Community acceptance (preferences)

The remedial alternatives considered are those which are typically applied or have been demonstrated as effective in treating the contaminants and site conditions associated with UST releases. For this document, cost estimates have not been provided for all technologies considered. Cost estimates have been provided only for those technologies which are considered feasible. For those technologies not considered feasible, cost estimates were not provided because site conditions preclude these technologies from effectively remediating the site. Because of the inefficiency of several remedial method, estimates of the duration and the effectiveness of the remedial action would be very unreliable.

2.0 SITE CHARACTERIZATION AND ASSESSMENT

The purpose of this section is to summarize and assess the available information relevant to the extent and significance of the soil and ground water contamination determined from the RI field effort. This section presents discussion of the local geology and hydrogeology, summary of contamination, and assessment of the data with respect to Model Toxics Control Act (MTCA) Method A cleanup standards.

2.1 LOCAL GEOLOGY AND HYDROGEOLOGY

Information pertaining to the local geology and hydrogeology in the vicinity of Jim's BP was obtained throughout the course of the borehole installation program conducted during the RI. Initial insight into the local geology was obtained from two previous UST investigations in the area, which were summarized in the Jim's BP project work plans (SAIC, 1992). One of these investigations was conducted 400 feet northeast of Jim's BP at the former Cenex station. The lithology encountered and observations with respect to the site stratigraphy are summarized below.

2.1.1 Local Geology

A total of four boreholes were installed in the immediate vicinity of Jim's BP in order to evaluate the subsurface geology. Soil in each borehole was sampled at 5-foot intervals. The borehole logs of each of the 4 soil borings were presented in Appendix C of the RI. In general, very fine sediments were encountered during borehole installation and gravel was present as the borings progressed in depth.

The subsurface geology at Jim's BP consists of silty clays probably indicative of the regional deltaic fan depositional environment. The initial 10 to 15 feet bgs in all four boreholes consisted of dense silty clay with little or no coarse material. An additional 5 to 10 feet of dense silty clay was present which sporadically exhibited the presence of sand, banding (either due to oxidation or slightly different colored clay), and in some cases small pebbles. Below this, in all four boreholes at depths ranging from 18 to 22 feet bgs, a very dense, compacted silty clay with gravel was present. During the installation of MW-1, which was drilled to a total depth of 33 feet bgs, this unit was present from roughly 18 to 33 feet bgs. This unit was encountered during the Cenex investigations at similar depths. No coarse-grained, moderately to highly permeable sediments were encountered during the drilling program.

2.1.2 Local Hydrogeology

To characterize the ground water conditions at Jim's BP, the four boreholes were completed as monitoring wells. The locations of the monitoring wells are shown in Figure 2-1. The four wells at Jim's BP were installed in the younger (Pliocene and Recent) unconsolidated materials that were deposited as part of a deltaic fan of the Columbia River, or possibly in the weathered, upper member of the Troutdale Formation (as evidenced by the gravel present at greater depth).

Static water levels indicate a substantial difference in the static water levels between two sets of monitoring wells. Monitoring wells MW-1 and MW-3 show a much greater depth to water than MW-5

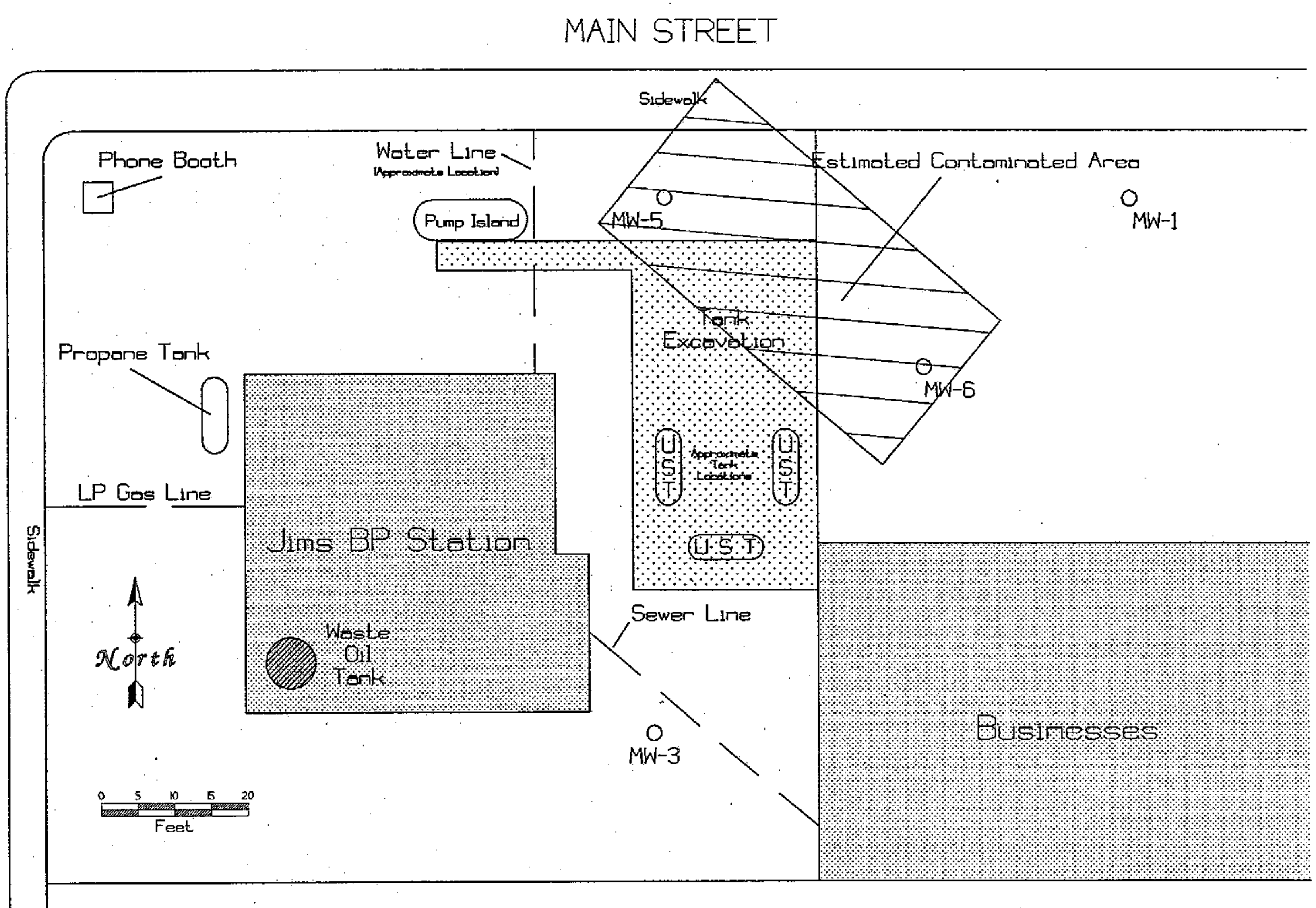


Figure 2-1

Locations of Monitoring Wells and
Estimated Area of Contamination at Jim's BP

and MW-6. It is believed that this is due to a ground water mounding effect centered near the northern end of the UST pit at Jim's BP. It is probably centered near the north end of the pit because the three USTs present in the southern portion of the pit will displace a fair amount of water. Measurement of two stand-pipes previously installed in the UST pit, had higher static water levels than monitoring wells MW-5 and MW-6. The ground water mounding effect is possible because the backfilled material in the UST pit probably has a much higher permeability than the surrounding soil, which would allow ground water to drain into the pit at a much faster rate than it would drain out.

The ground water mounding effect observed at Jim's BP has made it difficult to interpret the ground water gradient and flow direction. It has essentially allowed the use of only two wells as observation points for this information. Therefore, it is possible to provide only a qualitative discussion of these hydraulic parameters. The static water level in MW-1 is approximately one foot lower than in MW-3. Therefore, it appears that ground water is flowing away (north) from the excavation. However, an additional monitoring well which is not influenced by the ground water mound is necessary in order to provide an estimated flow direction. It is suspected that ground water levels in monitoring wells MW-1 and MW-3, are more similar to those in MW-5 and MW-6 during the wet season. This observation is based on the presence of contaminants in a soil sample collected at 10 feet bgs in MW-1. It is believed that these compounds are present due to downgradient flow of contaminated ground water and that the contamination is due to residual ground water left behind in the pore spaces of the silty clay as the ground water level dropped during the onset of the dry season.

It is also difficult to speculate on the extent of the water-bearing zone encountered in MW-1 and MW-3. The relatively low permeability of the silty clay allows for the formation of a perched zone(s), whose areal continuity can be difficult to establish. Water is present at a similar depth in the Cenex excavation. Cross-sections of the site stratigraphy and static water levels are presented in Figure 2-2. From the cross-section, it is observed that the static ground water level is within the compacted silty clay layer with cemented gravel. This layer, based on the slug tests conducted in each of the monitoring wells, has a horizontal hydraulic conductivity range of 8×10^{-5} to 7×10^{-4} cm/sec. Typically, vertical hydraulic conductivities are several orders of magnitude lower than the horizontal values. These values indicate a relatively low permeability layer(s) underlying the Jim's BP site. This low permeability unit does not transmit water easily in either the horizontal or vertical direction. A final observation made indicating the low permeability of this layer is that during the development of the wells it was not possible to pump them continuously.

2.2 SUMMARY OF CONTAMINATION

The following sections summarize the results of the soil and ground water sampling conducted for the RI at Jim's BP. Detected concentrations in both soil and ground water are compared with MTCA Method A cleanup standards in order to determine what, if any, further actions are necessary to remediate the Jim's BP site. The concentrations present in the soil gas were not compared with MTCA Method A cleanup standards because none exist for the contaminants in this medium.

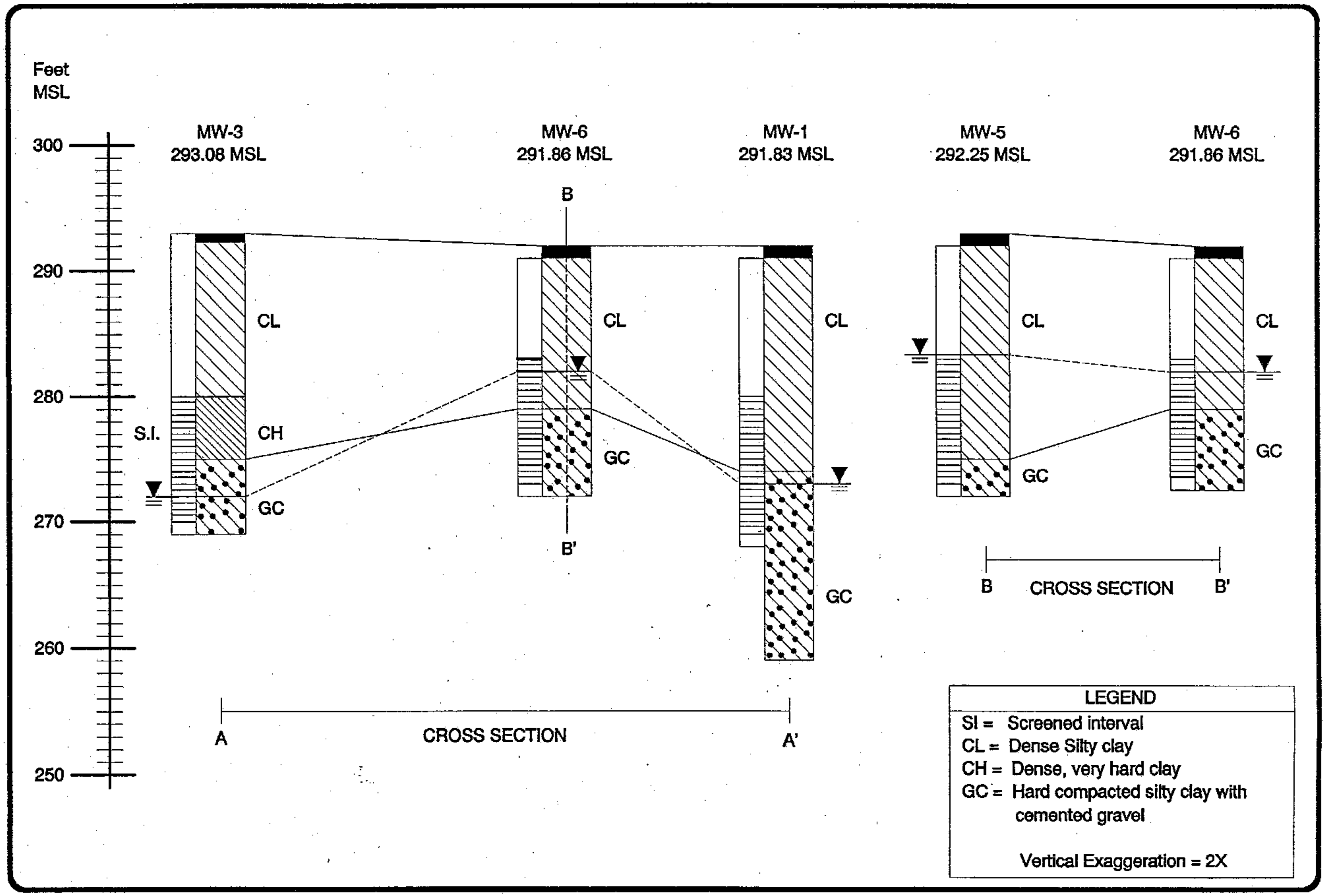


Figure 2-2

STRATIGRAPHIC CROSS SECTIONS

2.2.1 Soil Sampling Summary

A total of eight environmental soil samples were collected during the RI investigation and analyzed for BTEX, TPH-gasoline, and total lead. The results of these analyses are presented in Table 2-1. Comparison of the detected concentrations with the MTCA Method A cleanup levels (the column on the far right-hand side of the table), indicate that no soil contaminants are present in excess of the MTCA standards.

2.2.2 Ground Water Sampling Summary

A total of five ground water samples were collected as part of the RI and analyzed for BTEX, TPH-diesel, TPH-gasoline, and total lead. The results of the ground water sampling are also presented in Table 2-2. The analytical results indicate that a total of five compounds including TPH-gasoline, benzene, ethylbenzene, xylene, and lead are present in ground water at the site, with concentrations in excess of their respective MTCA Method A cleanup levels.

Benzene was detected in 3 of the 4 wells at concentrations above 5 μg/L. The maximum concentration was present in MW-6. This well is located adjacent to the UST pit. The second highest concentration is present in another well adjacent to the pit. The lowest detected concentration was in the furthest downgradient well (MW-1). The concentration in well MW-1 was just above the method detection limit and the MTCA Method A cleanup level. The other four compounds in excess of the cleanup levels were present in monitoring wells MW-5 and MW-6 (two wells adjacent to the excavation).

In summary, the most significant ground water contamination was present in monitoring wells installed adjacent to the UST pit. It is difficult to estimate a volume of contaminated ground water for several reasons. First, the complete extent of ground water contamination has not been determined, however, the edge of the plume appears to be MW-1. Because of the low permeability of the underlying soil, it is not believed that significant migration has occurred at this site. The other difficulty in estimating a volume of contaminated water is that the fluctuation in the static water table makes it difficult to estimate the vertical extent of contamination. It is believed that during the wet season, the water table may be significantly higher, therefore the volume of contaminated water could be greater as residual contamination in the pore spaces of the soil becomes saturated and is mobilized.

Based on the currently available RI data, ground water was assumed contaminated at significant concentrations in a 25- by 50-foot area (as shown on Figure 2-1). Because of the assumed fluctuation of the water table and the depth to water in MW-1, it was further assumed that ground water is potentially contaminated to a depth of 20 feet. Assuming a typical porosity value for silty clay of 40 percent (Freeze and Cherry, 1979) results in an estimated volume of 1,300 to 1,400 gallons of ground water that has contaminants significantly above the MTCA Method A cleanup level. It is also believed that of the compounds detected present, benzene is the only one that is likely to be consistently present above the MTCA cleanup level. The above estimate assumes that the contamination is due to a previous

Table 2-1

SOIL SAMPLE RESULTS (mg/kg)

HAZARDOUS SUBSTANCE	Soil Sample	SB1-3	SB3-3	SB3-4	SB5-2	SB5-2-DUP	SB5-3	SB6-1	SB6-2	SB6-4	MTCA CLEANUP LEVEL (mg/kg)
	Depth (ft. BLS)	13-14.5	13-14.5	18-19.5	8-11	8-11	13-14.5	3-4.5	8-9.5	18-19.5	
	Date	3-31-92	3-31-92	3-31-92	4-1-92	4-1-92	4-1-92	4-1-92	4-1-92	4-1-92	
Benzene		.004 U	.004 U	.004 U	.004 U	.004 U	.004 U	.01	.004 U	.004 U	0.5
Ethylbenzene		.007	.006	.004 U	.004 U	.004 U	.004 U	.22	.004 U	.004 U	20.0
Toluene		.035	.032	.004 U	.007	.005	.009	.007	.005	.005	40.0
Xylenes		.041	.034	.004 U	.045	.011	.023	.17	.010	.017	20.0
Lead		5.7	7.4	4.3	9	8	7	10	11	11	250.0
Total Petroleum Hydrocarbons- Gas		5U	5U	5U	5U	5U	5U	31	5U	5U	100.0

U- The analyte concentration is less than applicable listed reporting limit.

Table 2-2

GROUND WATER SAMPLE RESULTS (μg/L)

HAZARDOUS SUBSTANCE	MONITORING WELL NUMBER	MW-1	MW-1-DUP	MW-3	MW-5	MW-6	MTCA CLEANUP LEVEL (μg/L)
	Date	4-8-92	4-8-92	4-8-92	4-8-92	4-8-92	
Benzene		7	7	0.5 U	72	220	5.0
Ethylbenzene		4	4	0.5 U	53	98	30.0
Toluene		0.5 U	0.5 U	0.5 U	7	2	40.0
Xylenes		6	5	0.5 U	110	59	20.0
Lead		3	2U	4	2U	6	5.0
Total Petroleum Hydrocarbons-Diesel		250U	250U	250U	250U	250U	1,000
Total Petroleum Hydrocarbons-Gas		250U	250U	250U	1000	1500	1,000

U- The analyte concentration is less than applicable listed reporting limit.
The shaded areas indicate the values that equal or exceed MTCA Method A cleanup level

spill and is not indicative of an ongoing source. Thus, the estimate does not take into account all of the ground water that is present in the UST pit. However, it is presented later in this document that extraction of ground water would be conducted from the UST pit, which contains an estimated 600 gallons of water. Therefore, for purposes of this FS, a contaminated water volume of 2000 gallons will be assumed.

2.3 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are specific goals established for a particular medium that are considered to be protective of human health and the environment. Each remedial action objective includes specification of the following:

- The contaminant(s) of concern
- The exposure route and corresponding receptor of concern
- An acceptable contaminant level or range of levels for each exposure route

Specifying an exposure route rather than just the acceptable contaminant level is important because protectiveness can be achieved by preventing exposure (e.g., containment) as well as by cleanups.

As previously shown, RAOs are not needed for soil at the Jim's BP site. The contaminants found in the soil are below the MTCA Method A cleanup levels. In additional, the site is paved so airborne emissions and fugitive dusts are of minimal concern as well.

Ground water contaminants of concern are defined by those contaminants which exceed their respective MTCA Method A cleanup levels. These contaminants include benzene, ethylbenzene, total xylenes, total petroleum hydrocarbons as gasoline (TPH-gasoline), and lead. The exposure route for these contaminants would be migration from the aquifer underlying the site and into the Troutdale Formation. The receptor of concern would be users of the municipal wells installed in the Troutdale which are located roughly seven blocks west of the site. Acceptable contaminant levels for this site are those stipulated as the MTCA Method A cleanup levels.

3.0 CLEANUP ACTION ALTERNATIVES

3.1 CLEANUP ACTION OBJECTIVES

The State of Washington proposed Cleanup Standards Amendments to the Model Toxic Control Act Cleanup Regulations in 1990. These standards apply to the soil and ground water contamination detected during the remedial investigation conducted by SAIC. The Method A cleanup levels were previously presented along with the field sampling results in Table 2-1 and Table 2-2. Treatment of the contaminated soils and ground water must result in residual concentrations at the site being no higher than these levels. The primary medium of concern at this site is ground water. Soil contaminants were not present at concentrations exceeding the MTCA Method A cleanup levels. Air standards may apply to all types of treatment methods. Air quality standards adopted by Ecology limit hydrocarbon releases from UST remediation sites to 15 pounds per year.

3.2 SCREENING OF CLEANUP ACTION ALTERNATIVES

A preliminary list of cleanup action alternatives was established by using a screening system described in recent EPA guidance documents, entitled Assessing UST Corrective Action Technologies: Site Assessment and Selection of Unsaturated Zone Technologies and Assessing UST Corrective Action Technologies: Early Screening of Cleanup Technologies for the Saturated Zone. The screening methods employ a series of worksheets to determine the type of hydrocarbon phase most likely to exist at the site (liquid, vapor, or dissolved in pore water) and the relative mobility of each of these phases. Waste quantity and type, release rate, soil type, and precipitation characteristics are all incorporated into the analysis.

The completed worksheets for the saturated zone are included in Appendix A. The worksheets indicate, for example, that with the relatively shallow water table present at Jim's BP, the presence of dissolved contaminants in the saturated zone is moderately to highly likely based upon the site conditions and physical and chemical properties of the contaminants. However, if the water table is fluctuating (as is believed to be the case), than the presence of dissolved contaminants is even more likely. The worksheets also indicate that contaminants are more likely to be present as dissolved contaminants than as NAPL present on the water table. The results of the RI field sampling program are generally in agreement with the contaminant phase worksheets. It should be noted that certain critical information for completing these worksheets with respect to the amount of product released and the rate of release is unknown and had to be assumed. These factors could impose considerable influence on the likelihood of the contaminant phase and the accuracy of the worksheets.

The remaining worksheets in the saturated zone screening system were used to evaluate the effectiveness of six generic remedial actions. Ground water extraction technologies include pumping wells and trench excavation. Treatment technologies are represented by air stripping, carbon adsorption, biorestoration, and vacuum extraction.

3.3 ANALYSIS OF ALTERNATIVES

The preliminary screening of alternatives provided a list of feasible remedial action options for use at the site. In accordance with the Final Workplan, a "No Action" alternative was also evaluated.

3.3.1 Unsaturated Zone

As previously stated, although petroleum-related contaminants were present in the unsaturated zone, none of the detected concentrations exceeded the MTCA Method A cleanup levels for the respective compounds present. Therefore, it is possible that no further action with respect to the contaminated soil at Jim's BP may be warranted. Even though there is a slight possibility that concentrations of benzene found in the near surface soil at MW-6 (3 feet bgs) could potentially leach benzene into the ground water at concentrations that may approach the MTCA Method A cleanup level of 5 μg/L, it is not likely that this would impact a significant area. Additionally, the soil concentrations detected in a few samples are probably already at or near the contaminant concentrations that could be achieved by implementing a remedial measure. Additional discussion dealing directly with remedial actions in the unsaturated zone is not presented in this document.

3.3.2 Saturated Zone

The final list of remedial action alternatives for the remediation of the saturated zone includes the following:

- No-action
- Pumping Wells
- Trench Excavation
- Air stripping
- Carbon adsorption
- Biorestoration
- Vacuum extraction

These methods were selected because they represent readily available treatment technologies and (with the exception of the No-action Option) can result in attainment of cleanup standards. The above options were evaluated with criteria in EPA's Guidance Document for Conducting Remedial Investigations and Feasibility Studies under CERCLA. These criteria include the following:

- Overall protectiveness
- Compliance with ARARs
- Short-term effectiveness
- Long-term effectiveness
- Reduction of toxicity, mobility, or volume through treatment
- Cost
- Community concerns
- Recycling and waste minimization

The evaluation criteria with respect to the remedial alternatives are summarized in Table 3-1. A short discussion of the advantages and disadvantages of each of the alternatives follows.

No-action Alternative

The major advantage of the no-action alternative is that minimal costs would be required to implement this alternative. Monitoring of the existing onsite wells would be necessary to evaluate ongoing or future impacts to ground water. Assuming that wells MW-1, MW-5, and MW-6 are downgradient from the UST pit, samples from these wells would provide information concerning the downgradient movement of contamination. This alternative produces the least disruption to the current owner of the facility. The major disadvantage associated with this alternative is that ARARs would not be achieved and so the option would not be immediately protective of human health and the environment. It is expected that unless an additional release of petroleum product occurred, natural attenuation would eventually lower benzene concentrations in ground water below the MTCA Method A cleanup level.

Based on the hydrogeologic information collected in the RI, the threat to human health and the environment appears to be minimal. Benzene is the most significant compound in terms of human health threat and the greatest concentration is found in the monitoring well located adjacent and east of the UST pit. Within a distance of 40 feet in a northeast direction, the benzene concentration drops to near the method detection limit and the MTCA Method A cleanup level. Since the contamination is for the most part confined to near the previously excavated area, and the thickness of the compacted silty clay layer that separates the Jim's BP saturated zone from the Troutdale Formation is at least 15 feet thick, it appears that the risk to users of the Troutdale Formation is minimal. However, this risk has not been quantified.

If the no-action option is undertaken, it is possible that additional monitoring of the static water table at the Jim's BP site may indicate that additional monitoring wells are required. If static water level monitoring indicates that the ground water flow direction is true east, an additional monitoring well located 30 to 40 feet east of MW-6 may be necessary to verify that a no-action alternative is effective and that the maximum contaminant concentrations are confined to near the edge of the excavation.

Pumping Wells As A Containment System

Although the use of pumping wells does not by itself constitute a treatment technology, it could constitute a part of a more comprehensive remedial action undertaken at Jim's BP. In-situ treatment is probably not a feasible alternative because the permeability of the geologic layer underlying the site may be low enough to preclude effective injection of the nutrients and microorganisms involved in biorestoration, or air injection as part of vacuum extraction. Therefore, an extraction system to remove contaminated ground water followed by an effective treatment method is a possible option.

Two scenarios involving pumping wells at this site are possible. One scenario involves a ground water extraction network using pumping wells installed downgradient from the UST pit to provide capture of contaminated ground water. Extracted ground water could then be treated by one of several treatment

Table 3-1

EVALUATION OF CRITERIA WITH RESPECT TO REMEDIAL ALTERNATIVES FOR THE SATURATED ZONE[1]

CRITERIA	Remedial Alternative				
	Air Stripping	Air Sparging	Carbon Adsorption	Biorestoration	Vacuum Extraction
Overall Protectiveness	Pass	Pass	Pass	Pass	Pass
Compliance with ARARs	Pass	Pass	Pass	Pass	Pass
Short-term Effectiveness	Pass	Pass	Pass	Pass	Pass
Long-term Effectiveness/ Performance	Pass	Pass	Pass	Pass	Pass
Reduction of Toxicity, Mobility, or Volume through Treatment	Fail	Pass	Pass	Pass	Pass
Cost	Not Evaluated	Not Evaluated	Not Evaluated	Not Evaluated	Not Evaluated
Community Concerns	Pass	Pass	Pass	Pass	Fail
Recycling and Waste Minimization	Fail	Pass	Pass	Pass	Pass

Pass = Passes criteria for being a feasible alternative in conjunction with the specific remedial technology.

Fail = Fails criteria for being a feasible alternative in conjunction with the specific remedial technology.

Notes: [1] - All technologies may need additional treatment steps to treat non-organic contaminants as well as free product and turbidity.

technologies. Advantages of this option are that it is a proven technology and it can be implemented relatively quickly. Although, the 4-inch diameter monitoring wells installed at the site would be of sufficient diameter to be used as pumping wells, the current number and configuration of ground water monitoring wells is insufficient to provide capture zones so that all downgradient contaminants would be drawn into the well. The primary obstacle to this method is the low permeability of the subsurface soils underlying the site. The measured hydraulic conductivities are low enough that it would be very difficult for the wells to be pumped on a continuous basis. This problem could be overcome by using pumps which could be actuated by water levels, which would allow pumping only when sufficient water was present in the well. Again, it is likely that this would result in incomplete capture of the contaminated water.

The currently available data from the RI, has not established seasonal variation of the ground water table. Therefore, additional information would be necessary in order to determine the optimal depth to place the well screen and the appropriate length of well screen. Injection wells (used to return treated ground water to the saturated zone) would probably not be effective at this site. Due to the low permeability of the soils, it is anticipated that ground water mounding might occur and that this could impact ground water flow in a manner that would be difficult to control. An additional disadvantage to this method is that operation and maintenance costs are typically high. It is however, unlikely that long-term remediation at this site would be necessary.

The second scenario involving the use of pumping wells would entail installing one or two pumping wells into the UST pit at the site. It may be possible to pump this well(s) at a much higher rate, which would potentially be able to induce ground water in the immediate vicinity of the pit to flow into the pit. This scenario would allow more rapid removal of the most contaminated ground water, which was found adjacent to the pit. Further, this scenario would have the advantage of minimizing the downgradient migration of the most contaminated ground water. As previously discussed, due to the low volume of contaminated ground water it is not anticipated that this effort would require long-term operation and maintenance. It is likely, however, that downgradient monitoring of the ground water would be required to verify the performance of this alternative.

Subsurface Drains As A Containment System

This option would require the installation of a downgradient subsurface drain to intercept the migration of contaminated ground water. Ground water could then be pumped from the system; treated, and discharged to the sanitary sewer. It would be necessary to install the drainage system in an L-shape, so that ground water migrating from the north and east portions of the UST pit could be fully intercepted. Typically, with this type of extraction system a trench is dug to several feet below the water table, a pipe drainage system is installed, the trench is backfilled with gravel around the piping system, and the remainder of the trench is backfilled with other envelope material. As ground water accumulates in the system it is removed, treated, and discharged. Because of the disturbance a trench would cause to the owner of the station and the proximity of this site to other businesses, it would be necessary to restore the pavement. It is possible that a geo-fabric would have to be lapped around the gravel backfill, in order to prevent the drain from clogging due to the large amount of fine-grained sediment present.

The primary advantage this would offer over a pumping well extraction system in low permeability soil is that it would provide a more efficient and complete capture of contaminated ground water if the water table remains relatively constant. However, if the water table is shown to fluctuate greatly (more than a few feet), this system would only be implementable for certain portions of the year, which would essentially render it useless. With the water table data available from the RI, it cannot be demonstrated that this extraction system would reliably contain the ground water plume.

Air Stripping

This option would entail the use of one of several methods to introduce air to the extracted ground water to volatilize the organic contaminants present in the waste stream. Advantages associated with this option include relatively low cost, availability of "off-the-shelf" models, overall protectiveness, compliance with ARARs, short- and long-term effectiveness, ease of maintenance and operation, reduction of toxicity, and reduction of volume through treatment. The disadvantages to this option are the possible need for additional ground water treatment steps for contaminants that are difficult or impossible to strip (TPH compounds and compounds related to diesel fuel) and additional equipment for treatment of the stack emissions.

The ability for a compound to be stripped is related to its physical characteristics, including vapor pressure and water solubility. If the vapor pressure for the compound(s) is below approximately 10 millimeters of mercury, it is nearly impossible to strip the compound. Also, if the water solubility of the compound(s) is above approximately 1,000 mg/L then the compound is nearly impossible to strip. These compounds need to be handled through an additional treatment step. This step may involve piping the influent through a separator tank, settling tank, or heavy metals treatment step or piping the effluent from the tower or bubbler tank through a carbon adsorption system which would be needed to handle the TPH contaminants. The concentration of total suspended solids, total dissolved iron, and total dissolved manganese are important on the influent side because these metals can reach a concentration where they will precipitate and reduce the effectiveness of the air stripper or bubbler tank by blocking or clogging the flow paths. This could cause a release of contaminants to the environment due to a loss in the effectiveness of the system. The need for an additional treatment step (activated carbon) is usually related to either the presence of an organic compound which cannot be stripped or a concentration of dissolved contaminants that cannot be sufficiently treated within the designed residence time of the system. There are advantages and disadvantages to using activated carbon. Another potential disadvantage to the system is identifying a suitable place to discharge the treated water. Other disadvantages could be in obtaining a permit to discharge the treated water, space limitations for the system, and community concerns regarding the emissions of the system.

Carbon Adsorption

This method entails the use of an activated carbon adsorption unit to treat the contaminated ground water. The contaminated ground water is pumped from the aquifer and either through pretreatment steps and then to the unit or directly through the unit. The activated carbon grains are scoriaceous which allows the contaminants to chemically attach to the grain. The treatment system is efficient until the carbon is saturated with contaminants. If the activated charcoal has to be reactivated frequently, then the cost to operate the system becomes excessive. The concentration of the influent ground water and the rate that the ground water is pumped through the system will determine how rapidly the carbon needs to be reactivated and how large the system should be for optimum efficiency. A larger unit could become a disadvantage due to space limitations. This type of treatment unit would also need pretreatment steps if the concentrations of total organic carbon (TOC) content, suspended solids content, total dissolved iron, and total dissolved manganese are too high. Additional treatment steps would be necessary if the molecular weight (grams/mole) is too low and a separation of various compounds occurs. This step could be handled by using a pretreatment separator tank. The potential limitations for the air stripping technique hold true for the carbon adsorption method, as well. The advantages to the system are the same as for the air stripper except cost. The use of activated carbon does allow for beneficial re-use of the treatment material.

Activated carbon treatment systems are readily available in Washington State. The total cost of the system would be dependent upon the influent concentration of the contaminants, the flow rate of the ground water through the system, and the number of times the carbon would require regeneration.

Bioremediation

This in-situ method involves enhancing the natural biodegradation process by adding oxygen and other nutrients. Bacteria capable of biodegrading petroleum hydrocarbons are commonly found in subsurface soils. At a minimum, an above-ground mixing tank is needed to add nutrients and oxygen to the water being introduced to the subsurface. Oxygen can be added by the use of air, pure oxygen, or hydrogen peroxide. The primary advantages of this option are relatively low cost, overall protectiveness, compliance with ARARs, long-term effectiveness, technical feasibility (nutrients and organisms are readily available throughout the country including the Puget Sound-area), ease of maintenance and operation, reduction of toxicity. The primary disadvantages are that this method can take considerable time to reduce concentrations in the ground water to MTCA Method A cleanup levels (particularly for benzene).

Implementation of this remedial action at Jim's BP would be very difficult due to the low permeability of the water-bearing zone. The low permeability would inhibit introduction of the nutrient-enriched water and would also prevent good dispersion of the mixture into ground water. It is possible that the increased microbial activity would be concentrated near the injection wells, if significant biomass accumulates, this would further reduce the soil permeability and hinder adequate dispersion of the mixture. An additional complication would be verification of the effectiveness of this method in preventing downgradient contamination. As previously discussed, the benzene concentration in MW-1 is already near the detection limit and any decrease in the concentration would be difficult to correlate to the treatment method.

Costs for this method are very difficult to determine, primarily because they are dependent upon the site's geology and hydrogeology. Further, it is also difficult to predict the amounts of oxygen and nutrients that must be added in order to achieve optimal biodegradation at a site. If too few nutrients are added, the remedial action objectives will not be met. As previously stated, addition of more than the required nutrients will greatly inhibit the mixing of the nutrients into the saturated zone. Also, it is possible that the organic concentrations at the Jim's BP site are too low and the bacteria may favor another competing food source, if one is available. Generally, a pilot study is necessary to determine the appropriate nutrient additives and the required application rate (EPA, 1990).

Vacuum Extraction

A Vacuum Extraction System (VES) is commonly applied to unsaturated zone contamination. However, VES has been successfully applied to saturated zone contamination as well. Volatiles are extracted through a trench-pipe manifold system or monitoring well system, and vented directly (or after treatment) to the atmosphere. Advantages of the system are relatively low cost for large contamination volumes, overall protectiveness, compliance with ARARs, long-term effectiveness, reduction of toxicity, mobility, or volume through treatment, and waste minimization. Since the alternative is an in-situ method, disruptions to the site are minimized once the system is installed. Disadvantages are that lead and heavier hydrocarbons which are difficult to volatilize (TPH due to hydraulic fluid, for example) are not effectively treated with this method, however, heavier hydrocarbons and lead do not appear to be a concern at Jim's BP. Additional disadvantages are that the method requires 6 months to 2 years to achieve cleanup levels, and volatiles are merely shifted from one medium to another. An additional concern is that condensate liquid must be collected and treated or disposed. The air emissions must also be monitored on a periodic basis during operation.

A vacuum extraction system at the Jim's BP site could be designed with either a horizontal or vertical configuration. Because of the relatively shallow depth to ground water, trenches could be constructed to a depth near the water table and slotted pipes would be placed horizontally in the trench as part of a trench-pipe manifold system. Pipes could also be placed vertically as part of a soil gas monitoring well system. The slotted portion of the pipe would be installed very near the water table. One advantage of the vertical well system is that the amount of contaminated soil that requires excavation is typically significantly less. The advantages of the horizontal system are that a greater area can be treated with a smaller applied vacuum. The use of a lower vacuum means that a horizontal system is less likely to draw ground water into the system and that the slotted portion of the pipe is less likely to become plugged with sediment. However, because of the low permeability of the soil, a lower vacuum is less likely to be efficient.

A horizontal soil gas venting system typically consists of three components: a perforated pipe placed horizontally in a trench filled with a porous medium, an air/water separator, and a vacuum pump. For maximum removal efficiency of contaminants, an impermeable barrier is placed on top of the trench to prevent the system from drawing in ambient air. However, at sites where the trench is installed sufficiently close to the ground water table or if the zone of contaminated soil is relatively thin, an asphalt cap may provide sufficient inhibition to drawing in ambient air if an impermeable barrier is not placed above the trench.

Air Sparging

This option entails the introduction of air into the contaminated aquifer through one or a series of monitoring type wells. The air is introduced through a diffuser which is set at a predetermined depth below the ground water table. The introduced air adds oxygen to the water which in turn causes an increase in biologic activity and some volatilization of the petroleum contaminants. The amount the biodegradation is increased is dependent on the inherent characteristics of the surrounding soil. The volatilized contaminants are drawn toward a series of vapor extraction ports where the contaminants are removed from the subsurface and treated through an activated carbon filter or vented to the atmosphere. The advantages of this system are overall protectiveness, compliance with ARARs, short- and long-term effectiveness, ease of maintenance and operation, reduction of toxicity, and reduction of volume through treatment. The only by-product to manage during the treatment steps is the condensate from the extracted air. A system to collect the condensate would have to be designed prior to installing this type of system.

The disadvantages to this system are: contaminant transfer from one media to another and selective treatment of volatile organic compounds. In some states, the introduction of air into the subsurface constitutes the contamination of the media into which it is introduced. This could be partially eliminated by filtering the air prior to introduction. It has not been determined if the State of Washington abides by the conclusion that air is considered a contaminant. That the contaminants could migrate beyond the zone of capture could be a problem unless there is a vapor extraction well in close proximity to the sparge point. The vapor extraction system is designed to remove a portion of the volatilized contaminants not consumed by the microorganisms. The vapor extraction system causes a pressure difference between the extraction well (lower pressure) and the soil pore space (higher pressure). This causes the volatilized contaminants to migrate toward the lower pressure so that they can be extracted from the subsurface. The cost of this system is a function of the size of the plume and the depth to ground water. In general, several conditions must be met for this technology to be successful:

- A water table aquifer must be present to provide a way for the injected air to escape the saturated zone. In a confined aquifer system, injected air would be trapped by the saturated confining layer.

- The water table aquifer should have a hydraulic conductivity of 10^{-3} cm/sec or greater to ensure that injected air can displace water in the pore spaces and create pathways to the unsaturated zone.

- The VOCs must be relatively insoluble. Ideal contaminants are those that are amenable to air stripping, such as TCA, TCE, and BTEX. Highly soluble VOCs will not partition to the air and therefore will not be effectively removed (The Hazardous Waste Consultant, 1991).

This site meets two of the three above conditions. Because of the low hydraulic conductivity of the water table aquifer however, it is very unlikely this technology would be successful at the Jim's BP site. This technology is new and basically in the testing stages. The construction of the system does not differ greatly from other pump and treat and soil gas venting systems. The design is altered by the fact that water is agitated and not extracted as in a pump and treat system and the radius of influence is greatly reduced with sparging. The amount of information currently available is limited and the sparge system would need extensive pilot studies prior to design and construction.

3.4 SUMMARY WITH RESPECT TO REMEDIATION OF THE SATURATED ZONE

3.4.1 Conclusions

A summary of the worksheet evaluation criteria with respect to the technologies previously discussed is presented in Table 3-2. The worksheets, in general, confirm that because of the low permeability of the soil and the associated low hydraulic conductivity of the aquifer, very few of the technologies are likely to achieve the remedial action objectives. Pumping wells are only likely to be effective if they are installed in the UST pit (providing that the UST is backfilled with sand or gravel). Trench excavation and completion with subsurface drains is also unlikely to be effective, unless the water table shows little fluctuation. The worksheet predicts that success is more likely than it would be with pumping wells, however, it does not take into account the possibility of a fluctuating water table.

Some assumption of some water quality information was necessary (total suspended solids and total dissolved iron and manganese content of the ground water) in order to complete the worksheets for air stripping and carbon adsorption. With the assumption of moderate water quality values, air stripping shows a moderate success possibility according to the criteria evaluation. If the measured values are substantially lower than the assumed values, this technology would have a better probability of being successful. Carbon adsorption scores are similar to air stripping for the likelihood of success. Again, if these assumptions are incorrect, this technology could score higher or lower depending upon the measure values. The biorestoration worksheet scores moderately high, however, the score is somewhat deceiving because two critical components score relatively low. As previously discussed, it is not believed that this treatment technology would be successful at this site because of the low permeability of the soil. Vacuum extraction is also unlikely to be effective primarily because of the assumed fluctuation of the water table and the low hydraulic conductivity of the aquifer would also present difficulties.

3.4.2 Recommendations

Option 1 - No-action

Based on the data gathered during the RI, and from evaluation of the technology screening worksheets for the saturated zone, the No-action Option may be warranted for this site. It appears that the majority of the contaminated soil at the Jim's BP site was removed during the previous excavations and that ground water has been very minimally impacted. Further, the dense silty clayey soil present at the site has impeded the migration of released product through the saturated zone. Unless there is an ongoing source, it is likely that natural attenuation of the contaminants will reduce the residual contamination to insignificant concentrations before they enter the Troutdale Formation. This site is separated from the Troutdale Formation by a 15-foot thick compact, dense silty clay layer which will greatly inhibit the vertical migration of contaminants. The contaminants present are considered "floaters" and as such, they are unlikely to penetrate the layer separating Jim's BP from the Troutdale Formation. Additional

Table 3-2

EVALUATION OF CRITERIA FOR VARIOUS SATURATED ZONE REMEDIAL ACTIONS AT JIM'S BP

Remedial Action	Success Less Likely	Success Somewhat Likely	Success More Likely	CSFs[1] of Concern	Comments- Advantages/Disadvantages
Pumping Wells	4	0	2	Site stratigraphy	The hydraulic conductivity of the soil is very low, pumping wells would have a very limited zone of capture and could not be pumped on a continuous basis.
Trench Excavation/ Subsurface Drains	2	1	4	Depth to ground water, interfering structures	Primary advantage is a greater zone of capture is achievable. Disadvantage is that a fluctuating water table will not allow for complete capture of contaminted ground water.
Air Stripping	2	5	1	Dissolved contaminant concentrations	Air strippers are generally inefficient for removing BTEX compounds at the concentrations detected at Jim's BP.
Carbon Adsorption	1	4	1	Total organic carbon content of ground water	This method could provide effective removal of BTEX from ground water. Scores are lower because some data had to be assumed.
Biorestoration	1	3	3	Hydraulic conductivity, site stratigraphy	This technology would be very difficult to implement and verify its effectiveness because of the low hydraulic conductivity of the aquifer.
Vacuum Extraction	2	5	0	Soil air conductivity	The clayey soil found at Jim's BP has a very low soil air conductivity, greatly inhibiting phase transfer of contaminants

[1]CSFs - Critical Success Factors were evaluated to determine the likelihood of success of each technology. They are not all of equal importance for evaluating a particular technology. The CSFs in this column are those believed to be of greater importance because of site conditions or physical/chemical properties of the contaminants or treatment process.

information to be obtained for evaluating this option would include quarterly ground water sampling for BTEX and TPH-gasoline sampling and quarterly monitoring of the static water level. As indicated by the difficulty encountered while conducting the soil gas sampling, transfer of the contaminants to the vapor phase will be a slow process, and it may be some time before the concentrations in the monitoring wells adjacent to the excavation are in compliance with the MTCA Method A cleanup levels (particularly for benzene).

Option 2 - Pumping Wells Followed By Treatment

Another potential option is installation of a pumping well in the northeastern portion of the UST pit. This well could be pumped on a quarterly basis and the extracted ground water treated by passing it through an activated carbon system followed by discharge to the sanitary sewer system. This type of treatment unit typically has a flow capacity of 10 gpm. Additional water quality information as specified in the sections discussing activated carbon treatment would be necessary to determine the effectiveness of this system and whether pretreatment is necessary. The small size of this unit would allow for it to be easily moved onsite or removed from the site when not in use.

It is assumed that the pit could be pumped on a quarterly basis because the ground water mounding observed would allow ground water to be extracted even during the dry season. However, static water table monitoring throughout the summer is critical to determining if ground water can be extracted on a quarterly basis. Pumping from the UST pit would induce flow of the most contaminated ground water adjacent to the pit, back into the pit. In addition, the existing downgradient monitoring wells could also be pumped to further induce a reversal of ground water flow. The duration of this effort is unknown because the hydraulic conductivity of the aquifer is sufficiently low that it may take several years for benzene concentrations in wells MW-5 and MW-6 to be below the MTCA Method A cleanup level.

3.5 COST ESTIMATES

Provided in this section are cost estimates for the two options that were previously discussed and determined to be potentially successful for remediating the site. The costs for both options are summarized in Table 3-3.

Option 1 - No-action

The following assumptions were incorporated for determining the cost estimate for the No-action alternative:

- At least one additional monitoring well would be needed
- Sampling of each of four (4) downgradient monitoring wells would be on a quarterly basis, for a period of approximately 5 years
- Samples would require laboratory analysis of TPH-gasoline and BTEX compounds
- Does not include interpretation of the analytical results or additional site characterization

Table 3-3

SUMMARY OF COSTS FOR TWO
REMEDIAL ACTION OPTIONS

NO-ACTION OPTION (OPTION 1)	COST ($)
Installation of one additional ground water monitoring well	2,000
Analysis of samples collected from 4 monitoring wells - four times per year, for a period of five years	9,000
Collection in drums and disposal of purged, contaminated ground water @ $400/drum, 2 drums per sampling event, four times per year for a period of five years	16,000
TOTAL ESTIMATED COST	$27,000
PUMPING WELL WITH GROUND WATER TREATMENT	COST ($)
Installation of extraction well	4,000
Activated Carbon Unit (one 55-gallon drum contains 165 lbs of carbon) includes return of spent carbon to Calgon Corporation	1,000
2,500 gallon storage tank for temporary storage of effluent	3,000
Operation and Maintenance (for period of two years)	2,000
Sampling of ground water monitoring wells (4 wells, 4 times/year for 2 year period)	3,500
Sampling of effluent from carbon system (4 wells, 4 times/year for 2 year period)	3,500
TOTAL ESTIMATED COST	$17,000

The costs are summarized in Table 3-3. One of the primary expenses is collection and disposal of the contaminated ground water obtained from purging each monitoring well prior to sampling. It is also possible that the natural degradation of the BTEX compounds to levels below MTCA Method A cleanup levels could occur in less than a five-year period depending upon the biological activity already occurring onsite.

Option 2 - Pumping Well Followed By Ground Water Treatment

The cost estimate for the pumping well followed by ground water treatment with activated carbon incorporated the following assumptions:

- One additional well would need to be installed in the northeastern portion of the UST pit
- The volume of extracted ground water requiring treatment is approximately 2000 gallons (includes the UST pit)
- The UST pit will need to be pumped on a quarterly basis, for a period of two years
- No prefiltration step to remove suspended solids is needed prior to activated carbon treatment
- Lead is not a contaminant of concern and does not require treatment
- Flow will be no greater than 10 gpm
- Influent concentrations are; TPH-gasoline at 1 mg/L, benzene at 200 μg/L, ethylbenzene at 100 μg/L, and total xylenes at 110 μg/L
- Sampling of the three downgradient monitoring wells would also be conducted on a quarterly basis and analysis of the samples would be for TPH-gasoline and BTEX compounds
- System effluent would be sampled every 500 gallons of treated water or 4 times per pumping event
- Does not include interpretation of the analytical results or additional site characterization

The type of activated carbon system evaluated comes in 55-gallon polyethylene drums and contains approximately 165 pounds of carbon. The outlet and inlet nozzles do not require hard piping and will accept hose fittings. Additionally, the activated carbon drum is shipped prewetted and therefore requires a minimum of start-up time and expertise. Vendors have indicated that with the estimated influent concentrations, one drum (165 pounds of carbon) would probably last the lifetime of the remedial action.

Summary

The cost estimates indicate that extraction and treatment of contaminated ground water may be a cheaper alternative to the no-action alternative. However, if the collection of additional water quality information indicates that a prefiltration step is necessary, the use of activated carbon will be more expensive. In addition to requiring a prefiltration unit, the system would probably require hard piping and a greater amount of onsite space would be needed for the treatment system. The cost estimates also assume that the treatment system could remediate ground water contamination over a shorter time period than the no-action option. However, site conditions are such that complete removal of residual contamination contained in the soil pore water could require more than the two years that were estimated. One of the primary expenses of the no-action alternative is the collection and disposal of contaminated ground water. It is possible that a company which deals in disposal of hazardous wastes, that is under contract to Ecology may able to provide these services more cheaply.

4.0 REFERENCES

Freeze, R.A., and Cherry, J.A., 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

U.S. Environmental Protection Agency, March 1990. Assessing UST Corrective Action Technologies: Site Assessment and Selection of Unsaturated Zone Treatment Technologies. EPA/600/2-90/-11. Risk Reduction Engineering Laboratory, Office of Research and Development.

U.S. Environmental Protection Agency, June 1990. Assessing UST Corrective Action Technologies: Early Screening of Clean-up Technologies for the Saturated Zone. EPA/600/2-90/027. Risk Reduction Engineering Laboratory, Office of Research and Development.

Washington Department of Ecology. 1990. Cleanup Standards Amendments to Model Toxics Control Act Cleanup Regulation. March 9, 1990.

Washington Department of Ecology. October 1991. Guidance for Remediation of Releases From Underground Storage Tanks, Appendix L.

APPENDIX A

CLEANUP ALTERNATIVE EVALUATION WORKSHEETS

Table 11. Likelihood of Dissolved Contaminants Being Present in the Saturated Zone

FACTOR	UNITS	SITE OF INTEREST ▼	INCREASING LIKELIHOOD →		
RELEASE- RELATED					
* • Amount Released	gal	Estimated	Small (100) ○	Medium (100-1000) ●	Large (>1000) ○
* • Rate Of Release	-	Estimated	Instantaneous Release ○	--	Slow Release ●
* • Time Since Release	months		Short (<1) ○	Medium (1-12) ○	Long (>12) ●
SITE - RELATED					
• Depth To Groundwater	meters		Deep (>15) ○	Medium (2-15) ●	Shallow (<2) ○
• Fluctuating Water Table	-	Between Mod & High	Steady ○	Moderately Fluctuating ○ ←→	Highly Fluctuating ○
• Hydraulic Conductivity (of the Unsaturated Zone)	cm/sec	$10^{-4} - 10^{-5}$	Low ($<10^{-5}$) ○	Medium (10^{-5}-10^{-3}) ●	High ($>10^{-3}$) ○
* • Rainfall Infiltration Rate	cm/day		Low (<0.05) ○	Medium (0.05-0.2) ○	High (>0.2) ○
• Soil Temperature	°C	Estimated	Cool (<10) ○	Medium (10-20) ●	Warm (>20) ○
• Soil Sorption Capacity (Surface Area)	m^2/g		High (>1) ●	Medium (0.1-1) ○	Low (>0.1) ○
CONTAMINANT- RELATED					
• Liquid Viscosity	cP		High (>20) ○	Medium (2-20) ○	Low (<2) ●
• Vapor Pressure	mm Hg		High (>100) ●	Medium (10-100) ○	Low (<10) ○
* • Water Solubility	mg/L		Low (<100) ○	Medium (100-1000) ●	High (>1000) ○

* CSFs denoted with an asterisk are typically more important than other CSFs

Table 10. Likelihood of NAPL Being Present on the Water Table

FACTOR	UNITS	SITE OF INTEREST	INCREASING LIKELIHOOD →		
RELEASE- RELATED					
* • **Amount Released**	gal		Small (<1,000) ○	Medium (1000-10,000) ●	Large (>10,000) ○
* • **Rate Of Release**	-		Slow Release ●	-- ○	Instantaneous Release ○
• **Time Since Release**	months		Long (>12) ●	Medium (1-12) ○	Short (< 1) ○
SITE - RELATED					
* • **Preferential Flow Pathways**	-		Not Present ○	Unknown ●	Present ○
* • **Depth To Groundwater**	meters		Deep (>15) ○	Medium (2-15) ●	Shallow (< 2) ○
• **Hydraulic Conductivity (of the Unsaturated Zone)**	cm/sec		Low ($<10^{-5}$) ○	Medium (10^{-5}-10^{-3}) ●	High ($>10^{-3}$) ○
• **Rainfall Infiltration Rate**	cm/day		High (0.2) ○	Medium (0.05-0.2) ○	Low (<0.05) ○
• **Soil Temperature**	°C		Cool (<10) ○	Medium (10 - 20) ●	Warm (>20) ○
• **Soil Sorption Capacity (Surface Area)**	cm^2/g		High (>1) ●	Medium (0.1-1) ○	Low (<0.1) ○
CONTAMINANT- RELATED					
* • **Liquid Viscosity**	cP		High (>20) ○	Medium (2-20) ○	Low (<2) ●
• **Vapor Pressure**	mm Hg		High (>100) ○	Medium (10-100) ●	Low (<10) ○
• **Water Solubility**	mg/L		High (>1000) ○	Medium (100-1000) ●	Low (<100) ○

* CSFs denoted with an asterisk are typically more important than other CSFs

TABLE A-1. LIKELIHOOD OF LIQUID CONTAMINANTS BEING PRESENT IN THE UNSATURATED ZONE

FACTOR	UNITS	SITE OF INTEREST ▼	INCREASING LIKELIHOOD →		
RELEASE- RELATED					
• **Amount Released**	gallons		Small (<100) ○	Medium (100-1000) ●	Large (>1000) ○
• **Rate Of Release**			Slow Release ●	- - ○	Instantaneous Release ○
• **Time Since Release**	months		Long (>12) ●	Medium (1 - 12) ○	Short (< 1) ○
SITE - RELATED					
• **Depth To Groundwater**	meters		Shallow (< 1) ○	Medium (1-5) ●	Deep (>5) ○
• **Hydraulic Conductivity**	cm/sec		High ($>10^{-3}$) ○	Medium (10^{-5}-10^{-3}) ●	Low ($<10^{-5}$) ○
• **Rainfall Infiltration Rate**	cm/day		High (>0.1) ○	Medium (0.05 - 0.1) ○	Low (<0.05) ○
• **Soil Temperature**	°C		Warm (>20) ○	Medium (10 - 20) ●	Cool (<10) ○
• **Soil Sorption Capacity (Surface Area)**	m^2/g		Low (<0.1) ○	Medium (0.1 - 1) ○	High (>1) ●
CONTAMINANT- RELATED					
• **Liquid Viscosity**	cP		Low (<2) ●	Medium (2-20) ○	High (>20) ○
• **Liquid Density**	g/cm^3		High (>2) ○	Medium (1-2) ○	Low (<1) ●
• **Vapor Pressure**	mm Hg		High (>100) ○	Medium (10-100) ●	Low (<10) ○
• **Water Solubility**	mg/L		High (>1000) ○	Medium (100-1000) ●	Low (<100) ○

TABLE A-3. LIKELIHOOD OF CONTAMINANTS DISSOLVED IN PORE WATER BEING PRESENT IN THE UNSATURATED ZONE

FACTOR	UNITS	SITE OF INTEREST	INCREASING LIKELIHOOD →		
RELEASE- RELATED					
• Amount Released	gallons		Small (100) ○	Medium (100-1000) ●	Large (>1000) ○
• Rate Of Release			Instantaneous Release ○	— ○	Slow Release ●
• Time Since Release	months		Long (>12) ●	Medium (1-12) ○	Short (< 1) ○
SITE - RELATED					
• Depth To Groundwater	meters		Shallow (< 1) ○	Medium (1-5) ●	Deep (>5) ○
• Moisture Content	% volume		Low (<10) ○	Medium (10-30) ●	High (>30) ○
• Soil Porosity	% volume		Low (<20) ○	Medium (20-40) ●	High (>40) ○
• Rainfall Infiltration Rate	cm/day		Low (<0.05) ○	Medium (0.05-0.1) ○	High (>0.1) ○
• Soil Sorption Capacity (Surface Area)	m^2/g		Low (<0.1) ○	Medium (0.1-1) ○	High (>1) ●
CONTAMINANT- RELATED					
• Liquid Viscosity	cP		High (>20) ○	Medium (2-20) ○	Low (<2) ●
• Liquid Density	g/cm^3		High (>2) ○	Medium (1-2) ○	Low (<1) ●
• Vapor Pressure	mm Hg		High (<100) ○	Medium (10-100) ○	Low (>10) ●
• Water Solubility	mg/L		Low (<100) ○	Medium (100-1000) ●	High (>1000) ○

TABLE A-2. LIKELIHOOD OF CONTAMINANT VAPORS BEING PRESENT IN THE UNSATURATED ZONE

FACTOR	UNITS	SITE OF INTEREST	INCREASING LIKELIHOOD →		
RELEASE- RELATED					
• Amount Released	gallons		Small (<100) ○	Medium (100-1000) ●	Large (>1000) ○
• Rate Of Release			Slow Release ●	-- ○	Instantaneous Release ○
• Time Since Release	months		Long (>12) ●	Medium (1-12) ○	Short (< 1) ○
SITE - RELATED					
• Depth To Groundwater	meters		Shallow (< 1) ○	Medium (1-5) ●	Deep (>5) ○
• Air Conductivity	cm/sec		High ($>10^{-4}$) ○	Medium (10^{-6} - 10^{-4}) ○	Low ($<10^{-6}$) ●
• Rainfall Infiltration Rate	cm/day		High (>0.1) ○	Medium (.005-0.1) ○	Low (<0.05) ○
• Soil Temperature	°C		Cool (<10) ○	Medium (10 - 20) ●	Warm (>20) ○
• Soil Sorption Capacity (Surface Area)	m^2/g		Low (<0.11) ○	Medium (0.1 - 1) ○	High (>1) ●
CONTAMINANT- RELATED					
• Liquid Viscosity	cP		High (>20) ○	Medium (2-20) ○	Low (<2) ●
• Liquid Density	g/cm^3		High (>2) ○	Medium (1-2) ○	Low (<1) ●
• Vapor Pressure	mm Hg		Low (<10) ○	Medium (10-100) ○	High (>100) ●
• Water Solubility	mg/L		High (>1000) ○	Medium (100-1000) ●	Low (<100) ○

TABLE A-4. FACTORS TO EVALUATE THE MOBILITY OF LIQUID CONTAMINANTS

FACTOR	UNITS	SITE OF INTEREST	INCREASING MOBILITY →		
RELEASE RELATED					
• Time Since Release	Months		Long (>12) ●	Medium (1-12) ○	Short (<1) ○
SITE - RELATED					
• Hydraulic Conductivity	cm/sec		Low ($<10^{-5}$) ○	Medium (10^{-5} - 10^{-3}) ●	High ($> 10^{-3}$) ○
• Soil Porosity	% Soil Volume		Low (<10) ○	Medium (10-30) ○	High (> 30) ●
• Soil Surface Area	m^2 /g		High (>1) ●	Medium (0.1-1) ○	Low (< 0.1) ○
• Soil Temperature	°C		Low (<10) ○	Medium (10-20) ●	High (> 20) ○
• Rock Fractures	—		Absent ●	— ○	Present ○
• Moisture Content	% Volume		High (>30) ○	Medium (10-30) ●	Low (< 10) ○
CONTAMINANT- RELATED					
• Liquid Viscosity	cPoise		High (>20) ○	Medium (2-20) ○	Low (<2) ●
• Liquid Density	g/cm^3		Low (<1) ●	Medium (1-2) ○	High (>2) ○

Table 7 continued. WORKSHEET FOR EVALUATING THE FEASIBILITY OF USING PUMPING WELLS TO CONTAIN NAPL and/or DISSOLVED CONTAMINANT IN THE SATURATED ZONE					
CRITICAL SUCCESS FACTOR	UNITS	SITE OF INTEREST	SUCCESS LESS LIKELY	SUCCESS SOMEWHAT LIKELY	SUCCESS MORE LIKELY
RELEASE-RELATED					
Amount Released	gallons		Samll (<50,000) ●	Medium (50,000-500,000) ○	Large (>500,000) ○
Time Since Release	months		Short (<1) ○	Medium (1-12) ○	Long (>12) ●
SITE-RELATED					
*Site Stratigraphy			Complex ●	— ○	Simple ○
Depth to Ground Water	meters		Shallow (<5) ●		Deep (>5) ○
CONTAMINANT-RELATED					
Liquid Density	g/cm³		Low (<1) ●		High (>1) ○
Liquid Viscosity	cPoise		High (>2) ○	Medium (1-2) ○	Low (<1) ●

OTHER CONSIDERATIONS

- Installation of pumping wells can be delayed due to difficulties in delineating well ZOCs
- Extracted ground water must often be disposed of or treated
- This may be the only effective containment method at sites where depth to water table is great

* CSFs denoted with an asterisk are typically more important than other CSFs

Table 7 continued. WORKSHEET FOR EVALUATING THE FEASIBILITY OF USING TRENCH EXCAVATION TO CONTAIN FLOATING NAPL					
CRITICAL SUCCESS FACTOR	UNITS	SITE OF INTEREST	SUCCESS LESS LIKELY	SUCCESS SOMEWHAT LIKELY	SUCCESS MORE LIKELY
RELEASE-RELATED					
Amount Released	gallons		Large (>500,000) ○	Medium (50,000-500,000) ○	Small (<50,000) ●
Time Since Release	months		Long (>12) ●	Medium (1-12) ○	Short (<1) ○
SITE-RELATED					
*Depth to Ground Water	Phase		Deep (>5) ○	Medium (1-5) ●	Shallow (<1) ○
Stability of Soil Formation	—		Unstable ○		Stable ●
*Presence of Interfering Structures	—		Present ●		Not Present ○
CONTAMINANT-RELATED					
Liquid Viscosity	cPoise		High (>2) ○	Medium (1-2) ○	Low (<1) ●
*Liquid Density	g/cm^3		High (>1) ○		Low (<1) ●

OTHER CONSIDERATIONS

- Trench excavation can generally be implemented quickly
- Costs for this method are typically lower than for other methods
- Denser than water contaminants cannot typically be contained with trench excavation

* CSFs denoted with an asterisk are typically more important than other CSFs

Table 7 continued. WORKSHEET FOR EVALUATING THE FEASIBILITY OF USING AIR STRIPPING TO TREAT EXTRACTED GROUND WATER

CRITICAL SUCCESS FACTOR	UNITS	SITE OF INTEREST	SUCCESS LESS LIKELY	SUCCESS SOMEWHAT LIKELY	SUCCESS MORE LIKELY
RELEASE-RELATED					
*Amount Released	gallons		High (<1000) ●	Medium (1000-50,000) ○	Large (>50,000) ○
*Time Since Release	months		Short (<1) ○	Medium (1-12) ○	Long (>12) ●
SITE-RELATED					
*Ground Water Temperature	°C		Low (<10) ○	Medium (10-20) ●	High (>20) ○
Total Suspended Solids Content of Ground Water	mg/L		High (>20) ○	Medium (5-20) ●	Low (<5) ○
Total Dissolved Iron and Manganese Content of Ground Water	mg/L		High (>5) ○	Medium (0.2-5) ●	Low (<0.2) ○
CONTAMINANT-RELATED					
*Vapor Pressure	mm/Hg		Low (<10) ○	Medium (10-100) ●	High (>100) ○
*Water Solubility	mg/L		High (>1000) ○	Medium (100-1000) ●	Low (<100) ○
*Dissolved Contaminant Concentration	mg/L		Low (<1) ●	Medium (1-100) ○	High (>100) ○

OTHER CONSIDERATIONS

- Air stripping is not effective in removing contaminants to drinking water standards
- Permitting requirements can delay implementation
- Can cost effectively treat large volumes of ground water
- Treatment of contaminant vapors may be required before discharge to atmosphere

* CSFs denoted with an asterisk are typically more important than other CSFs

Table 7 continued: WORKSHEET FOR EVALUATING THE FEASIBILITY OF USING CARBON ADSORPTION TO TREAT EXTRACTED GROUND WATER

CRITICAL SUCCESS FACTOR	UNITS	SITE OF INTEREST	SUCCESS LESS LIKELY	SUCCESS SOMEWHAT LIKELY	SUCCESS MORE LIKELY
RELEASE-RELATED					
*Amount Released	gallons		Large (>50,000) ○	Medium (1000-50,000) ○	Small (<1000) ●
*Time Since Release	months		Long (>12) ●	Medium (1-12) ○	Short (<1) ○
SITE-RELATED					
*TOC Content of Ground Water	mg/L		High (>5) ○	Medium (1-5) ●	Low (<1) ○
Suspended Solids Content of Ground Water	mg/L		High (>20) ○	Medium (5-20) ●	Low (<5) ○
Total Dissolved Iron and Manganese Content of Ground Water	mg/L		High (>5) ○	Medium (0.2-5) ●	Low (<0.2) ○
CONTAMINANT-RELATED					
*Water Solubility	mg/L		High (>1000) ○	Medium (100-1000) ●	Low (<100) ○
*Molecular Weight	g/mole		Low (<100) ○	Medium (100-200) ○	High (>200) ○

OTHER CONSIDERATIONS

- Can remove contaminants to drinking water standards
- Costs increase significantly if large volumes or highly contaminated ground water is encountered

* CSFs denoted with an asterisk are typically more important than other CSFs

Table 7 continued. WORKSHEET FOR EVALUATING THE FEASIBILITY OF USING BIORESTORATION TO TREAT GROUND WATER					
CRITICAL SUCCESS FACTOR	UNITS	SITE OF INTEREST	SUCCESS LESS LIKELY	SUCCESS SOMEWHAT LIKELY	SUCCESS MORE LIKELY
RELEASE-RELATED					
*Time Since Release	months		Short (<1) ○	Medium (1-12) ○	Long (>12) ●
SITE-RELATED					
*Hydraulic Conductivity	cm/sec		Low ($<10^{-5}$) ○	Medium (10^{-3}-10^{-5}) ●	High ($>10^{-3}$) ○
*Site Stratigraphy			Complex ●		Simple ○
Ground Water Temperature	°C		Low (<5) ○	Medium (5-10) ●	High (>10) ○
pH	pH units		(<6 or >8) ○		(6-8) ●
CONTAMINANT-RELATED					
Biodegradability Refractory index			Low (<0.01) ○	Medium (0.01-0.1) ●	High (>0.1) ○
Total Organic Carbon Content of Ground Water	mg/L		(<10 or >1000) ○		(10-1000) ●

OTHER CONSIDERATIONS

- It is difficult to monitor the effectiveness of the system
- Minimizes health risks by keeping contaminants below the ground surface

* CSFs denoted with an asterisk are typically more important than other CSFs

Table 7 contineud. WORKSHEET FOR EVALUATING THE FEASIBILITY OF USING VACUUM EXTRACTION TO REMOVE FLOATING NAPL					
CRITICAL SUCCESS FACTOR	UNITS	SITE OF INTEREST	SUCCESS LESS LIKELY	SUCCESS SOMEWHAT LIKELY	SUCCESS MORE LIKELY
SITE-RELATED					
*Soil Air Conductivity	cm/sec		Low ($<10^{-6}$) ●	Medium (10^{-4}-10^{-6}) ○	High ($>10^{-4}$) ○
Soil Temperature	°C		Low (<10) ○	Medium (10-20) ●	High (>20) ○
Moisture Content	% volume		High (>30) ○	Medium (10-30) ●	Low (<10) ○
Soil Surface Area	m^2/g		High (>1) ●	Medium (0.1-1) ○	Low (<0.1) ○
Carbon Content	% weight		High (>10) ○	Medium (1-10) ●	Low (<1) ○
CONTAMINANT-RELATED					
*Vapor Pressure	mm/Hg		Low (<10) ○	Medium (10-100) ●	High (>100) ○
Water Solubility	mg/L		High (>1000) ○	Medium (100-1000) ●	Low (<100) ○
OTHER CONSIDERATIONS					
▪ Treatment of contaminant vapors may be required before discharge to atmosphere					
* CSFs denoted with an asterisk are typically more important than other CSFs					