Applied Geotechnology Inc.

A Report Prepared For

Burns Bros., Inc.
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FEASIBILITY STUDY
BINGO FUEL STOP
THORP, WASHINGTON

AGI Project No. 15,659.001

OFFICIAL COPY

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LIST OF ACRONYMS

AGI	Applied Geotechnology Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
AST	aboveground storage tank
ASTM	American Society of Testing and Materials
ATI	Analytical Technologies, Inc.
ATSDR	Agency for Toxic Substances and Disease Registry
BCF	bioconcentration factors
BETX	benzene, ethylbenzene, toluene, and total xylenes
bgs	below ground surface
CAP	Cleanup Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec	centimeter per second
COC	chemicals of concern
CPF	cancer potency factors
Ecology	Washington State Department of Ecology
GRA	General Response Actions
gpm	gallons per minute
K	hydraulic conductivity
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
μg/L	micrograms per liter
MRL	method reporting limit
MTCA	Model Toxics Control Act
MW	monitoring well
NOAA	National Oceanic and Atmospheric Administration

PAHs	polycyclic aromatic hydrocarbons
OVM	organic vapor meter
PID	photoionization detector
ppm	parts per million
PZ	piezometer
QC	quality control
RA	Remedial Action
RAO	Remedial Action Objectives
RfD	chronic reference dose
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
S	Sample
SG	staff gauge
SR 90	State Route 90
TPH	total petroleum hydrocarbons
UST	underground storage tank
EPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
WAC	Washington Administrative Code
WS	water sample

EXECUTIVE SUMMARY

This report presents the results of Applied Geotechnology Inc.'s (AGI) Feasibility Study (FS) of the former Bingo Fuel Stop, located 1 mile southeast of the Town of Thorp in the Yakima River Valley in central Washington. The site is leased by and the facilities are owned by Burns Bros., Inc., and were used as an auto and truck fueling facility from approximately 1968 until January 1992.

The Washington State Department of Ecology (Ecology) conducted a site visit on February 7, 1992 and issued an Enforcement Order based on observations of hydrocarbon contamination and potential threats to human health and the environment. The Enforcement Order directed Emergency Remedial Actions (RA) to occur. AGI prepared and submitted an Emergency RA Work Plan, which was reviewed and approved by Ecology.

Following completion of the Emergency RA, Ecology and Burns Bros., Inc. entered into an Agreed Order to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the site. AGI conducted the Remedial Investigation during late 1993 and early 1994. The RI report was submitted to Ecology on March 31, 1994.

This Feasibility Study provides the framework for developing, screening, and evaluating alternative cleanup actions. The following general steps were used to conduct the FS:

- The RI results and developed cleanup levels were synthesized into a statement of affected media and corresponding chemicals of concern at concentrations above cleanup levels in each of the affected media.
- Remedial action objectives (RAOs) were developed for media containing contaminants in excess of cleanup levels, and general response actions (GRAs) were formulated with an intent to achieve the RAOs.
- GRAs were resolved into remedial technologies, which were screened using technical and site-specific criteria. Surviving technologies were combined to produce cleanup alternatives for the site. In accordance with Model Toxics Control Act (MTCA) requirements, emphasis was placed on technologies that would produce permanent solutions.
- Cleanup alternatives were then analyzed and the most appropriate alternatives were recommended.

ALTERNATIVE SELECTION

Three alternatives were developed by this process and are summarized below.

Alternative 1 includes process options to limit and monitor environmental impacts with minimal reduction of site contamination sources and affected media.

Alternative 2 includes process options to limit and monitor environmental impact through removal of site contamination sources, and moderately aggressive reduction of affected media.

Alternative 3 includes process options to limit and monitor environmental impact through removal of site contamination sources, and aggressive reduction of affected media. Alternative 3 consists of product recovery, source area and downgradient contaminated soil excavation, and groundwater extraction and treatment. Groundwater monitoring following remediation will be shorter in duration than Alternative 2.

COMPARISON OF ALTERNATIVES

All three alternatives can be readily implemented with available equipment, materials, and contractors. Alternatives 2 and 3 could comply with MTCA cleanup levels where Alternative 1 does not. Alternative 1 generally isolates impacted media where Alternatives 2 and 3 take an active approach to treatment of impacted soil and groundwater. Alternative 3, though similar to Alternative 2, offers the shortest restoration time and is more effective in reducing hydrocarbon residuals.

The cost of Alternative 1 is significantly less than for Alternatives 2 or 3 because no active remediation is performed. Costs for Alternatives 2 and 3 are similar and fall within the estimated accuracy of plus or minus 50 percent.

1.0 INTRODUCTION

1.1 GENERAL

This report presents the results of Applied Geotechnology Inc.'s (AGI) Feasibility Study (FS) of the former Bingo Fuel Stop in Thorp, Washington, which was operated as an auto and truck fueling facility by Burns Bros., Inc. from approximately 1968 until January 1992. The location of the Bingo Fuel Stop is shown on **Figure 1-1**, Vicinity Map.

The Washington State Department of Ecology (Ecology) conducted a site visit on February 7, 1992 and issued an Enforcement Order (Ecology, 1992a) based on observations of hydrocarbon contamination and potential threats to human health and the environment. The order required implementation of an Emergency Remedial Action (RA). AGI performed the Emergency RA as described in our Emergency RA report (AGI, 1992c).

Following completion of Enforcement Order requirements, Burns Bros., Inc. and Ecology entered into an Agreed Order to conduct a Remedial Investigation/Feasibility Study (RI/FS). The RI was completed and submitted to Ecology on March 31, 1994 (AGI, 1994). This FS has been conducted in accordance with Agreed Order DE 93TC-C171 (Ecology, 1993b); with Washington Administrative Code (WAC) 173-340-350; and with AGI's approved Work Plan dated April 22, 1993 (AGI, 1993a).

The RI characterized surface and subsurface conditions and the nature and extent of contamination beneath the site. This FS determines what remedial actions, if any, are appropriate. The designated coordinators for this project are:

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1.2 PREVIOUS WORK

Ecology issued an Enforcement Order (Ecology, 1992a) on February 11, 1992 directing fuel dispensing activities at the site to stop and requiring preparation and implementation of an Emergency RA Work Plan. Five underground storage tanks (USTs) were temporarily taken out of service in February 1992 in compliance with the Ecology Enforcement Order.

AGI prepared and submitted an Emergency RA Work Plan on March 5, 1992 (AGI, 1992a). The Work Plan was reviewed and approved by Ecology, with several revisions, as described in our March 9, 1992 letter (AGI, 1992b). The five USTs were excavated during the Emergency RA, and approximately 700 gallons of floating product were recovered from four recovery sumps. Product was recovered to the maximum extent practicable. The results of the Emergency RA are summarized in our June 5, 1992 report (AGI, 1992c).

AGI conducted the Remedial Investigation during late 1993 and early 1994. The RI field work consisted of drilling 12 soil borings and completing them as groundwater monitoring wells and one piezometer. Soil and groundwater samples were collected and analyzed, and adjacent surface water bodies were studied. AGI prepared and submitted an RI report dated March 31, 1994. The report summarizes the nature and extent of petroleum hydrocarbon contamination at the site.

1.3 THE REGULATED CLEANUP PROCESS

In March 1989, a citizen-sponsored toxic waste cleanup law went into effect in Washington, changing site cleanup procedures statewide. Passed by voters as Initiative 97, this law is known as the Model Toxics Control Act (MTCA), Chapter 70.105, Revised Code of Washington. State regulations promulgated under MTCA (WAC 173-340) are known as the MTCA Cleanup Regulation. This regulation provides the framework for soil and groundwater remediation in Washington where "hazardous substances have come to be located." MTCA requires cleanup of hazardous substance releases and is thereby invoked when a hazardous substance release is discovered or suspected. The MTCA cleanup process includes:

- <u>Discovery and Reporting</u>. Any owner or operator who has information that a hazardous substance has been released from a UST to the environment and may be a threat to human health or the environment must report such information to Ecology's Toxics Cleanup Program within 24 hours of release confirmation. Contamination discovered at the site was reported to Ecology by Burns Bros., Inc. personnel.

- <u>Initial Investigation</u>. Ecology is required to perform an investigation within 90 days of discovery. Based on the initial investigation, further investigation or no further action may be required.

- Site Hazard Assessment and Ranking. Ecology conducts a hazard assessment to confirm the presence of hazardous substances and determine the relative risk the site poses to human health and the environment. The site is then ranked using the Washington Ranking Method. This method assigns a number to each site based on relative risk to human health and the environment. The Bingo Fuel Stop is ranked 2 on a scale of 1 (highest risk) to 5 (lowest risk).

- Remedial Investigation/Feasibility Study. The RI emphasizes data collection and site characterization and the FS emphasizes analysis of site-specific data and evaluation of cleanup actions. Specifically, the RI provides a mechanism for characterizing site conditions and the nature and extent of contaminants present, and assessing risk to human health and the environment. The FS develops, screens, and evaluates various potential remedial actions. This report presents the results of the FS conducted by AGI. The cleanup method(s) and contaminant action levels are selected in the RI/FS phase. Cleanup levels available are termed Method A, Method B, and Method C. Method A is used when all hazardous substances detected at the site are found on the list of 25 chemicals contained in WAC 173-340-720 or -740. Method B, which uses site-specific characteristics and contaminant distribution to determine cleanup levels, is applicable to all sites. Method C is only applicable to industrial sites.

- Interim Remedial Action. Interim RAs may be taken to reduce the threat to human health or the environment. Interim RAs are initiated before the RI/FS is complete. Removal and treatment of groundwater containing dissolved petroleum hydrocarbons has been initiated as an interim RA at the Burns Bros. site.

- Selection of Cleanup Method. Based on information gathered during the RI/FS, the preferred cleanup alternative is identified and a Cleanup Action Plan (CAP) is developed. The CAP identifies preferred cleanup methods and specifies cleanup standards and other requirements at the site.

- Site Cleanup. Cleanup begins when the CAP is implemented. This includes design, construction, operation, and monitoring of cleanup actions.

2.0 STUDY AREA DESCRIPTION

2.1 SITE AND SURROUNDING AREA DESCRIPTION

The former Bingo Fuel Stop is located on Thorp Highway at its junction with State Route 90 (SR 90). The site is located in the southeast quarter of the northeast quarter of Section 14, Township 18 North, Range 17 East, Willamette Meridian.

Land use in the surrounding area is predominantly agricultural as shown on **Figure 2-1**. One retail store is located within 2 miles of the site, across SR 90 to the northeast. The Puget Power Kittitas Service Center is located adjacent to the west of the site. One residence is present adjacent to the southern site boundary, and one residence is present adjacent to the eastern site boundary.

A review of Water Well Reports in Ecology's files and a door-to-door survey of houses nearby indicate nine domestic wells are located within a 1/2-mile radius of the site. Nearby water well locations are shown on **Figure 2-2**.

2.2 DEMOGRAPHY AND LAND USE

Population density in the area is sparse. It is estimated that fewer than 30 people reside within a 1/2-mile radius of the site.

The site is zoned for limited commercial use according to the Kittitas County Planning Department. Surrounding land zoning is agricultural.

Burns Bros., Inc. leases the Bingo Fuel Stop site from a group of landowners. An interview was conducted with the site owners' representative, Robert Dunnington, in May 1993 (AGI, 1993b). Mr. Dunnington indicated the site will likely be sold following site cleanup. Future site use is therefore unknown; however, it will likely be required to be in accordance with zoning restrictions.

2.3 REGIONAL TOPOGRAPHY, GEOLOGY, AND HYDROGEOLOGY

The Bingo Fuel Stop site is in the Kittitas Valley in central Washington, as shown on **Figure 1-1**. The topography near the site slopes to the northeast toward the Yakima River.

Regional geology was interpreted primarily by review of studies published by Waitt (1979) and Porter (1976). The topographically higher areas southwest of the site are most likely comprised of Kittitas and Lakedale Drifts. The topographically higher areas north and northeast of Thorp are comprised of Thorp Gravel Deposits. The low area between the two topographically higher areas is most likely recent alluvium deposited by the Yakima River and possible outwash alluvium from the Kittitas and Lakedale Drifts at depth.

The site resides in the approximately 30-mile-long, southeast-trending Kittitas Valley. The valley is bordered on the south by the Manastash Ridge and to the north by the Wenatchee Mountains. Hydrologically, this area is known as the Kittitas Basin and is within the Yakima River Basin.

Groundwater resources in the Kittitas Basin are plentiful due to high precipitation and runoff in the Cascade Mountains, where the Yakima River watershed originates. Snowmelt and rainfall provide most of the watershed's runoff throughout the fall, winter, and spring. Meltwater from glaciers in the western area of the watershed also sustains flows throughout the spring and summer. Permeable Yakima River alluvium throughout the basin provides reliable supplies of groundwater to wells. Nearby domestic and irrigation wells withdraw water from depths of 2 to 350 feet according to the Water Well Report files at Ecology.

Most groundwater withdrawn throughout the basin is pumped from Yakima River alluvium. These sediments are several hundred feet thick in many places in the basin. Most groundwater flow through the basin likely travels through these sediments. Groundwater in the Kittitas Basin is used for irrigation associated with agriculture. Most groundwater withdrawal occurs during the growing season from April through September. Groundwater is typically encountered in low-lying areas of the Kittitas Valley at depths of less than 20 feet below ground surface (bgs).

3.0 REMEDIAL INVESTIGATION SUMMARY

3.1 GENERAL

The purpose of the RI was to investigate soil and groundwater below the site and nearby surface water and sediments. Information obtained during the investigation was used to identify the nature and extent of contamination at the site, enabling the selection of a cleanup action alternative. The RI was submitted to Ecology on March 31, 1994, and conditionally approved by Ecology on May 12, 1994.

Activities included collecting surface water and sediment samples, drilling and sampling 12 soil borings (MW1 through MW12), completing the soil borings as groundwater monitoring wells and one piezometer, collecting samples from the wells, and conducting two aquifer tests.

3.2 SITE GEOLOGY

Geologic conditions at or near the site were characterized based on information obtained from the subsurface explorations conducted during the RI and a review of Water Well Reports from Ecology's files. Geologic cross sections were prepared using soil boring information and interpretation. Locations of cross sections are shown on **Figure 3-1** and the cross sections are show on **Figures 3-2 and 3-3**.

The most predominant material encountered in every exploration was a well graded gravel with sand and cobbles. In addition, a wide variety of material was encountered in the explorations varying from clay, silt, sandy silt, silty sand, silty gravel, and poorly graded and well graded sands and gravels. The varying thickness and wide diversity of materials encountered suggest that they comprise one geologic unit and were placed while the Yakima River meandered through the Kittitas Valley. The materials encountered during drilling are described in detail below.

Gravelly Clay: Brown gravelly clay, which was encountered from 2.5 to 25 feet bgs only in the boring drilled for MW6, was most likely fill material placed to construct Thorp Highway.

Silt: Black and brown, soft to very stiff silt was encountered in all borings drilled in the lower topographic areas north to east of the site (MW7, MW8, MW10, and MW12). The silt was encountered at depths ranging from 3 to 12 feet bgs. The black coloring encountered in MW7, MW8, and MW12 is attributed to organic material within the silt.

Sandy Silt: Black, very stiff to hard sandy silt was encountered directly below the crushed rock asphalt subgrade in MW1 and MW4 borings. Brown, loose to hard sandy silt was encountered at ground surface for all borings drilled in the lower topographic areas north to east of the site. This material was also encountered at depth (58 to 60 feet bgs) in MW3 and may act as an aquitard. A clay layer approximately 3 feet thick at approximately 10 feet lower in elevation was noted in a boring drilled by the Bonneville Power Administration approximately 3/4 mile to the northeast.

Silty Sand: Brown to gray, dense silty sand with gravel and cobbles was encountered near ground surface in borings MW2, MW4, and MW11 and at depth in MW3. MW6 encountered a gray, very dense silty sand below the gravel clay fill material at 25 feet bgs.

Sand: Gray, dense, poorly graded sand was encountered in only one of the shallow borings (MW9). Yellow to brown, very dense, poorly graded sand was encountered from 52 to 55 feet bgs in MW3. Gray, dense, well-graded sand was encountered in only one of the shallow borings (MW12). Brown, very dense, well graded sand with gravel was encountered from 49 to 52 feet bgs in MW3.

Gravel: Brown, very dense, poorly graded fine gravel with sand, interbedded with poorly graded sand with gravel, was encountered from 64 feet bgs to the total depth of 81 feet bgs in MW3. This material was not encountered in any of the other explorations. Brown, very dense, well-graded gravel with sand and cobbles was the most predominant lithologic unit and was encountered in all borings. In some areas the material had a gray color, possibly due to a reducing environment caused by petroleum hydrocarbons.

Silty Gravel: A 1- to 2-foot-thick layer of brown, very dense silty gravel was encountered at 15 feet bgs in both MW3 and MW11 borings, and may be a localized aquitard in this area. This material was also encountered at 48 to 49 feet bgs in MW3.

In summary, the variety of materials encountered, and the proximity to the Yakima River, suggest site geology is alluvial in origin.

3.3 SITE HYDROGEOLOGY

Site hydrogeology was studied during the RI to evaluate the impact of petroleum hydrocarbons on groundwater. Groundwater elevation maps were prepared based on depth to water measurements in groundwater monitoring wells. Groundwater flow directions were determined based on groundwater contours. Two aquifer tests were performed to evaluate hydraulic conductivity and velocity.

3.3.1 Groundwater Occurrence

We have identified two hydrostratigraphic zones below the site, termed the Upper and Lower Zones. The uppermost groundwater zone occurs under unconfined (water table) conditions within alluvial sediments. Eleven groundwater monitoring wells are screened in this zone. Depth to the water table generally varies approximately 22 feet across the study area. One on-site monitoring well (MW3) is screened in the Lower Zone, below silty sands, silty gravels, and a thin silt layer. The groundwater zone screened by MW3 exhibits lower hydraulic head than the overlying groundwater zone screened by the shallow PZ1 completion (consistently about 5 feet between PZ1 and MW3). This hydraulic head difference and the low permeability of overlying sediments suggest the deeper groundwater zone screened by MW3 (70 to 80 feet bgs) can be identified separately from the shallow groundwater.

3.3.2 Groundwater Elevations and Flow Directions

Water levels in monitoring wells MW1 through MW6 were measured on a weekly basis between July 1993 and March 1994, and MW7 through MW12 levels were measured on a weekly basis between November 1993 and March 1994. These data indicate groundwater elevations are consistently highest in the southwest portion of the site area, and gradually decrease to the northeast. Total change in water table elevation across the study area on November 5, 1993 was approximately 22 feet between MW11 and MW12 (approximately 720 feet apart), with a resulting groundwater gradient of approximately 0.03 foot per foot of horizontal distance. Horizontal groundwater flow is thus northeasterly toward the Yakima River. Depths to the water table and groundwater elevations for July 7 and November 5, 1993 are summarized in **Table 3-1.** Measurements on July 7 were collected when site wells were not being pumped; on November 5, measurements were collected when recovery sumps were being pumped. The groundwater flow directions are fairly consistent, indicating that pumping the recovery sumps has no net effect on flow direction.

The northeasterly groundwater flow direction has been consistent through each of the referenced measurement rounds. **Figures 3-4 and 3-5** show groundwater elevation contours and flow directions measured on July 7 and November 5, 1993, respectively. Local and regional hydrogeology suggest the overall northeasterly flow direction is consistent throughout the year.

At the PZ1 location, hydraulic head in the shallow zone well is higher than the head in MW3, indicating at least partial separation of the two zones, and the potential for limited downward flow from the Upper to the Lower Zone in this location. Vertical flow direction is not known elsewhere across the site.

Water level fluctuations at MW3 and MW4 under static (nonpumping) conditions are shown in the groundwater hydrographs on **Figure 3-6.** The maximum water level change exhibited during this monitoring period was approximately 0.05 foot at MW3 and 0.04 foot at MW4. Cyclic fluctuations evident in the data from MW3 may be attributed to pumping at a groundwater extraction well pumping large volumes of water at 6-hour intervals in the vicinity. The absence of a well-defined cycle in the data from MW4 further suggests the existence of two hydrogeologic zones.

3.3.3 Aquifer Hydraulic Properties

Aquifer testing was performed on the site on July 14, 15, 21, and 22, 1993. Data gathered during the testing were analyzed using different methods developed by Theis, Jacob, Lohman, and Thiem. The results of aquifer test data analysis provide values for transmissivity and hydraulic conductivity for the Upper and Lower Zones based on recovery data for the Lower Zone, and drawdown and recovery data for the Upper Zone. Aquifer test results are shown in **Table 3-2.** The results indicate hydraulic conductivity (K) of the Lower Zone is approximately 10^{-5} centimeters per second (cm/sec). The value of K for the Upper Zone is approximately 10^{-3} cm/sec, and assuming a porosity of approximately 0.30, average liner flow velocity is estimated to be approximately 0.3 feet/day. The gradient flow velocity was not calculated for the Lower Zone since the water level is only known in one location.

Aquifer test results for the Upper and Lower Zone are consistent with silty sand and silty gravel conditions; the Lower Zone results indicate a significantly lower permeability than the Upper Zone. Hydraulic communication between the zones appears to be minor based on: the relatively low hydraulic conductivity of the Lower Zone at MW3 compared to the Upper Zone; the difference in static water levels between well MW3 (Lower Zone) and piezometer PZ1 (Upper Zone); and lower conductivity and higher pH measured in water sampled from MW3 compared to other wells.

3.4 NATURE AND EXTENT OF CONTAMINATION

3.4.1 General

This section presents chemical analysis results for soil, groundwater, surface water, and sediment samples collected during the Emergency RA in March 1992 and Remedial Investigation in July, October, and November 1993. Because the site has a history of storing and handling large volumes of fuels, fuel hydrocarbons were the focus of the investigations. Lead, pesticide, and fertilizer distribution was also investigated at the request of Ecology.

3.4.2 Soil

Soil samples were collected during the Emergency RA in March 1992 and RI in July and October 1993. During the Emergency RA, a total of 28 soil samples were collected from the UST excavations, product piping trenches, beneath the fuel dispenser islands, and the soil stockpile.

During the RI, 20 soil samples were collected from 12 soil borings. Borings were then completed as groundwater monitoring wells MW1 through MW12. At least one sample was collected from each boring near the water table and up to two additional samples were collected from various interval(s) of the boring if evidence of contamination was noted during drilling. A field duplicate sample was collected from MW6 at 22.5 feet bgs. One soil sample was collected from near the drain box at the west end of the north culvert. Sample collection locations during the Emergency RA and soil boring locations from the RI are shown on **Figures 3-7 and 3-8**, respectively.

The following sections discuss soil sample results from the Emergency RA and the RI. Sample locations, depths, dates, and laboratory results are summarized in **Tables 3-3 and 3-4.** The distribution of total petroleum hydrocarbons (TPH) and benzene, ethylbenzene, toluene, and total xylenes (BETX) is discussed below.

TPH: All soil samples were analyzed for TPH. During the Emergency RA, elevated concentrations of TPH quantified as gasoline ranging up to 21,000 milligrams per kilogram (mg/kg) were detected in samples collected from UST removal areas, piping trenches, and dispenser islands. The extent of TPH contamination was not delineated since only surficial soil samples were collected at that time.

During the RI, soil samples were collected from subsurface on and off site, providing a more comprehensive delineation of lateral and vertical extent of TPH contamination in soil.

TPH was not detected in soil samples from borings MW1, MW2, MW4, MW7, MW8, MW9, MW10, MW11, and MW12. Gasoline and diesel concentrations were detected at 310 mg/kg and 3,100 mg/kg, respectively, in a sample collected from boring MW3 at 9 feet bgs, and diesel was detected at 34 mg/kg in a sample collected at 42.5 feet bgs. Low levels of TPH were detected in samples collected from boring MW5 at 7.5 feet bgs and MW6 at 17.5 and 22.5 feet bgs. The TPH concentrations ranged from 10 to 160 mg/kg.

A sample collected from near the drain box at the west end of the north culvert (see **Figure 3-8**) contained 340 mg/kg diesel-range TPH (Sample S32).

Oil: Samples collected from the east and south sidewalls of the former heating oil UST excavation (S15 and S16) during the Emergency RA were analyzed for oil-range TPH. Oil was detected in sample S15 at 22 mg/kg, but was not detected in sample S16.

BETX: All soil samples were analyzed for BETX except S3, S15, and S16, collected during the Emergency RA. In the UST removal area, elevated BETX concentrations were detected in samples collected from the north and east sidewalls of the former regular gasoline UST excavation, from the piping trenches, and beneath dispenser islands 6 and 7 (Samples S7, S8, S10, S27, and S28). The ranges of BETX concentrations in these samples are from 6.5 to 92 mg/kg (benzene), 19 to 300 mg/kg (ethylbenzene), 69 to 1,000 mg/kg (toluene), and 170 to 1,800 mg/kg (total xylenes).

During the RI, BETX was not detected in samples collected from MW1, MW2, MW7, MW8, MW10, MW11, MW12, and near the drain box at the west end of the north culvert. The highest BETX concentrations were in a sample collected from MW6 at 22.5 feet bgs. BETX concentrations in this sample were 3.5 mg/kg (benzene), 3.6 mg/kg (ethylbenzene), 17 mg/kg (toluene), and 21 mg/kg (total xylenes). BETX was detected in samples from MW3, MW4, and MW5 at lower concentrations.

Polycyclic Aromatic Hydrocarbons (PAHs): Soil samples collected during the Emergency RA were not analyzed for PAHs. All soil samples collected from borings during the RI were analyzed for PAHs. Naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, fluorene, and/or phenanthrene were detected in samples collected from MW3, MW5, and MW6. However, carcinogenic PAH compounds were not detected in any analyzed soil samples.

Lead: Surficial soil samples S5, S6, S7, S8, S20, S26, S27, and S28 and all samples collected during the RI were analyzed for total lead. Lead concentrations ranged from not detected to 21 mg/kg. No elevated lead concentrations were identified.

Vinyl Acetate: Two soil samples (S1 and S3) which contained elevated (up to 12,000 mg/kg) concentrations of diesel were analyzed for volatile organic hydrocarbons, including vinyl acetate, a component of Burns Red additive in diesel fuel. Vinyl acetate was not detected in either sample. The only volatile organic hydrocarbons detected in samples S1 and S3 were low concentrations of total xylenes.

3.4.3 <u>Groundwater</u>

During the Emergency RA, a total of four water samples (W-1 through W-4) were collected from four drinking water wells located within a 1/4-mile radius of the site. During the RI, 14 groundwater samples were collected from 11 of the 12 monitoring wells (MW1 through MW12, except MW4), including field duplicate samples collected from MW2 and MW11. Water sample locations are shown on **Figure 3-9.** Free product was present in MW4 and MW6 during July 1993 sampling and, therefore, samples were not collected from these two wells at that time. However, a sample was collected from MW6 in November for selected chemical analyses.

During the RI groundwater sampling, pH, conductivity, and temperature were measured and recorded to monitor parameter stabilization while purging wells. This procedure provides a cursory field assessment of groundwater chemistry, and promotes collection of samples representative of in situ groundwater conditions. Field parameters measured during groundwater sampling are summarized in **Table 3-5.**

The following sections discuss groundwater sample results from the Emergency RA and the RI. Sample locations, dates, and laboratory results are summarized in **Tables 3-6 and 3-7.** The distribution of TPH and BETX is discussed below.

TPH: Samples collected from Puget Power Service Center and the Thorp Antique and Fruit Mall during the Emergency RA were analyzed by Washington State Method WTPH-G. No hydrocarbons were detected. All groundwater monitoring well samples collected during the RI were analyzed by EPA Method 8015 Modified, except for the sample from MW6. The sample collected from MW6 was used to evaluate the concentration of vinyl acetate in groundwater. Samples collected from MW1, MW2, MW3, MW7, MW9, MW10, MW11, and MW12 did not contain detectable concentrations of hydrocarbons.

TPH quantified as gasoline was detected in MW5 at 34 milligrams per liter (mg/L) and MW8 at 3 mg/L. TPH quantified as diesel was detected in MW5 at 2 mg/L.

BETX: BETX was not detected in the four drinking water wells sampled during the Emergency RA. BETX was not detected in samples collected from wells MW1, MW7, MW9, MW10, MW11, and MW12 during the RI. Elevated BETX concentrations (ranging up to 21,000 micrograms per liter [μg/L] toluene) were detected in samples collected from MW5, MW6, and MW8. Low levels of ethylbenzene and/or benzene (slightly above detection limits) were detected in samples collected from MW2 and MW3.

PAHs: Samples collected during the Emergency RA were not analyzed for PAHs, lead, or agricultural chemicals. Concentrations of naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected in samples collected from MW2, MW3, MW5, and MW8 during the RI. Concentrations of fluorene, phenanthrene, and/or anthracene were also detected at MW2, MW3, and MW5. Carcinogenic PAH compounds were not detected in any groundwater samples.

Lead: Total lead was detected in groundwater samples collected from MW1 (0.013 mg/L), MW2 (0.005 mg/L), and MW3 (0.004 mg/L). No other groundwater samples contained detectable levels of lead.

Vinyl Acetate: The sample collected from MW6 during the RI was analyzed for volatile organic compounds (VOCs), including vinyl acetate, a Burns Red fuel additive. Vinyl acetate was not detected in the sample.

Nitrate/Nitrite: The sample collected from MW1 during the RI was analyzed for nitrate and nitrite. Nitrate was detected at a concentration of 6.4 mg/L and nitrite at 0.15 mg/L.

Pesticides: Samples collected from MW1 and MW6 during the RI were analyzed for chlorinated pesticides. Pesticides were not detected in either sample.

3.4.4 Surface Water

During the Emergency RA, surface water samples were collected from all surface water bodies within a 1/4-mile radius of the site. One sample was collected from a pond east of the site, from the swampy area south of the site, from the drainage ditch south and west of the site, and from the irrigation ditch adjacent to MW8 (see **Figure 3-10**).

Surface water samples were analyzed by some or all of the following: EPA Method 8020 for BETX, Washington State Method WTPH-G for TPH quantified as gasoline, and WTPH-D for TPH quantified as diesel. Results of chemical analysis are shown in **Table 3-8**. The only analyte detected in any of the samples was toluene at 0.99 μg/L in the sample from the swampy area.

3.4.5 Sediment

Sediment samples were collected during the RI from areas where potentially impacted sediment was expected to accumulate. One sample was collected from the east end of the north culvert; the other was collected from the swampy area south of the site (see **Figure 3-10**). Samples were analyzed for BETX and TPH quantified as diesel. Results of chemical analyses are shown in **Table 3-8**.

TPH quantified as diesel was detected at 2,100 mg/kg and toluene at 0.42 mg/kg in the sample collected from the east end of the north culvert (Sample S31). The hydrocarbon concentrations may be the result of surface run-off water or groundwater seepage from the subsurface near recovery sump RS2, discharged from the culvert, since diesel-range compounds were also detected in the soil near the drain box at the west end of the culvert (Sample S32). The impacted sediment did not likely result from impacted shallow groundwater directly, based on a comparison of the lower static water level in MW8 and the elevation of the irrigation canal (approximately 8 feet of difference in November 1993).

The sample collected from the southern swampy area (Sample S30) contained 57 mg/kg TPH as diesel, but no detectable BETX. The detected diesel may be attributable to run-off water from the aboveground tank area transported via the irrigation canal, or possibly to run-off water from the east portion of the site. The laboratory chromatogram indicates the presence of diesel and longer chain hydrocarbons similar to motor oil or asphalt. The most likely source of oil or asphalt is the paved area north of the swampy area.

3.5 CONTAMINANT FATE AND TRANSPORT

The following sections discuss the expected fate and transport of petroleum hydrocarbon compounds and lead based on our understanding of the site use and surrounding geology and hydrogeology.

3.5.1 Sources of Contamination

Sources of contamination beneath the site are primarily related to petroleum hydrocarbon compounds. These findings are consistent with historical data on site usage and widely reported environmental industry findings for similar sites.

The petroleum hydrocarbon contamination appears to be the result of point and nonpoint releases of petroleum products. Point sources potentially include aboveground and belowground petroleum storage tanks and the related piping and valves. Nonpoint sources may include leaks, drips, and spills that occurred during operations and maintenance. Historically, minor releases were not uncommon when transferring products or repairing storage systems at fuel handling facilities.

3.5.2 Contaminant Fate and Transport

Chemical fate and transport in the environment is complex and dependant on many factors. In part, contaminants may volatilize, adsorb onto soil particles, and/or migrate within the pore spaces of soil. Contaminant migration rates in the subsurface are commonly related to contaminant mass and volume; chemical properties such as solubility, molecular weight, and volatility; and soil characteristics (i.e., grain size, porosity, and moisture content).

TPH-Related Compounds: In subsurface soils, aqueous solubility, weathering, and biological degradation may change TPH composition and lead to a reduction of low weight alkanes, as well as change the ratios of BETX and PAH compounds. In addition, hydrocarbons with low vapor pressures tend to volatilize to a greater extent than semivolatile compounds; these vapors are usually nominally affected by soil adsorption processes.

Aromatic TPH components (BETX and PAHs) tend to remain associated with the bulk alkane TPH constituents; it is unusual to find significant concentrations of aromatic components in the absence of TPH. PAHs are less soluble than nonaromatic compounds (BETX) and may tend to adsorb preferentially to organic and inorganic materials in the subsurface.

In near-surface soils, preferential weathering and biodegradation of light alkanes and volatile aromatic compounds may result in higher relative concentrations of PAHs. Higher solubility of BETX compounds relative to PAHs tends to transport BETX compounds downward in the vadose zone. Thus, higher concentrations of PAH compounds associated with diesel TPH are likely to occur near the surface, and VOC contamination associated with gasoline is more likely at depth in unsaturated soil.

Diesel fuel is present at high concentrations in the former diesel and gasoline UST area immediately west of the existing building and below the former diesel fueling islands north of the building. Diesel fuel has been recovered from recovery sumps RS1, RS2, and RS4, and can be considered to have been present in areas between these sumps.

Gasoline constituents were identified at high concentrations south and east of the building, west of Thorp Highway, in the former gasoline UST area.

Subsurface materials beneath the site consist of coarse-grained deposits with varying amounts of fine-grained matrix. Petroleum releases onto the surface likely have infiltrated downward prior to the installation of asphalt pavement, or flowed downslope and infiltrated into the north ditch area, north of RS2. Infiltration likely continued until shallow groundwater was encountered. Petroleum then likely migrated downgradient, adsorbing onto soil along the soil/water interface.

A portion of the petroleum dissolved in water and migrated in groundwater. The dissolved petroleum constituents likely become diluted by unimpacted groundwater and attenuate by naturally occurring biological activity at the downgradient perimeter of the dissolved constituent plume.

3.5.3 Summary

Soil and groundwater beneath the site are contaminated with petroleum-related compounds. A groundwater sample collected from monitoring well MW1 contained an elevated concentration of dissolved lead. The petroleum hydrocarbon contamination is believed to result from spills and petroleum storage system leaks. The extent of impacted media is shown on **Figure 3-11.**

Based on observed phase-separated hydrocarbons in recovery sumps RS2 and RS4, and in monitoring wells MW4 and MW6, migration of hydrocarbons was likely continuing until the interim cleanup began in 1992, and has continued to the present. The phase-separated hydrocarbon and dissolved hydrocarbon plumes are located hydraulically downgradient from source areas, and extend slightly beyond the property boundaries. Based on water samples collected from nearby residences and samples from downgradient monitoring wells, no drinking water supplies have been impacted.

3.6 DRAFT CLEANUP LEVELS

Draft cleanup levels developed during the RI are presented in **Table 3-9.** The draft cleanup levels include risk-based cleanup levels for petroleum constituents, and the Method A cleanup level for TPH.

Ecology requires use of Method A, or the Matrix Evaluation, to develop cleanup levels for a TPH mixture instead of the Method B risk-based approach as outlined in WAC 173-340-705. Ecology stated in a January 28, 1994 internal memorandum (Ecology, 1994) that development of Method B risk-based cleanup levels is based on an incomplete toxicological characterization of all TPH constituents and may not be protective of human health and the environment. If the regulations governing establishment of TPH cleanup levels are revised in the future, cleanup of TPH will be modified in accordance with the new regulations.

3.7 DRAFT CLEANUP LEVEL EXCEEDANCES

This section identifies sampling locations where soil and groundwater chemicals of concern (COCs) concentrations exceed draft cleanup levels. Draft soil and groundwater cleanup levels are listed on **Table 3-9,** and exceedance locations for soil and groundwater are listed on **Tables 3-10 and 3-11.**

3.7.1 Soil

Method B Exceedances: Chemical concentrations in soil exceeding Method B cleanup levels are listed below by location:

- Soil samples S7, S8, S10, and S27 exceeded draft cleanup levels for benzene, ethylbenzene, and toluene; soil sample S8 also exceeded the cleanup level for total xylenes.
- Soil samples S21, S22, S28, MW6 @ 17.5 feet, and MW6 @ 22.5 feet exceeded draft cleanup levels for benzene only.
- No soil sample exceeded draft cleanup levels for any PAH or lead.

Method A TPH Exceedances: Method A cleanup levels for TPH-contaminated soil are outlined under WAC 173-340-740(2), and locations of exceedances are listed in **Table 3-12.**

In general, locations of Method A TPH cleanup level exceedances in soil are: in the former diesel and gasoline UST excavation (Excavation 1); in the north and east sides of the gasoline UST excavation (Excavation 2); in the dispenser island areas; at MW3 and MW5 at 9.0 and 7.5 feet bgs, respectively; at the drain box in the north ditch area north of RS2; at the east end of the north culvert; and likely in soil between the diesel dispenser islands, RS2 and RS3.

3.7.2 Groundwater

Method B Exceedances: Chemical concentrations in groundwater exceeding draft Method B cleanup levels are listed below by location:

- Monitoring wells MW5 and MW6 exceeded draft cleanup levels for benzene, ethylbenzene, and toluene.
- Monitoring well MW8 exceeded draft cleanup levels for benzene and ethylbenzene.
- Monitoring wells MW1, MW2, and MW3 exceeded draft cleanup levels for lead; monitoring well MW1 also exceeded the cleanup level for nitrate/nitrite.

The draft groundwater cleanup level for lead was exceeded in three monitoring wells. The highest concentration of lead detected on site occurred in the southernmost (upgradient) well, MW1. This concentration, 13 μg/L, is above the draft cleanup level of 3.2 μg/L (based on surface water criteria); however, it is below the federal Maximum Contaminant Level (MCL) of 15 μg/L. Lead is the only chemical detected on site where its cleanup level is based on its surface water criteria; this may be inappropriate since natural attenuation and dilution will occur during groundwater transport from the Bingo Fuel Stop to the Yakima River. Further investigation of background groundwater quality may be appropriate if exceedances of lead in groundwater represent unacceptable risks to human health and the environment.

Method A TPH Exceedances: Method A cleanup levels for TPH-contaminated water are outlined under WAC 173-340-720(2), and locations of exceedances are listed in **Table 3-13**. Locations of Method A TPH cleanup level exceedances in groundwater are MW5, MW8, and likely MW4 and MW6 due to the presence of phase-separated hydrocarbons.

4.0 FS OBJECTIVES AND GENERAL RESPONSE ACTIONS

This Feasibility Study provides the framework for developing, screening, and evaluating alternative cleanup actions. MTCA details requirements for the selection of cleanup actions (WAC 173-340-360). These requirements, in conjunction with data from the RI and established cleanup levels (calculated in Section 3.6), were used to evaluate potential cleanup actions.

The following general steps were used to conduct the FS:

- The RI results and developed cleanup levels were synthesized into a statement of affected media and corresponding COCs at concentrations above cleanup levels in each of the affected media.
- Remedial action objectives (RAOs) were developed for media containing contaminants in excess of cleanup levels, and general response actions (GRAs) were formulated with an intent to achieve the RAOs.
- GRAs were resolved into remedial technologies, which were screened using technical and site-specific criteria. Surviving technologies were combined to produce cleanup alternatives for the site. In accordance with MTCA requirements, emphasis was placed on technologies that would produce permanent solutions.
- Cleanup alternatives were then analyzed in detail using an extensive set of criteria. After the detailed analysis, the most appropriate alternative was recommended.

RAOs represent the expected result of a cleanup action and help define the general types of cleanup actions that may be appropriate. RAOs can be specific (i.e., COCs, exposure rates and receptors, and acceptable COC levels for each exposure route) or general (i.e., the goal of protecting uncontaminated groundwater).

Based on the analysis of the nature and extent of contamination exceeding cleanup levels presented in Section 3.7, RAOs were developed for protection of both human health and the environment. These objectives were evaluated for both soil and groundwater; the results are presented in **Table 4.1**. Soil and groundwater were the only media considered because achieving cleanup levels in these media will protect others, such as surface water and air.

General response actions are also presented in **Table 4.1**. These include a list of remedial technologies that could be used to achieve RAOs in both soil and groundwater. GRAs are used to define specific remedial technologies and process options, which are then screened, as described in following sections.

5.0 TECHNOLOGY SCREENING AND DEVELOPMENT OF CLEANUP ALTERNATIVES

5.1 GENERAL

Volumetric considerations for contaminated media influence how technologies and process options are applied. Volumetric considerations are discussed in Section 5.2.

Screening was performed in two steps:

- Remedial technologies and process options were initially screened on the basis of technical implementability. Criteria include the nature and extent of contamination, site hydrogeology, accessibility of the site to heavy equipment, and other potentially limiting factors. Technologies that cannot be implemented were eliminated.

- Secondary screening used three criteria to evaluate those technologies and associated process options surviving initial screening: 1) effectiveness and permanence, 2) implementability, and 3) order of magnitude costs. Greatest weight was placed on effectiveness and permanence. A technology was not eliminated based on cost unless other less-costly technologies were equally effective and permanent.

MTCA requirements (WAC 173-340-360) were also considered in the evaluation of appropriate technologies. For example, MTCA indicates that technologies addressing specific hazardous substances or pathways shall be considered in the following order of descending preference:

- Reuse or recycling.

- Destruction/Detoxification.

- Separation or volume reduction followed by reuse, recycling, destruction, or detoxification of the residual hazardous substance.

- Immobilization of hazardous substances.

- On-site or off-site 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.

Technologies that provide permanent solutions and minimize the remaining untreated hazardous substances were given highest priority in the screening process, as required by MTCA.

Cleanup alternatives were formulated by combining screened cleanup technologies. Those technologies that survived the screening and appeared suitable for use were retained to provide a range of cleanup alternatives for the site.

5.2 VOLUMETRIC CONSIDERATIONS

The volume and area of impacted soil and groundwater were estimated to the degree practical based on the nature and extent of contamination exceeding cleanup levels as presented in Section 3.4.

5.2.1 Soil

Site soils have been impacted by BETX and TPH in excess of cleanup levels. Petroleum contamination primarily comprises diesel-range hydrocarbons, although gasoline range hydrocarbons are present, particularly around the former gasoline USTs and the east side of the site. For the purposes of the FS, contamination was considered to occur under two conditions, generally described as source to groundwater and at the groundwater elevation.

The first condition is where contamination originated from sources such as tanks and pipes, and extends from at or near ground surface down to the groundwater elevation. Specifically, this condition occurs at aboveground and underground tanks, along connecting pipelines, and at dispenser islands. A total estimated volume of 7,000 to 11,000 cubic yards (bank measure) of soil has been impacted under this condition.

The second condition is where contamination has migrated along the surface of the groundwater away from the sources and has impacted soil over a range of depth (approximately 6 feet) that the groundwater elevation has fluctuated within. Specifically, this condition occurs over a region which extends primarily to the north of the underground tanks and dispenser islands. Between 3 and 6 feet of clean soil overlies the range of soil depth impacted by migrating contamination. A total estimated volume of 3,000 to 7,000 cubic yards (bank measure) has been impacted under this condition, and 2,000 to 3,000 cubic yards (bank measure) are present as clean overburden.

5.2.2 Groundwater

Site groundwater has been impacted by BETX and TPH in excess of cleanup levels. Because the primary site contaminant is diesel, the overall impact on groundwater is limited due to the low solubility of diesel fuel in water. Gasoline hydrocarbons have impacted groundwater, mainly over an area extending along the east side of the site and under adjoining roads.

Floating product, primarily diesel fuel, is present in discontinuous zones which are not well defined. Floating product is likely on the order of hundreds of gallons.

5.3 SELECTION AND SCREENING OF CLEANUP TECHNOLOGIES

5.3.1 Initial Screening of Remedial Technologies

Tables 5.1 (soil) and **5.2** (groundwater) summarize the initial media-specific screening of remedial technologies for Bingo Fuel Stop. Applicability or rationale for elimination is described for each technology and process option considered. Those process options and technologies deemed not applicable were eliminated based on engineering and scientific judgment.

5.3.2 Secondary Screening and Selection of Process Options

Tables 5.3 (soil) and **5.4** (groundwater) summarize the secondary screening of process options for each medium. Typically, one process option within each remedial technology is saved for further consideration. Where process options varied significantly in performance and effectiveness, two process options associated with a technology were carried into later stages of the FS.

5.3.3 Summary of Process Options

Process options for both soil and groundwater remediation are summarized below in order of increasing ability to provide effective solutions.

Process Options Applicable to Soil Remediation:

- Land use restrictions limit human contact with contaminated soils by restricting future property uses through amendments to deeds and land-use planning documents. This option may complicate future transfer of ownership.

- Fencing limits human contact with contaminated soils by restricting property access.

- Grading and surface water controls prevent surface water infiltration (which may leach contaminants from the unsaturated zone to groundwater) primarily by sloping surfaces to drain toward catch basins. Much of the site is already paved, with surface controls in place; some additional paving would be required. This process option is often implemented in conjunction with asphalt or concrete capping (see below).

- Revegetation places vegetative growth over areas exposed as a result of cleanup activities. Because revegetation is a minor component of any remedial alternative, it is not discussed further.

- Asphalt Cap controls and collects storm water runoff (preventing its infiltration to groundwater) and provides the vapor barrier needed to operate an in situ soil vapor extraction system (VES).

- Mechanical excavation removes soil for surface treatment, to allow grading, and to facilitate the installation of equipment and process piping. Excavation is a likely component of any cleanup alternative selected.

- Landfill disposal disposes of contaminated soils in an appropriately permitted landfill. This option requires laboratory analysis of soils and does not meet MTCA requirement for permanent solutions.

- Low temperature thermal soil treatment volatilizes VOCs and some semivolatile organic compounds (SVOCs) from soil; the off-gases are then thermally destroyed. This option meets the MTCA preference for contaminant destruction.

- Aerobic biological soil treatment uses microorganisms to degrade organics in excavated soil, at a location either on or off the site.

- Aerobic biological soil treatment (in situ) uses microorganisms to degrade organics in place, without soil excavation. This option occurs in conjunction with other process options: vapor extraction (see below) to draw more oxygen into the unsaturated zone and groundwater reintroduction (see below) to mound the water table in the unsaturated zone. Heterogeneous soil conditions and the inability to actively influence all soils can limit process effectiveness.

- In situ soil vapor extraction extracts VOC-laden soil gas from unsaturated zone soils; clean air flowing through the soil becomes saturated by VOCs and carries them to a screened extraction manifold, where they are collected and possibly treated before discharge. See **Figure 5-1.**

Process Options Applicable to Groundwater Remediation:

- Groundwater monitoring meets MTCA requirements for compliance monitoring and is required at all cleanup sites. The duration and extent of monitoring are determined by the nature of the selected cleanup alternative.

- Groundwater use restrictions prevent the future use of contaminated groundwater through restrictions placed on the property deed. Shallow groundwater at the site is not currently used for any purpose. This option may constrain future sale of the property.

- Product Recovery reduces the volume of free petroleum floating on the groundwater surface which would continue to impact uncontaminated soil as it moves with migrating groundwater. Product recovery is accomplished through passive means where product is skimmed from the groundwater surface, or active means where the groundwater surface is depressed with groundwater extraction methods which draw product to wells for recovery.

- Groundwater extraction hydraulically controls the migration of contaminants and removes contaminated groundwater for treatment at the surface. Well spacing, well size, and the amount of groundwater extracted would be determined through pilot testing. The required technologies are readily available (see **Figure 5-2**).

- Groundwater treatment by aerobic biodegradation (ex situ) uses microorganisms to degrade organic compounds by pumping extracted groundwater into a bioreactor in the presence of oxygen and nutrients (see **Figure 5-3**).

- Oil/water separation separates free petroleum product from a water stream or discharge, usually relying on differences in specific gravity for separation although other chemical and physical separation methods can be used in special applications.

- Groundwater treatment with granular-activated carbon removes VOCs and other organic compounds from extracted groundwater by absorbing them into carbon granules, which are then reactivated, regenerated, or appropriately discarded when fully saturated.

- Treated water discharge through reintroduction discharges extracted groundwater at upgradient or other appropriate site locations to increase the groundwater gradient and associated flow velocity, reducing the time it takes groundwater to travel to extraction wells and, consequently, reducing the overall length of treatment. A portion of the treated water might be discharged to surface water under a National Pollutant Discharge Elimination System (NPDES) permit.

- NPDES discharge disposes of treated groundwater through discharge to surface water. An NPDES permit, and associated monitoring of the discharge, would be required to dispose of treated water in surface water.

- In situ groundwater sparging volatilizes VOCs through the injection of compressed air into a sparge well. Bubbles (sparged air) carry the VOCs out of the water, from which the VOCs are then recovered. Sparged air that collects beneath buildings could create a safety issue. Sparging enhances naturally occurring biological activity, promoting in situ bioremediation. Uncertainties include the ability of the process to adequately influence subsurface areas and to recover sparged air.

5.4 ALTERNATIVE EVALUATION PROCESS

5.4.1 Alternative Development

Appropriate remedial alternatives were developed by combining remedial technologies and their respective process options. Three alternatives were developed by this process and are described in detail in Section 6.0.

5.4.2 Preliminary Alternative Evaluation

A preliminary evaluation is typically performed to reduce the number of alternatives before analyzing them in detail. For petroleum contaminated sites similar to Bingo Fuel Stop, the number of appropriate technologies is limited. The three alternatives were subjected to a detailed analysis process as described in Section 5.4.3 to provide decisionmakers with sufficient information to select the most appropriate remedy.

5.4.3 Detailed Analysis Criteria and Process

The following approach to analyzing the three cleanup alternatives was designed to provide decisionmakers with sufficient information to adequately compare alternatives, select an appropriate remedy for the site, and demonstrate that MTCA requirements are satisfied.

MTCA's seven requirements for cleanup actions are fully described in WAC 173-340-360, which states that all cleanup actions:

1. Shall protect human health and the environment.

2. Shall comply with cleanup standards (WAC 173-340-700 through 173-340-760).

3. Shall comply with applicable state and federal laws (WAC 173-340-710).

4. Shall provide for compliance monitoring (WAC 173-340-410).

5. Shall use permanent solutions to the maximum extent practical (WAC 173-340-360 [4], [5], [7], and [8]).

6. Shall provide for a reasonable restoration time frame (WAC 173-340-360[6]).

7. Shall consider concerns raised during public comment on the draft Cleanup Action Plan (WAC 173-340-360[10] through [13]).

The fifth requirement, that permanent solutions be used to the maximum extent practical, presents seven evaluation criteria that must be used in evaluating cleanup technologies. These criteria (which overlap somewhat with the first seven requirements) are:

1. Overall protection of human health and the environment

2. Long-term effectiveness

3. Short-term effectiveness

4. Permanent reduction of toxicity, mobility, and volume

5. Implementability

6. Cleanup costs

7. Community concerns

These technology evaluation criteria and cleanup requirements are fully described in MTCA. However, MTCA does not specifically establish an alternatives analysis process. Consequently, we combined the first seven cleanup requirements with the seven technology evaluation criteria to create a total of 11 alternative evaluation criteria used for alternative analysis. These 11 criteria, which were used to evaluate each alternative in Section 6.0, are:

1. Overall protection of human health and the environment

2. Compliance with cleanup levels

3. Compliance with state and federal laws (ARARs)

4. Compliance monitoring

5. Restoration time frame

6. Long-term effectiveness

7. Short-term effectiveness

8. Reduction of toxicity, mobility, and volume (TMV)

9. Implementability

10. Cost

11. Community concerns

The context in which these 11 criteria will be used to evaluate each of the cleanup alternatives is discussed below.

1. Overall protection of human health and the environment includes an evaluation of the degree to which existing risks are reduced, of the time required to reduce risks and attain cleanup levels, of on-site and off-site impacts resulting from the alternative, of the degree to which the alternative may perform to a higher level than the cleanup standards, and of overall improvement of environmental quality.

2. Compliance with cleanup levels includes an evaluation of the cleanup alternative and its ability to meet or exceed cleanup levels established in accordance with MTCA requirements.

3. Compliance with state and federal laws is an evaluation of those laws that may be applicable to implementation of the alternative and whether or not those laws can be satisfied. If the laws cannot be satisfied, it may be possible to obtain waivers. A summary of potential Applicable and Relevant or Appropriate Requirements (ARARs) is provided in **Appendix A.**

4. Compliance monitoring includes an evaluation of whether an alternative will satisfy this MTCA requirement. In general, compliance monitoring must be performed such that protection of human health and the environment can be confirmed during implementation, operation, and completion of the cleanup action.

5. Restoration time frame includes an evaluation of each alternative with respect to the time required to complete cleanup actions. To meet this MTCA requirement, a cleanup action shall provide a reasonable restoration time considering several factors. These factors include potential risks posed to human health and the environment, practicability of achieving restoration in a shorter time, current use of the site, future use of the site, costs associated with using alternatives with shorter restoration times, and others.

6. Long-term effectiveness includes evaluation of the degree of certainty that the alternative will be successful, of long-term reliability, of the magnitude of residual risks, and of the effectiveness of controls required to manage treatment residues or remaining waste.

7. Short-term effectiveness includes the protection of human health and the environment during the implementation/construction phase and the degree of risk to human health and the environment during treatment prior to cleanup.

8. Reduction of toxicity, mobility, and volume includes an evaluation of the adequacy of the alternative to destroy hazardous substances, of the reduction or elimination of hazardous substance releases and sources of releases, of the degree of irreversibility of the treatment process, and of the characteristics and quantity of treatment residuals.

9. <u>Implementability</u> includes an evaluation of whether the alternative is technically possible; of the availability of off-site facilities, services, and materials; of the administrative and regulatory requirements; of the alternative's schedule, size, complexity, and monitoring requirements; of access for construction, monitoring, and operations; and of integration with existing facility operations.

10. <u>Cost evaluation</u> includes conceptually designing and estimating the cost of elements necessary to implement and complete each cleanup action. Because alternatives are at a conceptual stage, costs are typically considered to be accurate to plus or minus 50 percent, sufficient to evaluate overall cost differences and benefits between alternatives. Detailed costs for each alternative are presented in **Appendix B.**

11. <u>Community concerns</u> includes an evaluation of the degree to which community concerns are addressed as part of the cleanup action. These concerns are not applicable at this stage of the FS because the community typically does not become involved until a final FS or draft Cleanup Action Plan has been prepared.

6.0 ALTERNATIVES DESCRIPTION AND EVALUATION

This section describes the remedial technologies and process options included under each of the three alternatives and evaluates them according to the criteria identified in Section 5.0. Components of Alternatives 1, 2, and 3 are summarized in **Table 6-1.**

6.1 ALTERNATIVE 1

6.1.1 Description

Alternative 1 includes process options to limit and monitor environmental impacts with minimal reduction of site contamination sources and affected media, as described below:

Physical Barriers:

- Land Use Restrictions. The objective is to limit or prevent human contact with contaminated soils by restricting future use. Primary restrictions would directly limit site access and prevent excavation and contact with contaminated soils. Excavation restrictions could be added to the property deed and restrictions placed in appropriate land use planning documents. Restrictions would not necessarily prevent excavation, but would require use of appropriate health and safety standards in the event that any excavation on the property was necessary. These restrictions could likely be implemented in a relatively short time.

  The primary limitations associated with land use restrictions are the unavailability of the property for future uses and the potential to complicate future land sales.

- Fencing. The objective is to limit or prevent human contact with contaminated soils and groundwater by restricting access to the property with a trespass barrier (fence).

  Limitations do not exist because fence maintenance and repair are routine procedures. Access to contamination beneath nearby roads cannot be limited through fencing, but existing pavement acts as a barrier to exposure.

- Grading/Surface Water Controls. The primary objective is to prevent infiltration of surface water, which may leach contaminants from the unsaturated zone to groundwater. Most of the site is already paved and contains surface water controls, but unpaved areas where buildings or other aboveground structures may be removed will require additional work as part of the cleanup. Grading is expected to achieve necessary surface water controls, including sloping surfaces to drain toward catch basins or off site.

  Grading and surface water controls would likely be implemented in conjunction with asphalt or concrete capping performed as a separate process option.

- Asphalt Cap. The objective is to enable control and collection of storm water runoff (preventing infiltration). Most of the property is paved, but some additional areas would likely require paving as part of cleanup actions, especially areas where buildings and other aboveground structures may be removed. Areas that could be paved as part of the cleanup are shown on **Figure 6-1**.

  Placement of an asphalt cap requires site preparation. First, all debris would be removed and existing soils compacted with appropriate equipment to create a stable base and prevent settlement. Approximately 6 inches of 3/8-inch crushed rock or granular fill would then be placed over a vapor barrier and compacted as a base course. The final step would be to place pavement approximately 3 to 4 inches thick, depending on anticipated use. Also, some currently paved areas disturbed during cleanup will require sealing or repair.

  Capping would be performed in conjunction with placement of storm water controls. Collected storm water would be discharged to surface water.

  No limitations or uncertainties are anticipated with paving; it is a commonly performed procedure.

Groundwater Monitoring and Product Recovery:

- Groundwater Monitoring. The objective is to meet MTCA requirements for compliance monitoring, which is necessary at all cleanup sites. Groundwater monitoring would be performed by purging and sampling some or all of the 12 existing groundwater monitoring wells on a quarterly basis. Chemical analyses would likely include BETX and TPH. Specific compliance monitoring requirements would be determined as part of remedial design (RD). A minimum monitoring period of 30 years is anticipated since source reduction is not performed as part of Alternative 1.

- Groundwater Use Restrictions. The objective is to prevent future use of contaminated groundwater. Restrictions could be placed on the property deed to prevent groundwater use.

- Product Recovery. The objective is to reduce free product, which would broaden impact to soil and groundwater if left unchecked. Product recovery would be accomplished by installing a system of trenches along the hydraulically downgradient borders of the site. The trenches would extend vertically across the groundwater surface and intercept floating product. Floating product would be withdrawn by sumps placed at intervals along the trenches, where it would be pumped into a temporary aboveground storage tank.

  Uncertainties include maximum practical pumping rates and the amount of time required to finally remove free product at the site.

6.1.2 Evaluation

Overall Protection of Human Health and the Environment: Some increased protection of human health and the environment would be realized with institutional controls. The risk of direct human exposure to contaminants in soil or groundwater would be reduced with groundwater use restrictions and land use controls. Additional asphalt capping and improved surface water controls may limit some potential leaching of soil contaminants to groundwater. Groundwater monitoring would be used to evaluate impacts from groundwater migration, but no active controls are provided to prevent contaminant migration. The primary exposure route (groundwater migrating toward surface water) is not blocked, so overall environmental quality would not be substantially improved.

Compliance with Cleanup Levels: Institutional controls would not be adequate to meet cleanup levels for soil or groundwater. Some hydrocarbon constituents would slowly degrade and their concentrations lessen over time, but at a rate much slower than typically required for cleanup actions.

Compliance with ARARs: The primary ARAR, MTCA cleanup regulations, most likely would not be met with this alternative because no active cleanup is performed. Other ARARs would be limited to handling purge water from monitoring wells. ARARs related to these activities could likely be met. A summary of potential ARARs is provided in **Appendix A.**

Compliance Monitoring: Compliance monitoring requirements could be met under this alternative with quarterly monitoring of some or all of the 12 existing groundwater monitoring wells placed both upgradient and downgradient of the impacted areas. For cost estimates, we have assumed that 30 years of groundwater monitoring would be required.

Restoration Time Frame: No active cleanup actions are performed; the only restoration or cleanup would occur as a result of natural attenuation and degradation. The primary contaminant of concern, benzene, will naturally attenuate through degradation and volatilization. Based on levels currently encountered on site, this process would likely take longer than 30 years.

Long-Term Effectiveness: No active treatment is performed with institutional controls, so long-term effectiveness would be poor. Direct exposure to soil or groundwater could be prevented by implementing institutional controls, but the primary exposure route, which is from groundwater to surface water, would not be blocked. Monitoring will allow evaluation of potential impacts. The residual risk comes from the existing contaminants that are not treated.

Short-Term Effectiveness: Workers would experience some exposure during monitoring well installation and quarterly sampling. This exposure could be controlled by implementing a Health and Safety Plan and through proper use of field procedures. Because no active cleanup is performed, risks to human health and the environment resulting from groundwater migration do not change over the short term.

Reduction of Toxicity, Mobility, and Volume: Because no active treatment is performed, toxicity, mobility, and volume are not reduced over the short term. Some long-term reduction would occur as a result of natural degradation and attenuation.

Implementability: All construction activities (paving, surface water controls, and monitoring well sampling) should be readily completed using known procedures.

Cost: Costs for Alternative 1 (estimated at $1 to $1.3 million) are presented in detail in **Appendix B.** For cost estimates, we assumed that institutional controls and groundwater monitoring would be required for 30 years.

6.2 ALTERNATIVE 2

6.2.1 Description

Alternative 2 includes process options to limit and monitor environmental impact through removal of site contamination sources, and moderately aggressive reduction of affected media, as described below:

Physical Barriers:

- Land Use Restrictions. The objective is to limit or prevent human contact with contaminated soils by restricting future use. Primary restrictions would directly limit site access and prevent excavation and contact with contaminated soils. Excavation restrictions could be added to the property deed and restrictions placed in appropriate land use planning documents. Restrictions would not necessarily prevent excavation, but would require use of appropriate health and safety standards in the event that any excavation on the property is necessary. These restrictions could likely be implemented in a relatively short time.

  The primary limitations associated with land use restrictions are the unavailability of the property for future uses and the potential to complicate future land sales.

- Fencing. The objective is to limit or prevent human contact with contaminated soils and groundwater by restricting access to the property with a trespass barrier (fence).

  Limitations do not exist because fence maintenance and repair are routine procedures. Access to contamination beneath nearby roads cannot be limited through fencing, but existing pavement acts as a barrier to exposure.

- Grading/Surface Water Controls. The primary objective is to prevent infiltration of surface water, which may leach contaminants from the unsaturated zone to groundwater. Most of the site is already paved and contains surface water controls, but unpaved areas where buildings or other aboveground structures may be removed will require additional work as part of the cleanup. Grading is anticipated to achieve necessary surface water controls, including sloping surfaces to drain toward catch basins or off site.

  Grading and surface water controls would likely be implemented in conjunction with asphalt capping performed as a separate process option.

- Asphalt Cap. The objective is twofold: controlling and collecting storm water runoff (preventing infiltration) and providing a vapor barrier necessary for operation of an in situ soil VES. Most of the property is paved, but some additional areas would likely require paving as part of cleanup actions, especially areas where buildings and other aboveground structures may be removed. Areas that could be paved as part of the cleanup are indicated on **Figure 6-2.**

Placement of an asphalt cap requires site preparation. First, all debris would be removed and existing soils compacted with appropriate equipment to create a stable base and prevent settlement. Approximately 6 inches of 3/8-inch crushed rock or granular fill would then be placed over a vapor barrier and compacted as a base course. The final step would be to place pavement approximately 3 to 4 inches thick, depending on anticipated use. Also, some currently paved areas disturbed during cleanup will require sealing or repair.

Capping would be performed in conjunction with placement of storm water controls. Collected storm water would be discharged to surface water.

No limitations or uncertainties are anticipated with paving; it is a commonly performed procedure.

Contaminated Soil Removal:

- Mechanical Excavation. This commonly performed procedure would be necessary with Alternatives 2 and 3. Excavation would be used to remove soil from the ground for surface treatment, to grade pavement subgrade, or to install remediation equipment and process piping. Excavation equipment typically includes tracked excavators or smaller, rubber-tired backhoes.

  Excavation would be primarily associated with the removal of impacted soils around dispensers, tanks, and buried pipelines. For the rest of the property, excavation would likely be limited to trenching and installing the process piping needed to implement other process options.

  Excavation is a routine construction procedure, and no limitations or uncertainties are anticipated.

Contaminated Soil Remediation:

- Landfill Disposal. The objective is to dispose of contaminated soils at an appropriately permitted landfill. Petroleum contaminated soils from Bingo Fuel Stop can be disposed at a RCRA Subtitle D Landfill. After excavation, soils (an estimated 9,000 to 14,000 cubic yards) would be loaded into trucks on site and transported directly to the landfill. Prior to landfill disposal of any soils, analytical testing would be required to characterize soils and obtain landfill acceptance. During transport, manifesting would be required.

  Major limitations do not exist with landfill disposal because appropriate permitted facilities are available. However, landfilling does not meet MTCA requirements for permanent solutions.

- Low Temperature Thermal Soil Treatment. The objective is to destroy VOCs or SVOCs in excavated soils. Low temperature thermal desorption volatilizes VOCs and some SVOCs from soil. The off-gases are then thermally destroyed. Because we expect a limited quantity of soil is impacted by these compounds, excavated soils would most likely be transported to an off-site treatment location; the nearest available location is the Taneum Recovery Company. After treatment, soils are reused as general construction fill in accordance with MTCA guidelines.

- Aerobic Biological Soil Treatment. The primary objective is to degrade organics in excavated soil to harmless organic chemicals. Ex situ aerobic biological treatment uses microorganisms to degrade or transform organic contaminants to safe organic chemicals. Soils are tilled for aeration (oxygen), fertilizer is added for nutrients, and water is added as necessary to maintain optimum moisture content for microbial activity. Under proper conditions, existing microorganisms multiply and digest or degrade organic compounds. During treatment, some of the volatile components can also be volatilized and further degraded by sunlight (ultraviolet radiation).

  Treatment would occur on a lined and bermed pad. The pad would be designed with a low-permeability base and means for collecting and controlling storm water runoff. A relatively small area could be used (1/8 to 1/2 acre) for soil treatment. Time required for treatment depends on pad size, but should be less than 6 months. Soils treated on site would be reused as site backfill. Soils treated off site could be reused as backfill in accordance with MTCA guidance.

  Aerobic biodegradation of gasoline to diesel-range hydrocarbons is a commonly used and effective treatment where sufficient on-site space is available for remediation. A paved area is available outside the limits of potential excavation at Bingo Fuel Stop.

Product Recovery, Groundwater Extraction, and Treatment:

- Product Recovery. The objective is to remove free petroleum product floating on the groundwater surface which could otherwise migrate into uncontaminated site areas.

  Product recovery is accomplished in conjunction with groundwater extraction, where the groundwater surface is depressed and product flows to extraction points. Product is separated from water and temporarily stored prior to off-site disposal.

  Uncertainties include the volume and rate of product recovery.

- Oil/Water Separation. The objective is to physically separate free petroleum product from a water stream or discharge. Limited petroleum product has been encountered on the water table. Based on the thickness of the product encountered, oil/water separation likely would not be required for extracted groundwater.

  Oil/water separators are common and utilized throughout the region; no design or installation difficulties are expected.

- Groundwater Extraction. The objective is to hydraulically control migration of contaminants and remove contaminated groundwater for surface treatment.

Groundwater extraction would require installation of extraction wells and/or extraction trenches. Because of relatively shallow groundwater and presence of contaminated groundwater under nearby roads, we assumed that a groundwater extraction system comprised of both trenches and wells would be most feasible.

A conceptual groundwater extraction well (see **Figure 5-2**) was developed for cost estimates. The well would extend 5 to 10 feet into groundwater. Conceptual groundwater well spacing and trench locations are presented on **Figure 6-2**. Possible locations for groundwater extraction trenches are discussed with the reintroduction process option. Process piping would be placed in process pipe trenches similar to those used for the vapor extraction system. Extraction pumps are assumed to be electric submersible pumps.

Uncertainties regarding the groundwater extraction system are related to the volume of groundwater produced.

- <u>Groundwater Treatment by Aerobic Biodegradation</u>. The primary objective is to remove VOCs and TPH from extracted groundwater.

  Aerobic biodegradation is a means of organically degrading organic compounds in the presence of adequate oxygen and nutrients. This is accomplished by pumping extracted groundwater into an appropriately sized bioreactor tank. (The tank is sized depending on the influent flow rate and the retention time required to achieve treatment.) Oxygen is supplied to the system by a blower, which aerates water in the tank. Nutrients, typically consisting of potassium, nitrogen, and phosphorus, are injected into the tank with a feed system. A typical schematic of this system is presented on **Figure 5-3**. In some cases, a granular-activated carbon filter is necessary to remove remaining organics and achieve drinking water quality standards.

  In addition to the bioreactor tank, the aerobic biological treatment system would include a power drop, electrical supply, and electrical controls interfaced with extraction pumps to prevent overflows. Water could be discharged from the bioreactor tank with granular activated carbon (GAC) filtering, if necessary, to an on-site reintroduction system or NPDES discharge to the surface water.

  Biologically active groundwater reintroduced into the subsurface will stimulate in situ degradation of petroleum hydrocarbons remaining in subsurface soil downgradient of the source areas.

  All components necessary to construct the bioreactor and ancillary equipment are readily available and commonly used. The entire system could likely be installed in approximately 1 to 2 months.

- <u>Treated Water Discharge Through Reintroduction</u>. The objective is to discharge at upgradient or other appropriate site locations to increase the groundwater gradient and associated flow velocity. This helps to reduce groundwater travel time to extraction wells and, consequently, treatment time. Also, reintroduced water can help facilitate or promote in situ biodegradation of some organic compounds.

Treated groundwater would be reintroduced through galleries located upgradient of contaminated areas or within the hydraulically controlled area. Reintroduction systems can be used to influence overall groundwater flow or to treat smaller areas or isolated pockets of contamination.

Reintroduction galleries typically consist of shallow or deep trenches backfilled with discharge piping and high permeability fill. A layout of reintroduction and extraction trenches is presented on **Figure 6-2.** These locations are only conceptual and will be further defined during RD.

Reintroduction gallery construction and process pipe would be installed in conjunction with other process piping, such that similar process pipe trenches would be used for all process options as applicable.

One of the largest uncertainties associated with reintroduction of treated water is hydraulic control of overall site groundwater; forced migration of contaminants into uncontaminated areas is to be avoided. A portion of the treated water may require NPDES discharge to surface water.

- NPDES Discharge. The objective is to provide a second option for disposal of treated groundwater. A supplemental storm drainage system or modification of the existing system may be required to facilitate discharge.

  An NPDES permit would be required for discharge to the surface water. Monitoring of discharged water is required to confirm that no adverse impacts are being created, regardless of whether the NPDES permits are required.

  There are no uncertainties with regard to discharge provided a permit can be obtained.

Groundwater Monitoring and Restrictions:

- Groundwater Monitoring. The objective is to meet MTCA requirements for compliance monitoring, which is necessary at all cleanup sites. Groundwater monitoring would be performed by purging and sampling some or all of the 12 existing groundwater monitoring wells on a quarterly basis. Chemical analyses would likely include BETX and TPH. Specific compliance monitoring requirements would be determined as part of RD. A minimum monitoring period of 10 years is expected since only limited removal of impacted soil is performed as part of Alternative 2.

- Groundwater Use Restrictions. The objective is to prevent future use of contaminated groundwater. Restrictions could be placed on the property deed to prevent groundwater use.

6.2.2 Evaluation

Overall Protection of Human Health and the Environment: Alternative 2 protects human health and the environment because all contaminants in excess of cleanup levels are actively treated and potential exposure pathways or routes are blocked during treatment. The primary exposure route, groundwater migration to surface water, is blocked by active pumping, which will hydraulically control groundwater and prevent migration toward surface water.

On-site impacts are not of concern since the site is not being actively used. Off-site impacts would also be limited and would occur primarily during installation of extraction wells in the SR 90 right-of-way. Overall environmental quality would be improved by permanent treatment of contaminants in both soil and groundwater.

Compliance with Cleanup Levels: This alternative should adequately reach MTCA cleanup levels in both soil and groundwater. The primary contaminant requiring treatment is benzene. Potential for localized zones of residual benzene remains, but overall treatment should reduce benzene concentrations to acceptable risk levels at property boundaries.

Compliance with ARARs: Many ARARs may apply to this alternative, but all of them should be met with proper implementation of cleanup actions. ARARs will apply primarily to the discharge of treated water, well installation, and local requirements regarding permitting, activities in the SR 90 right-of-way, and grading. Potential ARARs are summarized in **Appendix A.**

Compliance Monitoring: Compliance monitoring under Alternative 2 would primarily involve sampling and testing groundwater to verify that hydraulic control is maintained and that contaminants do not migrate from the treatment area. This would be completed by quarterly monitoring of 12 wells.

Restoration Time Frame: Based on our engineering judgment, the combined groundwater extraction and treatment and soil vapor extraction systems would be operated for about 10 years to achieve cleanup. Monitoring would likely be performed for several years after treatment is complete to verify that the treatment was adequate. This would meet MTCA requirements for a reasonable restoration time.

Long-Term Effectiveness: Technologies utilized under Alternative 2 should successfully treat hydrocarbon constituents now in excess of cleanup levels. The overall reliability and certainty of success would be relatively high, but there may be some potential for smaller, isolated zones of residual contaminants which do not meet cleanup levels to remain. These zones would most likely be minor and would slowly attenuate and naturally degrade with time. The presence of significant residual contamination would be verified with compliance monitoring. If necessary, treatment could resume. No other controls for groundwater residuals are considered necessary.

Land use restrictions would be required over the long term because of the presence of TPH in soil. Although TPH does not require direct treatment, restrictions should limit excavation and disposal off site.

Short-Term Effectiveness: Workers would face short-term risks during implementation and construction. These risks could be minimized by staffing with properly trained personnel and implementing a site Health and Safety Plan.

During the treatment period, workers would also face risks while maintaining and monitoring the treatment systems. All extraction system components would be subsurface, and treatment would be performed in the enclosed tank farm. Consequently, risks to the community are minimal because all water discharged from the treatment systems would be treated to applicable safety standards.

Reduction of Toxicity, Mobility, and Volume: All active treatment performed under Alternative 2 would be adequate to destroy petroleum hydrocarbons and benzene. Soil vapor recovered with the VES would be treated in a thermal oxidizer or aerobic biofilter, and most hydrocarbons would degrade.

The intent of the alternative would be to remove the sources of releases, thereby eliminating any future hazardous substance releases. All treatment processes used under this alternative are irreversible. Some subsurface residual hydrocarbons could remain following treatment. These residuals should not impact groundwater, but may require long-term land use restrictions to control excavation and soil handling.

Implementability: All technologies used under Alternative 2 are well known and have been utilized at numerous other cleanups. All necessary off-site facilities, services, and materials are readily available. Uncertainties associated with extraction well location and spacing could be resolved during RD.

Cost: Costs for Alternative 2 are presented in detail in **Appendix B.** The estimated cost of Alternative 2 ranges, depending on the selected soil treatment option, as summarized below:

▸ RCRA D Landfill	$1,3 million to $1.6 million
▸ Low Temperature Thermal Desorption	$1.5 million to $1.9 million
▸ Aerobic Biodegradation	$1 million to $1.3 million

Unit costs associated with this alternative are considered relatively accurate. However, there could be some variation in actual cost resulting from spacing and sizing of the extraction wells and treatment equipment.

6.3 ALTERNATIVE 3

6.3.1 Description

Alternative 3 includes process options to limit and monitor environmental impact through removal of site contamination sources, and aggressive reduction of affected media. As described above, Alternative 1 consists of only recovery and long-term groundwater monitoring. Alternative 2 consists of product recovery, excavation of source area contaminated soil, and recovery and treatment of contaminated groundwater. Alternative 2 would include groundwater monitoring for a shorter duration than monitoring under

Alternative 1.

Alternative 3 consists of product recovery, source area and downgradient contaminated soil excavation, and groundwater extraction and treatment. Groundwater monitoring following remediation will be shorter in duration than Alternative 2. Alternative 3 consists of:

Physical Barriers:

- Land Use Restrictions. The objective is to limit or prevent human contact with contaminated soils by restricting future use. Restrictions may be necessary if contaminated soil remains beneath Thorp Highway.

  The primary limitations associated with land use restrictions are the unavailability of the property for future uses and the potential to complicate future land sales.

- Fencing. The objective is to limit or prevent human contact with contaminated soils and groundwater by restricting access to the property with a trespass barrier (fence). Fencing will be necessary during the excavation phase of remediation.

  Limitations do not exist because fence maintenance and repair are routine procedures. Access to contamination beneath nearby roads cannot be limited through fencing, but existing pavement acts as a barrier to exposure.

Contaminated Soil Removal:

- Mechanical Excavation. This commonly performed procedure would be necessary with any of the cleanup alternatives chosen. Excavation would be used to remove soil from the ground for surface treatment, to grade pavement subgrade, or to install remediation equipment and process piping. Excavation equipment typically includes tracked excavators or smaller, rubber-tired backhoes.

  Excavation would be primarily associated with the removal of impacted soils around dispensers, tanks, and buried pipelines. Excavation would include removal of contaminated soil from source areas generally extending from the ground surface down to groundwater, and at groundwater elevation outside source areas where soil has been contaminated through association with contaminated groundwater and floating product. Excavation outside source areas would involve removal of clean soil overburden to expose contaminated soil at the groundwater elevation. For the rest of the property, excavation would likely be limited to trenching and installing the process piping needed to implement other process options.

  Excavation is a routine construction procedure, and no limitations or uncertainties are expected.

Contaminated Soil Remediation:

- Landfill Disposal. The objective is to dispose of contaminated soils at an appropriately permitted landfill. Petroleum contaminated soils from Bingo Fuel Stop can be disposed of at a RCRA Subtitle D Landfill. After excavation, soils (an estimated 14,000 to 17,500 cubic yards) would be loaded into trucks on site and transported directly to the landfill. Prior to landfill disposal of any soils, analytical testing would be required to characterize soils and obtain landfill acceptance. During transport, manifesting would be required.

Major limitations do not exist with landfill disposal because appropriate permitted facilities are available. However, landfilling does not meet MTCA requirements for permanent solutions.

- Low Temperature Thermal Soil Treatment. The objective is to destroy VOCs or SVOCs in excavated soils. Low temperature thermal desorption volatilizes VOCs and some SVOCs from soil. The off-gases are then thermally destroyed. Because we expect a limited quantity of soil impacted by these compounds, excavated soils would most likely be transported to an off-site treatment location; the nearest available location is the Taneum Recovery Company. After treatment, soils would be reused as general construction fill in accordance with MTCA guidelines.

- Aerobic Biological Soil Treatment. The primary objective is to degrade organics in excavated soil to harmless organic chemicals. Ex situ aerobic biological treatment uses microorganisms to degrade or transform organic contaminants to safe organic chemicals. Soils are tilled for aeration (oxygen), fertilizer is added for nutrients, and water is added as necessary to maintain optimum moisture content for microbial activity. Under proper conditions, existing microorganisms multiply and digest or degrade organic compounds. During treatment, some of the volatile components can also be volatilized and further degraded by sunlight (ultraviolet radiation).

  Treatment would occur on a lined and bermed pad. The pad would be designed with a low-permeability base and means for collecting and controlling storm water runoff. A relatively small area could be used (1/8 to 1/2 acre) for soil treatment. Time required for treatment depends on pad size, but should be less than 6 months. Soils treated on site would be reused as site backfill. Soils treated off site could be reused as backfill in accordance with MTCA guidance.

  Aerobic biodegradation of gasoline to diesel-range hydrocarbons is commonly used and effective treatment where sufficient on-site space is available for treatment. A paved area is available outside the limits of potential excavation at Bingo Fuel Stop

Product Recovery, Groundwater Extraction, and Treatment:

- Product Recovery. The objective is to remove free petroleum product floating on the groundwater surface which could otherwise migrate into uncontaminated site areas.

  Product recovery is accomplished in conjunction with groundwater extraction, where the groundwater surface is depressed and product flows to extraction points. Product is separated from water and temporarily stored prior to off-site disposal.

  Uncertainties include the volume and rate of product recovery.

- Oil/Water Separation. The objective is to physically separate free petroleum product from a water stream or discharge. Limited petroleum product has been encountered on the water table. Based on the thickness of the product encountered, oil/water separation likely would be required for extracted groundwater.

  Oil/water separators are common and are utilized throughout the region; no design or installation difficulties are expected.

- Groundwater Extraction. The objective is to hydraulically control migration of contaminants and remove contaminated groundwater for surface treatment.

  Dewatering the contaminated soil excavation (open hole) could be used as a method to remove a large portion of contaminated water for treatment. Because of the presence of contaminated groundwater under nearby roads, a groundwater extraction system that includes trenches would also be required. Reintroduction trenches would be used to increase the rate of recovery from extraction trenches.

  Open hole dewatering would involve pumping water from one end of the excavation and discharging it into the opposite end after treatment. The pumping system for this method is simple and involves no special construction other than installation of a screen to remove solids which cannot be pumped.

  Possible locations for groundwater extraction trenches are discussed with the reintroduction process option. Conceptual groundwater extraction and reintroduction trench locations are presented on **Figure 6-3**. Extraction pumps are assumed to be electric, submersible pumps.

  Uncertainties regarding the groundwater extraction system are related to the volume of groundwater produced.

- Groundwater Treatment by Aerobic Biodegradation. The primary objective is to remove VOCs and TPH from extracted groundwater.

  Aerobic biodegradation is a means of organically degrading organic compounds in the presence of adequate oxygen and nutrients. This is accomplished by pumping extracted groundwater into an appropriately sized bioreactor tank. (The tank is sized depending on the influent flow rate and the retention time required to achieve treatment.) Oxygen is supplied to the system by a blower, which aerates water in the tank. Nutrients, typically consisting of potassium, nitrogen, and phosphorus, are injected into the tank with a feed system. A typical schematic of this system is presented on **Figure 5-3**. In some cases, a granular-activated carbon filter is necessary to remove remaining organics and achieve drinking water quality standards. Treatment could be expedited by introducing nutrients into water standing in the open hole, which would initiate biological processes and reduce residence time in the bioreactor.

In addition to the bioreactor tank, the aerobic biological treatment system would include a power drop, electrical supply, and electrical controls interfaced with extraction pumps to prevent overflows. Water could be discharged from the bioreactor tank with GAC filtering, if necessary, to an on-site reintroduction system or NPDES discharge to the surface water. Biologically active groundwater reintroduced into the subsurface will stimulate in situ degradation of petroleum hydrocarbons remaining in soil below Thorp Highway.

All components necessary to construct the bioreactor and ancillary equipment are readily available and commonly used. The entire system could likely be installed in approximately 1 to 2 months.

- Treated Water Discharge Through Reintroduction. The objective is to discharge at upgradient or other appropriate site locations to increase the groundwater gradient and associated flow velocity. This helps to reduce groundwater travel time to extraction wells and, consequently, treatment time. Also, reintroduced water can help facilitate or promote in situ biodegradation of some organic compounds.

  Treated groundwater would be reintroduced to the open hole or through galleries located upgradient of the extraction wells. Reintroduction systems can be used to influence overall groundwater flow or to treat smaller areas or isolated pockets of contamination.

  Reintroduction galleries typically consist of shallow or deep trenches backfilled with discharge piping and high permeability fill. A possible layout of reintroduction and extraction trenches is presented on **Figure 6-3**.

  Reintroduction gallery construction and process pipe would be installed in conjunction with other process piping, such that similar process pipe trenches would be used for all process options as applicable.

  One of the largest uncertainties associated with reintroduction of treated water is hydraulic control of overall site groundwater; forced migration of contaminants into uncontaminated areas is to be avoided. A portion of the treated water may require NPDES discharge to surface water.

- NPDES Discharge. The objective is to provide for disposal of treated groundwater. A supplemental storm drainage system or modification of the existing system may be required to facilitate discharge.

  An NPDES permit would be required for discharge to the surface water. Monitoring of discharged water is required to confirm that no adverse impacts are being created, regardless of whether an NPDES permit is required.

  There are no uncertainties with regard to discharge provided a permit can be obtained.

Groundwater Monitoring and Restrictions:

- Groundwater Monitoring. The objective is to meet MTCA requirements for compliance monitoring, which is necessary at all cleanup sites. Groundwater monitoring would be performed by purging and sampling some or all of the 12 existing groundwater monitoring wells on a quarterly basis. Chemical analyses would likely include BETX and TPH. Specific compliance monitoring requirements would be determined as part of RD. A minimum monitoring period of 5 years is expected as excavation of most of the impacted soil is performed as part of Alternative 3.

- Groundwater Use Restrictions. The objective is to prevent future use of contaminated groundwater. Restrictions will not likely be necessary following the completion of remediation using Alternative 3.

6.3.2 Evaluation

Overall Protection of Human Health and the Environment: Same as Alternative 2.

Compliance with Cleanup Levels: Alternative 3 should also be effective in reducing hydrocarbon concentrations to below cleanup levels. The main difference between Alternative 3 and Alternative 2 is that cleanup levels may be achieved in a shorter time under Alternative 3, and Alternative 3 should be more effective in reducing some, but not all, residuals.

Compliance with ARARs: Same as Alternative 2.

Compliance Monitoring: Compliance monitoring under Alternative 3 is similar to that in Alternative 2, but the time required for compliance monitoring may be reduced to about 5 years.

Restoration Time Frame: Based on our engineering judgment, Alternative 3 would likely achieve cleanup levels in approximately 5 years. This time frame meets the intent of MTCA requirements for cleanup actions.

Long-Term Effectiveness: Long-term effectiveness of Alternative 3 is similar to that of Alternative 2, except that Alternative 3 should be more effective in treating residual contaminants outside source areas.

Short-Term Effectiveness: Same as Alternative 2.

Reduction of Toxicity, Mobility, and Volume: The reduction of toxicity, mobility, and volume for Alternative 3 is generally similar to that for Alternative 2. The primary difference is that Alternative 3 would be more effective at reducing residual contamination outside source areas.

Implementability: Same as Alternative 2.

Cost: Costs for Alternative 3 are presented in detail in **Appendix B.** The estimated cost of Alternative 2 ranges, depending on selected soil treatment option, as summarized below:

▸ RCRA D Landfill	$1.5 million to $1.7 million
▸ Low Temperature Thermal Desorption	$1.8 million to $2.1 million
▸ Aerobic Biodegradation	$1 million to $1.3 million

Unit costs associated with this alternative are considered relatively accurate. However, there could be some variation in actual cost resulting from spacing and sizing of the extraction wells and treatment equipment. These requirements will be further defined as part of RD prior to full implementation.

Community Concerns: Not applicable at this time.

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares alternatives for both operable units (soil and groundwater) relative to the detailed analysis criteria discussed in Section 6.0. The comparative analysis is intended to highlight the advantages and disadvantages of each alternative so that trade-offs are evident to decisionmakers.

Overall protection of human health and the environment is provided by both Alternatives 2 and 3. Alternative 1 provides protection from direct contact with soil or groundwater, but does not block migration of contaminated groundwater to surface water. However, Alternative 1 does provide monitoring of potential impacts. Institutional controls under Alternative 1 are not adequate to comply with MTCA cleanup levels. Based on our engineering judgment, both Alternatives 2 and 3 could comply with cleanup levels.

All three alternatives provide for compliance monitoring and likely could be accomplished in accordance with all identified state and federal laws (ARARs).

Restoration time varies among the alternatives. Because no active cleanup is performed under Alternative 1, cleanup will only occur as a result of natural processes and attenuation and would likely require more than 30 years. Alternative 2 would require an estimated 10 years and Alternative 3 would require approximately 5 years.

Long- and short-term effectiveness of the alternatives varies slightly. Over the short term, Alternative 1 would have less impact than Alternatives 2 or 3 because fewer cleanup actions, which may expose contaminants, would be performed. The long-term effectiveness of Alternative 1 is poor because no active cleanup would be performed. Long-term effectiveness of Alternatives 2 and 3 is generally similar, although Alternative 3 would likely reduce the potential for residual hydrocarbons.

Toxicity, mobility, and volume of existing contaminants would not be reduced with the institutional controls implemented under Alternative 1. Both Alternatives 2 and 3 would actively treat and permanently destroy petroleum hydrocarbons. High levels of residual contaminants would not remain with either Alternative 2 or 3, but there would be potential for some residual in areas where influence and treatment were not entirely effective. Alternative 3 would likely be more effective at addressing potential residuals due to more thorough removal of soil and groundwater impacted outside contamination source areas.

All three alternatives can be readily implemented with available equipment, materials, and contractors.

The cost of Alternative 1 is significantly less than for Alternatives 2 or 3 because no active remediation is performed. Costs for Alternatives 2 and 3 are similar and fall within the estimated accuracy of plus or minus 50 percent, so trade-offs are difficult to evaluate at this stage.

Comparison of Alternative Costs:

Alternative	Cost
Alternative 1 - Restrictions, Controls, Product Recovery, and Monitoring	$1,050,000 to $1,290,000
Alternative 2 - RCRA D Landfill Soil Disposal	$1,340,000 to $1,630,000
2 - Low Temperature Thermal Desorption Soil Treatment	$1,530,000 to $1,910,000
2 - Aerobic Biodegradation Soil Treatment	$1,030,000 to $1,260,000
Alternative 3 - RCRA D Landfill Soil Disposal	$1,470,000 to $1,700,000
3 - Low Temperature Thermal Desorption Soil Treatment	$1,780,000 to $2,110,000
3 - Aerobic Biodegradation Soil Treatment	$1,050,000 to $1,290,000

In summary, Alternatives 2 and 3 could comply with MTCA cleanup levels where Alternative 1 does not. Alternative 1 generally isolates impacted media where Alternatives 2 and 3 take an active approach to treatment of impacted soil and groundwater. Alternative 3, though similar to Alternative 2, offers the shortest restoration time and is more effective in reducing hydrocarbon residuals.

8.0 USE OF THIS REPORT

This report has been prepared exclusively for Burns Bros., Inc. and its other consultants for this project only. The analyses, conclusions, and recommendations in this report are based on data described herein and our experience and professional judgment. The data were either made available to AGI or reasonable obtained within the practical constraints of our scope of services. AGI cannot be responsible for the interpretation by others of the data contained herein.

Our work has been performed in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the area. No other warranty, express or implied, is made.

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GMB/PPB/jlh

Table 3–1
Groundwater Elevation Data
Burns Bros./Bingo Fuel Stop
Thorp, Washington

	Reference Elevation	07/07/93		11/05/93	
		Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation
Well I.D.	(ft MSL)	ft btc	ft MSL	ft btc	ft MSL
MW1	1644.44	7.10	1637.34	7.00	1637.44
MW2	1644.69	8.05	1636.64	8.25	1636.44
MW3	1641.38	14.20	1627.18	15.44	1625.94
PZ1	1641.38	8.91	1632.47	10.19	1631.19
MW4	1640.32	8.21	1632.11	9.01	1631.31 *
MW5	1642.14	6.55	1635.59	7.67	1634.47
MW6	1639.34	20.85	1618.49	22.99	1616.42 *
MW7	1624.25	N/A	N/A	7.16	1617.09
MW8	1626.66	N/A	N/A	10.52	1616.14
MW9	1626.16	N/A	N/A	10.13	1616.03
MW10	1628.27	N/A	N/A	11.34	1616.93
MW11	1645.73	N/A	N/A	8.37	1637.36
MW12	1623.53	N/A	N/A	7.99	1615.54

Notes:

July 7, 1993 data obtained when groundwater was not being pumped at the site.
November 5, 1993 data obtained when groundwater was being pumped at the site.
*Corrected for the presence of free product using:
Corrected depth to water = (measured depth to water) – (product thickness) x 0.8.
ft btc – Feet below top of casing.
ft MSL – Feet above Mean Sea Level.
N/A – Not available.

Table 3–2
Aquifer Test Results
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Solution Method	Transmissivity (T) (ft^2/min)	Hydraulic Conductivity (K)* (ft/min)	(cm/sec)	(gal/day–ft^2)
MW3 Recovery Data				
Theis (Recovery)	3.8×10^{-3}	1.1×10^{-4}	5.5×10^{-5}	1.2
MW4 Drawdown Data				
Jacob–Lohman (Variable Discharge)	3.5×10^{-1}	8.3×10^{-3}	4.3×10^{-3}	91.1
Thiem (Distance–Drawdown)	1.9×10^{-1}	4.5×10^{-3}	2.3×10^{-3}	48.7
MW4 Recovery Data				
Theis (Recovery)	1.7×10^{-1}	4.0×10^{-3}	2.1×10^{-3}	44.5

Notes:

*Based on saturated thickness of 35 feet for the Lower Zone and 42 feet for the Upper Zone.
cm/sec – Centimeters per second.
ft/min – Feet per minute.
ft^2/min – Square feet per minute.
gal/day–ft^2 – Gallons per day per square foot.

Table 3–3
Hydrocarbons and Lead Detected in Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Sample ID	Sample Location	Sample Depth	Sample Date	EPA Test Methods: BETX – 8020 Benzene (mg/kg)	BETX – 8020 Ethylbenzene (mg/kg)	BETX – 8020 Toluene (mg/kg)	BETX – 8020 Total Xylenes (mg/kg)	TPH – 8015M Gasoline (mg/kg)	TPH – 8015M Diesel (mg/kg)	WTPH 418.1M (mk/kg)	EPA 7421 Lead (mg/kg)
S1	S.WALL, EXCAV.1 @ 8'	8	03/11/92	0.032	0.28	0.13	2.8	930	12,000	NA	NA
S2	E.WALL, EXCAV.1 @9'	9	03/11/92	0.22	1.9	2.1	10	1,200	8,700	NA	NA
S3	N.WALL, EXCAV.1 @8'	8	03/11/92	NA	NA	NA	NA	1,600	10,000	NA	NA
S4	W.WALL, EXCAV.1 @8'	8	03/11/92	<0.028	0.23	<0.028	2.2	140	540	NA	NA
S5	S.WALL, EXCAV.2 @7.5'	7.5	03/12/92	<0.030	<0.030	<0.030	<0.030	<5	<25	NA	<5.8
S6	W.WALL, EXCAV.2 @8'	8	03/12/92	<0.029	0.10	<0.029	0.034	20	32	NA	<5.6
S7	N.WALL, EXCAV.2 @8'	8	03/12/92	26	61	210	470	2,500	420	NA	<5.6
S8	E.WALL, EXCAV.2 @ 8'	8	03/12/92	92	300	1,000	1,800	10,000	600	NA	<5.4
S9	EXC.2, W. PIPING @ 3'	3	03/12/92	<0.028	<0.028	<0.028	<0.028	7	<25	NA	NA
S10	PIPING TRENCH @ 4'	4	03/13/92	21	69	200	410	1,000	100	NA	NA
S11	PIPING TRENCH @ 3'	3	03/13/92	<0.032	0.40	0.056	2.6	240	2,000	NA	NA
S12	PIPING TRENCH @ 3'	3	03/13/92	<0.031	<0.031	<0.031	<0.031	<5	<25	NA	NA
S13	PIPING TRENCH @ 3'	3	03/13/92	<0.035	<0.035	<0.035	<0.035	<5	<25	NA	NA
S14	PIPING TRENCH @ 4'	4	03/13/92	<0.030	<0.030	<0.030	<0.030	7	350	NA	NA
S15	E.WALL, EXCAV.3 @ 7'	7	03/13/92	NA	NA	NA	NA	<5	<25	22	NA
S16	S.WALL, EXCAV.3 @ 8'	8	03/13/92	NA	NA	NA	NA	<5	<25	<20	NA
S17	PIPING TRENCH @ 2'	2	03/17/92	0.037	<0.028	0.066	0.039	<5	<25	NA	NA
S18	DISPEN. ISL.1 @ 2'	2	03/13/92	<0.027	<0.027	0.032	0.029	<25	2,100	NA	NA
S19	DISPEN. ISL.2 @ 2.5'	2.5	03/13/92	<0.030	0.070	<0.030	0.61	430	18,000	NA	<5.6
S20	DISPEN. ISL.3 @ 5'	5	03/16/92	0.039	1.4	0.48	7.9	280	2,200	NA	NA
S21	DISPEN. ISL.4 @ 5'	5	03/16/92	0.67	1.8	0.80	9.0	2,500	21,000	NA	NA
S22	DISPEN. ISL.5 @ 5'	5	03/16/92	0.59	1.1	0.91	6.1	740	9,100	NA	NA
S23	PIPING TRENCH @ 5'	5	03/16/92	<0.028	0.81	0.080	6.1	980	3,100	NA	NA
S24	PIPING TRENCH @ 5'	5	03/16/92	<0.028	<0.028	<0.028	<0.028	<5	87	NA	NA
S26	PIPING TRENCH @ 3'	3	03/17/92	0.44	3.6	5.6	25	300	72	NA	<6.0
S27	DISPEN. ISL.7 @ 3'	3	03/17/92	6.5	44	130	330	1,100	160	NA	<5.6
S28	DISPEN. ISL.6 @ 3'	3	03/17/92	10	19	69	170	1,600	300	NA	11
S29	SOIL STOCKPILE	--	03/18/92	<0.028	<0.028	<0.028	<0.028	10	210	NA	NA
S32	Drain Box	0.25	06/29/93	<0.029	<0.029	<0.029	<0.029	NA	340 *	NA	NA
MW1 @ 7.5'	MW1	7.5	07/02/93	<0.027	<0.027	<0.027	<0.027	<5	<27	NA	2.1
MW2 @ 7.5'	MW2	7.5	07/02/93	<0.026	<0.026	<0.026	<0.026	<5	<26	NA	1.9
MW3 @ 9.0'	MW3	9.0	06/28/93	<0.026	1.0	0.055	5.9	310	3,100	NA	2.0
MW3 @ 42.5'	MW3	42.5	06/29/93	<0.028	<0.028	<0.028	0.041	<6	31	NA	2.3
MW4 @ 7.5'	MW4	7.5	07/06/93	<0.026	0.17	0.11	1.3	<5	<26	NA	3.0
MW4 @ 17.5'	MW4	17.5	07/06/93	<0.027	<0.027	<0.027	<0.027	<5	<27	NA	2.1

Table 3–3
Hydrocarbons and Lead Detected in Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

				EPA Test Methods							EPA
				BETX – 8020			Total	TPH – 8015M		WTPH	7421
Sample ID	Sample Location	Sample Depth	Sample Date	Benzene (mg/kg)	Ethylbenzene (mg/kg)	Toluene (mg/kg)	Xylenes (mg/kg)	Gasoline (mg/kg)	Diesel (mg/kg)	418.1M (mk/kg)	Lead (mg/kg)
MW5 @ 7.5'	MW5	7.5	07/01/93	<0.030	0.12	0.080	0.50	160	43	NA	2.1
MW5 @ 10.0'	MW5	10.0	07/01/93	<0.028	<0.028	<0.028	<0.028	<6	<28	NA	1.3
MW6 @ 17.5'	MW6	17.5	07/06/93	0.64	1.2	0.55	4.3	10	<31	NA	21
MW6 @ 50'	MW6, Duplicate	17.5	07/06/93	0.48	0.79	0.40	2.8	12	<30	NA	19
MW6 @ 22.5'	MW6	22.5	07/06/93	3.5	3.6	17	21	99	38	NA	6.8
MW6 @ 30'	MW6	30	07/06/93	<0.026	<0.026	<0.026	<0.026	<5	<26	NA	1.2
MW7 @ 4.5'	MW7	4.5	10/26/93	<0.036	<0.036	<0.036	<0.036	<7	<36	NA	3.4
MW8 @ 8.5	MW8	8.5	10/27/93	<0.029	<0.029	<0.029	<0.029	<6	<29	NA	2.6
MW9 @ 8'	MW9	8	10/27/93	<0.027	<0.027	<0.027	<0.027	<5	<27	NA	<1.7
MW10 @ 8'	MW10	8	10/28/93	<0.038	<0.038	<0.038	<0.038	<8	<38	NA	2.4
MW10 @ 50'	MW10, Duplicate	8	10/28/93	<0.035	<0.035	<0.035	<0.035	<7	<35	NA	2.4
MW11 @ 3.5'	MW11	3.5	10/29/93	<0.031	<0.031	<0.031	<0.031	<6	<31	NA	3.8
MW11 @7.5'	MW11	7.5	10/29/93	<0.032	<0.032	<0.032	<0.032	<6	<32	NA	3.6
MW12 @ 3.5'	MW12	3.5	10/28/93	<0.031	<0.031	<0.031	<0.031	<6	<31	NA	3.0

Notes:

Sample Number S25 does not exist – this identification number was bypassed during sample collection.
Samples S30 and S31 are sediment samples, included on Table 6–9.
*Analyzed by Washington State Method WTPH–D.
mg/kg – Milligrams per kilogram.
TPH – Total petroleum hydrocarbons.
NA – Not analyzed.
< – Indicates compound not detected at stated detection limit.

Table 3–4
Polycyclic Aromatic Hydrocarbon Results for Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Analyte	Method Reporting Limit (mg/kg, dry wt.)	Sample I.D. and Depth (ft bgs)											
		MW1	MW2	MW3		MW4		MW5		MW6			
		7.5	7.5	9.0	42.4	7.5	17.5	7.5	10.0	17.5	17.5*	22.5	30
		mg/kg, dry wt.											
Acenaphthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	0.21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) anthracene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo (a,h) anthracene	0.042	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	0.010	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	0.044	ND
Indeno (1,2,3–cd) pyrene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1–Methylnaphthalene	0.21	ND	ND	9.2	ND	ND	ND	0.30	ND	ND	ND	0.26	ND
2–Methylnaphthalene	0.21	ND	ND	10	ND	ND	ND	1.0	ND	ND	ND	0.59	ND
Naphthalene	0.10	ND	ND	2.3	ND	ND	ND	0.44	ND	ND	ND	0.28	ND
Phenanthrene	0.010	ND	ND	2.8	0.023	ND	ND	0.041	ND	ND	ND	ND	ND
Pyrene	0.021	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 3–4

Polycyclic Aromatic Hydrocarbon Results for Soil

Burns Bros./Bingo Fuel Stop

Thorp, Washington

Analyte	Method Reporting Limit (mg/kg, dry wt.)	Sample I.D. and Depth (ft. bgs)							
		MW7	MW8	MW9	MW10		MW11		MW12
		4.5	8.5	8.0	8.0	8.0*	3.5	7.5	3.5
		mg/kg, dry wt.							
Acenaphthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	0.21	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) anthracene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo (a,h) anthracene	0.042	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Indeno (1,2,3–cd) pyrene	0.021	ND	ND	ND	ND	ND	ND	ND	ND
1–Methylnaphthalene	0.21	ND	ND	ND	ND	ND	ND	ND	ND
2–Methylnaphthalene	0.21	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	0.10	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	0.021	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

*Field duplicate.

Method reporting limit may vary with sample moisture content, matrix interference, etc.

ft bgs – Feet below ground surface.

mg/kg – Milligrams per kilogram.

ND – Not detected.

Table 3–5
Groundwater Sample Collection and Field Parameter Data
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Well I.D.	Date Collected	Well Depth (ft bmp)	Depth to Static Water Level (ft bmp)	Well Casing Volume (gallons)	Volume Purged (gallons)	Purge Method	Field Parameters			Comments (Sample Appearance, Odor, etc.)
							Temperature (°C)	Conductivity (µmhos/cm)	pH	
MW1	07/08/93	17.95	7.05	7.1	25	Bailer	13.5	475	7.06	Turbid/no odor.
MW2	07/08/93	18.25	8.01	6.7	25	Bailer	13.2	533	6.76	Slightly turbid.
MW3	07/08/93	80.35	14.34	42.9	45	Bailer	13.8	287	7.92	Clear/no odor.
MW5	07/08/93	17.75	6.57	7.3	40	Bailer	14.9	370	6.84	Clear/hydrocarbon odor.
MW7	10/29/93	15.00	6.95	5.2	49	Bailer	12.8	385	7.04	Very turbid with sediment/no odor.
MW8	10/29/93	15.99	10.26	3.7	16	Bailer	12.3	550	6.78	Very turbid with sediment/slight hydrocarbon odor.
MW9	10/29/93	17.50	9.85	4.98	38	Bailer	12.8	402	6.8	Very turbid/yellowish–brown
MW10	11/01/93	16.50*	11.19	4.6	48	Bailer	12.3	396	6.39	Light milky white color/no odor.
MW11	11/01/93	17.50*	8.25	1.3	40	Bailer	11.8	360	6.17	Light brown milky color/no odor.
MW12	10/29/93	15.95	7.70	5.36	43	Bailer	13.5	443	6.83	Very turbid with sediment/no odor.

Notes:

Wells MW4 and MW6 parameters were not measured due to presence of free product in the wells.
*Depth below ground surface.
ft bmp – Feet below measuring point; top of PVC casing used as measuring point.

Table 3–6
Hydrocarbons, Lead, and Nitrate/Nitrite Detected in Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

			EPA Test Methods								
			BETX – 8020				TPH – 8015 M		7421	353.2	354.1
							TPH as				
		Sample	Benzene	Ethylbenzene	Toluene	Xylenes	Gasoline	Diesel	Lead	Nitrate/ Nitrite	Nitrite
Sample I.D.	Sample Location	Date	µg/L				mg/L				
MW1–7/93	MW1	07/08/93	ND	ND	ND	ND	ND	ND	0.013	6.4	0.15
MW2–7/93	MW2	07/08/93	0.7	ND	ND	ND	ND	ND	0.005	NA	NA
MW50–7/93	MW2, Duplicate	07/08/93	0.6	ND	ND	ND	ND	ND	0.004	NA	NA
MW3–7/93	MW3	07/08/93	1.4	0.9	ND	5.1	ND	ND	0.004	NA	NA
MW4–7/93	MW4	07/08/93	NS	NS	NS	NS	NS	NS	NS	NA	NA
MW5–7/93	MW5	07/08/93	1,300	840	4,500	7,000	34	2	ND	NA	NA
MW6–11/93	MW6	11/22/93	6,800	3,400	21,000	20,000	NA	NA	NA	NA	NA
MW7–10/93	MW7	10/29/93	ND	ND	ND	ND	ND	ND	ND	NA	NA
MW8–10/93	MW8	10/29/93	2,800	410	79	950	3	ND	ND	NA	NA
MW9–10/93	MW9	10/29/93	ND	ND	ND	ND	ND	ND	ND	NA	NA
MW10–10/96	MW10	11/01/93	ND	ND	ND	ND	ND	ND	ND	NA	NA
MW11–10/96	MW11	11/01/93	ND	ND	ND	ND	ND	ND	ND	NA	NA
MW100–10/96	MW11, Duplicate	11/01/93	ND	ND	ND	ND	ND	ND	ND	NA	NA
MW12–10/93	MW12	10/29/93	ND	ND	ND	ND	ND	ND	ND	NA	NA
W–1	Puget Power Service Center	03/26/92	ND	ND	ND	ND	ND *	NA	NA	NA	NA
W–2	House Adjacent to South	03/26/92	ND	ND	ND	ND	NA	NA	NA	NA	NA
W–3	House Adjacent to East	03/26/92	ND	ND	ND	ND	NA	NA	NA	NA	NA
W–4	Thorp Antique Mall	03/26/92	ND	ND	ND	ND	ND *	NA	NA	NA	NA
Method Reporting Limit			0.5	0.5	0.5	0.5	1	1	0.003	0.01	0.001

Notes:

*Analyzed by Washington State Method WTPH–G.
mg/L – Milligrams per liter.
µg/L – Micrograms per liter.
NA – Not analyzed.
ND – Not detected.
NS – Not sampled due to the presence of free product.

Table 3–7
Polycyclic Aromatic Hydrocarbon Results for Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Analyte	Method Reporting Limit (µg/L)	Sample I.D.								
		MW1	MW2	Dup MW2	MW3	MW4	MW5	MW6	MW7	MW8
		µg/L								
Acenaphthene	0.50	ND	ND	ND	ND	NS	ND	NS	ND	ND
Acenaphthylene	1.0	ND	ND	ND	ND	NS	ND	NS	ND	ND
Anthracene	0.05	ND	ND	ND	ND	NS	0.075	NS	ND	ND
Benzo (a) anthracene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Benzo (b) fluoranthene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Benzo (k) fluoranthene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Benzo (g,h,i) perylene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Benzo (a) pyrene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Chrysene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Dibenzo (a,h) anthracene	0.20	ND	ND	ND	ND	NS	ND	NS	ND	ND
Fluoranthene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
Fluorene	0.10	ND	0.29	0.36	0.35	NS	0.59	NS	ND	ND
Indeno (1,2,3–cd) pyrene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND
1–Methylnaphthalene	0.50	ND	0.58	0.71	1.1	NS	50	NS	ND	5.8
2–Methylnaphthalene	0.50	ND	0.96	1.2	ND	NS	97	NS	ND	4.7
Naphthalene	0.50	ND	ND	ND	ND	NS	190	NS	ND	27
Phenanthrene	0.05	ND	ND	ND	0.13	NS	0.45	NS	ND	ND
Pyrene	0.10	ND	ND	ND	ND	NS	ND	NS	ND	ND

Table 3–7
Polycyclic Aromatic Hydrocarbon Results for Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Analyte	Method Reporting Limit (µg/L)	Sample I.D.				
		MW9	MW10	MW11	Dup MW11	MW12
		µg/L				
Acenaphthene	0.50	ND	ND	ND	ND	ND
Acenaphthylene	1.0	ND	ND	ND	ND	ND
Anthracene	0.05	ND	ND	ND	ND	ND
Benzo (a) anthracene	0.10	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	0.10	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	0.10	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	0.10	ND	ND	ND	ND	ND
Benzo (a) pyrene	0.10	ND	ND	ND	ND	ND
Chrysene	0.10	ND	ND	ND	ND	ND
Dibenzo (a,h) anthracene	0.20	ND	ND	ND	ND	ND
Fluoranthene	0.10	ND	ND	ND	ND	ND
Fluorene	0.10	ND	ND	ND	ND	ND
Indeno (1,2,3–cd) pyrene	0.10	ND	ND	ND	ND	ND
1–Methylnaphthalene	0.50	ND	ND	ND	ND	ND
2–Methylnaphthalene	0.50	ND	ND	ND	ND	ND
Naphthalene	0.50	ND	ND	ND	ND	ND
Phenanthrene	0.05	ND	ND	ND	ND	ND
Pyrene	0.10	ND	ND	ND	ND	ND

Notes:

Method reporting limit may vary due to dilution, matrix interference, etc.
Dup – Duplicate sample.
ND – Not detected.
NS – Not sampled.
µg/L – Micrograms per liter.

Table 3–8
Analytical Results for Surface Water and Sediment
Burns Bros./Bingo Fuel Stop
Thorp, Washington

			EPA Test Methods				Washington State Test Methods	
			BETX – 8020				WTPH	
Sample I.D.	Sample Location	Sample Date	Benzene	Ethylbenzene	Toluene	Xylenes	Gasoline	Diesel
Surface Water			μg/L				mg/L	
W–5	Pond Adjacent to East	03/26/92	<0.5	<0.5	<0.5	<0.5	NA	NA
W–6	Swampy Area Adjacent to South	03/26/92	<0.5	<0.5	0.99	<0.5	<0.1	NA
Irrig. Canal, Near S31	Adjacent to north culvert, east of Thorp Highway	03/01/94	<0.5	<0.5	<0.5	<0.5	<0.1	<0.25
Drainage Ditch, west of site	Adjacent to Puget Power Cattle Guard	03/01/94	<0.5	<0.5	<0.5	<0.5	<0.1	<0.25
			mg/kg				mg/kg	
Sediment								
S30	Swampy Area Adjacent to South (0.25 ft. in depth)	06/29/93	<0.10	<0.10	<0.10	<0.10	NA	57
S31	East Culvert (0.25 ft. in depth)	06/29/93	<0.086	<0.086	0.42	<0.086	NA	2,100

Notes:

mg/kg – Milligrams per kilogram.
mg/L – Milligrams per liter.
μg/L – Micrograms per liter.
NA – Not analyzed.
< – Indicates compound not detected at stated detection limit.

Table 3–9
Draft Cleanup Levels for Soil and Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Chemical	Soil (mg/kg)	Basis for Selection	Groundwater (µg/L)	Basis for Selection
Volatile Organic Compounds				
Benzene	0.5	Cross media (groundwater ARAR)	5.0	Groundwater ARAR
Ethylbenzene	40	Cross media (groundwater risk–based)	400	Risk–based: groundwater
Toluene	80	Cross media (groundwater risk–based)	800	Risk–based: groundwater
Total Xylenes	800	Cross media (groundwater risk–based)	8,000	Risk–based: groundwater
Polycyclic Aromatic Hydrocarbons				
Anthracene	ND		4,800	Risk–based: groundwater
Fluorene	32	Cross media (groundwater risk–based)	320	Risk–based: groundwater
1–Methylnaphthalene	NE		NE	
2–Methylnaphthalene	NE		NE	
Naphthalene	32	Cross media (groundwater risk–based)	320	Risk–based: groundwater
Phenanthrene	NE		NE	
Semivolatile Organic Compounds				
Lead	250	Risk Based	3.2	Surface water ARAR
Nitrate/Nitrite	NA		800	Risk–based: groundwater

Notes:

Cleanup levels have been rounded to two significant digits.
ARAR – Applicable and Relevant or Appropriate Requirement.
mg/kg – Milligrams per kilogram.
µg/L – Micrograms per liter.
NA – Chemical not analyzed in soil.
ND – Chemical not detected in soil.
NE – Not established.

Table 3–10
Summary of Draft Chemical Exceedances – Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

				EPA Test Method			
				BETX – 8020			Total
Sample I.D.	Sample Location	Sample Depth	Sample Date	Benzene (mg/kg)	Ethylbenzene (mg/kg)	Toluene (mg/kg)	Xylenes (mg/kg)
S7	N.WALL, EXCAV.2 @8'	8	03/12/92	26	61	210	470
S8	E.WALL, EXCAV.2 @ 8'	8	03/12/92	92	300	1,000	1,800
S10	PIPING TRENCH @ 4'	4	03/13/92	21	69	200	410
S21	DISPEN. ISL.4 @ 5'	5	03/16/92	0.67	1.8	0.80	9.0
S22	DISPEN. ISL.5 @ 5'	5	03/16/92	0.59	1.1	0.91	6.1
S27	DISPEN. ISL.7 @ 3'	3	03/17/92	6.5	44	130	330
S28	DISPEN. ISL.6 @ 3'	3	03/17/92	10	19	69	170
MW6 @ 17.5'	MW6	17.5	07/06/93	0.64	1.2	0.55	4.3
MW6 @ 22.5'	MW6	22.5	07/06/93	3.5	3.6	17	21

Notes:

Shaded values exceed draft Method B cleanup levels.
mg/kg – Milligrams per kilogram.
TPH – Total petroleum hydrocarbons.
NA – Not analyzed.
ND – Not detected.
< – Indicates compound not detected at stated detection limit.

Table 3–11
Summary of Draft Chemical Exceedances – Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

			BETX – 8020				7421	353.2	354.1
	Sample	Sample	Benzene	Ethylbenzene	Toluene	Xylenes	Lead	Nitrate/Nitrite	Nitrite
Sample I.D.	Location	Date	μg/L						
MW1–7/93	MW1	07/08/93	ND	ND	ND	ND	13	6,400	150
MW2–7/93	MW2	07/08/93	0.7	ND	ND	ND	5	NA	NA
MW3–7/93	MW3	07/08/93	1.4	0.9	ND	5.1	4	NA	NA
MW5–7/93	MW5	07/08/93	1,300	840	4,500	7,000	ND	NA	NA
MW6–11/93	MW6	11/22/93	6,800	3,400	21,000	20,000	NA	NA	NA
MW8–10/93	MW8	10/29/93	2,800	410	79	950	ND	NA	NA
Method Reporting Limit			0.5	0.5	0.5	0.5	0.003	0.01	0.001

Notes:

Shaded values exceed draft Method B cleanup levels.
*Analyzed by Washington State Method WTPH–G.
mg/L – Milligrams per liter.
μg/L – Micrograms per liter.
NA – Not analyzed.
ND – Not detected.
NS – Not sampled due to the presence of free product.

Table 3–12
Summary of Method A TPH Exceedances in Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Sample I.D.	Sample Location	Sample Depth	Sample Date	EPA Test Method TPH – 8015M Gasoline (mg/kg)	EPA Test Method TPH – 8015M Diesel (mg/kg)
S1	S.WALL, EXCAV.1 @ 8'	8	03/11/92	930	12,000
S2	E.WALL, EXCAV.1 @9'	9	03/11/92	1,200	8,700
S3	N.WALL, EXCAV.1 @8'	8	03/11/92	1,600	10,000
S4	W.WALL, EXCAV.1 @8'	8	03/11/92	140	540
S7	N.WALL, EXCAV.2 @8'	8	03/12/92	2,500	420
S8	E.WALL, EXCAV.2 @ 8'	8	03/12/92	10,000	600
S10	PIPING TRENCH @ 4'	4	03/13/92	1,000	100
S11	PIPING TRENCH @ 3'	3	03/13/92	240	2,000
S14	PIPING TRENCH @ 4'	4	03/13/92	7	350
S18	DISPEN. ISL.1 @ 2'	2	03/13/92	<25	2,100
S19	DISPEN. ISL.2 @ 2.5'	2.5	03/13/92	430	18,000
S20	DISPEN. ISL.3 @ 5'	5	03/16/92	280	2,200
S21	DISPEN. ISL.4 @ 5'	5	03/16/92	2,500	21,000
S22	DISPEN. ISL.5 @ 5'	5	03/16/92	740	9,100
S23	PIPING TRENCH @ 5'	5	03/16/92	980	3,100
S26	PIPING TRENCH @ 3'	3	03/17/92	300	72
S27	DISPEN. ISL.7 @ 3'	3	03/17/92	1,100	160
S28	DISPEN. ISL.6 @ 3'	3	03/17/92	1,600	300
S29	SOIL STOCKPILE	--	03/18/92	10	210
S32	Drain Box	0.25	06/29/93	NA	340 [a]
MW3 @ 9.0'	MW3	9.0	06/28/93	310	3,100
MW5 @ 7.5'	MW5	7.5	07/01/93	160	43
Method A TPH Cleanup Level [b]				100	200

Notes:

Shaded values exceed cleanup levels.
Sample Number S25 does not exist – this identification number was bypassed during sample collection.
Samples S30 and S31 are sediment samples, included on Table 6–9.
a) Analyzed by Washington State Method WTPH–D.
b) Method A suggested cleanup level for residential soil promulgated under Washington Administrative Code Chapter 173–340, Model Toxics Control Act Cleanup Regulation.
mg/kg – Milligrams per kilogram.
TPH – Total petroleum hydrocarbons.
NA – Not analyzed.
< – Indicates compound not detected at stated detection limit.

Table 3–13
Summary of Method A TPH Exceedances in Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Sample ID	Sample Location	Sample Date	EPA Test Method TPH – 8015 M TPH as Gasoline (mg/L)	EPA Test Method TPH – 8015 M TPH as Diesel (mg/L)
MW5–7/93	MW5	07/08/93	34	2
MW8–10/93	MW8	10/29/93	3	ND
Method Reporting Limit			1	1
Method A TPH Cleanup Level*			1.0	1.0

Notes:

Shaded values exceed cleanup levels.
*Method A suggested cleanup level for groundwater promulgated under Washington Administrative Code Chapter 173–340, Model Toxics Control Cleanup Act Regulation.
mg/L – Milligrams per liter.
ND – Not detected.

Table 4-1
Remedial Action Objectives and General Response Actions
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Environmental Media	Remedial Action Objectives		General Response Actions (GRA)
	Human Health Protection Objectives	Environmental Protection Objectives	
Contaminated Soils	Prevent ingestion/direct contact with soil having carcinogens and/or noncarcinogens in excess of acceptable risk levels.	Prevent migration of contaminants that would result in groundwater contamination in excess of acceptable risk levels. Prevent migration of contaminants that would result in surface water contamination in excess of acceptable risk levels.	No Action Institutional Controls: Access Restrictions Containment Actions: Surface Controls Capping Subsurface Barriers Excavation/Removal Actions: Excavation Disposal On Site or Off Site Excavation/Treatment Actions: Thermal Treatment Biological Treatment Chemical Treatment Physical Treatment *In Situ* Treatment Actions: Biological Treatment Physical Treatment Chemical Treatment Air/Dust Controls: Dust Controls
Groundwater	Prevent ingestion of water having carcinogens and/or noncarcinogens in excess of MTCA cleanup levels or in excess of acceptable risk levels. Prevent inhalation/direct contact with water having carcinogens and/or noncarcinogens in excess of acceptable risk levels. Protect groundwater not currently contaminated.	Restore groundwater aquifer to concentrations with acceptable risk levels based on plant uptake or groundwater discharge to surface water. Protect groundwater not currently contaminated.	No Action Institutional Controls: Groundwater Monitoring Groundwater Restrictions Alternative Water Supply Protection Actions: Capping Contaminated Soil Removal Containment Actions: Vertical Barriers Horizontal Barriers Collection Actions: Groundwater Extraction Treatment Actions: Biological Treatment Chemical Treatment Physical Treatment Disposal Actions: On-site Discharge Off-site Discharge *In Situ* Treatment Actions Chemical Treatment Biological Treatment Physical Treatment

Table 5-1
Initial Screening of Remedial Technologies - Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Actions	Remedial Technologies	Process Options	Description	Determination of Applicability
No Action	None	None	No action.	Not acceptable based on RI results and MTCA requirements.
Institutional Controls	Access Restriction	Land Use Restrictions	Apply long-term restrictions on property use/ development within potentially contaminated areas.	Potentially applicable.
		Fencing	Security fences installed around potentially contaminated areas to limit access.	Potentially applicable. Already in place in most areas.
Containment (may also apply to pockets of contamination)	Surface Controls	Grading/Surface Water Controls	Reshaping of topography to manage infiltration and run-off and to limit contaminant leaching and control erosion. Would likely include asphalt or concrete cap.	Potentially applicable. Currently in place over most of site
		Revegetation	Seeding, fertilizing, and watering until a stand of vegetation has established itself.	Potentially applicable.
	Capping	Concrete	Concrete pavement of varying thickness usually used in high traffic areas, roadways, loading docks, etc.	Potentially applicable; currently used on some site areas. Effective at reducing infiltration.
		Asphalt	Design of asphalt pavement section dependent upon future site uses and probable design life.	Currently in use; normally has high effectiveness in reducing infiltration. Potentially applicable.
		Single Barrier	Geomembrane or compacted clay over site areas. Usually protected with additional fill above and topsoil. Clay cap is normally 2 feet thick.	Not applicable; is not compatible with anticipated future site use.
		Double Barrier	Compacted clay covered with a synthetic membrane (20 mil minimum) followed by 1 foot of sand, 1.5 feet of fill, and 6 inches of topsoil to provide erosion and moisture control and freeze-thaw protection.	Not applicable; is not compatible with anticipated future site use.
	Subsurface Barriers	Horizontal or Vertical Barriers	(See groundwater process option description).	(See groundwater process option description).

Table 5-1
Initial Screening of Remedial Technologies - Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Actions	Remedial Technologies	Process Options	Description	Determination of Applicability
Removal	Excavation	Mechanical Excavation	Use of mechanical excavation equipment to remove and load contaminated soils for disposal or treatment.	Potentially applicable for contaminated soils. May release VOCs to the atmosphere.
	Excavation (cont'd)	Consolidation	Refers to consolidation under a landfill cap of excavated material from contaminated areas.	Not applicable; site is not suitable for landfill siting.
Excavated Soil Disposal	Disposal On Site	RCRA Subtitle D Landfill	Permanent storage facility on site, double lined with clay and a synthetic membrane liner and containing a leachate collection/ detection system.	Not applicable; site is not suitable for landfill siting.
	Disposal Off Site	RCRA Subtitle C Landfill	Transport of excavated soil to a RCRA Subtitle C permitted landfill.	Not applicable for hydrocarbons. Restrictions may require treatment of waste prior to landfilling.
		RCRA Subtitle D Landfill	Transport of excavated soil to a RCRA Subtitle D permitted landfill.	Potentially applicable for excavated materials with immobile contaminants and/or low levels of contamination or TPH-impacted soils.
Excavated Soil Treatment	Thermal Treatment	Incineration	Excavated wastes are thermally destroyed in a controlled oxygen-sufficient environment.	Not applicable for TPH-contaminated soils, due to permitting, availability, and cost.
		Low Temperature Thermal Desorption	VOCs removed from soil in a drying unit, and off gases are incinerated.	Potentially applicable; primary soil contaminants are TPH, which are often treated by this method.
	Biological Treatment	Aerobic Biodegradation	Soil treated with nutrients to promote biological degradation in the presence of oxygen and proper moisture content.	Potentially applicable. Pilot testing may be required to identify optimum conditions and degradation rates.
	Chemical Treatment	Soil Washing	Mixing solvent or water with soil in a controlled system to extract contaminants from soil.	Potentially applicable. Potential solvents include water, surfactants, and chemical solvents.
		Chemical Oxidation	Hydrocarbons are degraded by addition of chemical oxidants (H_2O_2).	Not applicable. Many other technologies are readily applied and more cost effective. However, can be used to potentially speed biological degradation.

Table 5-1
Initial Screening of Remedial Technologies - Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Actions	Remedial Technologies	Process Options	Description	Determination of Applicability
Excavated Soil Treatment (con't)	Physical Treatment	Solidification/Stabilization	Soil mixed with a pozzolanic/cement material that can solidify and reduce mobility of contaminants.	Not applicable for hydrocarbon-contaminated soil.
		Asphalt Incorporation	Soil used to make asphalt pavement and contaminants are immobilized.	Potentially applicable.
		Aeration	Soil is aerated in soil screen or tilled to volatilize organics.	Not applicable since some of the contaminants are diesel, which does not readily volatilize.
In Situ Treatment (may also apply to pockets of contamination)	Biological Treatment	Aerobic Biodegradation	Soils treated with nutrients to increase biological degradation in the presence of oxygen.	Potentially applicable to contaminated soils. Bench testing is required to identify optimum conditions and efficiency.
	Physical Treatment	Vapor Extraction	VOCs stripped from soil and recovered in vapor form through extraction wells.	Potentially applicable for gasoline range hydrocarbons.
		Steam Injection	Steam injected into the ground in conjunction with vapor extraction to recover hydrocarbons.	Potentially applicable for diesel range hydrocarbons.
		Vitrification	Subsurface soils solidified to glass-like substance with very high electric voltage.	Not applicable due to cost, existing utilities, access, etc.
	Chemical Treatment	Solidification/Stabilization	Soil mixed *in situ* with a material that can solidify and reduce mobility of contaminants.	Not applicable for hydrocarbons.
		Soil Washing	Mixing of solvent or water with soil to extract contaminants from soil. Water is recovered with a pump and treat system.	Not applicable due to surface conditions.
		Hydrolysis	Removal of some organics by hydrolysis.	Not applicable.
Air/Dust	Dust Controls	Cover/Cap	Uncontaminated native soil or asphalt/ concrete cap placed over contaminated areas.	Potentially applicable. Asphalt currently covers much of the site.
		Wetting	Soils wetted with water to prevent dust generation during activities disturbing soil.	Potentially applicable, but would be applied as part of other process options as necessary during construction phase.

Table 5-2
Initial Screening of Remedial Technologies - Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Actions	Remedial Technologies	Process Options	Description	Determination of Applicability
No Action	None	None	No action.	Not acceptable based on RI results and MTCA requirements.
Institutional Controls	Groundwater Monitoring	Groundwater Monitoring	Groundwater monitoring of existing or new wells to detect changes in groundwater movement or contamination.	Potentially applicable.
	Groundwater Restrictions	Deed Restrictions	Long-term restrictions are placed on development of groundwater resources within contaminated areas.	Potentially applicable.
	Alternative Water Supply	Public Water Supply	Potable water supplied by a municipal system or non-contaminated wells.	Not applicable at this time since no domestic wells exist within contaminated area.
Groundwater Protection	Source Control by Capping	See Table 5-1	Prevent infiltration of storm water to prevent contaminants from leaching.	Potentially applicable. Asphalt or concrete pavement currently covers much of the site.
	Source Control by Removal of Contaminated Soil	See Table 5-1	Remove soil contaminants so that source for groundwater contamination no longer exists.	Potentially applicable.
Groundwater Containment	Vertical Barriers	Slurry Wall	Bentonite or other impermeable barriers placed as a vertical wall or barrier.	Not applicable based on plume dimensions and access constraints.
		Sheet Pile	Steel interlocking plates are driven to form a near impermeable vertical wall or barrier.	Not applicable based on plume dimensions and access constraints.
		Bio Curtain	A vertical barrier trench operated as a large bioreactor constructed to treat contaminants.	Not applicable based on plume dimensions and access constraints.
	Horizontal Barriers	Bottom Sealing	Grout is pumped into site soils at a specific depth to form a seal.	Not applicable based on cost and site access.
Groundwater Collection	Groundwater Extraction	Extraction Wells	Series of vertical wells to extract contaminated groundwater and maintain hydraulic control of site groundwater.	Potentially applicable.
		Extraction Trenches	Trenches are excavated, then backfilled with horizontal collection pipe and drain rock.	Potentially applicable, but may be difficult due to utilities, streets, etc.
Treatment of Collected Water	Chemical	UV Oxidation	VOCs in groundwater destroyed by passing water through clear columns and exposing to UV light.	Potentially applicable.
		Oxidation	Oxidizing agents such as H_2O_2 added to water to oxidize/reduce organics.	Potentially applicable.

Table 5-2

Initial Screening of Remedial Technologies - Groundwater

Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Actions	Remedial Technologies	Process Options	Description	Determination of Applicability
Treatment of Collected Water (con't)	Biological Treatment	Aerobic	Use of aerobic microbes within a bioreactor tank to degrade organics.	Potentially applicable. Currently used for interim treatment.
		Anaerobic	Use of anaerobic microbes to degrade organics.	Not applicable; it is less efficient for TPH than aerobic process.
	Physical Treatment	Granular-Activated Carbon (GAC) Adsorption	Passage of contaminated water through a bed of GAC so contaminants adsorb on particle surfaces.	Potentially applicable for hydrocarbon primary treatment or final polish.
		Air Stripping	Water passed through designed column with packing with a large air volume-forced against water to strip VOCs.	Potentially applicable for lighter hydrocarbons (VOCs).
		Sparging	Water is passed through a tank with mass aeration to volatilize VOCs.	Potentially applicable.
Treated Water Disposal	On-Site Discharge	Aquifer Reintroduction	Extracted, treated groundwater is reintroduced into the aquifer to accelerate the cleanup.	Potentially applicable.
	Off-Site Discharge	Discharge to Sewage Treatment Works	Extracted groundwater is discharged to Sewage Treatment Plant (STP) for further treatment and discharge.	Not applicable since no local STP is available.
		NPDES Permit	Extracted groundwater is discharged to surface water in accordance with an NPDES Permit.	Potentially applicable.
In situ Groundwater Treatment	Chemical Treatment	Oxidation	Injection of an oxidizing agent into the subsurface to oxidize contaminants.	Not applicable since it may be difficult to control or uniformly apply because of access constraints or subsurface conditions.
	Biological Treatment	Aerobic	Use of aerobic microbes to destroy contaminants *in situ*. Usually performed in conjunction with reintroduction of water amended with nutrients and oxygen.	Potentially applicable.
		Anaerobic	Turn subsurface water to anaerobic conditions to allow anaerobic microbes to destroy waste.	Not applicable since aerobic process is more efficient for hydrocarbons.
	Physical	Sparging	Compressed air is blown into the aquifer to volatilize VOCs. Air is then recovered by VES. Also stimulates aerobic biodegradation due to increased oxygen availability.	Potentially applicable.

Table 5-3
Evaluation of Process Options - Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Investigate Further	Justification
Institutional Controls	Access Restrictions	Land Use Restrictions	Effective in limiting exposure to contaminated soil. Does not reduce contamination.	Land development restrictions are generally easy to implement.	Low capital, no O&M.	Yes	Easily implemented; may be used in conjunction with other technologies.
		Fencing	Effective in limiting human exposure to contaminated soil. Does not reduce contamination.	Easily implemented in some areas.	Low capital, low O&M.	Yes	Fence currently exists around site.
Containment	Surface Controls	Grading/Surface Water Controls	Effective in reducing exposure to contaminated soil and lowering infiltration to reduce potential groundwater impacts.	Easily implemented.	Low capital and O&M.	Yes	May be required to a limited degree in unpaved areas.
		Revegetation	Effective in reducing infiltration and cover erosion.	Easily implemented.	Very low capital and O&M.	Yes	Likely used in conjunction with grading and surface water controls, but will have limited use at Bingo Fuel Stop site.
	Capping	Concrete	Effective in limiting/preventing infiltration and contact with contaminated soils.	Moderate effort to design and install.	Moderate capital, low O&M.	No	Potentially useful in traffic areas. Currently used in some areas.
		Asphalt	Effective in limiting/preventing infiltration and contact with contaminated soils. Does require maintenance to retain effectiveness.	Easy to implement; requires no special equipment or personnel.	Moderate capital, low O&M	Yes	Already in use in some areas and bisecting site streets. Would serve to limit infiltration and as a vapor seal for *in situ* VES.
Excavation/Removal	Excavation	Mechanical Excavation	Effective in removing contaminants to depths of approximately 20 feet.	Usually easily implemented. Site access conditions will limit use at site.	Low capital and O&M.	Yes	Excavation is an integral part of any direct treatment technology.
Excavated Soil Disposal	Landfill	RCRA Subtitle D Landfill	Does not reduce volume or toxicity of contaminated materials. Effective at reducing mobility. Risk of future contamination if off-site landfill protective system fails.	Soils will require characterization prior to disposal.	Moderate capital, no O&M.	Yes	RCRA Subtitle D disposal may be appropriate for hydrocarbon-impacted soils excavated from site.

Table 5-3
Evaluation of Process Options - Soil
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Action / Remedial Technology / Process Option	Effectiveness	Implementability	Cost	Investigate Further	Justification
Excavated Soil Treatment Thermal Treatment Low Temperature Thermal Desorption (LTTD)	Effective for removing VOCs and some SVOCs from soils. Does not remove metals.	Easily implemented.	Moderate capital and O&M.	Yes	May be effective in remediating VOCs and some SVOCs. Treatability testing would be needed for CPAHs.
Aerobic Biodegradation	Effective for removal of some organics. Limited effectiveness for inorganics.	Relatively easy to implement by constructing treatment pad on site or off site. Can be very slow for some organics.	Low capital and moderate O&M.	Yes	Potential remedial technology for remediation of contamination pockets: effective for aromatic VOCs and some PAHs.
Soil Washing	Effective for treating many organic contaminants in coarse-grained soils.	Moderately difficult to implement and perform treatment.	Moderate to high capital, low O&M.	No	Aerobic biodegradation or LTTD are more cost effective.
Asphalt Incorporation	Effective for treating many organic contaminants in coarse-grained soils.	Moderately difficult to implement and perform treatment.	Moderate to high capital, low O&M.	No	Aerobic biodegradation or LTTD are more cost effective.
In Situ Treatment Biological Treatment Aerobic Biodegradation	Proven effectiveness for some organic compounds; however, very slow for heavier organic compounds.	Difficult to implement in heterogeneous soils.	Moderate capital and O&M.	Yes	Refer to groundwater pumping and treatment technology.
Physical Treatment Vapor Extraction	Effective for VOCs in homogeneous soils.	Moderately difficult to implement.	Moderate capital and O&M.	Yes	Applicable for soil that cannot be excavated due to proximity to buildings, etc. Very effective for benzene.
Steam Injection	Effective for VOCs and SVOCs when used in conjunction with vapor extraction.	Difficult to implement.	Moderate capital and O&M.	No	Other technologies are equally effective at lower cost.
Air/Dust Dust Controls Wetting	Effective in limiting dust generation during soil disturbance activities.	Easily implemented.	Low capital and O&M.	Yes	May be necessary to protect local residential/industrial areas if excavation is performed during hot/dry weather.

Table 5-4
Evaluation of Process Options - Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Action / Remedial Technology / Process Option	Effectiveness	Implementability	Cost	Investigate Further	Justification
Institutional Controls / Groundwater Monitoring / Groundwater Monitoring	Provides documentation of existing conditions and changes over time. Does not achieve RAOs.	Easily implemented. Likely, alone, not acceptable to local/state/federal governments.	Low capital and O&M.	Yes	Likely part of most remedial alternatives.
Groundwater Restrictions / Deed Restrictions	Does not reduce contamination effectiveness. Depends on continued future implementation.	Easily implemented.	Low capital, no O&M.	Yes	Necessary to prevent constructing of water supply wells if groundwater remains untreated.
Alternative Water Supply / Public Water Supply	Effective in preventing use of contaminated groundwater. Does not reduce contamination.	Moderate difficulty in implementation: permits required, extensive utility trenching.	High capital, low O&M.	No	Impact to groundwater not apparent at downgradient monitoring wells.
Groundwater Protection / Source Control / Capping	Asphalt and concrete cap currently effective on site; does require maintenance. Either is typically good at limiting infiltration.	Well-developed and easy to implement.	Low to moderate capital and O&M.	Yes	Asphalt or concrete cap and stormwater controls are currently in use over much of the site. Unpaved areas may require pavement depending on alternative. Refer to capping for soil technologies.
Collection / Groundwater Extraction / Extraction Wells	Extraction wells are typically very effective at hydraulically controlling groundwater.	Technology is versatile, flexible, and widely used. Will require pump tests to verify site parameters.	Moderate capital and O&M.	Yes	Groundwater extraction will be necessary to hydraulically control site contaminants.
Extraction Trenches	Trenches are very effective at total groundwater influence to the depth excavated.	Moderate to difficult to implement depending on geology and depth. Site access will make trenches difficult to implement.	Moderate capital and O&M.	Yes	Groundwater extraction will be necessary to hydraulically control site contaminants.
Treatment of Collected Water / Chemical / UV Oxidation	Effective in treating VOCs in low flow systems.	Technology is in development, and testing stages. Requires low flow rates.	High capital and O&M.	No	Other technologies are equally effective at lower cost.
Oxidation	Effective in treating many organic contaminants.	Technology is typically implemented without difficulty.	High capital and O&M.	No	Other technologies are equally effective at lower cost.
Biological / Aerobic Degradation	Effective in treating many organics, particularly gas to diesel range TPH.	Relatively easy to implement depending on contaminants being treated.	Moderate capital and O&M.	Yes	Typically one of the lowest cost alternatives for TPH treatment.

Table 5-4
Evaluation of Process Options - Groundwater
Burns Bros./Bingo Fuel Stop
Thorp, Washington

General Response Action / Remedial Technology / Process Option	Effectiveness	Implementability	Cost	Investigate Further	Justification
Physical Treatment Granular Activated Carbon (GAC) Adsorption	Effective in removing organic contaminants. Moderately effective in removing some inorganics.	Well developed and easily implemented. Usually used if total loading is low.	Low capital, low to moderate O&M.	Yes	May be useful for final polish or direct treatment of organics depending on contaminant concentration.
Air Stripping	Very effective in removing VOCs, but excessive fouling occurs if elevated metals present.	Easily implemented with minimal area requirements.	Moderate capital, low O&M.	No	Effective means of treating VOCs at low to high flow rates, but not appropriate for diesel.
Sparging	Effective in removing VOCs, but not heavy organics.	Easily implemented, yet can require sizeable area.	Moderate capital and O&M.	No	Air stripping is more cost-effective at removing hydrocarbons.
Oil/Water Separation	Very effective in removing free-phase hydrocarbons.	Easily implemented.	Moderate capital, low O&M.	Yes	Effective means of removing free-phase hydrocarbons if they occur in extracted water or surface run-off.
Disposal On-site Discharge Aquifer Reintroduction	Very effective and would likely speed remediation time frame. Promotes *in situ* biodegradation.	Easily implemented but hydraulic control must be verified.	Low capital, low O&M.	Yes	Effective means of treated water disposal and may also aid cleanup. Permits may be required.
NPDES	Effective method of disposing of treated water.	Requires NPDES permitting process before discharge and permit compliance during discharge.	Low capital, low to moderate O&M.	Yes	May be best option depending on use of reintroduction, which could be limited.
In Situ Groundwater Treatment Biological Aerobic Degradation	Can be effective at reducing organic contaminants *in situ.*	Can be difficult to implement and obtain complete aquifer influence.	Low capital and O&M.	Yes	Can be effective and is usually implemented with other technologies
Physical Sparging	Can have partial effectiveness to volatilize VOCs in the subsurface and will promote biological degradation due to oxygen increase.	Readily implemented. VES required to collect vapors.	Moderate capital and O&M.	Yes	May be effective for treatment of localized contamination.

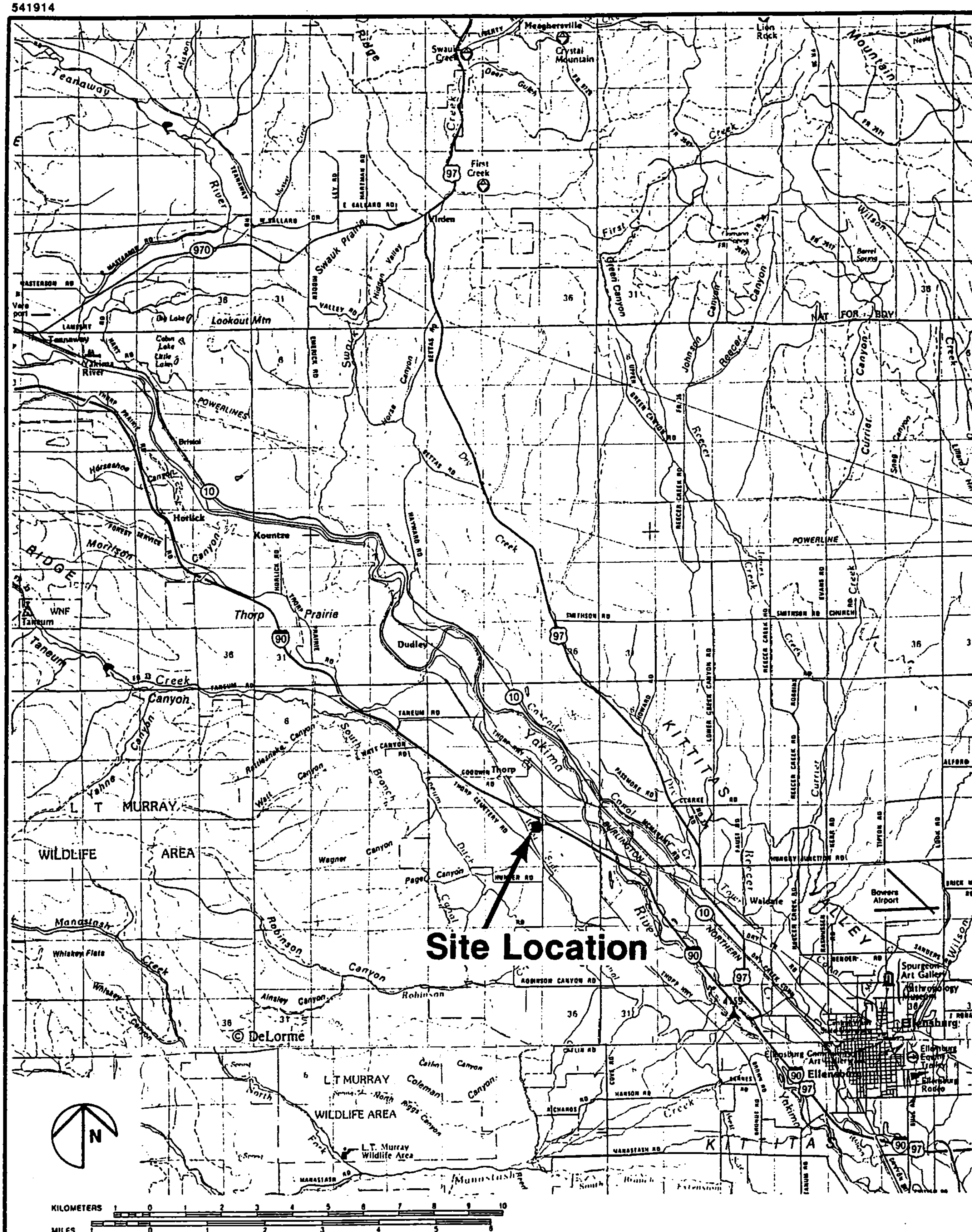
Table 6-1
Summary of Alternatives
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Media / Remedial Technology / Process Option	Alternatives 1	2	3
Soil			
Access Restrictions			
Land Use Restrictions	X	O	O
Fencing	X	X	X
Surface Controls			
Grading/Surface Water Controls	X	X	X
Revegetation		X	X
Capping			
Asphalt	X	X	
Excavation			
Source Area Only		X	X
Source Area All Practical			X
Disposal Off Site			
RCRA D Landfill		O	O
Thermal Treatment (On Site)			
Low Temperature Thermal Desorption		O	O
Biological Treatment (On Site)			
Aerobic Biodegradation		O	O
In Situ Treatment			
Biological Treatment		C	C
Vapor Extraction		C	C
Groundwater			
Groundwater Monitoring	X	X	X
Groundwater Use Restrictions	X	X	X
Product Recovery	X	X	X
Groundwater Extraction			
Wells		X	X
Trenches		X	C
Open Hole			X
Biological Treatment			
Aerobic		X	X
Physical Treatment			
GAC Adsorption		C	C
Oil/Water Separation		X	X
In Situ Sparging		C	
On-Site Discharge			
Aquifer Reintroduction		X	X
Off-Site Discharge			
NPDES Permit		X	C

Notes:

C – Contingency; utilized if required.
O – Optional treatment method for excavated soil.
X – Remedial technology used in preliminary alternative.
NPDES – National Pollutant Discharge Elimination System.

541914



Reference: From DeLorme Mapping Co., page 66

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Geology & Hydrogeology

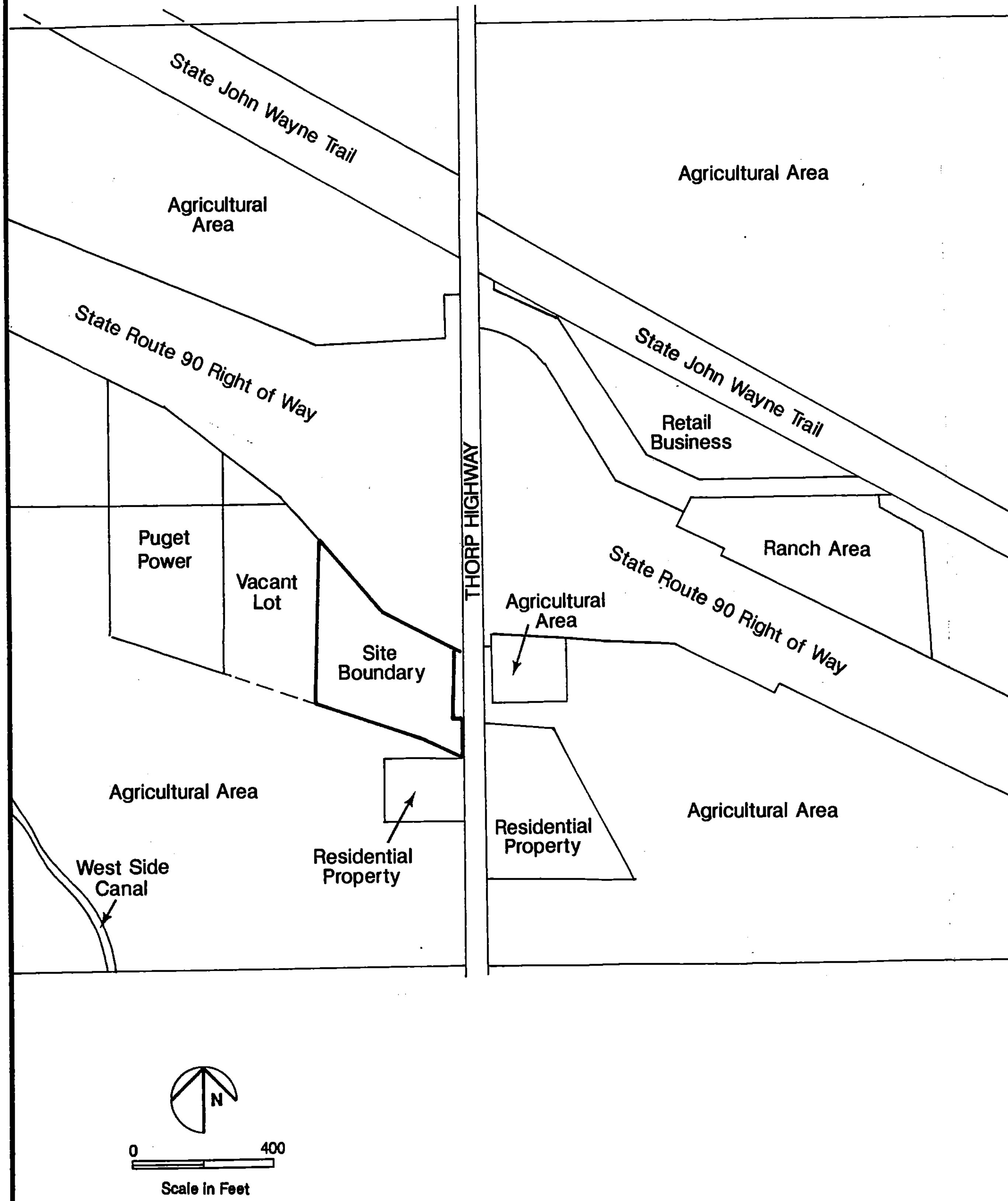
Vicinity Map

Burns Bros./Bingo Fuel Stop
Thorp, Washington

FIGURE
1-1

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF	APB	3 Mar 92		

563799



Reference: Map from Kittitas Co. Assessor Official Map

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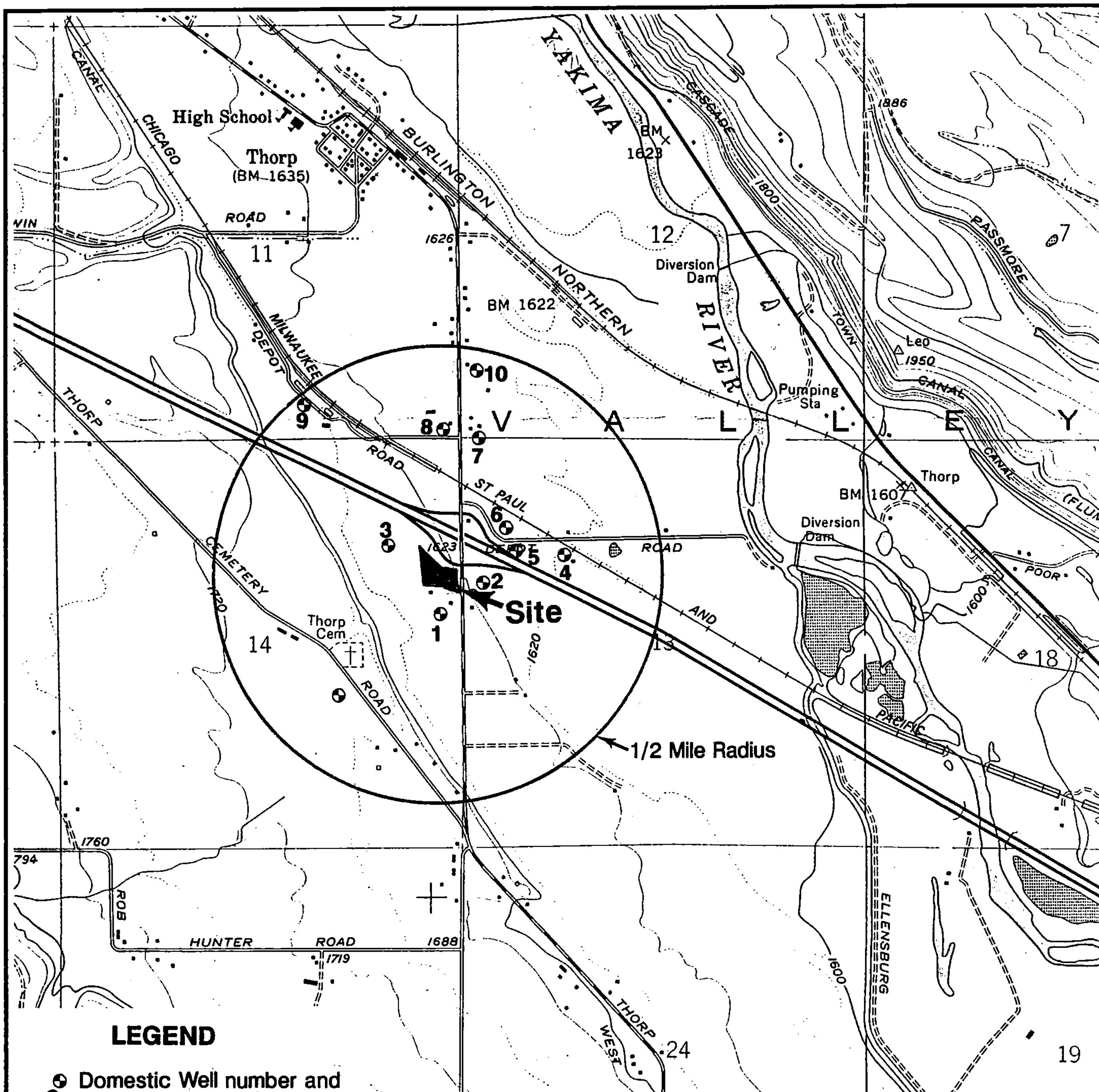
Adjacent Land Use Area Map
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **2-1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF	PPB	3/31/94		



LEGEND

Domestic Well number and approximate location

0 1000 2000 3000

Scale In Feet

Well Location	Location	Name	Depth of Well (Below Ground Surface)
1	Thorp Hwy. residence south of Bingo Fuel Stop	Brain Residence	Unknown
2	Thorp Hwy. residence east of Bingo Fuel Stop	Howry Residence	9'
3	West of Bingo Fuel Stop	Puget Power	350'
4	Depot Rd. residence east of Antique Mall	Rowley Residence	125'+
5	Depot Road	Thorp Antique Mall	100'+
6	Depot Rd. residence NW of Antique Mall	Unknown	Unknown
7	East side of Thorp Hwy., north of Depot Rd.	Gibson Residence	"Shallow"
8	West side of Thorp Hwy., north of Depot Rd.	George Residence	285
9	Depot Rd., 1/2 mile west of Thorp Hwy.	Unknown	Unknown
10	East side of Thorp Hwy., 1000' north of Depot Rd.	Wells Residence	? 153'
11	Cemetery Road southwest of site	Unknown	Unknown

Reference: From USGS 7.5 min. quadrangle titled Thorp, dated 1978.

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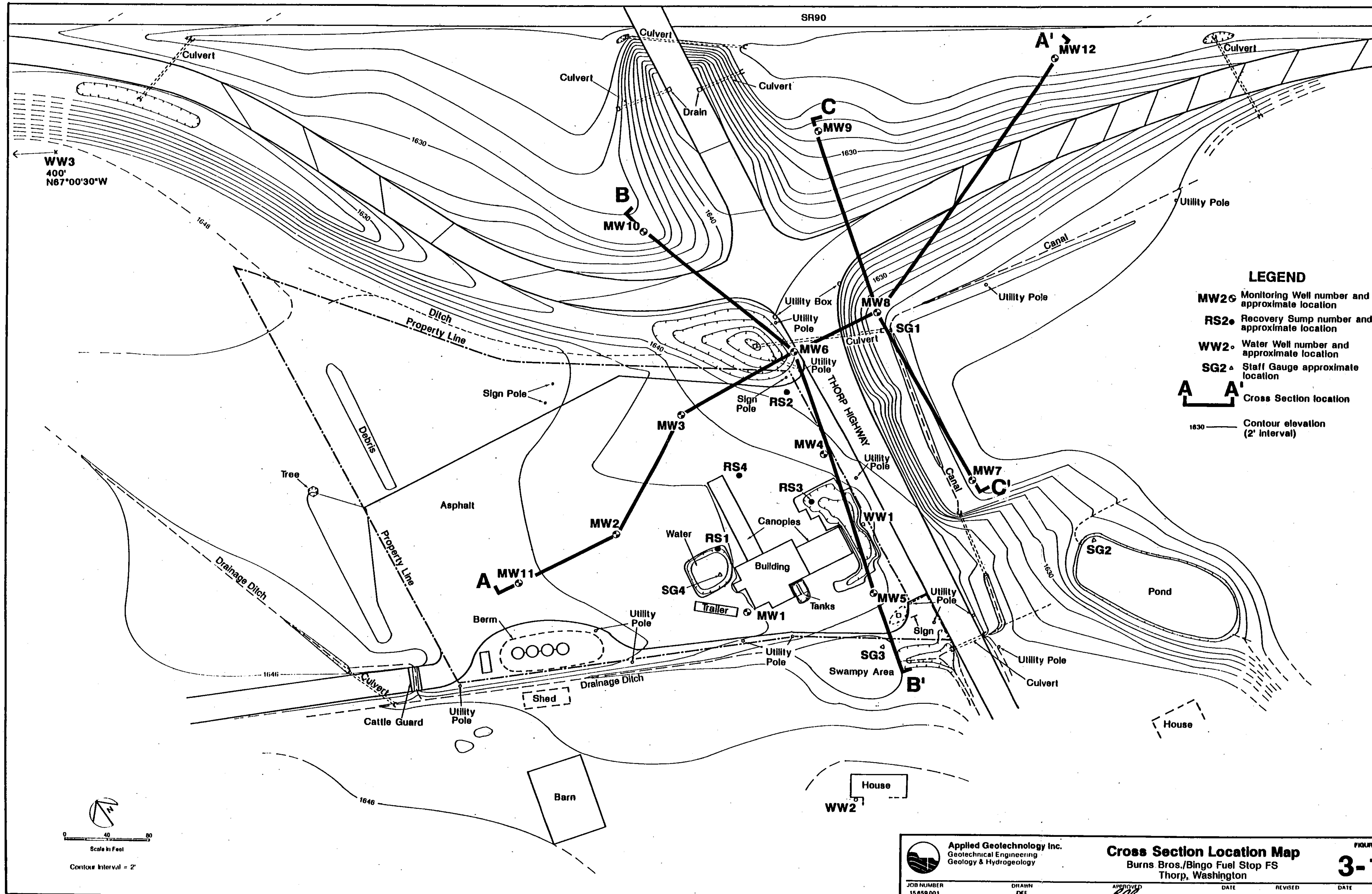
Nearby Well Location Map
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE
2-2

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF	PPB	3/31/94		



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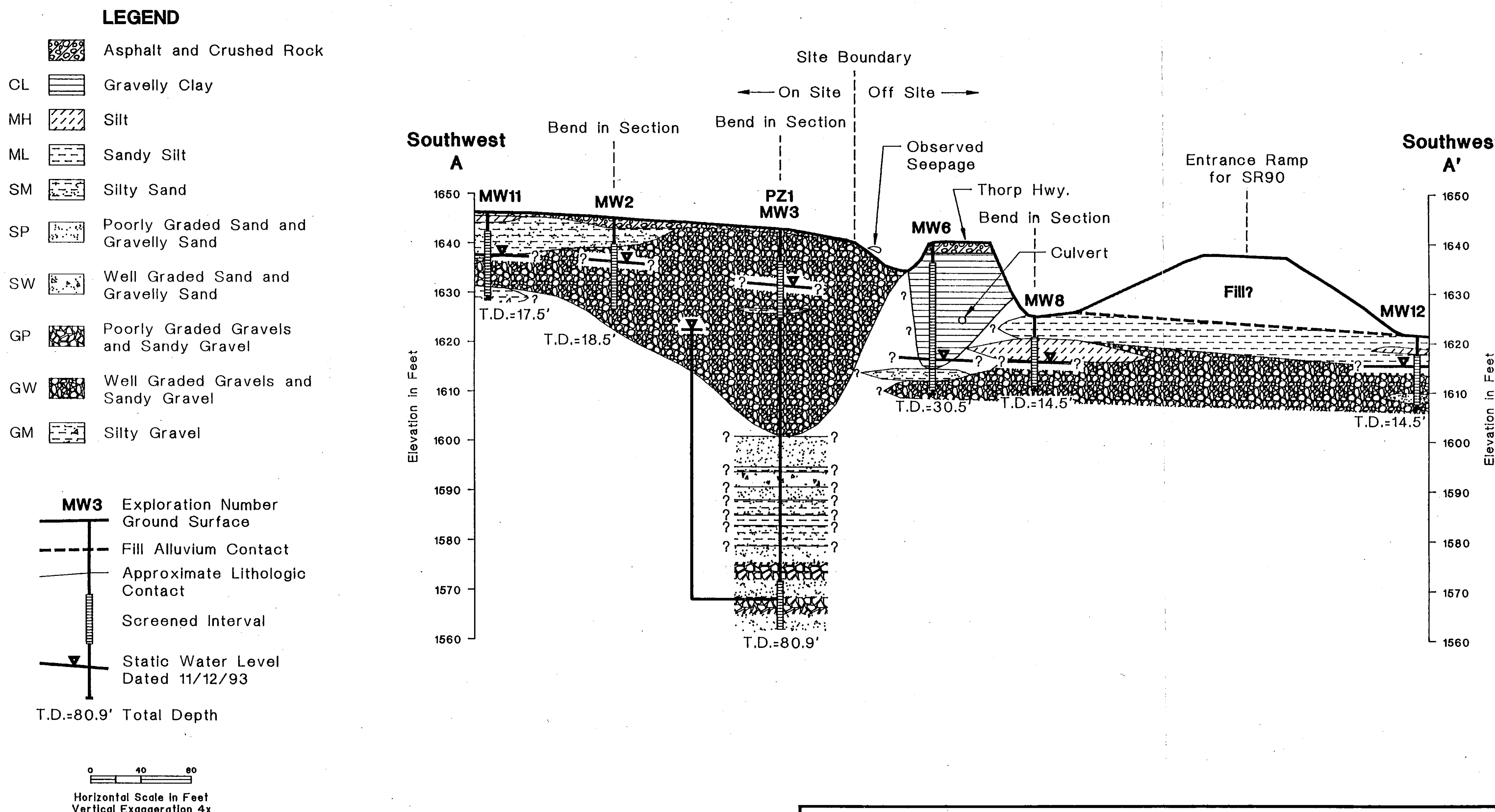
Cross Section Location Map
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **3-1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659 001	DFF				



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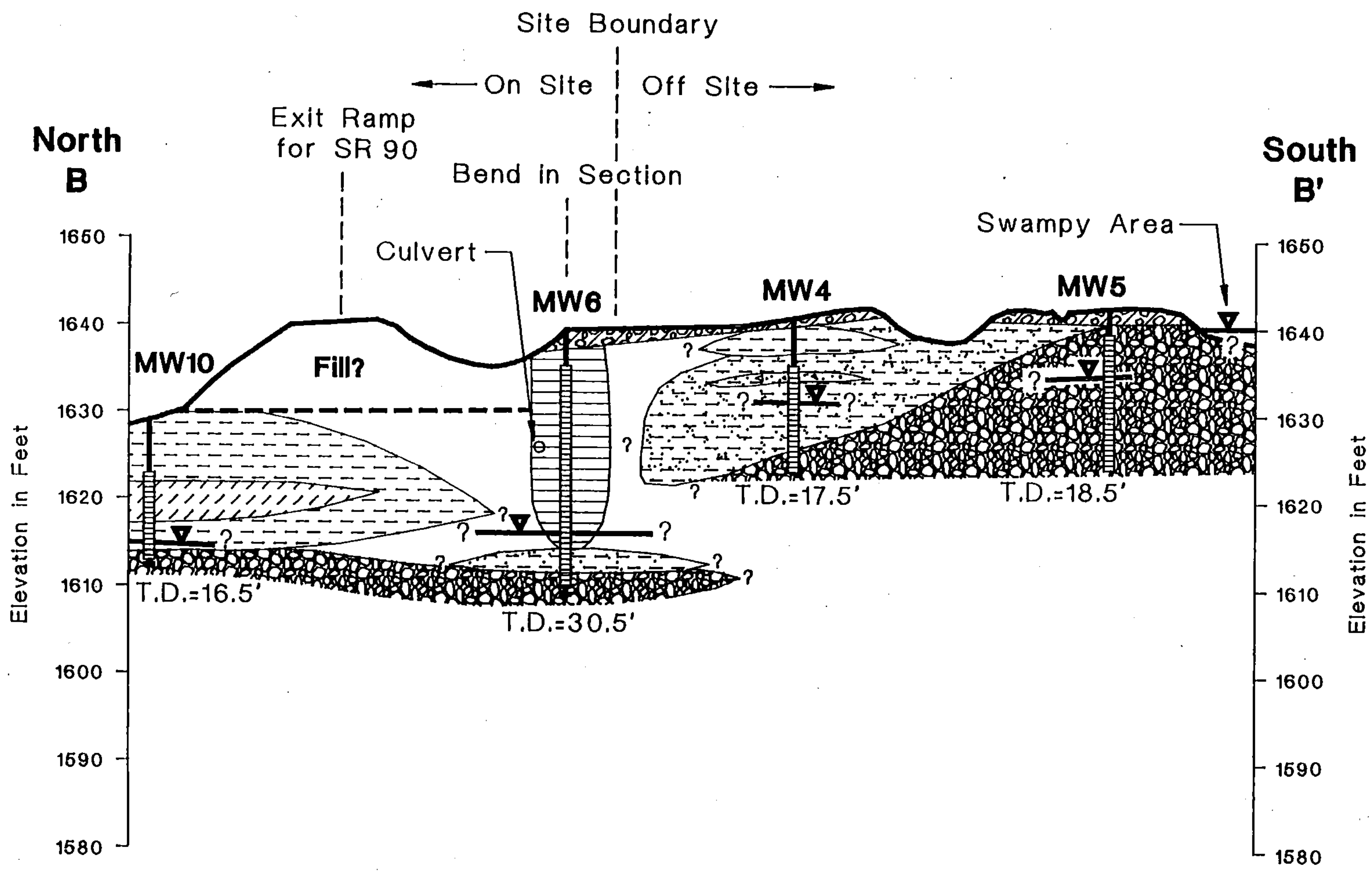
Cross Sections - A to A'
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

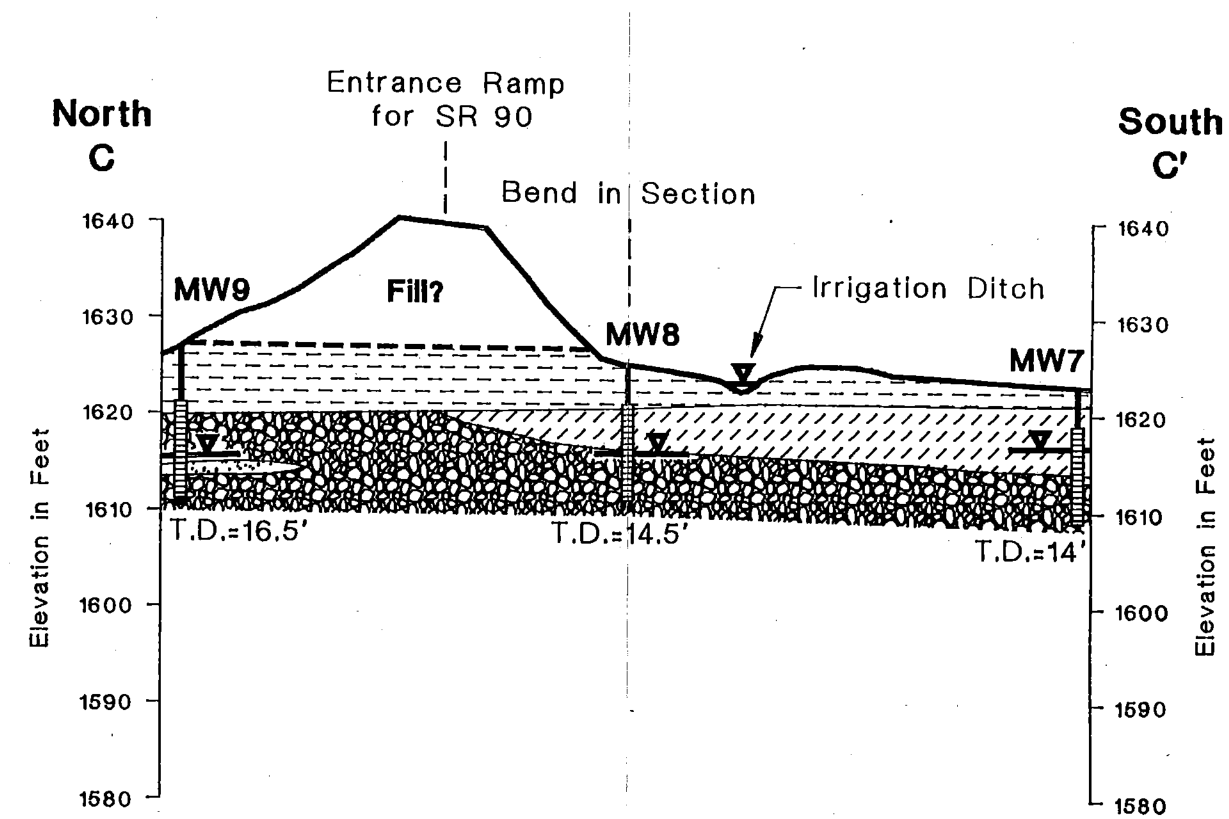
FIGURE **3-2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	JFL	[signature]	7 June 94		

563799



Cross Section B - B'



Cross Section C - C'

LEGEND

		Asphalt and Crushed Rock
CL		Gravelly Clay
MH		Silt
ML		Sandy Silt
SM		Silty Sand
SP		Poorly Graded Sand and Gravelly Sand
GW		Well Graded Gravels and Sandy Gravel
GM		Silty Gravel

MW3	Exploration Number
	Ground Surface
	Fill Alluvium Contact
	Approximate Lithologic Contact
	Screened Interval
	Static Water Level Dated 11/12/93
T.D.=80.5'	Total Depth

0 40 80
Horizontal Scale in Feet
Vertical Exaggeration 4x

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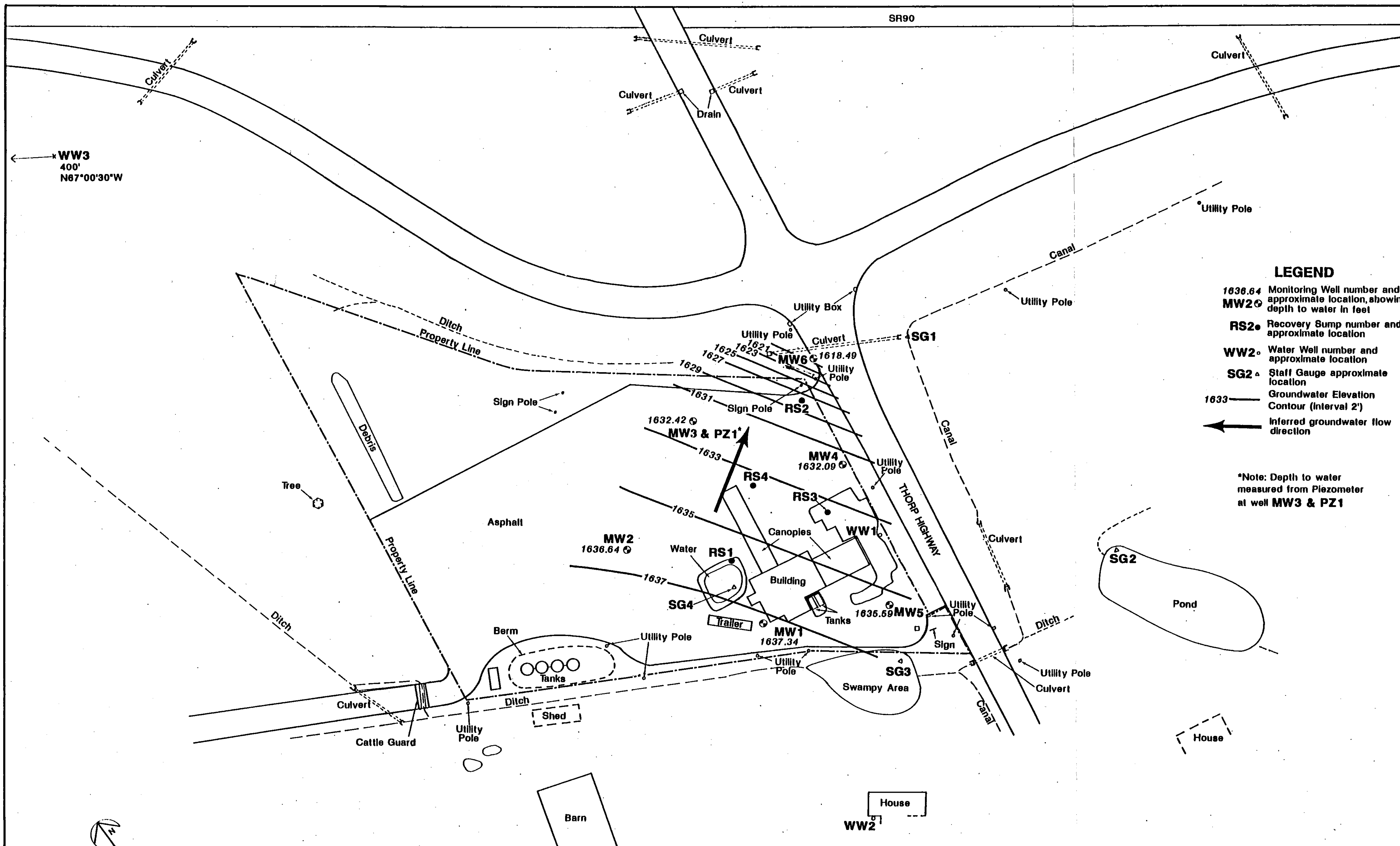
Cross Sections - B to B' and C to C'
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **3-3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	JFL		6 Dec. 93		

552900



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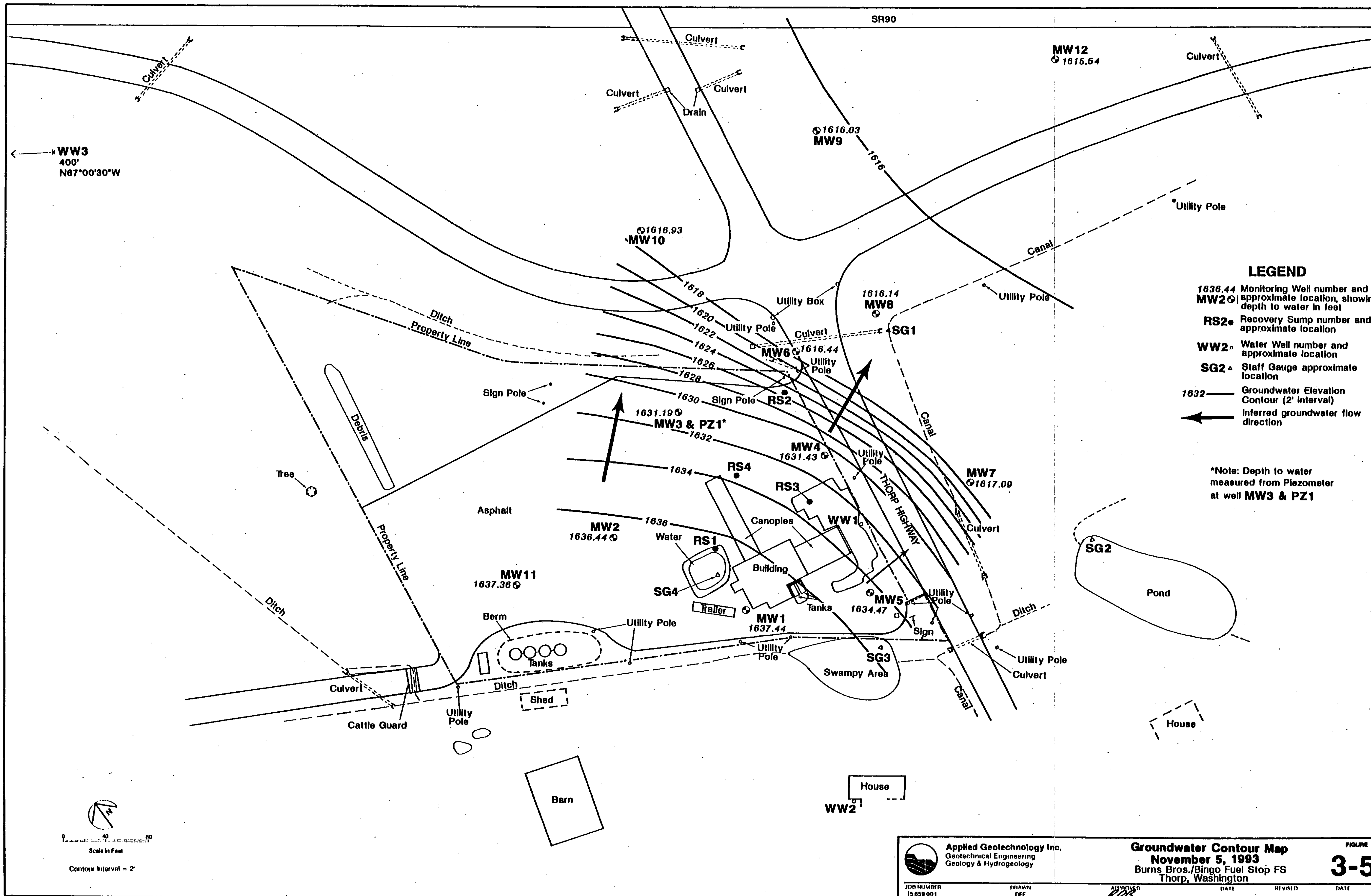
Groundwater Contour Map
July 7, 1993
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **3-4**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF				


SR90
Culvert
Drain
MW12
1615.54
1616.03
MW9
1616
WW3
400'
N67°00'30"W
Utility Pole
1616.93
MW10
Canal
1618
1620
1622
1624
1626
1628
1630
1632
1634
1636
Utility Box
1616.14
MW8
SG1
Utility Pole
MW6
1616.44
Ditch
Property Line
Sign Pole
RS2
1631.19
MW3 & PZ1*
Debris
MW4
1631.43
RS4
RS3
THORP HIGHWAY
MW7
1617.09
Tree
Asphalt
Canopies
WW1
MW2
1636.44
Water
RS1
Building
SG2
Pond
MW11
1637.36
SG4
Trailer
MW1
1637.44
Tanks
MW5
1634.47
Sign
Berm
SG3
Swampy Area
Shed
Culvert
Cattle Guard
House
Barn
WW2
LEGEND
1636.44 MW2 Monitoring Well number and approximate location, showing depth to water in feet
RS2 Recovery Sump number and approximate location
WW2 Water Well number and approximate location
SG2 Staff Gauge approximate location
1632 Groundwater Elevation Contour (2' interval)
Inferred groundwater flow direction
*Note: Depth to water measured from Piezometer at well MW3 & PZ1
N
0 40 80
Scale in Feet
Contour Interval = 2'
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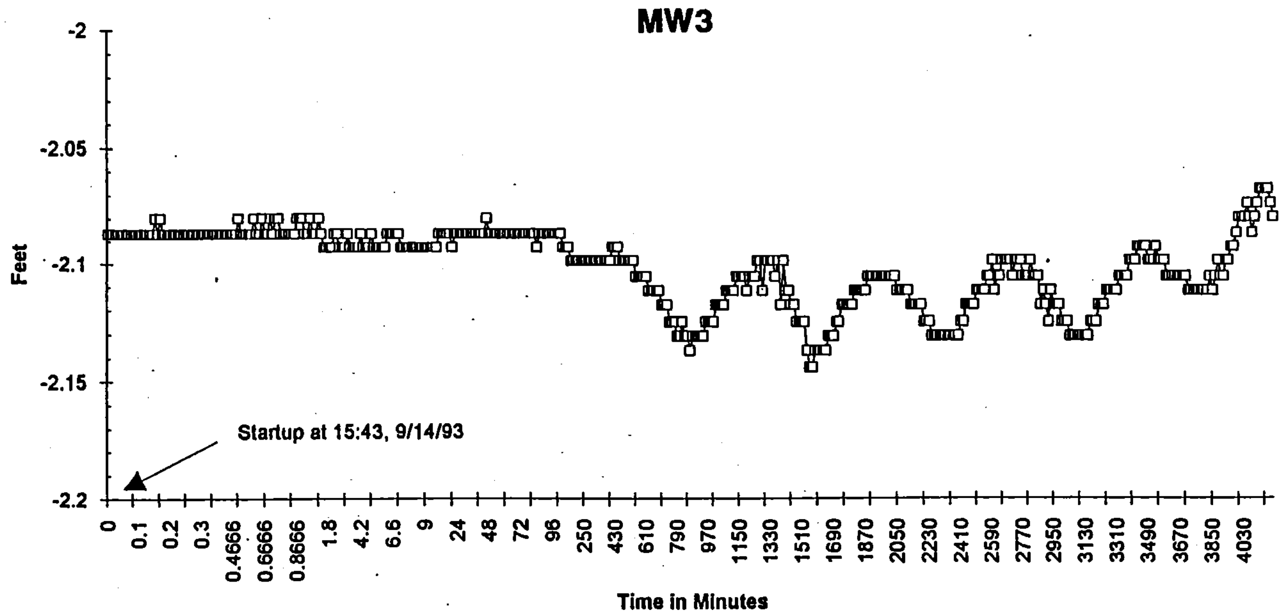
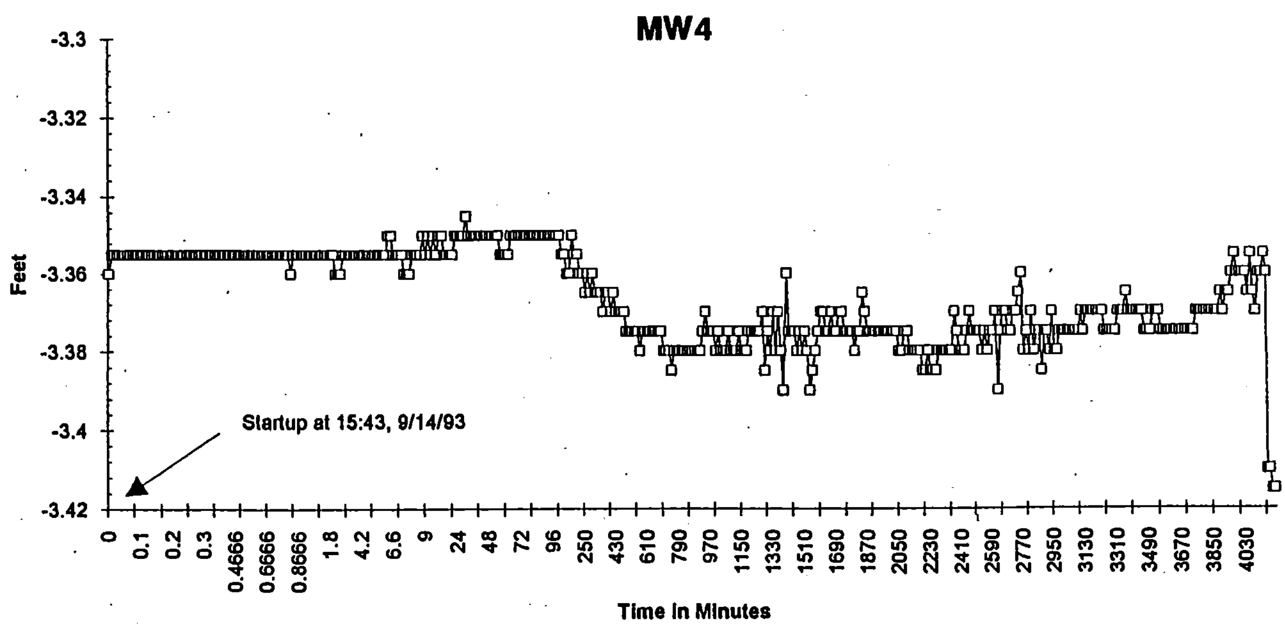
Geology & Hydrogeology
Groundwater Contour Map
November 5, 1993
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington
FIGURE
3-5
JOB NUMBER
15,659 001
DRAWN
DFF
APPROVED
DATE
REVISED
DATE





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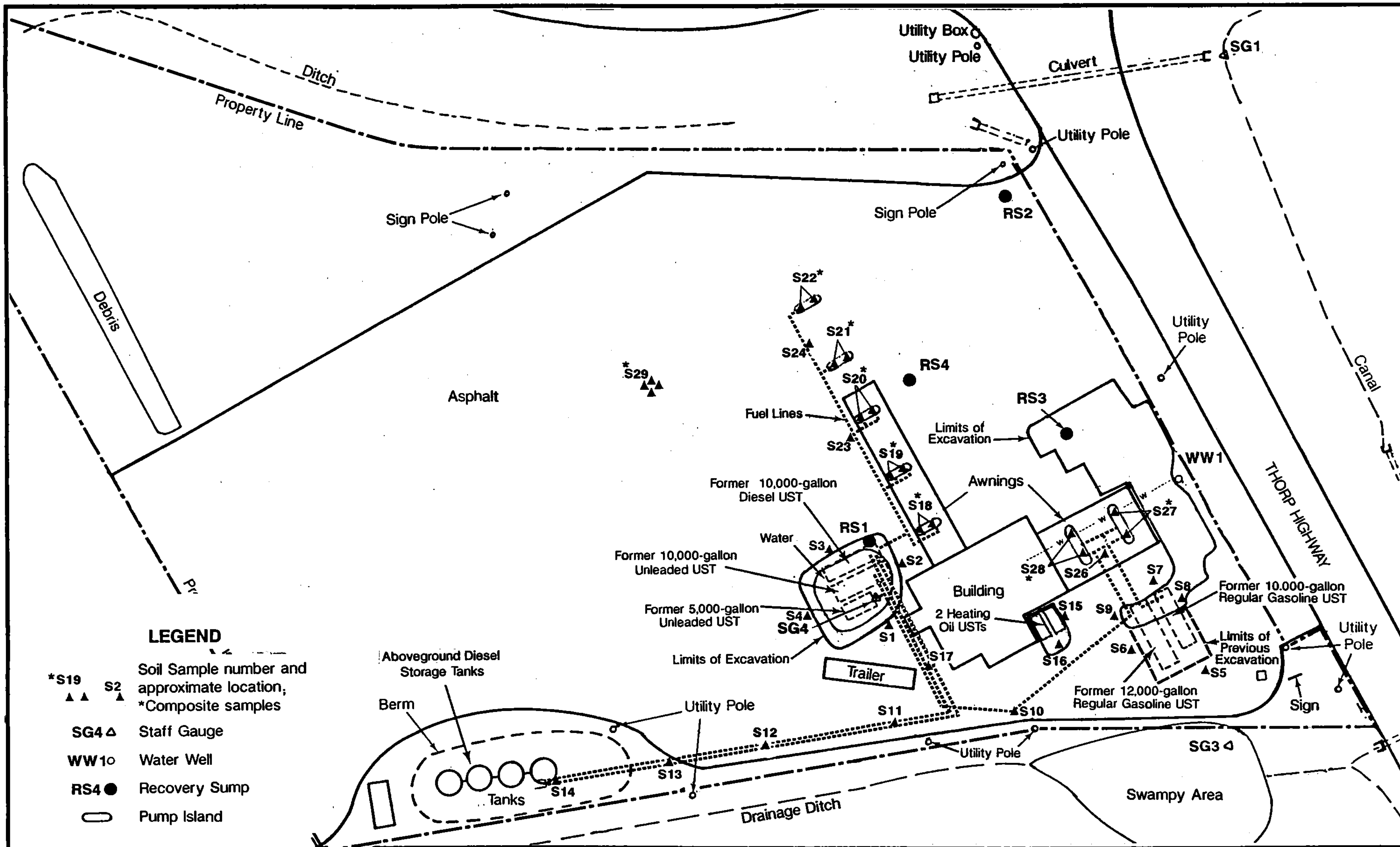
Groundwater Hydrographs MW3 & MW4
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE
3-6

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF	PPB	3/31/94		



LEGEND

*S19 S2	Soil Sample number and approximate location; *Composite samples
SG4	Staff Gauge
WW1	Water Well
RS4	Recovery Sump
	Pump Island

0 40 80

Scale In Feet

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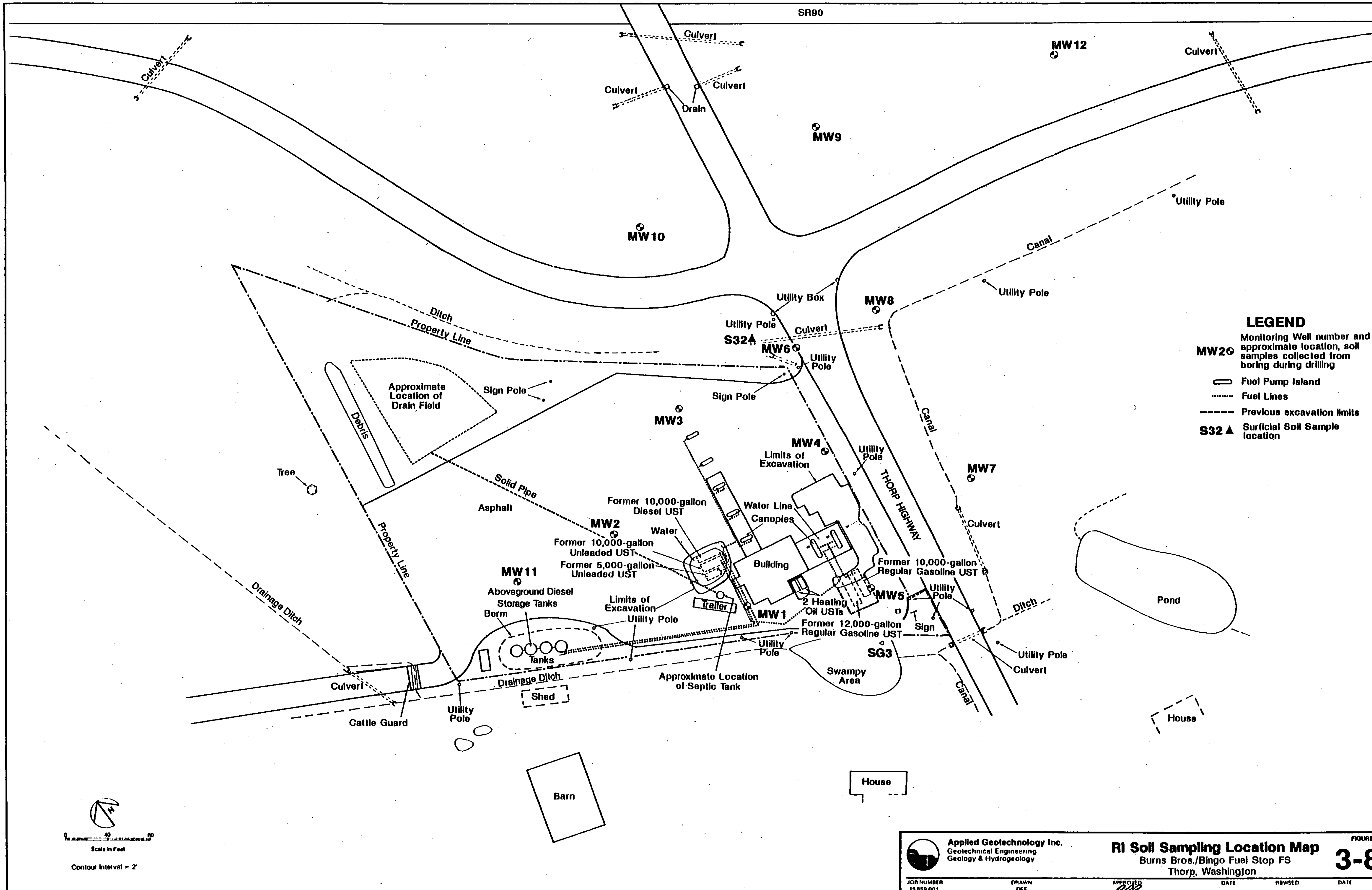
UST Removal Area Soil Sampling Location Map

Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **3-7**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF	PMB			

555044



SR90
Culvert
Culvert
Culvert
Culvert
Drain
Culvert
MW12
MW9
MW10
Utility Pole
Canal
Utility Pole
Utility Box
MW8
Utility Pole
S32
Culvert
MW6
Utility Pole
Sign Pole
Ditch
Property Line
Approximate Location of Drain Field
Sign Pole
Debris
MW3
MW4
Limits of Excavation
Utility Pole
Canal
THORP HIGHWAY
MW7
Tree
Solid Pipe
Asphalt
Former 10,000-gallon Diesel UST
Water Line
Canopies
MW2
Water
Former 10,000-gallon Unleaded UST
Former 5,000-gallon Unleaded UST
Building
Culvert
Former 10,000-gallon Regular Gasoline UST
Property Line
MW11
Aboveground Diesel Storage Tanks
Berm
Limits of Excavation
Trailer
2 Heating Oil USTs
MW5
Utility Pole
Ditch
Pond
Drainage Ditch
Utility Pole
MW1
Former 12,000-gallon Regular Gasoline UST
Sign
Tanks
Utility Pole
SG3
Utility Pole
Culvert
Swampy Area
Canal
Culvert
Drainage Ditch
Shed
Approximate Location of Septic Tank
Cattle Guard
Utility Pole
House
House
Barn
N
0 40 80
Scale in Feet
Contour Interval = 2'
LEGEND
MW2 Monitoring Well number and approximate location, soil samples collected from boring during drilling
Fuel Pump Island
Fuel Lines
Previous excavation limits
S32 Surficial Soil Sample location
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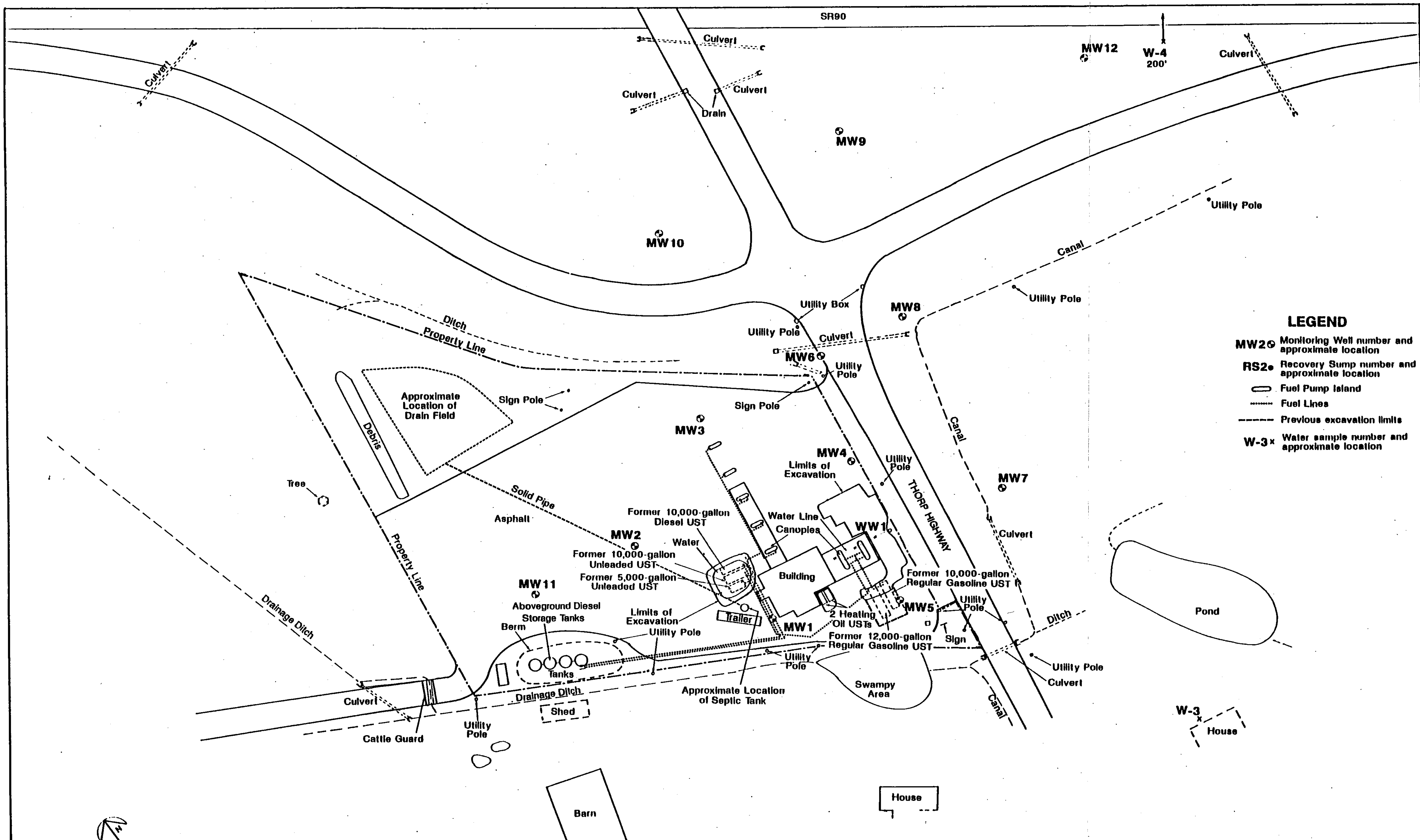
Geotechnical Engineering
Geology & Hydrogeology
RI Soil Sampling Location Map
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington
FIGURE
3-8
JOB NUMBER 15,659.001
DRAWN DFF
APPROVED
DATE
REVISED
DATE



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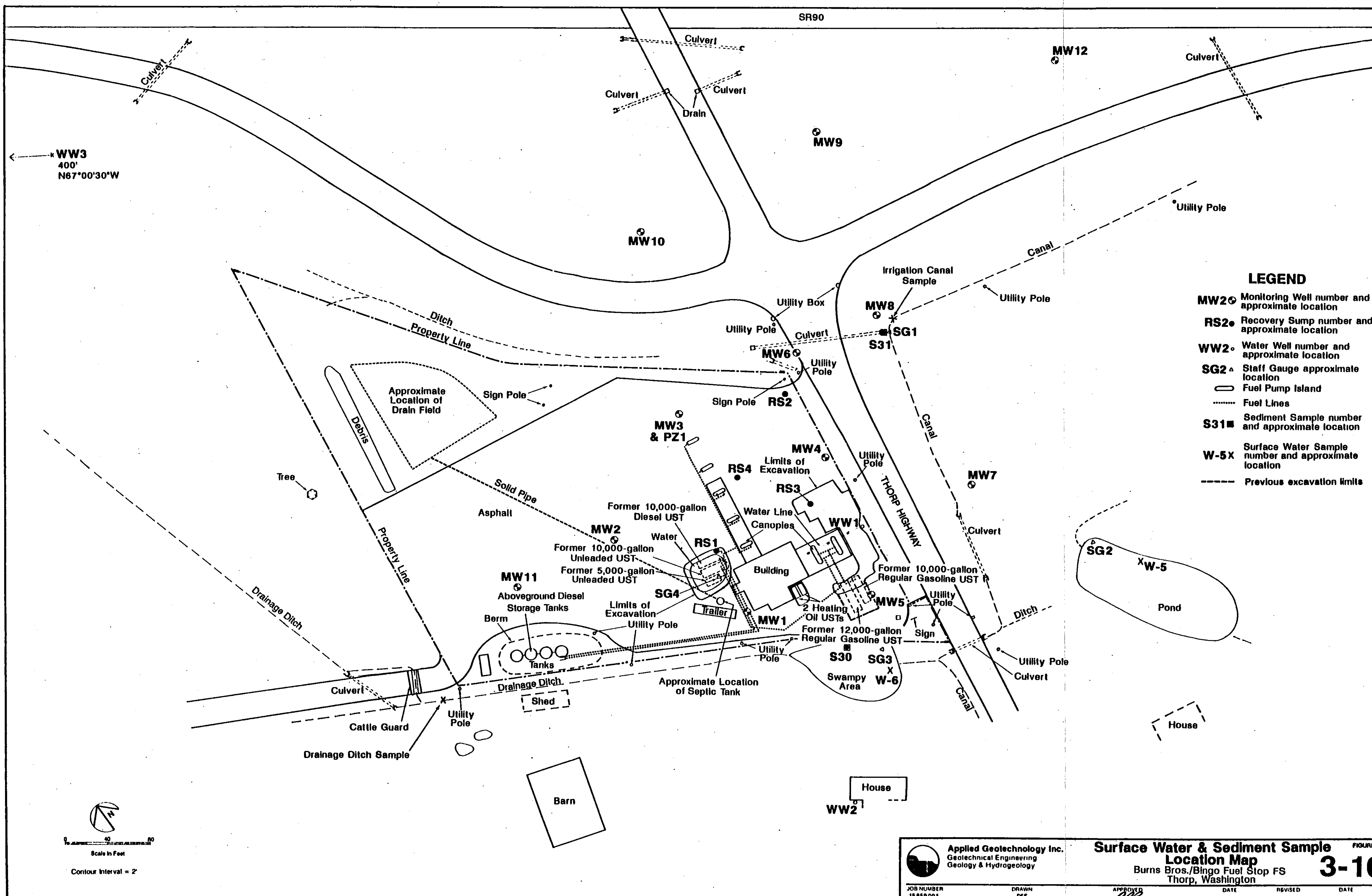
Groundwater Sampling Location Map
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **3-9**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,859.001	DFF				



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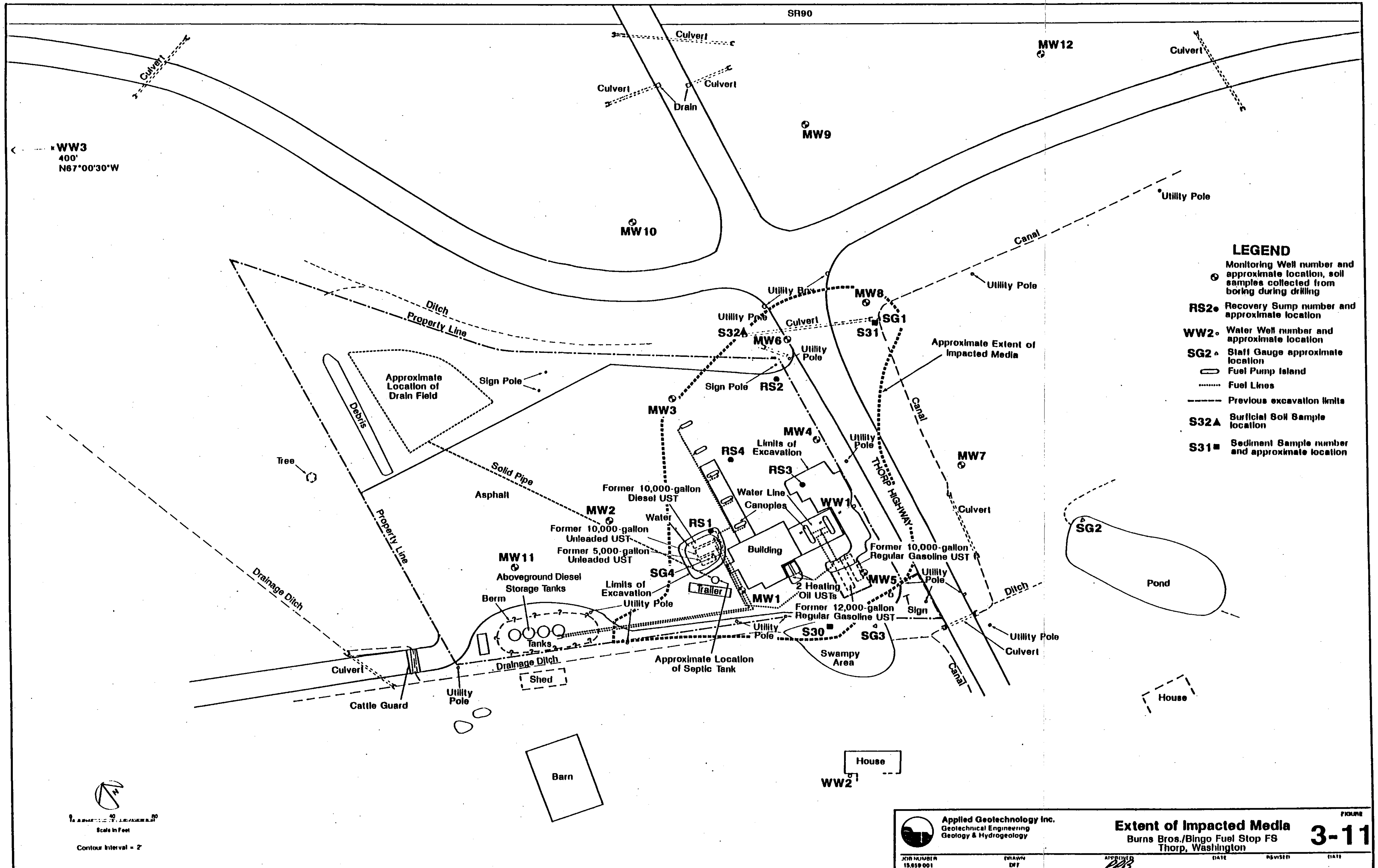
Surface Water & Sediment Sample Location Map
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

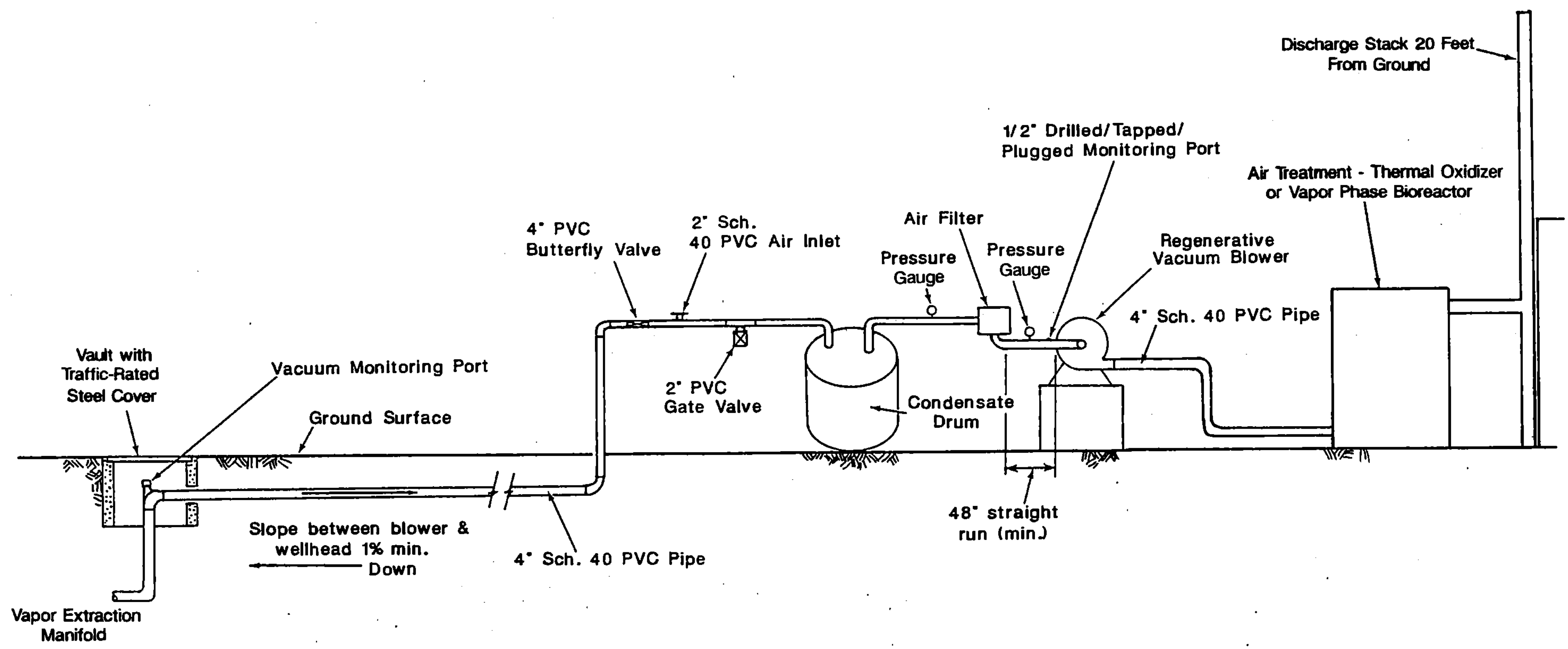
FIGURE **3-10**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,859.001	DFF	PAB			



Extent of Impacted Media
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE 3-11



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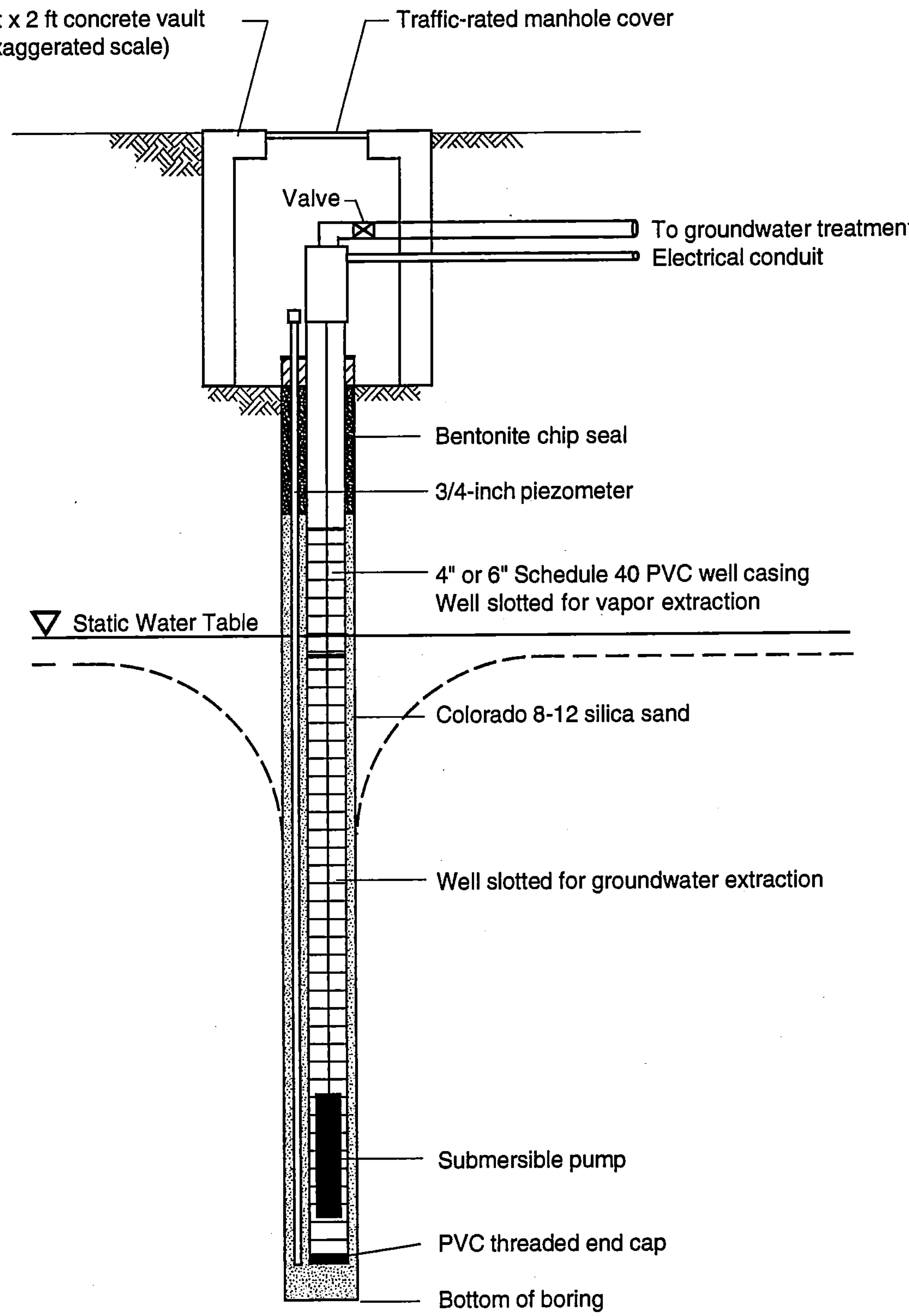
Typical Vapor Extraction System Schematic

Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **5-1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF				

563799



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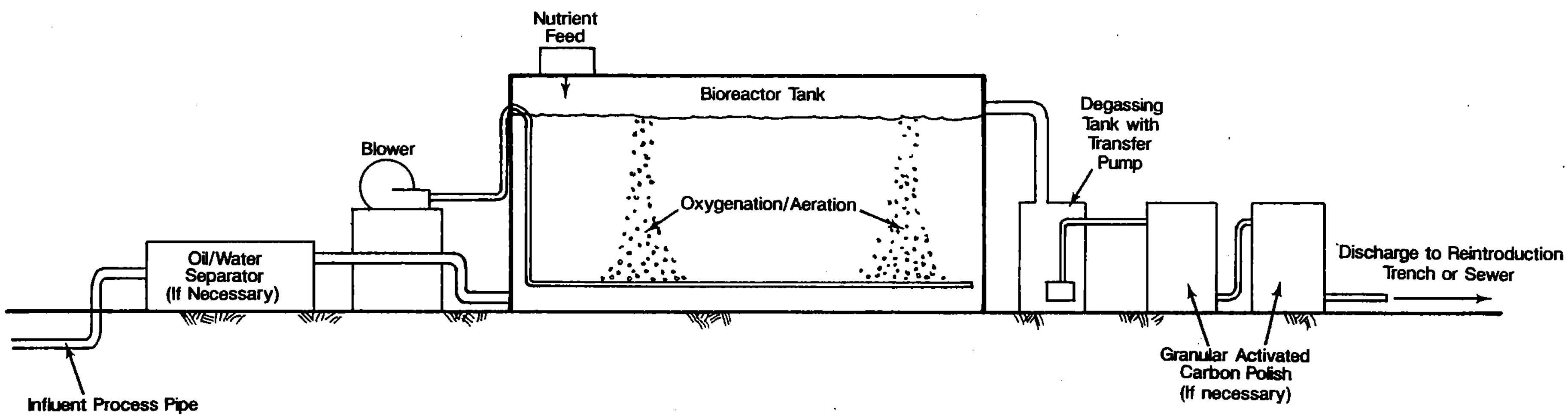
Conceptual Groundwater Extraction Well

Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **5-2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF				



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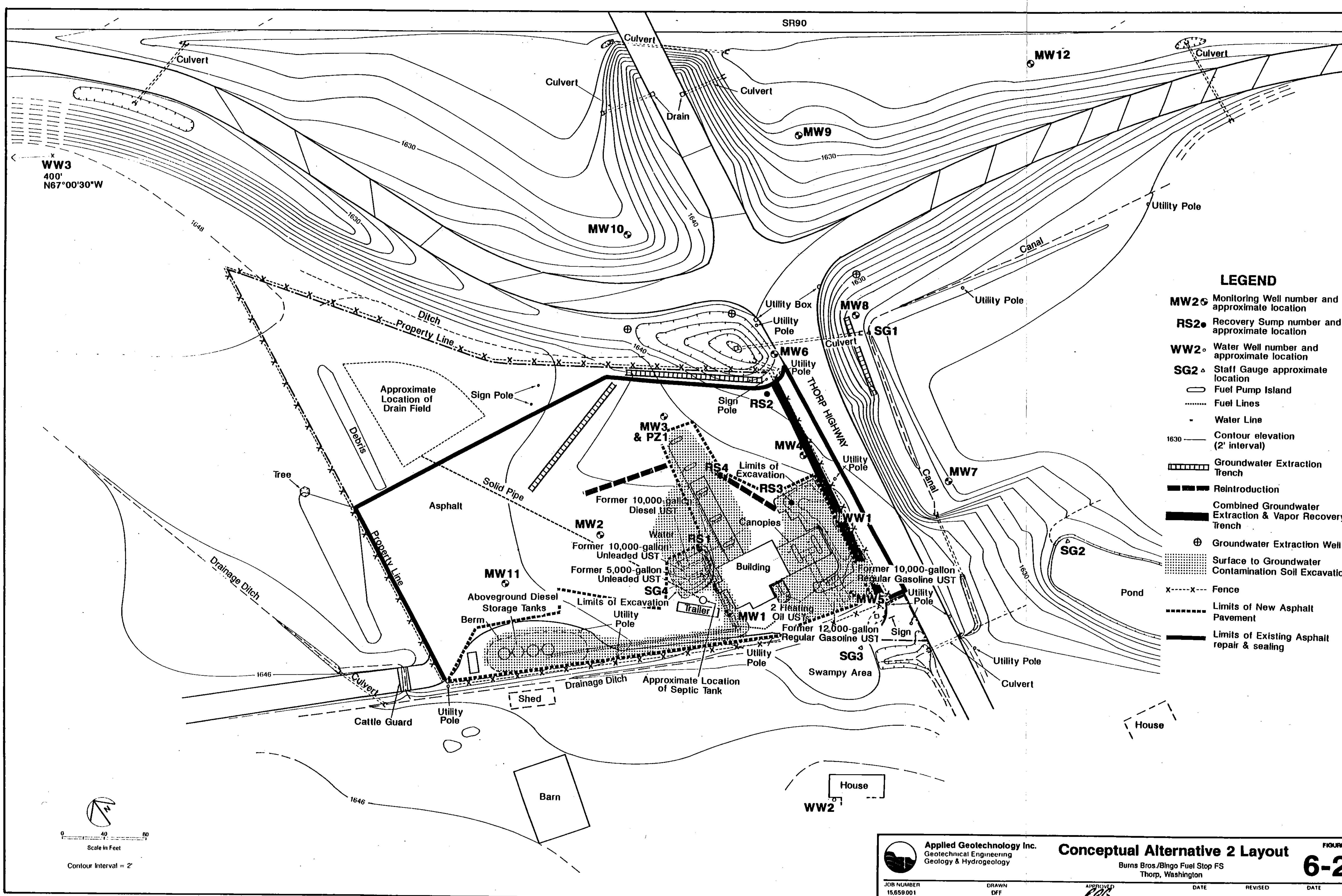
Typical Biological Treatment System

Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **5-3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF				

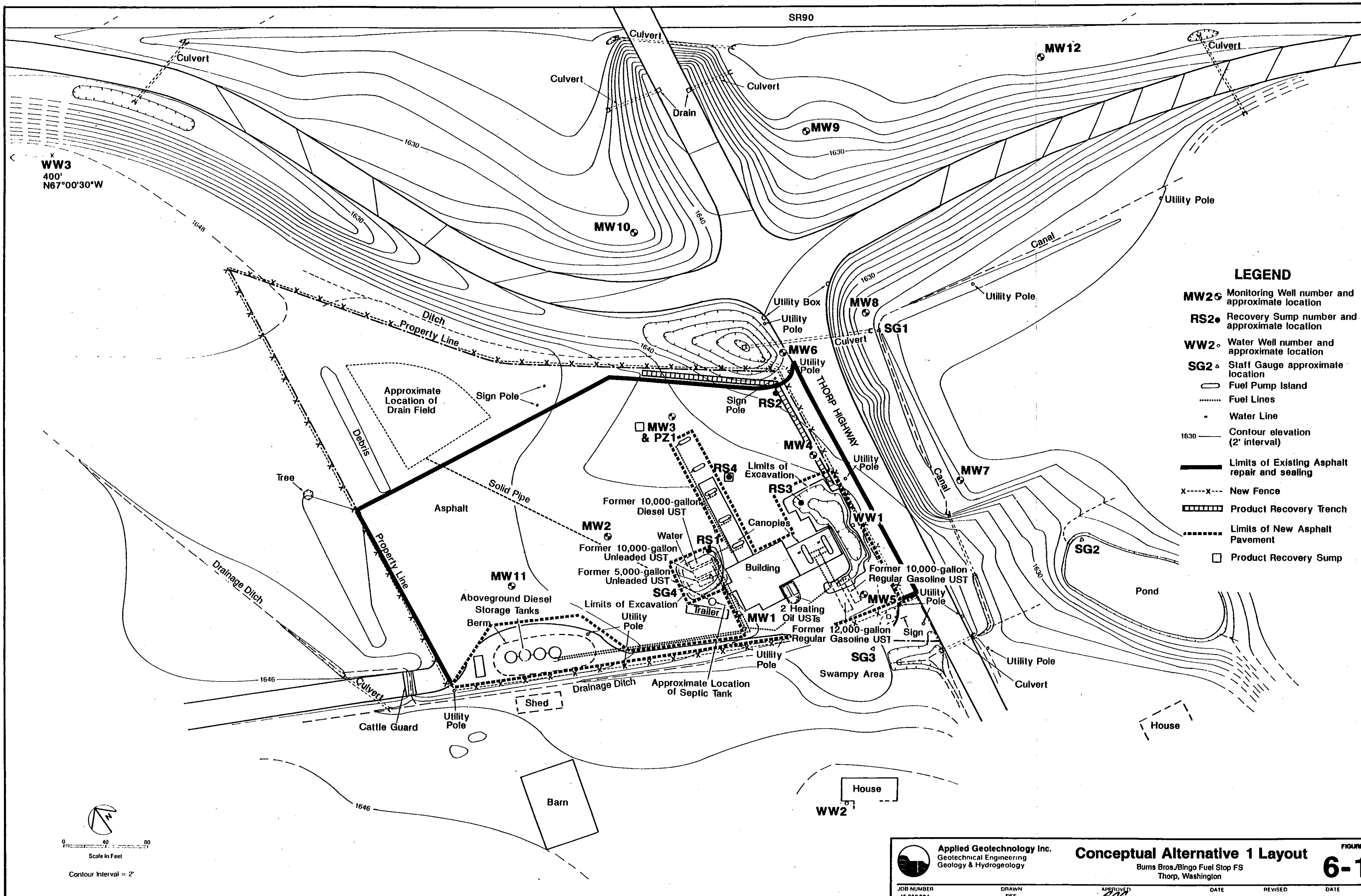
563799



Conceptual Alternative 2 Layout

Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **6-2**



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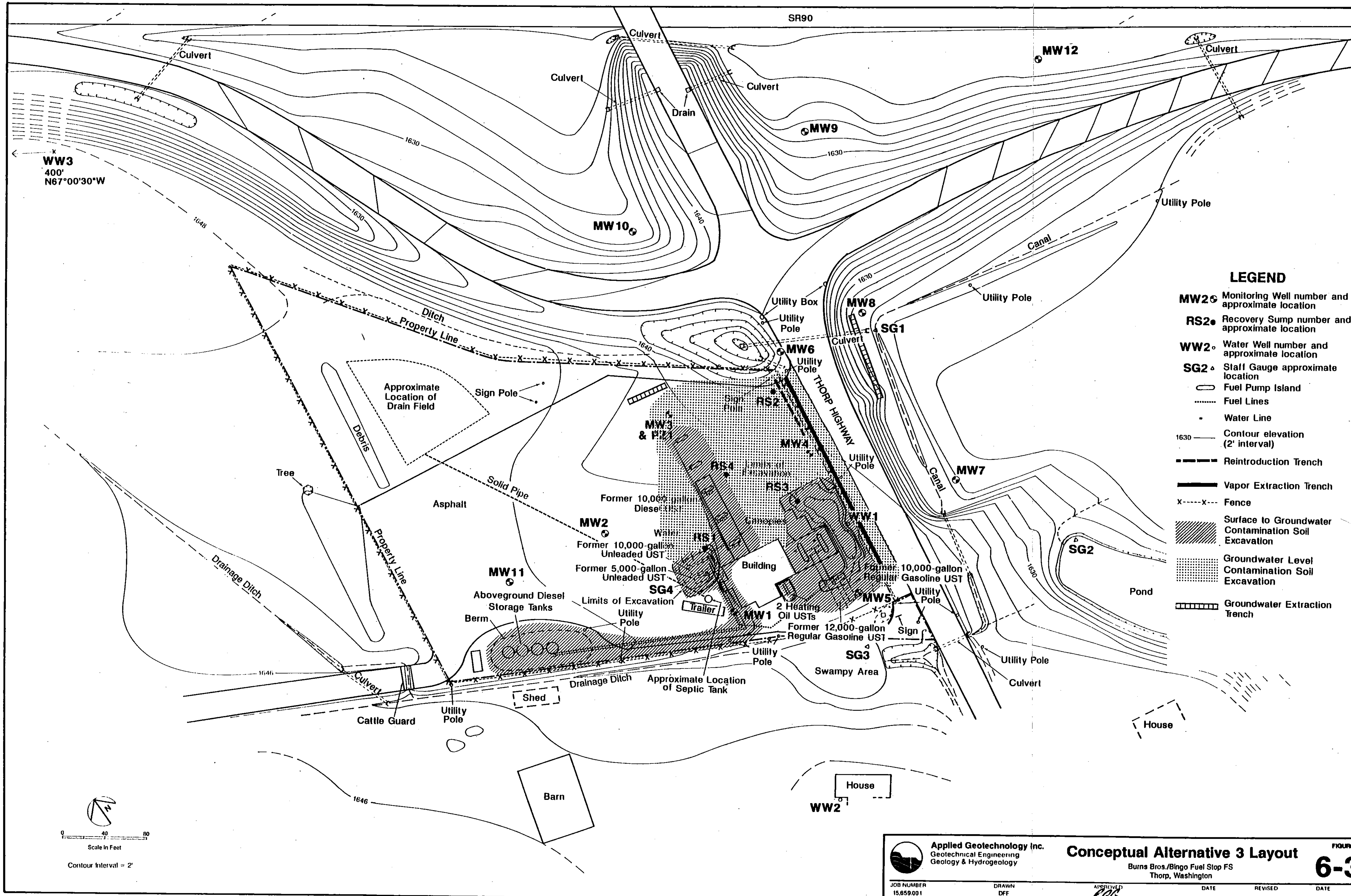
Conceptual Alternative 1 Layout

Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

FIGURE **6-1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,659.001	DFF				



Conceptual Alternative 3 Layout
Burns Bros./Bingo Fuel Stop FS
Thorp, Washington

APPENDIX A

Summary of Potential ARARs

APPENDIX A

Summary of Potential ARARs

ACTION-SPECIFIC ARARs

Federal

40 CFR Part 50; National Primary and Secondary Ambient Air Quality Standards

40 CFR Part 61; National Emission Standards for Hazardous Air Pollutants

40 CFR Part 261; Identification and Listing of Hazardous Waste

40 CFR Part 262; Standards Applicable to Generators of Hazardous Waste

40 CFR Part 268; Land Disposal Restrictions

40 CFR Part 122; Administered Permit Programs The National Pollutant Discharge Elimination System

40 CFR Part 125, Subpart A; Criteria and Standards for Imposing Technology-Based Treatment Requirements

40 CFR Part 131; Water Quality Standards

40 CFR Part 136; Guidelines Establishing Test Procedures for the Analysis of Pollutants

40 CFR Part 403; General Pretreatment Regulations of Existing and New Sources of Pollution

49 CFR Part 171; Subchapter C-Hazardous Materials Regulations

49 CFR Part 172; Hazardous Materials Tables, Hazardous Materials Communication Requirements, and Emergency Response Information Requirements

29 CFR 1910.120; Hazardous Waste Operations and Emergency Response

State

WAC 173-400; General Regulations for Air Pollution Sources

WAC 173-460; Controls for New Sources of Toxic Air Pollutants

WAC 173-470; Ambient Air Quality Standard for Particulate Matter

WAC 173-303; Dangerous Waste Regulations

WAC 192-11; SEPA Rules

WAC 173-201A; Washington Water Quality Standards

WAC 173-216; State Waste Discharge Permit Program

WAC 173-220; NPDES Permit Program

WAC 173-154; Protection of Upper Aquifer Zones

WAC 173-160; Minimum Standards for Construction and Maintenance of Wells

CHEMICAL-SPECIFIC ARARS

Federal

40 CFR Part 131; Water Quality Standards

State

WAC 173-340; Model Toxics Control Act Cleanup Regulation

APPENDIX B

Cleanup Alternative Costs

APPENDIX B

Cleanup Alternative Costs

UNCERTAINTIES IN COST ESTIMATES

Traditionally, cost estimates in feasibility studies use single "point" estimates of task variables, such as unit costs, total volumes, etc., to predict the cost to perform a specific task. The estimated costs are then summed over the tasks in an alternative, and a somewhat arbitrary cost distribution of -30 percent to +50 percent is assumed to reflect actual costs to perform the alternative. Unfortunately, the arbitrary range does not usually reflect actual uncertainties in costing.

Feasibility studies are usually performed with fairly accurate unit costs, but with incomplete site- or waste-specific data, for the following reasons:

- Accurate unit costs are usually available for construction, permitting, engineering, and most treatment tasks unless the task contains innovative technologies or would need to be performed under difficult conditions (extreme weather, operating facilities, etc.).
- Gathering necessary data for potential alternatives prior to a fairly detailed screening would often be prohibitively expensive and unnecessary since many of the alternatives would be eliminated during the primary evaluation.
- Complete characterization of the site prior to beginning the Feasibility Study (FS) typically adds several months to the process. This may be unacceptable due to regulatory, corporate, or public concerns; it may be unnecessary if sufficient data can be collected to evaluate and rank the alternatives.
- For many cleanups it is far more efficient in both time and money to determine accurate volumes of contaminated media during remedial design or action.

Increasingly, feasibility studies are being performed as soon as the minimum amount of necessary data has been collected. Feasibility studies performed at this stage can usually successfully rank alternatives, but may be unable to select process options.

Costing procedures capable of reflecting actual uncertainties are valuable for the following reasons:

- They allow more accurate ranking and evaluation of the alternatives because the uncertainties are more clearly identified.
- They help focus discussions of data needs during remedial design by identifying those data gaps that have profound effects on the costing and selection of the preferred alternative.
- They allow more accurate input of what is known (or unknown) about costs or quantities as well properly modeling their interrelationships (i.e., higher quantities of soil excavation would correlate to lower unit costs).

- They provide a more accurate and usually narrower range of costs than "worst-case/best-case" estimates since all of an alternative's uncertainties are combined by effectively running hundreds of "what-if" scenarios simultaneously. This is graphically shown by a probability distribution curve where each outcome versus its likelihood of occurrence is shown.

Note that although this discussion focuses on uncertainties in costs and quantities, these uncertainties are almost always reflected in other evaluation criteria such as implementability or effectiveness.

USING MONTE CARLO-TYPE SIMULATIONS TO ESTIMATE UNCERTAINTIES

The task of estimating the uncertainty in cost estimates can be thought of as a form of propagation of errors. Each parameter in the cost estimate has an uncertainty associated with it. The goal is to propagate the effect of all of these uncertainties through the calculations to obtain an estimate of the uncertainty in the total cost.

Some parameters, such as unit costs, can have symmetric uncertainties; for example, a cubic yard of pit run gravel will cost ± 10 percent. Some parameters, such as the number of extraction wells, may be best defined as a cumulative probability distribution.

A probability distribution can be defined for each parameter. Since many of these distributions may be nonsymmetric, the easiest way to estimate the total uncertainty in the cost is usually to perform a large number of simulations of the total cost. In each simulation, each parameter is pulled randomly from its distribution and inserted into the cost equation to estimate the total cost. Each parameter is assumed to be independent of all other parameters unless a dependency relationship is specified. Dependency relationships can be proportional, inverse, or some gradation in between. The simulation can be performed many times (500 to 5,000 simulations are typical) and a frequency distribution plotted of the total cost outcomes. The distribution is used to define the most likely total cost of the alternative and the uncertainty in the estimated cost.

This general approach is referred to as Monte Carlo simulation and is available as a computer add-in program to popular computer spreadsheet programs. This estimate of uncertainties used a commercially available program called @RISK (Palisade Corp., Newfield, New York) as an add-in to Microsoft's Excel spreadsheet program. A specific approach called "Latin Hypercube" was used to randomly select parameter values from their distribution. The following description is taken from the @RISK manual (Version 1.1 of @RISK for Windows).

LATIN HYPERCUBE SAMPLING

Latin Hypercube sampling is a recent development in sampling technology designed to accurately recreate the input distribution through sampling in fewer iterations when compared with the classical Monte Carlo method. The key to Latin Hypercube sampling is stratification of the input probability distributions. Stratification divides the cumulative curve into equal intervals on the cumulative probability scale (0 to 1.0). A sample is then randomly taken from each interval or "stratification" of the input distribution. Sampling is forced to represent values in each interval, and thus, is forced to recreate the input probability distribution.

The technique being used during Latin Hypercube sampling is "sampling without replacement." The number of interviews of the cumulative distribution is equal to the number of iterations performed. A sample is taken from each interval. However, once a sample is taken from an interval, this interval is not sampled again--its value is already represented in the sampled set.

Latin Hypercube helps the analysis of situations where low probability outcomes are represented in input probability distributions. By forcing the sampling of the simulation to include these outlying events, Latin Hypercube samples assure they are accurately represented in the simulation output.

NOTE ON COSTING TABLES

The full implementation of uncertainty analysis was not performed for this FS. The uncertainties associated with unit costs and with some site parameters have been implemented herein, and these are clearly shown on the following costing tables. Many site parameters were not varied within the FS because they have cumulative effects difficult to model within individual process options, which then may impact some or all alternatives. The level of effort used is appropriate at the FS stage, which is used to compare alternatives and determine cost/benefit impacts. After specific alternatives are chosen, site parameters could be further varied at the remedial design level to further define potential cost ranges based on more specific data.

GLOSSARY OF TERMS

QUANTITIES AND UNIT COSTS

Quantities and unit costs are input using a histogram probability distribution based on a range from the low (minimum) to the high (maximum). This range is divided into five classes based on its percent of the range: 0 to 20 percent, 21 to 40 percent, etc. Each class is assigned a weight *p*, reflecting the probability of occurrence of a value, within the class. Each class is assigned a weight one with the exception of the class containing the likely value which is assigned a value of three. The probability function normalizes these values by summing all of the specified weights and dividing each by this sum.

TOTAL PRESENT VALUE

The total present value is calculated for each alternative and rounded to the nearest 10,000 from the Latin Hypercube simulation (1,000 iterations) with low, likely, and high defined by the following probabilities:

- Low - 10 percent (there is only a 10 percent probability that actual costs will be at or below this cost).
- Likely - 50 percent (there is a 50 percent probability that actual costs will be at or below this cost).
- High - 90 percent (there is a 90 percent probability that actual costs will be at or below this value or only a 10 percent chance that this value will be exceeded).

All cash flows are converted to present value using an interest rate of 5 percent as part of the simulation.

UNIT ABBREVIATIONS

bgs	below ground surface
cf	cubic feet
cfs	cubic feet per second
cy	cubic yard
ea	each
ft	feet
gpm	gallon per minute
ls	lump sum
qtr	quarterly
sf	square feet
sy	square yard
yd	yard
yr	year

Table B1
Alternative 1 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

8/16/94

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
Soil								
Land Use Restrictions								
Formulation & Implementation		1 ls		3,500	5,000	10,000		
New Fencing		1,600 ft		7.00	9.50	11.00		Commercial 6' chain link fence with 20' gate
Total Present Value (low, likely, high)				**18,000**	**21,000**	**24,000**		
Surface Water Controls & Capping								
Asphalt Pavement		90,000 sf		0.40	0.50	0.65		Includes 2" overlay over existing pavement
Total Present Value (low, likely, high)				**39,000**	**44,000**	**55,000**		
Groundwater								
Groundwater Use Restrictions								
Formulation & Implementation		1 ls		3,500	5,000	10,000		
Total Present Value (low, likely, high)				**4,000**	**6,000**	**9,000**		
Groundwater Monitoring								
Sampling Wells (12)		4 qtr		1,000	1,500	2,500	30 **	
Analytical Testing		4 qtr		1,500	2,000	3,000	30 **	
Reporting		4 qtr		1,000	2,000	4,000	30 **	
Total Present Value (low, likely, high)				**302,000**	**374,000**	**465,000**		
Product Recovery								
Product Recovery Trench		235 ft		10.00	13.00	17.00		
Product Recovery Sump		2 ea		5,000	8,000	12,000		
Operation & Maintenance		1 yr		12,000	14,400	21,600	5 **	
Total Present Value (low, likely, high)				**77,000**	**88,000**	**107,000**		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

Table B1
Alternative 1 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

8/16/94

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
Indirect Costs (as a % of capital costs)								
Engineering & Project Management					15%			
Alternative Total Present Values* (low, likely, high)								Includes capital plus operation & maintenance costs
Institutional Controls with Product Recovery				481,000	551,000	646,000		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

8/16/94

Table B2
Alternative 2 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Process Description	Quantities (# of units) Low	Likely	High	Costs ($/unit) Low	Likely	High	Years	Comments
Soil								
Land Use Restrictions								
Formulation & Implementation		1 ls		3,500	5,000	10,000		
New Fencing		1,600 ft		7.00	9.50	11.00		Commercial 6' chain link fence with 20' gate
Total Present Value (low, likely, high)				**18,000**	**21,000**	**24,000**		
Surface Water Controls & Capping								
Asphalt Pavement		90,000 sf		0.40	0.50	0.65		Includes 2" overlay over existing pavement
Total Present Value (low, likely, high)				**39,000**	**44,000**	**55,000**		
Excavation								
Contaminated Soil	7,000	9,000 cy*	11,000	10.00	12.00	15.00		
Sampling & Analytical Testing	40	50 ea	60	300	450	600		Includes sampling costs
Total Present Value (low, likely, high)				**112,000**	**134,000**	**157,000**		
Disposal Off-Site								**Alternative 2a**
Aerobic Biodegradation and Landfill Use	9,000	11,500 cy	14,000	35	40	45		Includes load, haul,and recycling soil for use as landfill cover. Assume 1.5 tons/cy
Backfill and Compact (Imported Fill)	9,000	11,500 cy	14,000	8.00	10.00	15.00		
Total Present Value (low, likely, high)				**486,000**	**582,000**	**691,000**		
Thermal Treatment On-Site								**Alternative 2b**
Low Temperature Thermal Desorption	9,000	11,500 cy	14,000	55	65	75		Assume 1.5 ton/cy
Backfill and Compact (Treated Soil)	9,000	11,500 cy	14,000	3.00	3.50	4.75		Includes load, haul, place & compact. Assume treated soil will be used as site fill
Total Present Value (low, likely, high)				**659,000**	**789,000**	**934,000**		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

Table B2
Alternative 2 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
Biological Treatment On-Site								Alternative 2c
Aerobic Biodegradation	9,000	11,500 cy	14,000	15	20	30		
Backfill and Compact (Treated Soil)	9,000	11,500 cy	14,000	3.00	3.50	4.75		Includes load, haul, place & compact. Assume treated soil will be used as site fill
Total Present Value (low, likely, high)				**231,000**	**283,000**	**382,000**		
Groundwater								
Groundwater Use Restrictions								
Formulation & Implementation		1 ls		3,500	5,000	10,000		
Total Present Value (low, likely, high)				**4,000**	**6,000**	**9,000**		
Groundwater Monitoring								
Sampling Wells (12)		4 qtr		1,000	1,500	2,500	10 **	
Analytical Testing		4 qtr		1,500	2,000	3,000	10 **	
Reporting		4 qtr		1,000	2,000	4,000	10 **	
Total Present Value (low, likely, high)				**159,000**	**185,000**	**238,000**		
Groundwater Extraction								
Wells		3 ea		4,000	5,000	6,000		
Recovery Trench		250 ft		10.00	13.00	17.00		
Operation & Maintenance		1 yr		12,000	14,400	21,600	8 **	
Total Present Value (low, likely, high)				**103,000**	**120,000**	**149,000**		
Treatment & Discharge								
Aerobic		1 ls		13,000	15,000	18,000		Includes additional tank
Oil/Water Separation		1 ls		4,000	6,000	8,000		
Reintroduction Trench and Piping		220 ft		13.00	15.00	18.00		On-Site discharge
NPDES Permit for Off-Site Discharge		1 ls		4,000	6,000	10,000		Partial discharge for enhanced control
Total Present Value (low, likely, high)				**29,000**	**31,000**	**34,000**		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

Table B2
Alternative 2 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
Indirect Costs (as a % of capital costs)								
Engineering & Project Management					15%			
Alternatives Total Present Values (low, likely, high)**								Includes capital plus operation & maintenance costs
2a Off-Site Disposal with Groundwater Treatment				1,160,000	1,270,000	1,390,000		
2b On-Site Thermal with Groundwater Treatment				1,340,000	1,500,000	1,660,000		
2c On-Site Aerobic Biodegradation with Groundwater Treatment				830,000	920,000	1,030,000		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

Table B3
Alternative 3 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

8/16/94

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
<u>Soil</u>								
<u>Land Use Restrictions</u>								
Formulation & Implementation		1 ls		3,500	5,000	10,000		
New Fencing		1,600 ft		7.00	9.50	11.00		Commercial 6' chain link fence with 20' gate
Total Present Value (low, likely, high)				**18,000**	**21,000**	**25,000**		
<u>Surface Water Controls & Capping</u>								
Asphalt Pavement		90,000 sf		0.40	0.50	0.65		Includes 2" overlay over existing pavement
Total Present Value (low, likely, high)				**39,000**	**44,000**	**55,000**		
<u>Excavation</u>								
Contaminated Soil	11,000	12,500 cy*	14,000	10.00	12.00	15.00		
Clean Soil	2,000	2,500 cy*	3,000	10.00	12.00	15.00		Clean soil to be used as backfill
Sampling & Analytical Testing	70	80 ea	90	150	250	400		Includes sampling costs
Total Present Value (low, likely, high)				**183,000**	**208,000**	**238,000**		
<u>Disposal Off-Site</u>								**Alternative 3a**
Aerobic Biodegradation and Landfill Use	14,000	15,500 cy	17,500	35	40	45		Includes load, haul,and recycling soil for use as landfill cover. Assume 1.5 tons/cy
Backfill and Compact (Clean Soil)	2,500	3,000 cy	4,000	3.00	3.50	4.75		Includes load, haul, place & compact. Assume treated soil will be used as site fill
Backfill and Compact (Imported Fill)	11,500	12,500 cy	14,000	8.00	10.00	15.00		
Total Present Value (low, likely, high)				**707,000**	**781,000**	**863,000**		
<u>Thermal Treatment On-Site</u>								**Alternative 3b**
Low Temperature Thermal Desorption	14,000	15,500 cy	17,500	55	65	75		Assume 1.5 ton/cy
Backfill and Compact (Treated & Clean Soil)	16,500	19,000 cy	21,500	3.00	3.50	4.75		Includes load, haul, place & compact. Assume treated soil will be used as site fill
Total Present Value (low, likely, high)				**969,000**	**1,096,000**	**1,224,000**		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

Table B3
Alternative 3 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
Biological Treatment On-Site								Alternative 3c
Aerobic Biodegradation	14,000	15,500 cy	17,500	15	20	30		
Backfill and Compact (Treated & Clean Soil)	16,500	19,000 cy	21,500	3.00	3.50	4.75		Includes load, haul, place & compact. Assume treated soil will be used as site fill
Total Present Value (low, likely, high)				**335,000**	**400,000**	**514,000**		
Groundwater								
Groundwater Use Restrictions								
Formulation & Implementation		1 ls		3,500	5,000	10,000		
Total Present Value (low, likely, high)				**4,000**	**6,000**	**9,000**		
Groundwater Monitoring								
Sampling Wells (12)		4 qtr		1,000	15,000	2,500	5 **	
Analytical Testing		4 qtr		1,500	2,000	3,000	5 **	
Reporting		4 qtr		1,000	2,000	4,000	5 **	
Total Present Value (low, likely, high)				**90,000**	**110,000**	**135,000**		
Groundwater Extraction								
Open Hole System		1 ls		3,000	5,000	8,000		
Operation & Maintenance		1 yr		12,000	14,400	21,600	3 **	
Total Present Value (low, likely, high)				**42,000**	**48,000**	**61,000**		
Treatment & Discharge								
Reintroduction Trench and Piping		220 ft		13.00	15.00	18.00		On-Site discharge
Total Present Value (low, likely, high)				**3,000**	**3,000**	**4,000**		

* bank cubic yards ** Assumes a discount rate of 5% for future costs

Table B3
Alternative 3 Costs
Burns Bros./Bingo Fuel Stop
Thorp, Washington

Process Description	Quantities (# of units)			Costs ($/unit)			Years	Comments
	Low	Likely	High	Low	Likely	High		
Indirect Costs (as a % of capital costs)								
Engineering & Project Management					15%			
Alternatives Total Present Values (low, likely, high)**								Includes capital plus operation & maintenance costs
3a Off-Site Disposal with Open Hole Groundwater Treatment				1,280,000	1,390,000	1,500,000		
3b On-Site Thermal with Open Hole Groundwater Treatment				1,590,000	1,750,000	1,920,000		
3c On-Site Aerobic Biodegradation with Open Hole Groundwater Treatment				860,000	960,000	1,090,000		

* bank cubic yards ** Assumes a discount rate of 5% for future costs