Trans Mountain Oil Pipeline/SIT 3.2.11

REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN
TRANS MOUNTAIN OIL PIPE LINE, CORP.
LAUREL STATION
BELLINGHAM, WASHINGTON

Prepared for:
TRANS MOUNTAIN OIL PIPE LINE, CORP.

Prepared By:
DAMES & MOORE
JOB NO.: 21199-032-005
September 30, 1992

DAMES & MOORE

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Presented herein is the Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the Trans Mountain Oil Pipe Line Corporation Laurel Station facility located in Bellingham, Washington. The RI/FS is being conducted pursuant to WAC 173-340-350 in accordance with the First Amended Enforcement Order No. DE91-N192 (Enforcement Order) dated June 15, 1992. The purpose of the RI/FS is to collect, develop and evaluate data regarding the site conditions to enable the selection of a cleanup action under WAC 173-340-360.

The State of Washington Department of Ecology (Ecology) was notified of petroleum product releases which occurred on January 15, 1991; December 11, 1991 and March 7, 1992. In addition, soil contamination not related to the petroleum product releases referenced above, were identified on October 25, 1991 during an upgrade of the Laurel Station facility. Trans Mountain commenced with containment and cleanup in accordance with WAC 173-340-430, Interim Actions.

The scope of work presented in this Work Plan was developed in accordance with the requirements specified in the Enforcement Order; Exhibit A, Scope of Remedial Actions; Part II. A.

2.0 SITE BACKGROUND & SETTING

2.1 SITE HISTORY

The Trans Mountain Oil Pipe Line Corporation (TMOPL, Trans Mountain or "site") Laurel Station is located at 1009 East Smith Road in Bellingham, Whatcom County, Washington (Figure 1). The site is situated approximately 4 miles north of the Bellingham city limits in an area of mixed agricultural and residential land use. Green belts and wooded park land are common in surrounding properties. The site itself once logged is now a mix of deciduous forest and service areas for the pipeline, pump station and appurtenant tanks.

Laurel Station was constructed in 1956 and pumping commenced at the site in December, 1956. Originally the site was used to ship crude oil from Alberta, Canada through to Ferndale and Anacortes, Washington. The pipeline divides into Ferndale and Anacortes branches at Laurel Station. In 1972, crude oil delivery from Canada was significantly reduced and the use of the pumping station was virtually discontinued with only one to two deliveries of crude oil per year. In late 1977, deliveries of crude oil and condensate increased to frequencies of 2 to 3 deliveries per month. In 1982, Mobil began using the storage tanks at the site to store condensate which was shipped via the pipeline to a refinery located in Ferndale. BP Oil subsequently took over use of these tanks from Mobil. At present, one of the storage tanks has been removed from service. The remaining tank will be removed from service by April 16, 1993.

The facilities at the site consist of the pump station and office, two 96,000 barrel (bbl) bulk storage tanks (constructed in 1972) and a 3,000 bbl pressure relief tank. A site plan of the facility is shown on Figure 2.

The pump station (station) originally consisted of four 2,000 horsepower main pumps and one 300 hp booster pump prior to the current modifications.

An oily water collection sump was formerly located in the station area (Figure 2). This sump received discharges from a number of sources including drain lines from the four main pumps, valve and pipe fittings, and oily water from the storage tanks which had separated out from the crude oil. The former oily water sump was designed to discharge water along a drain line to a burn pit located west of the control building (Figure 2). The accumulated oil in the oily water sump was pumped back into the pipeline.

Prior to reconstruction of the burn pit and the addition of an oil/water separator in 1983, the oily water drained directly to the fire brick and steel lined burn pit. Oil which accumulated at the surface was burned or skimmed off prior to water discharge from the site. In 1983 the burn pit was reconstructed, as the fire bricks lining the pit were deteriorating. Reconstruction involved removing the steel tank and some of the surrounding soil, relining the excavation with bricks and placing the tank back in the original position. At this time an oil/water separator was added to this drain so that water and any residual oil could be separated prior to discharge.

In 1991, Trans Mountain received an Enforcement Order (No. DE91-N192) from the Washington Department of Ecology concerning a release of natural gas condensate on January 15, 1991. Since this spill, TMOPL elected to upgrade the Laurel Station facility and removed unnecessary fittings and piping. The upgrade was undertaken in order to minimize the potential for future leaks at the station. Construction work on the Laurel Station refit commenced on October 25, 1991. Soon after work commenced it became apparent that subsurface leakage of crude oil and/or condensate had occurred from either pumps, drain lines, or the oily water sump. Discovery of these conditions prompted TMOPL to contact Ecology (letter to B. Trejo, Ecology, dated November 27, 1991) and in accordance with the provisions of the Model Toxic Control Act (MTCA), initiate an Interim Remedial Investigation (RI) of the station area. The Interim RI was subsequently performed in conjunction with excavation work for the upgrade.

During construction activities on December 11, 1991, a fitting on a 16-inch diameter, pressurized oil pipeline was accidentally broken off resulting in a limited discharge of crude oil into the air and onto the ground surface at the site. Some oil was transported off-site to the northeast by a southwesterly breeze at the time of the discharge and into a surface drainage ditch along East Smith Road by surface water runoff. Ecology was notified and interim containment measures and surface water quality monitoring were implemented. An additional incident occurred on March 7, 1992 when a pressure relief valve malfunctioned resulting in a partial diversion of oil to the pressure relief tank. The tank eventually overflowed resulting in an accumulation of oil within the tank containment dikes. An estimated 30 to 50 barrels escaped through a partially open dike drain valve into the adjacent wooded area.

2.2 POTENTIAL SOURCES OF CONTAMINATION

The principal potential contaminants at the site are crude oil and natural gas condensate. These products were the only materials passed through the pipeline and stored in tanks at the site. Other potential contaminants are polychlorinated biphenyls (PCBs) that may have been present in the on-site transformers and xylene. Xylene was used in the past to clean the seals on the pumps. The used xylene was then

reportedly disposed of into the former oily water sump. The laboratory on site was never used by Trans Mountain as a laboratory at any time in the station's history

In addition to the January 15, 1991 condensate leak mentioned above, other releases which are known or may have occurred at the site include: historical oil spills previously reported to Ecology, and the December 11, 1991 and March 7, 1992 oil spills discussed above. Other potential sources of chemical or petroleum release include the electrical substation, the former oily water sump and associated piping, the former draintile, the former waste pit, the former burn pit, the former oil/water separator, the storage tanks, pressure relief tank, areas where oily soils have been stockpiled in the past, and the oil pipeline and attendant underground equipment.

2.2.1 Historical Spills and Releases

Dames & Moore conducted an initial inspection of the site on November 15, 1991. Potential historical releases identified at that time and subsequently discussed with current and former TMOPL employees are the "1971 Spill", a tank release into a diked containment area, and minor releases resulting from past management practices. Information regarding these spills/releases is summarized below.

The 1971 spill occurred in July 1971, when 6,300 barrels of crude oil leaked from a flange on the main line pump at Laurel Station. The crude oil leaked into a ditch leading to the property north of Smith Road Approximately 3,500 barrels were recovered with the balance either evaporating or infiltrating into surficial soils in the spill area. Soils that were affected by this spill were excavated and placed in the Boneyard (Figure 2). The excavated hydrocarbon containing soils were landfarmed by tilling with agricultural equipment.

The containment area around the pressure relief tank and an area adjacent to the containment berm are suspected to contain soils bearing crude oil and condensate. These soils were derived from three sources, the burn pit area, small quantities of soils from miscellaneous small spills and leaks and a Smith Road spill. When the burn pit was refurbished in 1983, hydrocarbon bearing soils were placed in the enclosure of the pressure relief tank or in an area to the south of the tank enclosure. In addition, it was reported that it was common practice to place soils containing hydrocarbons from small spills/leaks in the pressure relief tank enclosure.

On February 1, 1979 a tank roof drain line froze and ruptured resulting in a condensate release in the containment area of Tank No. 170. This release of approximately 1149 barrels formed a pool of condensate approximately 2 feet deep inside the bermed containment area surrounding this tank. The condensate was pumped back into the tank and no further remedial actions or investigations were reportedly implemented. The frozen soils and surface water in this area probably slowed the potential migration through soils at this time.

2.2.2 Station Area

The station upgrade began on October 15, 1991. On October 25, 1991 hydrocarbon bearing soils were encountered in an excavation. The extent of hydrocarbons in the soil was initially thought to be minor, but as the excavation continued it became apparent that the area of hydrocarbon contaminated soils was more

extensive in the upgrade area. The main source of subsurface hydrocarbons in this area appears to have been the oily water sump and associated piping (Figure 2).

When the oily water sump was exposed, it was apparent that connections to the sump were broken allowing oily water to escape from the sump into the adjacent soils. The pathways for subsurface migration appear to have been trenches excavated in the pump station area for pipelines, drain lines and conduit runs. These trenches had been backfilled with what appears to be native soil. This disturbed soil had a greater permeability than the surrounding undisturbed native soils allowing preferential migration. When the trench for the drain line running from the oily water sump to the burn pit was exposed, oily water was detected in the backfill materials of the trench to the burn pit area.

During excavation for the station upgrade, soils exhibiting field evidence of hydrocarbons were excavated and stockpiled onsite in lined storage cells. Prior to backfilling these areas, soil samples were collected from the sidewalls and base of the excavation to provide confirmatory data regarding removal of the hydrocarbon bearing soils. It is estimated that presently approximately 12,500 cubic yards (cy) of soils are stockpiled on the site. In accordance with WAC 173-340-400(4)(b and c), an Operations and Maintenance Plan was developed for the petroleum contaminated soil (PCS) stockpiles (storage cells) which was submitted to Ecology on August 17, 1992.

A former waste pit was encountered near the control building during excavation of the drain line (Figure 2). This pit appeared to contain organic material such as tree stumps and the appearance of residual petroleum hydrocarbons.

A Puget Power electrical substation with a transformer is located on the northwest portion of the site (Figure 2). This substation provides power for cathodic protection of the pipeline and operation of station equipment. To our knowledge there are no documented releases of PCBs at the substation. The pumps at the station did not use cooling oil since the pump bearings were lubricated by the petroleum product passing through the pipeline. Thus, PCBs are not considered a potential contaminant on the site with the possible exception of the electrical substation.

2.2.3 December 11, 1991 Spill

The December 11, 1991 spill occurred during excavation operations being carried out as part of the upgrade project. The spill was caused by the failure of a non-standard, unprotected vent fitting. The break occurred during excavation activities above a 16-inch lateral just off the mainline. The crude oil escaped vertically under a pipeline pressure of approximately 200 psi. which caused crude oil to jet vertically into the air. Approximately one half hour elapsed before the leak could be stopped. It is estimated by Trans Mountain that 84 barrels of crude oil were released.

At the time of the release there was a slight breeze from the southwest towards the north east. Consequently, a fine mist of crude oil was blown to the northeast. However, the bulk of the spilled oil was discharged to the ground in the station area. The grass and tree covered area between the source leak and Smith Road had a thin coating of oil. On the surface of Smith Road there were discrete droplets of oil. Across Smith Road in the adjacent lot owned by Trans Mountain, a slight sheen was observed on some of the surface water accumulation in this area as a result of airborne hydrocarbons settling out onto the ground.

After the leak was stopped, an estimated 51 barrels of crude oil which had ponded in the excavations and on the surrounding ground was recovered. Surficial soils affected by direct spillage onto the ground surface were excavated and stored in the existing soil stockpiles.

Surface water samples of runoff from the site were collected from the drainage ditch along Smith Road and Dams 2 and 3 (Figure 2) during regular intervals after the spill occurred. Detectable concentrations of hydrocarbons in this water were detected only immediately after the spill. The concentrations detected were less than MTCA Method A ground water cleanup levels.

2.2.4 March 7, 1992 Spill

On March 7, 1992, a pressure relief valve malfunction at the station during a delivery of crude oil to Anacortes resulted in a partial diversion of oil from the pipeline to the 3,000 barrel pressure relief tank (Figure 2). The tank eventually overflowed and an estimated 1250 barrels entered the surrounding spill containment dike. The relief tank dike is equipped with a normally closed drain valve leading to an oil/water separator. The valve is operated to release stormwater which accumulates within the dike. Following the incident, this drain valve was found to be in a partially open position resulting in a release of 30 to 50 barrels of oil from the dike into an adjacent wooded wetland area. The spilled oil travelled along a narrow depression for approximated 600 feet where a temporary dam (designated the March 7, 1992 Spill Containment Dam) was constructed to prevent further migration (Figure 2).

Investigations in this area were confined to sampling surface water downgradient of a containment dam to evaluate the effectiveness of the dam in stopping the migration of oil into the wetlands. Emergency response cleanup measures initiated by Trans Mountain were completed by March 31, 1992 by which time the majority of the crude oil had been removed from the spill area.

The maintenance and inspection of the March 7, 1992 Containment Dam and Dam 2 and Dam 3 mentioned above, is outlined in the Dam & Surface Water Inspection And Maintenance Plan dated September 4, 1992.

2.3 ENVIRONMENTAL SETTING

2.3.1 Physiography

The region around the site is composed of gently rolling hills of about 40 feet relief. Elevation of the site is approximately 300 feet above mean sea level (msl). Three storage tanks at the site are located on a low hill with an elevation of approximately 330 feet msl. From this hill, the ground surface slopes to the northwest to Smith Road with an average gradient of about 9 feet per 100 feet. The main station facilities are located on a graded pad at an elevation of about 300 feet msl. Surface water drainage off the main portion of the site is via a drainage ditch. This ditch drains to an oil water separator complete with spill retention capability and alarmed hydrocarbon detector which notifies the control center in Vancouver, B.C. The separator discharges into a ditch along Smith Road which drains to a tributary of Deer Creek, a tributary of the Nooksack River (Figure 2). The site has been previously logged and now consists of second growth deciduous and conifer forest, access roads and service areas to the pump station facilities and tanks. The area surrounding the site is predominantly pasture, transportation and residential land use.

2.3.2 Geologic Setting

The study area is underlain by sandstones and siltstones of the Chuckanut Formation at a depth of approximately 350 feet below ground surface (bgs). The Chuckanut is exposed at the surface to the south and east of the study area. Above the Chuckanut Formation lies a series of unconsolidated glacial deposits which are capped by the Bellingham Drift. The sediments of the Bellingham Drift consist of unsorted, unstratified pebbly, sandy silt and clay deposited by floating ice. Underlying the Bellingham Drift is the Demming Sand, an advance outwash deposit which occurs as discontinuous lenses of coarse sand, gravelly sand, and layers and lenses of gravels and silty clays. The Demming Sand is underlain by the Kulshan Drift, which consists of unsorted, unstratified mixture of silt, clay, sand and pebbles. The Vashon Till underlies the Kulshan and consists of a compact mixture of pebbles in a matrix of silt, clay, and sand. The Esperance Sand Member of the Vashon Drift underlies the Vashon till and unconformably overlies bedrock of the Chuckanut Formation. The Esperance Sand Member consists of crossbedded outwash deposits of sand and gravel.

Site specific geological information has been obtained from previous investigations and upgrading activities which have been documented in the RI Report submitted in June, 1992 (Figure 3). Excavations, test pits and exploratory borings in the station area indicate that the site is covered by a nearly continuous layer of relatively low permeability silty sandy gravelly clay or till, which corresponds to the Bellingham Drift. This layer dips towards the west, appears to follow the natural slope on the site, and thickens at the base of the slope near the station. In the area of the former oily water sump the silty clay layer is not currently present and was apparently removed during grading for initial construction of the station. Beneath this silty clay layer are undifferentiated glacial deposits consisting of silty sandy gravels and gravely sandy silts ranging from 100 to 150 feet in thickness. This unit appears to have been deposited as discontinuous lenses with significant heterogeneity and varying permeabilities.

In general, the shallow soils are characteristic of the "Bellingham Drift". It is difficult to correlate the underlying glacial deposits from borings and soil samples in the site area with the units described by Easterbrook (1976). Thus, these deposits have simply been designated as the undifferentiated glacial sediments. The Bellingham drift is described in the field to consist generally of grey or brown over consolidated silty clays with small amounts of scattered rounded gravel. These soils are very dense and possess low to very low permeabilities. Underlying the drift soils at depth generally 50 feet below ground surface (bgs) is a moderately heterogenous grey to tan silty gravelly sand with higher permeability than the Bellingham drift material. In the station area where the borings encountered this unit, local heterogenous zones consisting of horizontal lenses with lesser silt content and/or greater gravel content with greater relative hydraulic conductivity than the surrounding material were noted.

2.3.3 Hydrogeological Setting

The main water bearing zones in the vicinity, consist of an upper discontinuous aquifer in the Demming Sand formation and a lower aquifer system in the Vashon Till. The depth to water in the Demming Sand is reportedly between 44 to 74 feet below ground based upon wells located within 1 mile of the site (Purnell and Associate, December 11, 1991), however, this unit is discontinuous and the Demming Sand was not encountered in a majority of wells around the site. A north to south geologic cross section through the site area is shown on Figure 3. The cross section was constructed from available residential well boring logs.

All of the wells encountered surficial material consistent with the Bellingham Drift formation. Shallow ground water when encountered in these wells was found to occur at approximately 270 to 100 feet above mean sea level. The underlying material was characterized by undifferentiated glacial sediments. Ground water in the deeper aquifer was encountered at approximately elevation 130 to 140 feet above mean sea level (Figure 3).

During the interim RI, ground water was encountered in the borings on the site in the deep aquifer at approximately 124 feet above mean sea level (i.e. approximately 200 feet below ground surface), and isolated occurrences of shallow water in the pump station upgrade area. The deep aquifer piezometric surface gently slopes towards the west. The deep ground water encountered at the site may be part of the local aquifer tapped by residential wells. It is not clear from the sequence of undifferentiated glacial deposits encountered which geologic unit this aquifer correlates with. However, saturated material which could correlate to the Demming Sand were not encountered in any of the borings at Laurel station.

2.3.4 Surface Water Hydrology

No permanent streams are located on Trans Mountain property. Located north of the site, across East Smith Road, is an intermittent stream which is a tributary to Deer Creek. This tributary is fed by surface water runoff which is contained in two drainage ditches running parallel with East Smith Road (Figure 2). The tributary runs primarily in a northwesterly direction where it terminates at the confluence with Deer Creek approximately 1300 feet from its beginning (Figure 2).

2.4 PREVIOUS INVESTIGATIONS

Prior to this RI/FS Work Plan, a number of investigations were conducted at the site. These investigations are listed and discussed below:

- Laurel Pump Station Condensate Spill: Fisheries Assessment, May 16, 1991, Seymour & Associates
- Site Assessment Report - Soil & Water Analysis, Laurel Pump Station Natural Gas Condensate Spill, May 17, 1991; W.D. Purnell & Associates, Inc.
- Response to Enforcement Order No. DE91-N192; Items No. 1.G.1 November 25, 1991; W.D. Purnell and Associates, Inc. c. 1992 ?
- Remedial Investigation Report, Laurel Station, June 12, 1991; Dames &
- Report On The Drain Tile Excavation Interim Cleanup Action, Laurel Sta [illegible] Dames & Moore Inc.

2.4.1 Fisheries Assessment

To address the effects of the January 15, 1991 spill, nine sampling stations between the spill and the mouth of Dear Creek were sampled on March 26th, 1991. Approximately 150 to 300 feet of the creek was electrofished at each station. Juvenile fish were stunned, netted, identified as to species and age class, then

returned to the creek. Stations included spawning areas, pool and riffle sections, forest and residential areas, agricultural section and an area within the spill clean up zone. The purpose of the sampling was to evaluate the diversity of juvenile fish in the creek and to detect any abnormal situation which may have been the result of the condensate spill. No attempt was made to enumerate total population size from this investigation.

Based on the results it was the opinion of Seymour & Associates that the condensate spill did not have a measurable impact upon the fish resources of Deer Creek below Hannegan Road.

2.4.2 Site Assessment Report - Soil & Water Analysis (May 17, 1991)

On January 15, 1991, a leak estimated at 75 barrels of natural gas condensate occurred near the southwest corner of Laurel station. There were three areas affected by the spill which were designated, Areas 1, 2, and 3 by Purnell & Associates. These areas are not presented on a figure in this workplan. Area 1 is the region to the west of the pump station where the condensate flowed over the ground. Area 2 is located to the north of area 1, on the northern side of East Smith Road. This area was contaminated when a dam overflowed and water mixed with condensate flowed over the area. The streams and drainage ditch downstream of the spill site are Area 3. A soil sampling program for Areas 1 and 2 was implemented on February 16, 1991. Approximately 40,000 square feet of soil in Area 1 was estimated to be contaminated to an average depth of approximately 16 inches. The contaminated soils in Area 2 are located near several small intermittent streams. Approximately 15,000 square feet are potentially contaminated in Area 2. Soils in this area contain residual condensate to an average depth of approximately 3 inches. A surface water sampling program for Area 3 was started on January 17, 1991 in which 4 stations were monitored twice weekly from January 17, 1991 to April 4, 1991, and once weekly from April 4, 1991 to April 28, 1991. Detectable total petroleum hydrocarbons (TPH) were found in the water from January 17, 1991 to January 28, 1991. From January 28, 1991 to April 24 1991, TPH was not detected in the waters.

Three shallow ground water monitoring wells were installed to a depth of 3.5 feet bgs in Area 1. These wells were sampled in two rounds (March and April 1991) and analyzed for TPH and benzene (BETX) (second round only). TPH and BETX were detected in MW-1 and MW-2 and BETX in MW-3. TPH levels were found to exceed the MTCA Method A ground water cleanup limits in MW-1 and 2 (4 and 21 mg/l, respectively) in round 1 and was only exceeded in MW-2 in round 2 (7.3 mg/l).

Four residential wells in the immediate site vicinity were sampled during this investigation. TPH and BETX were not detected in these well waters.

W.D. Purnell & Associates considered four alternatives for remediation of Areas 1 and 2: undisturbed in-situ remediation, in which the hydrocarbons are left in the soils to degrade naturally; surface treatment, in-situ remediation, in which the soils are tilled to the depth of contamination which allows the soils to aerate and promotes bacterial degradation of the hydrocarbons in the soils; removal of soils and treatment on site, in which the contaminated soils are excavated and placed on plastic allowing the soils to aerate and bacteria to degrade the hydrocarbons; and removal of soil for off-site treatment or disposal. Surface treatment, in situ remediation was recommended to be used for the site remediation subject to wetlands regulations and the approval of the state and federal regulatory agencies.

2.4.3 Response to Enforcement Order No. DE-91-N192

A Sampling and Analysis Plan was developed to further assess the soil and ground water contamination in Areas 1 and 2 of Trans Mountain property. Additional soil borings and ground water monitoring wells were proposed. Subsequent to Purnell's Site Assessment Report submitted on May 17, 1991, additional field observations and sampling was conducted at the site in April through June 1991. The location of the highest residual soil TPH (Method 8015) level in Area 1 (15,411 mg/kg) was resampled on April 8, 1991 and was found to have a TPH concentration of 4,907 mg/kg. It was concluded that changes in the vertical and horizontal extent of contamination may have occurred at the site as a result of biodegradation.

Additional shallow ground water samples were collected in May and June 1991. MW-1 sampled in May, had a TPH (modified 8015) and BETX (Method 8240) concentration less than the detection limits of 1 mg/l and 0.001 mg/l, respectively. MW-1 and MW-3 sampled in June, had a TPH concentration of less than 1 mg/l and 6.6 mg/l, respectively.

2.4.4 Remedial Investigation Report

2.4.4.1 Soils

The site soils have been locally impacted by occasional releases of petroleum hydrocarbons over the history of the pump station operation. The spread of these releases has been limited by the site geology. The site investigation did not find any evidence of contamination of the aquifer ground water from the historic releases. There are however residual petroleum hydrocarbons localized in site soils. These residual petroleum hydrocarbons are underlain by a thick dense unsaturated zone providing a barrier to downward migration.

In the station upgrade area to the East of the control building residual petroleum hydrocarbons were found to occur in the disturbed soils where pipes and other appurtenances of the station had been placed underground. They were also found in the silty sandy gravel material immediately beneath the Bellingham Drift material at the south end of the construction area, near the location of the oily water sump. The drift material in the area of the oily water sump appears to have been removed during the course of the construction of station in the 1950s. The soils containing evidence of residual petroleum hydrocarbons were removed in areas to the north of the oily water sump. Deep soils containing residual petroleum hydrocarbons around the sump below the excavation depth for removal of the oily water sump were not entirely removed during upgrading activities.

Shallow subsurface water encountered in the construction area during the investigation appears to have been present due mainly to the collection of rain in the large open excavations and leakage from the oily water sump which collected storm waters. The waters and preferential backfill pathways allowed local dispersions of petroleum hydrocarbons from the oily water sump and other limited spills along the pipeline trenches, and below the contact between the upper till material and the silty sandy gravel.

The surface soils around the drain line area from the former oily water sump appeared to have been historically modified during the station operation and construction. The upper 5 to 8 feet in places consists of fill material composed of organic debris and silty sandy clay material. This upper layer has provided a

lateral pathway for water entering the drain line area from the oily water sump and a discovered leaking fire water main to disperse through the shallow soils in this area.

Petroleum hydrocarbon contamination around the drain line area appears to have been caused by the lateral drainage of water contaminated with petroleum hydrocarbons. The leaking fire water main has been repaired. This residual contamination appears to be confined to the upper layers of soils in this area between 5 to 12 feet bgs.

There are two other areas; of known residual petroleum hydrocarbons in this area the burn pit area and the waste pit. Soil samples from the burn pit and the waste pit area indicate that the soils are contaminated with petroleum hydrocarbons and possibly the solvent xylene. The vertical and horizontal extent of contamination of soils in these areas is not yet defined. It is likely that the potential deep percolation is vertically restricted since it was not detected in the aquifer and is underlain by dense low permeability soils.

The potential pathway of residual petroleum hydrocarbon transport identified by this investigation is the subsurface drainage of shallow perched ground water towards the West to a wetland. From the wetland there is a potential for contribution to the intermittent tributary to Deer Creek.

The other area on site where residual petroleum hydrocarbon contaminated soils were identified is in the pressure relief tank area. Test pits in these areas identified that residual petroleum hydrocarbon containing soils had been stockpiled in this area. The depth of these contaminated soils appears to be no greater than 5 feet, the lateral extent is unknown.

Hydrocarbon contamination was not detected in the other areas covered in this investigation including the tank storage area and the Boneyard Area. No evidence of contamination was detected in the Smith Road spill site. The December 11, 1991 spill area exhibited no evidence of contamination.

The results of falling head tests conducted in selected borings on the site indicated that the estimated hydraulic conductivity (K) of the upper drift material (Bellingham Drift) is approximately 5.0 E-07 ft/sec. The undifferentiated glacial sediments were found to have hydraulic conductivities in the range of 5.0 E-04 ft/sec (1.6 E-05 centimeters per second (cm/sec)) to 1.0 E-03 ft/sec (3.3 E-05 cm/sec). These ranges are consistent with published values (Freeze and Cherry, 1979) for these types of materials. These values report the horizontal hydraulic conductivity rather than the vertical hydraulic conductivity based on the in place testing method. Horizontal permeabilities are generally greater than the vertical permeabilities.

Sieve analyses and hydrometer analysis from Bellingham Drift and the lower geologic unit indicated that both units are poorly sorted, with a wide range in grain size distribution. Grain sizes ranging from gravels greater than 1 inch in diameter to fines with diameters of less than 0.001 millimeter occur in the majority of samples, although the relative proportions of each type of grain size differed. This type of grain size distribution, with a broad range of particle sizes is typical of glacially derived sediments, and characteristic of the local glacial drift. Poor sorting and the density of these glacially compacted materials are the cause of low hydraulic conductivity, available pores are filled by finer grains and the compressive force of the glacier on the soil matrix.

Based on the sieve and hydrometer analyses results, sediment samples collected from the Bellingham Drift geologic unit ranging in depth from 8 to 25 feet below ground surface consist primarily of sandy to gravelly silty clays. Samples collected from the undifferentiated glacial sediments ranged in depth from 24 to 69 feet below ground surface. These sediments consist primarily of gravelly silty sand and silty gravelly sand. Purnell & Associates, Inc. (1991) have reported permeability values of silty clays of the Bellingham Drift ranging from 1 E-08 to 1 E-09 cm/s.

Hydraulic conductivities of selected sediment soil samples were determined in Dames & Moore Geotechnical Laboratory in Seattle, Washington. The Back Pressure Constant Head Permeability Test (Pbp) method was used which applied hydraulic pressure through the sample and measures the reduction through the saturated sample difference of this hydraulic pressure. The hydraulic conductivity of the sample is derived from the hydraulic pressure drop across the sample at three increasing higher applied pressures.This testing method provides an indication of the materials vertical hydraulic conductivity. Hydraulic conductivities calculated for a sample collected from the Bellingham Drift sediments (TM-B7) ranged from 2.5 E-08 to 8.5 E-08 cm/sec. This result is within published values for this type of over consolidated and poorly sorted material. Vertical hydraulic conductivities calculated for samples collected from the undifferentiated glacial sediments ranged from 2.5 E-04 cm/sec to 8.4 E-06 cm/sec. These results are somewhat lower than would be generally expected for this type of material probably resulting from their silt and clay content.

2.4.4.2 Ground Water

The deep ground water aquifer at this site is located approximately 120 feet above mean sea level. The hydraulic gradient in this aquifer is approximately 1 foot drop in 150 feet to the west. No contamination was found in any of the five water samples collected from the monitoring wells in this aquifer.

The shallow wells in the station upgrade area are installed in a localized perched saturated zone. It is expected that this perched water table will dry up now that the water main leak is repaired and the upgrade compacted fill is in place. Water samples were collected from three shallow wells, only one of these wells, SW-5, located adjacent to the former oily water sump exhibited hydrocarbon contamination. This was the well sited adjacent to the location of the former oily water sump.

The potential pathways identified in this investigation for transport of residual petroleum hydrocarbons are the subsurface drainage of contaminated ground water towards the West. This water could surface in the wetland area. From the wetland there is a potential for transport to Deer Creek tributary. Based upon the site stratigraphy, transport to the deep ground water aquifer is unlikely to pose a threat at this site due to the thick low hydraulic conducting glacial sediments.

2.4.4.3 Conclusions

Some areas of the site were not comprehensively investigated during the course of the interim RI. In addition the area affected by the March 7, 1992 pressure relief tank spill and Area 1, west of the site were not included in the interim RI report.

The following areas require further sampling and analysis: downgradient of the burnpit to investigate if contamination from this area has migrated offsite; around the waste pit area near the control building, the area around and downgradient of the pressure relief tank March 7, 1992 spill.

A risk assessment is required for this site to assess potential impacts from the residual petroleum remaining in the shallow soils in the station area. This risk assessment should be focussed on the impacts of the potential transport pathway in the shallow subsurface zone to the west of the site and to the wetlands and Deer Creek.

2.4.5 Drain Tile Excavation Interim Cleanup Action

This report presents the results of the interim Cleanup Action of petroleum hydrocarbons in soil in the drain tile area.

Under this interim action soils were removed from the excavated areas until Organic Vapor Meter (OVM) readings and visual observations indicated the soil containing hydrocarbons had been removed. These field observations were supported by laboratory analytical results with the exception of the results for the sample DTE-1. This sample had a detectable concentration of 460 mg/kg TPH based on laboratory analysis and 680 mg/kg based on the field screening analysis. This sample was taken from the shallow end of the excavation at a depth of approximately 4 feet below the ground surface. The TPH-HCID results for this sample indicates that the hydrocarbon is similar to diesel range petroleum hydrocarbons. The January 15, 1991 spill was natural gas condensate which primarily contains gasoline range petroleum hydrocarbons with 25% percent diesel range hydrocarbons. This result suggests that the hydrocarbon present in DTE-1 was probably residual highly degraded condensate or a heavier hydrocarbon compound which may have been in the water discharge through the drain tile prior to the spill. Excavation of the drain tile and surrounding soils has mitigated the potential for further migration of hydrocarbons from this source to the wetlands area.

3.0 SUMMARY OF EXISTING DATA

The information presented in this section summarizes the existing analytical data associated with the site soils, ground water and sediment collected during the RI and the surface water collected during the monitoring program required under the Enforcement Order. The individual media are discussed in the following order: soil, ground water, surface water and sediment.

3.1 SOIL DATA

Soil samples have been collected at various locations across the site. As presented in the RI Report, for clarification purposes, the site has been subdivided into Study Units numbered one through six (Figure 4). The individual Study Units correspond to the following general site areas:

- Study Unit 1 - Pump Station Operations Area
- Study Unit 2 - Oil Bulk Storage Tank Area

- Study Unit 3 - Pressure Relief Tank Area
- Study Unit 4 - Boneyard Area
- Study Unit 5 - Area North of Smith Road Spill
- Study Unit 6 - December 11, 1991 Spill Area

The following section is a discussion of the data collected for each of the Study Units.

3.1.1 Study Unit 1

The location of Study Unit 1 is shown on Figure 3.3.1. Within the Pump Station Operations Area are eleven sub-areas potentially containing petroleum and/or volatile organic (VOC) contamination, they consist of the:

- Former pump station area
- Former oily water sump
- Former burn pit
- Former drainline between oily water sump and burn pit
- Former drain tile
- Former waste pit
- Former oil/water separator
- Ferndale 16-inch product line
- Main 20-inch product line
- Historical spills
- Electrical (Puget Power) substation

It must be recognized that due to the close proximity of many of the sub-areas to one another, distinguishing the exact source or contribution of contamination identified in the soils in each sub-areas may be difficult or impossible to determine. The majority of the sub-areas presented above (i.e., designated "former") no longer exist at the site , as they were removed during the upgrading activities conducted at Laurel Station between 1991 and 1992. The field investigation conducted during the RI initially focused on the areas around the former drainline between the oily water sump and burnpit. The area of soil exploration was then extended out from the boundaries of these areas to assess the lateral extent of hydrocarbon

occurrence. Where hydrocarbons extended beyond the depth capabilities of the backhoe utilized to perform test pits, soil borings were drilled to complete the assessment in the areas. A discussion of each sub-area follows.

3.1.1.1 Pump Station Area

Three old pumps were removed from the former pump station area during the upgrading. Soil samples collected from test pits below the pumps were designated PB-1, PB-2 and PB-4 (Figure 5). The test pits were sampled at two foot intervals down to a depths of between 12 to 17 feet below ground surface (bgs) and the soil samples were analyzed by field screening methods (GC-FID analysis). Visual signs of residual hydrocarbon were noted at PB-2 at a depth of 12 feet bgs. A sample was collected in this material at a depth of 14 feet bgs (PB-2-4). TPH concentrations in this sample measured 5300 mg/kg. No TPH contamination was identified in the other test pit samples, other than in PB-1 from a shallow zone which was subsequently excavated. A post excavation sample at this location was collected at 10 feet bgs (PB-4-3) measured 64 mg/kg. Additionally, test pits TP-1, TP-2, and TP-18 were performed in the station area (Figure 5). Samples collected at 4 feet bgs in these test pits and analyzed by field screening methods did not detect TPH above the 25 mg/kg detection limit.

Soil borings TM-B14 and TM-B15 were drilled in the pump station area (Figure 5). The borings were drilled to a depths of 54.5 feet and 35 feet bgs, respectively. Field screening of samples indicated TPH was detected in TM-B14 at a depth of 13 feet bgs (430 mg/kg) and in TM-B15 at a depth of 29-30 feet (1600 mg/kg). TM-B10 located just north of the pump station area near the former 300 HP pump, was drilled to a depth of 40 feet bgs. Field screening samples and one laboratory sample analyzed for WTPH-HCID, were found to contained TPH levels less than 28 mg/kg.

A north to south geologic cross section depicting the apparent zone of TPH contamination within the station area is shown on Figure 6. Based on Figure 6, residual TPH is present in the site soils at varying depths within the station area.

3.1.1.2 Former Oily Water Sump

Borings TM-B4 and TM-B16 were drilled adjacent to the former oily water sump (Figure 7). Field screening of the soil samples collected from these borings indicated that residual TPH was present in both borings. TPH was detected at TM-B4 at a concentration 400 mg/kg at depths of 18 feet and 23 feet. A duplicate sample was collected at TM-B4 from 18 feet bgs and analyzed for BTEX, base neutral/acid extractable compounds (BNA), WTPH-HCID, TPH-418.1 and priority pollutant metals. Total xylenes were identified at 980 ug/kg, total BNA's at 2.2 mg/kg, WTPH-HCID at 320 mg/kg, TPH-418.1 at 1200 mg/kg and metals, at level which appear to be within expected background. Analysis of soil samples collected at TM-B16 at depths of 13 feet and 18 feet bgs detected TPH-HCID levels of 3100 mg/kg and 510 mg/kg, respectively. TM-B16 was extended to a depth of 39 feet bgs and no additional samples analyzed detected TPH above 30 mg/kg.

A geologic cross section depicting the apparent zone of residual TPH within the area of the former oily water sump is shown on Figure 6.

3.1.1.3 Former Burn Pit

Soil borings and test pits were performed in the vicinity of the former burn pit (Figure 8). Test pits TP-6 and TP-7 (Figure 8) which were located downgradient of the burn pit encountered residual TPH from depths ranging from 5 to 15 feet bgs. Field screening TPH concentrations ranged from 220 mg/kg (TP-6, 15 feet) to 13,200 mg/kg (TP-7, 5 feet). Boring drilled downgradient of the burn pit (TM-B2 and TM-B3) which were converted into shallow monitoring wells SW-1 and SW-2 did not detect TPH levels above 21 mg/kg during field screening of soil samples. Ground water samples collected at these shallow wells did not detect petroleum hydrocarbon or volatile organic compounds (with the exception of chloroform at 14 ug/l) above detection limits.

A soil sample was collected at a depth of 3 feet bgs from the test pit located next to the burn pit (sample BurnPit #1, Figure 8). The sample analyses detected total xylenes and ethylbenzene at concentrations of 2.4 mg/kg and 0.72 mg/kg, respectively. TPH-HCID analysis of the sample indicated hydrocarbons were present in the diesel range at a concentration of 170 mg/kg.

3.1.1.4 Former Drainline Between Oily Water Sump and Burn Pit

Soil borings and test pits were performed in the general vicinity of the former drainline between the oily water sump and the burn pit (Figure 9). Two boring were drilled on the north (TM-B20 and TM-B22) and one on the south (TM-B24) side of the drainline. Field screening results indicated levels of TPH below method detection limits. Test pit, TP-8 (Figure 9) located on the south side of the drainline detected TPH (Method 418.1) concentrations at 140 mg/kg at a depth of 6 feet bgs.

3.1.1.5 Former Drain Tile

As previously mentioned, the draintile was removed as part of the Interim Cleanup Action conducted at the site which is documented in our recently revised "Report On the Drain Tile Excavation" dated July 31, 1992. The drain tile area was excavated and petroleum contaminated soil was removed. Post excavation samples indicated adequate soil removal was conducted, with the exception of an area located in the northern portion of the drain tile (Figure 10). TPH diesel-end hydrocarbon contamination was identified at a concentration of 460 mg/kg (TPH-HCID) at sample DTE-1 at approximately 4 feet bgs. Field screening results for the same sample detected TPH at a level of 680 mg/kg.

Soil borings TM-B5 and TM-B11, were drilled on the southwest side of the drain tile (Figure 10). TM-B5 did not encounter TPH at levels above detection limits during field screening of soil samples. TM-B11 encountered residual hydrocarbon at a depth of 5 feet bgs. TPH-HCID analysis of the soil sample from this depth detected levels of 2000 mg/kg. Contamination was not identified at greater depths within the boring which extended to a depth of 32 feet bgs.

3.1.1.6 Former Waste Pit

Borings TM-B18 through TM-B25 were drilled to evaluate the suspected location of a disposal pit which was encountered during earlier phases of site upgrading (Figure 11). These borings did not encounter any residual TPH. Upon re-evaluation of the boring locations, another boring (Pit #1) was drilled in the area

of the suspected pit location. The boring, Pit #1 (Figure 11) was sampled at a depth of 15 feet bgs and detected toluene (440 ug/kg), xylenes (330 ug/kg) and polycyclic aromatic hydrocarbons (PAH's, 300 ug/kg).

Test pits TP-4 and TP-5 were performed north of the waste pit. Field screening results from samples collected in TP-4 at 1, 5 and 10 feet in depth were less than 25 mg/kg. Field screening result at TP-5 from a sample collected at 5 feet bgs was 50 mg/kg. A sample was also collected at 14 feet bgs and analyzed for TPH-418.1 and was found to have a concentration of less than 10 mg/kg.

3.1.1.7 Former Oil/Water Separator

Soil borings and test pits performed in the general vicinity of the former oil/water separator included TM-B2 and TM-B3 and TP-7 and TP-10, respectively (Figure 8). TPH was not identified during field screening of soil samples at TM-B2, TM-B3 and TP-10 above method detection limits. Field screening results for TP-7 indicated TPH was present at a depth of 5 feet bgs at a level of 3000 mg/kg. The TPH levels declined to concentrations ranging from 200 to 600 mg/kg at 7 feet bgs in this test pit.

3.1.1.8 Ferndale 16-Inch Product Line

The Ferndale 16-inch product line was partially excavated as part of the upgrading program, as described in Dames & Moore Report on the Drain Tile Excavation dated July 31, 1992. Soil samples were collected along the exposed pipeline as shown on Figure 10. TPH contaminated soil was excavated from around the line and was sampled and analyzed. The results of field screening indicated TPH was present in the excavated soil ranging from 67 mg/kg (EXFERN-3) to 3700 mg/kg (EXFERN-11). Post excavation field screening samples did not detect TPH levels above detection limits.

3.1.1.9 Main 20-Inch Product Line

Post excavation samples were collected along the main 20-inch product line (Figures 12A and 12B). The line was exposed for inspection and maintenance purposes. A total of 19 and 16 samples were collected from the base (PLB) and sidewall (PLS) of the excavation, respectively. The field screening TPH results were all below method detection limits. Only one of the samples, PLB-1-1-7, collected at the base of the excavation (7 feet bgs) had level of 110 mg/kg by TPH-HCID analysis. Additional soil was later removed from this area.

3.1.1.10 Historical Spills

As previously mentioned, on December 11, 1991 a spill of an estimated 84 US barrels of crude oil occurred during the excavation above a 16-inch lateral off of the main product line. Crude oil escaped vertically into the air as a result of the high pipe line pressures (i.e., 200 psi). A fine mist of crude oil was blown to the northeast, however, the bulk of the spill was discharged to the ground surface in the pump station area. An estimated 51 US barrels of oil was recovered from an excavation adjacent to the spill. Surficial soils affected by the oil spray and pooling in the station area were excavated. Post excavation samples EX-10 through EX-17 were collected to evaluate the cleanup efforts (Figure 13). The post

excavation samples were field screened for TPH and none of the samples tested were found to exceeded 61 mg/kg.

3.1.1.11 Electrical (Puget Power) Substation

Four shallow hand auger boring were performed in the electrical substation area (ES-1 through ES-4) and one (ES-5) adjacent to the transformer next to the control building (Figure 14) to evaluate if polychlorinated biphenyls (PCB's) were present in the soils around adjacent to electrical transformers. Samples were collected at two depths, between 4 and 6-inches and 8 and 12-inches. PCB's (Methods 1242, 48, 54, 60) were not detected in any of the ten samples analyzed.

3.1.2 Study Unit 2

Study Unit 2, the bulk fuel storage area, is shown on Figure 15. The investigation of this area stems from potential environmental impact due to past crude oil releases from the two bulk oil storage tanks (Tank 170 and Tank 180). The affected media from a tank release(s) would be shallow soils within the bermed containment area surrounding each tank. A subsurface soils sampling program was conducted during the interim RI to identify and characterize the presence of petroleum hydrocarbons in this area. The program included soil sampling from one boring adjacent to the north end of Tank 180 (TMB-13) and two borings adjacent to the north and south ends of Tank 170 (TMB-8 and 7, respectively). Samples were collected for analysis from depths of 9 and 24 feet from boring TMB-13. Field GC analyses indicated that TPH levels were below the 25 mg/kg detection limit. Samples were collected for analysis from depths of 3 and 8 feet form boring TMB-7 and 4, 9, and 34 feet from boring TMB-8. TPH was identified above the field GC detection limit in the sample collected at a depth of 9 feet from TMB-8 at the north end of Tank 170, at a concentration of 140 mg/kg. One sample, TMB-13 from a depth of 24 feet, was sent to the fixed laboratory for WTPH-418.1 analysis. The results show that TPH is below the 10 mg/kg detection limit, which corresponds to the field GC findings.

3.1.3 Study Unit 3

Study Unit 3, the pressure relief tank area, is shown on Figure 16. Two potential sources of petroleum hydrocarbons exist in this area, the pressure relief tank and the former contaminated soil disposal area. The pressure relief storage tank was the site of the March 7, 1992 release. The impacted media from the release would be principally surface and subsurface soils within the containment berm surrounding the tank. Shallow soils within the former contaminated soil disposal area may contain residual petroleum hydrocarbon contamination. This study unit was initially evaluated under the interim RI, which included surface and subsurface soils sampling and TPH analysis.

Surface soils (0-4 inches) were collected from three locations (HA3-1, 2, and 3) within the pressure relief tank containment area prior to the March spill. Field GC results showed one detection of TPH at a level of 200 mg/kg in the sample from HA3-2, located in the northeast corner of the bermed area. A confirmatory duplicate of this sample was also analyzed for WTPH-HCID at the fixed laboratory with no detection of petroleum hydrocarbons. Subsequent to the March spill, petroleum impacted soils were excavated from the containment area, and the area was relined with compacted clay.

Subsurface soils were collected and analyzed from locations within the suspected former soil disposal area located south of the pressure relief tank. Samples were collected from depths of 0.5, 5, an 8 feet from hand auger borings HA-4 and HA-5, and from depths of 0.5, 5, and 10 feet from test pits TP3-1, 2, and 3 (Figure 16). Of the 15 samples collected in this area, two samples showed field GC TPH concentrations above the 25 mg/kg detection limit. The TPH concentration in sample TP3-2 from a depth of 5 feet was 4000 mg/kg, and the TPH concentration at TP3-1 from a depth of 0.5 foot was 80 mg/kg.

3.1.4 Study Unit 4

Study Unit 4, the "Boneyard", is shown on Figure 17. The "Boneyard" area, formerly used for landfarming of hydrocarbon contaminated soils, was evaluated for the presence of residual contamination under the interim RI. This investigation involved the excavation of six test pits (TP-19 through TP-24) with samples collected from depths of 1, 5, and 10 feet. Field GC analysis indicated the presence of low levels of TPH, ranging from 30 to 50 mg/kg, in shallow soils (depths of 1 foot) in test pits TP-20, 21, and 23. Confirmatory WTPH-HCID analyses were conducted on four samples, TP-20, 21, 22, and 24 at depths of 10, 1, 5, and 1 feet, respectively. The fixed laboratory results showed one detection of TPH at 16 mg/kg (TP-21 from a depth of 1 foot).

3.1.5 Study Unit 5

Study Unit 5, the area north of Smith Road, is shown on Figure 18. The interim RI soils investigation consisted of six test pits (TP5-1 through TP5-6) sampled at depths of 1, 5, and 10 feet in the area of the former Smith Road spill. The objective was to determine whether previously conducted remedial actions had effectively mitigated environmental contamination in this area. Field Screening analytical results, indicated that TPH concentrations in all samples collected were below the 25 mg/kg instrument detection limit.

3.1.6 Study Unit 6

Study Unit 6, the December 11, 1991 spill area, is shown on Figures 19A and 19B. During the interim RI, shallow soil samples were collected from 0 to 4 inches in depth at 40 locations (HA-1 through HA-20 and SS-6-1 through SS-6-20) within this study unit to determine the impact from wind blown crude oil from the December 11, 1991 spill. These samples were analyzed for the presence of petroleum hydrocarbons by field GC methods, and six of these were sent for WTPH-HCID analysis to confirm field results. Analytical results indicated that all samples were below field and laboratory detection limits (25 mg/kg and 10 mg/kg, respectively).

3.2 ONSITE AND OFFSITE SURFACE WATER STUDY AREAS

As a result of the January 15, 1991 natural gas condensate and December 11, 1991 and March 7, 1992 crude oil spills, surface water monitoring has been conducted at the facility directly following the spills and is ongoing on a weekly basis in conformance with the Enforcement Order (Exhibit A, Part III. D.1.). The January 15, 1991 natural gas condensate spill affected the drainage area north of the facility. This area included drainage ditches running parallel with East Smith Road which drain into a tributary of Deer Creek. Figure 20 shows the locations of dams 2 and 3 which were constructed to contain and recover any

hydrocarbons noted on the surface water. Surface water sampling locations (i.e., SWRO-D2) are also shown on Figure 20. The March 7, 1992 crude oil spill affected a wooded area downgradient of the pressure relief tank (Figure 21). Figure 21 shows the location of the March 1992 Spill Dam constructed to contain and recover hydrocarbons. Surface water sampling locations (i.e., SW-1) are also shown on Figure 21. Inspection and maintenance of the dams is being implemented in accordance with the revised Dam and Surface Water Inspection and Maintenance Plan dated September 4, 1992.

The results of the surface water monitoring program conducted by Dames & Moore are summarized on Table 1. As indicated on Table 1, only three sampling events (December 11, 1991, March 13, 1992 and March 10, 1992) have detected BETX or TPH above method detection limits.

3.3 GROUND WATER

To assess the ground water quality and flow conditions in the shallow saturated zone and deeper aquifer, ground water monitoring wells were installed at the site during the interim RI. A total of five shallow monitoring wells (i.e., SW-1 through SW-5) and five deep monitoring wells (i.e., DW-1 through DW-5) were installed at the locations shown on Figure 22. General monitoring well information including: screen intervals, reference and screen elevations and the Study Units evaluated by each well are summarized on Table 2.

Ground water was encountered at the site during the boring program in a shallow discontinuous saturated zone and in a deeper saturated zone. Ground water level measurements collected in the shallow saturated zone (Table 3) indicated that ground water flow is in a northwesterly direction (Figure 23). Ground water level measurements collected in the deeper aquifer (Table 3) indicated ground water flow is predominantly in a westerly direction (Figure 24).

The shallow ground water encountered in the upgrade area is likely to be present as a result of the artificial influences of the installation and operations at Laurel station. For instance, during the course of the upgrade project, in December, 1991, a leaking fire water line was discovered and repaired. The leak was located approximately midway between the Ferndale Line and the drain line adjacent to the road way. The leak was coming from a hole in a 4-inch PVC pipe which had been crushed, probably when the pipeline excavation was backfilled during the station construction. The hole was 2 to 3 inches long and the line was under a constant pressure of 200 psi. The water from the leak migrated mainly through the very fine cracks, observed in the upper 10 feet of the silty clays and into the drain line trench and from there generally downslope towards the northwest. Boreholes and test pits performed in the area around the burn pit generally encountered water in the first 20 feet but no deeper.

Around the area of the former oily water sump, water was encountered at shallow depths during construction activities. It is thought that the presence of this water is due mainly to rain water runoff entering the excavation during facility upgrade construction. Also small amounts of water was able to escape from the sump when it became full from a loose fitting that led to the drain line. The level of water as measured in shallow monitoring wells in this area has declined significantly since the area was backfilled and regraded. Monitoring wells screened within the shallow zone were found to yield small quantities of water, in some cases less than one gallon per hour.

The deeper aquifer zone is under confined conditions. During well development, the deeper wells were pumped at a rate of 2.5 gallon per minute (gpm) and no appreciable drawdown was observed in the wells. Based on the stratigraphy encountered in the deeper wells (Figure 6), it does not appear that the Demming Sand Unit was encountered in the site area. Therefore, the deeper wells may be screened within Kulshan Drift deposits which are characteristically, unsorted and unstratified mixtures of silt, clay, sand, and pebbles or the Vashon Till, which is characterized by poorly sorted mixtures of pebbles cobbles in a silt, clay and sand matrix.

The ground water sampling analytical results from the shallow and deeper saturated zone are summarized on Table 4. The ground water samples were analyzed for selected inorganic parameters, priority pollutant metals (total), modified TPH-418.1, and volatile organic compounds (VOC) (Method 8240). Due to insufficient recharge of ground water in the shallow monitoring or no ground water (i.e., SW-4), some of the analytical parameters mentioned above were not analyzed for.

The shallow ground water was found to have elevated levels of naturally occurring metals (i.e., chromium and lead). TPH-418.1 analyses of shallow ground water samples indicated that only one well, SW-5, contained levels above method detection limits. TPH was detected in SW-5 at a concentration of 18 mg/l. Low part per billion levels of benzene (1.3 ug/l) and the chlorinated VOC's 1,1,1-trichloroethane (5.7 ug/l) and 1,1-dichloroethane (1.2 ug/l) were also detected in SW-5. These results appear to be consistent with the observations of oily water in excavations made during the station upgrade at the former oily water sump which was located in close proximity to SW-5. The TPH was the only organic parameter found to exceed the MTCA Method A Ground Water Cleanup Level (1 mg/l) at SW-5.

As was identified in the shallow ground water, elevated levels of total metals (i.e., chromium and lead) were also detected in the deeper ground water which appear to be associated with background ground water concentrations. No TPH-418.1 or VOC's were detected in the deeper wells above method detection limits, with the exception of DW-2, which detected chloromethane at a concentration of 1.6 ug/l. The occurrence of chloromethane was believed to be the result of laboratory contamination.

Based on the result of the ground water characterization program it appears that the deeper aquifer has not been impacted by site operations. Deep monitoring wells situated downgradient of Study Units 1, 2, 4 and 6 did not detect any petroleum hydrocarbon components, supporting this conclusion. Ground water in the intermittent shallow saturated zone appears to have been impacted by site operations in the southeastern portion of Study Unit 1, in the vicinity of SW-5. Ground water flow in the shallow saturated zone appears to be in a northwesterly direction (Figure 23).

3.4 ONSITE AND OFFSITE SEDIMENT STUDY AREAS

Sediment quality data for the Tributary of Deer Creek (i.e., Dam 2), Deer Creek (i.e., Dam 3) and the area affected by the March 7, 1992 spill has not been obtained to date. General observations on the sediment conditions in these area have been noted as part of the dam and surface water inspection and maintenance program being conducted at the site as required under the Enforcement Order. Residual petroleum hydrocarbons (i.e., surface sheen) have been noted in the bottom sediments behind Dam 2 when disturbances of the sediment have occurred. In addition, some residual petroleum hydrocarbons have been observed in the soil/sediment downgradient from the March 7, 1992 spill.

4.0 FEASIBILITY STUDY

4.1 DEVELOPMENT OF ALTERNATIVES

The purpose of the Feasibility Study (FS) is to identify and evaluate remedial alternatives potentially applicable to the conditions at the various study units. Once cleanup standards have been established, the FS will include the identification of potential alternatives based on the site specific conditions encountered during the RI, a screening of alternatives in order to select alternatives which warrant further analysis, treatability studies (if necessary), and detailed and comparative analyses of the selected alternatives. In addition to the technical aspects of the alternatives, estimated costs and the relative cost/benefit ratio for each alternative will be assessed. Based on the results of the FS, a preferred alternative or combination of alternatives will be identified. The evaluation and screening approach will be consistent with MTCA criteria.

The Phase I Interim Action Plan submitted to Ecology on August 29, 1992 prepared to address the Petroleum Contaminated Soil Stockpiles, will provide a framework for initial development of the FS. The remedial actions that have been screened and developed for the petroleum contaminated soil stockpiles will be brought forward, amended as necessary, and considered for the contaminated soils in other study areas. Additional remedial action alternatives will be screened and developed, as applicable, to address any contamination associated with a shallow saturated zone or ground water aquifer, if necessary.

The following sections describe how the FS will conducted.

4.1.1 Development of Cleanup Standards

The general objective of future remedial actions at the site is to provide a cost-effective remedial alterative (or alternatives) that effectively mitigates and minimizes threats to, and provides adequate protection of, human health and the environment. Remedial actions are designed to attain or exceed regulatory requirements. This section discusses the development of appropriate cleanup standards for hydrocarbon compounds of potential concern at the site, based upon a site specific risk assessment, a review of regulatory standards, criteria, and guidelines outlined in MTCA, and other applicable or relevant and appropriate requirements (ARARS).

Cleanup standards for the study units will be established based on information collected during the RI. These standards are medium-specific or study unit-specific cleanup levels for each compound of concern which are suitable for protecting human health and the environment. In addition, points of compliance will be established for the cleanup levels. These objectives will be developed by Dames & Moore and will specify the hydrocarbon compounds of concern, exposure route(s) and receptor(s), and acceptable levels or range of levels for each exposure route (i.e. a preliminary remediation goal). The acceptable levels will be based on criteria specified in MTCA and applicable or relevant and appropriate requirements (ARARs) for each compound, or site-specific risk-based objectives. Where achievable, specified cleanup levels sufficiently protective of human health and the environment will be directly adopted as the remediation goal for that compound. If it is determined that these levels are not readily achievable given the site conditions, alternative levels will be proposed which can be shown to provide sufficient protection for human health and the environment.

4.1.2 Development of General Response Actions

General response actions and medium-specific actions that will satisfy the cleanup standards will be developed by Dames & Moore. General Response Actions potentially applicable to the site include:

Media	Potential General Response Actions
Ground Water	No Action Containment Collection Treatment Discharge Institutional Controls
Soil	No Action Containment Excavation Treatment Disposal Institutional Controls

If additional media (such as sediment, surface water etc.) are determined during the RI to require remediation, general response actions will be expanded during the FS.

4.1.3 Identification of Volumes or Areas of Media

Dames & Moore will make an assessment of the areas or volumes for each medium of interest associated with the study units to which general response actions may be applied. This assessment will include a consideration of not only acceptable exposure levels and potential exposure routes, but also site conditions and the nature and extent of hydrocarbons in the various environmental media.

4.1.4 Identification and Screening of Remedial Technologies and Process Options

Predicting the remedial technologies that are potentially applicable at the site plays an important role in the workplan. Many of the remedial actions involving treatment potentially require lengthy treatability studies and can lead to delays in the completion of the FS. Dames & Moore will narrow the realm of potentially applicable technology types and process options, by evaluating these options with respect to technical implementability. In screening a technology for implementability, Dames & Moore will utilize existing site information, and information gathered during the RI to assess whether a given technology can be effectively implemented at the site.

As mentioned previously, the work performed by Dames & Moore on the Phase I Interim Action Plan provides a starting point for the identification and screening of remedial technologies potentially applicable for the contaminated soils in each of the six study areas. The implementability of the following technologies were considered for the petroleum contaminated stockpiles:

- Asphalt Incorporation
- Thermal Desorption
- Biological Landfarming - On-site
- Biological Landfarming - Off-site
- Biological Composting
- Offsite Disposal
- Soil Washing

Since the nature of soil contamination in the study areas will likely be similar to the contamination in the petroleum contaminated stockpiles, each of above technologies will be reconsidered for each study unit using any additional data collected during the RI.

Other potentially appropriate soil and ground water remedial technologies will be evaluated and screened out based upon implementability during the FS process. Specific criteria considered during the screening process include:

Contaminant characteristics
- organic/inorganic
- physical characteristics (such as volatility)
- chemical characteristics (such as reactivity)
- horizontal/vertical extent of contamination

Site Characteristics
- depth and characteristics of ground water
- presence of surface structures
- site geology

Other site-specific criteria will be defined as the RI progresses. This identification and screening process will be documented in appropriate figures and text.

4.1.5 Evaluation of Process Options

Dames & Moore will evaluate the technology process options considered to be implementable, and then select one representative process, if possible, for each technology type. These process options will be evaluated using the criteria of implementability, and cost. Innovative technologies will be appropriately integrated with this step in the FS.

4.1.6 Formation of Alternatives

The general response actions and the representative process options chosen will be combined by Dames & Moore to form alternatives for each site. Both source control and ground water control actions will be considered for the sites. This process will be documented in appropriate text and figures to clearly define and illustrate the range of potential alternatives, including the locations of areas to be excavated or contained, the approximate volumes of soil and/or ground water to be excavated and/or collected, the approximate locations of interceptor trenches, wells, etc., and any other information needed to describe the

alternative adequately and to document the logic behind the assembly of general response actions into specific remedial action alternatives.

4.2 SCREENING OF ALTERNATIVES

The following subsections describe the basic steps to be taken by Dames & Moore during the screening of alternatives.

4.2.1 Definition of Alternatives

Appropriate aspects of developed alternatives will be defined by Dames & Moore. These aspects may include: refinement of volumes or areas of contaminated media, further details of the individual process options, sizing requirements of technologies, remediation time frames, interactions among media, and protectiveness requirements. Alternatives will be defined to provide sufficient quantitative information to allow differentiation among alternatives with respect to effectiveness, implementability, and cost. The following elements will be developed, as appropriate, for the various technology processes considered an alternative: size and configuration of on-site extraction and treatment systems or containment structures; time frame in which treatment, containment, or removal goals can be achieved; rates or flows of treatment; spatial requirements for constructing treatment or containment technologies or for staging construction materials or excavated soil or waste; distances for disposal technologies; and required permits for off-site actions and imposed limitations.

4.2.2 Screening Evaluation

Dames & Moore will evaluate each alternative against the short-term and long-term aspects of three broad criteria: effectiveness, implementability, and cost. The effectiveness evaluation will focus upon the alternative's effectiveness in achieving the cleanup standards established for protecting human health and the environment, and in reducing the toxicity, mobility, or volume of contaminants. The evaluation of implementability will include a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative. The focus of the cost evaluation will be to make comparative estimates for alternatives with relative accuracy, so that cost decisions among alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. Innovative technologies will be carried through the screening process if there is reason to believe they may offer significant advantages.

4.2.3 Alternatives Screening

Dames & Moore will retain those alternatives with the most favorable composite evaluation of all factors for further consideration during the detailed analysis. The number of alternatives carried through the screening process is not expected to exceed five and may be considerably less, as appropriate. Any additional investigations that may be necessary will be identified by Dames & Moore in conjunction with needs identified during the development and screening process and required for the detailed analysis of alternatives. Dames & Moore will identify medium/contaminant-specific cleanup levels and recommend treatability testing and additional site characterization, as appropriate.

4.3 TREATABILITY INVESTIGATION

Dames & Moore will evaluate the need for planning and performance of bench or pilot treatability studies during the feasibility study process. Alternatives involving biological treatment are likely to involve additional treatability investigations. If the need for these investigations arises, Dames & Moore will describe these in sufficient detail within a Treatability Study Work Plan. The results of these investigations, if any, will be described and integrated as appropriate in relevant sections of the FS report and presented in a separate Treatability Study Report as an Appendix to the FS report.

4.4 DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives builds upon previous evaluations conducted during the development and screening process and incorporates any treatability study data and additional site characterization information that may have been collected. A description of the analysis process follows.

4.4.1 Alternative Definition

If necessary, Dames & Moore will further define each of the alternatives with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

4.4.2 Individual Analysis of Alternatives

Dames & Moore will evaluate each alternative according to the following evaluation criteria:

- Overall protectiveness of human health and the environment;
- Compliance with cleanup levels;
- Restoration time frame
- Long-term effectiveness and permanence;
- Overall reduction of toxicity, mobility, and volume of the hazardous substance;
- MTCA preference of the cleanup technology;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

The presentation of the individual analysis of alternatives will occur in the FS report as a detailed narrative discussion with appropriate summary tables and figures.

4.4.3 Comparative Analysis of Alternatives

Dames & Moore will conduct a comparative analysis of each individually assessed alternative to evaluate the relative performance of each alternative in relation to each evaluation criterion. Dames & Moore will identify the advantages and disadvantages of each alternative relative to one another. Presentation of the

comparative analysis will include a matrix and a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each evaluation criterion, and how variations in key uncertainties could affect relative performance.

4.5 FS REPORT

At the conclusion of the Comparative Analysis of Alternatives, Dames & Moore will prepare an FS Report. The FS Report will summarize the relevant site data and methods used to select the recommended cleanup actions. Site background information and the major findings from the RI report will be summarized in the introductory section of the FS Report. This introductory section will include, at a minimum, sections containing:

- Site description;
- The nature and extent of contamination at the sites;
- A discussion of the pathways for contaminant migration and the mechanisms of contaminant transformation; and
- A listing of the cleanup levels and permits of compliance.

The second section of the report will discuss the development and screening of technologies. The objectives of site remediation and general response actions consistent with the objectives will be clearly articulated.

The development and screening of the preliminary remedial alternatives will be detailed in the FS Report. This section will present details of the preliminary alternatives such as target compounds and environmental media, component technologies, and rough order-of-magnitude costs. The selection of the final cleanup actions will be discussed, and the major features of these final alternatives will be summarized.

The detailed analysis of cleanup action alternatives will include:

- A detailed description of the alternatives;
- A discussion of the comparison of the alternatives;
- A review of the Baseline Risk Assessment, if completed for the RI;
- Presentation of risk calculations performed to evaluate the short- and long-term effects of the alternatives;
- A discussion of the estimated costs of cleanup; and
- A summary of the detailed evaluation.

4.6 SUPPLEMENTAL DATA COLLECTION

To support the evaluation of potential remedial alternatives in the FS, several supplemental physical soil properties will be evaluated during the RI. Sieve analyses will be performed to establish soil grain size distribution. Finer grained soils will be evaluated using the Atterberg Limit test method. Soil moisture content, pH and permeability tests will also be performed in the RI. Soil permeability testing will utilize the Falling Head method and will be performed selectively in unsaturated zones of contamination.

5.0 REMEDIAL INVESTIGATION

5.1 WORK PLAN OBJECTIVES AND RATIONALE

The RI/FS work plan has been designed to focus on data collection activities that will allow a thorough evaluation of conditions on and off-site relevant to the ecological and human health risk assessment and the FS. This section presents the objectives and rationale associated with the RI/FS sampling. In general, the objectives of the RI/FS are to:

- further characterize the nature and extent of contamination present in the Study Units
- better define potential contaminant pathways, environmental and human health risks and risk-based cleanup objectives; and
- diminish the range of potential remedial alternatives (if applicable) to be considered during the FS.
- evaluate the feasibility of removing Dams 2 and 3 and the March 1992 Spill Dam

To meet these objectives a scope of work has been developed which includes sampling of air, soil, sediment, surface water and ground water; a wetland determination/delineation plan; a baseline ecological and human health risk assessment; an assessment of surface water hydraulics and an assessment of aquifer characteristics. The overall rationale for the field sampling plan is based on satisfying the objectives outlined in Table 5. The selection of sampling locations is based on previous work conducted under the Interim Action RI and historical information related to the operations at Laurel Station. The frequency of sampling is based on existing analytical data and seasonal constraints. The specific objectives and rationale of the proposed investigation activities for each media and Study Unit evaluated is presented in the following section.

5.2 FIELD SAMPLING AND ANALYSIS PLAN

This section describes the general approach and specific tasks to be performed under this RI. The RI field program includes soil borehole drilling and sampling, the installation of shallow ground water monitoring wells, air, sediment, surface water and ground water sampling, and wetlands delineation. The field investigation program for the Laurel Station has been divided into six study units (see Figure 4) and onsite and offsite sediment study areas that correspond to areas potentially impacted by past activities and/or documented spills. Specific methods and procedures to be employed during the conduct of field activities

are presented as General Operating Procedures in Appendix A. The equipment decontamination procedures, presented as Appendix A, apply to all non-dedicated sampling equipment employed during the field investigation.

Field quality assurance and quality control procedures presented in the Quality Assurance Project Plan (QAPP) will be followed during field activities (Appendix B). These include procedures for field quality control sampling, sample handling and preservation, and field documentation and record keeping. In addition, all field activities will be conducted in accordance with the Health and Safety Plan provided in Appendix C. This plan will contain provisions for the monitoring of the work place air quality during the RI.

5.2.1 Subsurface Soils Investigation

The objectives of the subsurface soil sampling are to determine the nature and extent of contamination at the six Study Units and provide data to support a risk assessment and FS (Table 5). As discussed in Section 3.0, each Study Unit is associated with different site features or spill events. The sampling rationale is based on defining the nature and lateral and vertical distribution of contamination in each Study Unit. An equally important objective of the soil investigation is to supplement information concerning the engineering properties of the soil in the unsaturated and saturated zones that may influence the type, rate and pathways of potential contaminant movement to ground water and surface water. In addition this information will be utilized to evaluate the selection of the most viable remedial alternative which will be developed during the FS.

Table 6 presents a summary of the RI/FS soil sampling investigation proposed for each Study Unit. The location of the Study Units are shown on Figure 4. Soil samples will be collected continuously throughout the entire depth of the boring, and each soil sample will be classified through visual inspection to obtain stratigraphic information, as well as information on the extent of residual TPH in the soils. In general soil samples will be selected for chemical analysis when visually staining, and/or field screening of soil samples indicates contamination is present in the sample. If the contamination is found to extend over several feet in thickness, only one representative sample of the contaminated material will be retained for analysis. An additional sample will be collected in these borings below the zone of apparent contamination to evaluate the vertical extent of the contamination and verify underlying material is not contaminated. Soil samples from borings used to verify that previously remediated areas have achieved appropriate cleanup, will be collected from the same depth horizon as previous sampling conducted in the area. If no contamination is detected in the boring used to evaluate the lateral extent of contamination in an area, soil samples will be collected from the depth interval previously identified with contamination in borings or test pits in the area. Since one of the main objectives of the soil investigation is to evaluate the lateral extent of soil contamination, additional boring may be added to the boring program during the course of the field investigation to meet this objective.

Supplemental laboratory data will be obtained from borings drilled at a number of previous boring locations (i.e., TM-B5 and TM-B7) to confirm field screening data collected in these areas.

Selected soil samples will be subjected to tests for index properties at Dames & Moore geotechnical laboratory in Seattle, WA. The grain size distribution (sieve analysis) of selected unsaturated and saturated

zone samples will be determined using ASTM D422 and D1140 testing procedures. Fine grained soil samples will be submitted for Atterberg Limits determination using ASTM D4318 testing procedures. The moisture content, specific gravity and pH of the samples will be determined using ASTM D2216, D854 and D2976 testing procedures, respectively. In addition, a limited number of soil samples in the Study Units identified with TPH contamination will be subjected to permeability tests within the unsaturated zone using the Falling Head Method (Fixed Wall Permeameter, Bowles Method). Relatively undisturbed soil samples will be collected with the Dames and Moore Type U sampler.

The basis for the completion depth of each boring is based upon the RI findings in each Study Unit. Boring depths may be extended to deeper depths based on the conditions encountered during the completion of the boring. Shallow borings advanced to depths of 3 feet or less will be drilled using hand auger techniques. Borings greater than 3 feet in depth will be drilled using hollowstem auger drilling techniques. For borings installed by hollow stem drilling techniques, subsurface soil sampling will be accomplished using split spoon sampler and standard penetration test (SPT) methods (ASTM D1586-87D). A photoionization detector (PID) will be used to screen each splitspoon immediately as it is opened and the reading will be recorded on the boring log

The onsite geologist will maintain a detailed log of all drilling operations and will describe the samples in accordance with the Unified Soil Classification System. Details of sample handling procedures are provided in the QAPP presented in Appendix B.

Surface soil samples will also be collected at Study Unit 6 during the soils investigation program. These samples will be collected at depths less than 6 inches bgs, according to the procedures outlined in Appendix A.

Operational restraints on access to some areas can affect the choice of sampling techniques to be used. Operational restraints on site access include the existence of buried utilities (i.e., oil pipelines). Drilling and sampling in some instances may not be accomplished where advancement of the augers or split spoon sampler encounter an obstruction or refusal. The soil sampling plan is tailored to allow the most effective technique of site-specific restrictions. A description of the field exploration techniques that will be used during the subsurface soil sampling and analysis program are describe below

The following subsections describe the site specific rationale and specific soils investigation programs to be implemented within each of the six study units and study areas.

5.2.1.1 Study Unit 1 - Pump Station Operations Area

Residual petroleum contamination was identified in the Pump Station Operations Area during the interim RI. Additional borings are proposed in the nine of the eleven subareas in Study Unit 1. The proposed boring locations shown on the accompanying figures were selected to confirm TPH levels, and in some instances VOC levels detected in previous borings or test pits and to evaluate the lateral and vertical extent of any contamination identified. A description of the proposed soil investigation in each subarea is presented below.

Former Pump Station Area

Five soil borings are proposed as shown on Figure 5, to further evaluate the extent of the residual TPH. Residual TPH was identified to a depth of 30 feet in one boring in the area (TM-B15), therefore, the proposed soil borings will be extended to at least 35 feet in depth in this area. Soil samples selected for analysis, will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range (i.e., WTPH-G, D or 418.1) if hydrocarbons are detected.

Former Oily Water Sump

Three soil borings are proposed as shown on Figure 7, to evaluate the extent of the residual TPH. Residual TPH was detected in this area to a depth of 19 feet bgs. Therefore, soil boring will be drilled to a minimum depth of 24 feet. Soil samples selected for analysis will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if hydrocarbons are detected. As a result of the detection of xylenes in the soil and chlorinated VOC's in the shallow ground water at monitoring well SW-5 which is in close proximity to the oily water sump, soil samples will also be analyzed for VOC's (Method 8240).

Former Burn Pit

Three soil borings are proposed as shown on Figure 8, to evaluate the extent of residual TPH contamination. Residual TPH was detected in this area to a depth of 15 feet bgs. Therefore, soil borings will be drilled to a minimum depth of 20 feet. Soil samples selected for analysis will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if hydrocarbons are detected. In addition the samples will also be analyzed for VOC's (Method 8240).

Former Drainline Between Oily Water Sump and Burn Pit

Two soil borings are proposed as shown on Figure 9, to evaluate if residual TPH is present in the soil along a section of the drainline not previously evaluated. The borings will be extended to 10 feet bgs, well below the drain line. Soil samples selected for analysis will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if hydrocarbons are detected. In addition, the samples will be analyzed for VOC's (Method 8240).

Former Draintile and Ferndale 16-Inch Product Line

Two soil borings are proposed at the northern end of the draintile (Figure 10) area at the location of elevated TPH levels which were identified in a post excavation sample collected at approximately 4 feet bgs, DTE-1 (Figure 10). Three additional boring will be drilled southwest of the draintile around the Ferndale 16-Inch Product Line to assess an area which was identified in testpit sampling as containing elevated TPH levels to a depth of 10 feet bgs. The borings will be extended to a minimum of 15 feet in depth. Soil samples selected for analysis will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if hydrocarbons are detected.

Former Waste Pit

Three soil borings are proposed in the area of the former waste pit as shown of on Figure 11. Elevated levels of toluene, xylene and TPH were identified in the area at a depth of 15 feet bgs. The soil borings will be extended to a minimum depth of 20 feet. The soil samples selected for analysis will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if hydrocarbons are detected. In addition, the samples will also be analyzed for VOC's (Method 8240).

Former Oil/Water Separator

Three soil borings are proposed in the area of the former oil/water separator as shown on Figure 8. Based on elevated levels of TPH identified a test pit conducted in the general area (TP-7, at a depth of 7 feet), the borings will be drilled to a minimum depth of 12 feet bgs. The soil samples selected for analysis will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon, if hydrocarbons are detected.

Historical Spills

As previously mentioned, approximately 75 barrels of natural gas condensate leaked from the 16 inch Ferndale pipeline within the southwest quarter of Study Unit 1. The condensate flowed over the ground surface toward the northwest (Figure 13A and 13B). Purnell & Associates collected shallow soil samples within the impacted area and reported TPH at concentrations from below detection to 15,411 mg/kg. In order to assess the current conditions within the area impacted by this release, six shallow subsurface soil samples will be collected within the area defined in the Purnell report (November 25, 1991). Samples will be obtained from depths of approximately 18 to 24 inches using hand augering techniques from locations depicted on Figure 13B. Samples will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if TPH is detected.

To assess soil cleanup actions conducted in association with the December 11, 1991 spill, two soil borings will be drilled in the cleanup area as shown on Figure 13A. The borings will be extended to a minimum depth of 5 feet bgs. The selected samples will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon, if hydrocarbons are detected

5.2.1.2 Study Unit 2 - Oil Bulk Storage Tank Area

Although interim RI analytical results for the bulk oil storage area indicated limited impact from petroleum hydrocarbons to this area, additional borings are proposed to confirm the interim RI results and to characterize the subsurface soils in the portions of the containment areas surrounding the two bulk storage tanks not previously evaluated.

The soils investigation of the bulk oil storage tanks area will consist of drilling three additional borings to the east, south, and west of Tank 180, and three additional borings to the east, west, and north of Tank 170 as shown of Figure 15. These borings will be advanced to a depths of 15 feet. Samples will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if TPH is detected.

5.2.1.3 Study Unit 3 - Pressure Relief Tank Area

The interim RI findings for the pressure relief tank area indicated that additional soil data is required in this study unit to supplement previous soil data.

Soils have been removed in the containment area and reconstructed with clean compacted low permeability fill materials, no further sampling of the area within the containment berm is necessary. However, subsurface soils sampling is proposed adjacent to the bermed containment area to determine whether subsurface migration from the containment area has occurred.

A total of four borings will be drilled and sampled in the area of the pressure relief tank. Borings will be advanced to depths of 10 feet.

In addition, the detection of TPH exceeding MTCA cleanup levels at interim RI test pit TP3-2, located within the former soil disposal area south of the pressure relief tank, indicates the need for additional subsurface soil sampling to delineate the lateral extent of this contamination.

Three borings will be drilled in the former soil disposal area. The three borings will be located around the interim RI test pit location TP3-2. These boring locations are shown on Figure 16. The borings will be extended to a depth of 10 feet and soil samples will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if TPH is detected.

5.2.1.4 Study Unit 4 - Boneyard Area

The interim RI findings for the "boneyard" area indicate the presence of low concentrations of TPH (below MTCA cleanup levels) in shallow soils. Based on these findings, it is apparent that the extent and concentration of petroleum related contamination within this study unit is limited. However, additional surface and shallow subsurface soils sampling is proposed near the property boundary to verify the lateral extent of TPH.

Four shallow hand auger borings will be drilled to a depth of 3 feet at the west, northeast and eastern edge of the "boneyard" study unit (Figure 17). Samples will be analyzed for WTPH-HCID. If TPH is detected, analysis for the dominant hydrocarbon range detected will be conducted.

5.2.1.5 Study Unit 5 - Area North of Smith Road Spill

The interim RI field GC results for the area north of Smith Road indicate that petroleum hydrocarbons are not present at concentrations exceeding MTCA cleanup levels. However, confirmation of these results is proposed through resampling of select previous soil boring locations and one additional location. The soils investigation in the area north of Smith Road will consist of the drilling and sampling of two borings. Two of these borings will correspond to two previous sample locations (TP5-6 and TP5-2) and the third boring will represent a new location within the study area (Figure 18). The soil borings will be advanced to a minimum of five feet depth. Samples will be analyzed for WTPH-HCID, followed by, analysis for the dominant hydrocarbon range, TPH is detected.

5.2.1.6 Study Unit 6 - December 11, 1991 Spill Area

The interim RI field screening results for the December 11, 1991 spill area indicate that residual hydrocarbons are not present at concentrations exceeding MTCA cleanup levels within this study unit. However, confirmation of these results is proposed through resampling of selected previous surface soil sample locations.

The soils investigation in the area of the December 11, 1991 spill will consist of resampling two previous sample locations (HA-6 and SS6-1) as shown on Figure 19. Samples will be collected from 1 to 4 inches below the ground surface. Samples will be analyzed for WTPH-HCID, followed by analysis for the dominant hydrocarbon range, if TPH is detected.

5.3 SURFACE WATER AND SEDIMENT INVESTIGATION

The objectives of the surface water and sediment investigation are to: assess surface water quality, assess surface water hydrological conditions, characterize the areal and vertical distribution and concentration of hydrocarbon residuum in sediment and wetland soils upstream and downstream of the dams (Nos. 2, 3 and March 7, 1992 spill dam), assess potential exposure pathways and assess human health and ecological risk. As previously mentioned, extensive surface water quality data has be gathered and is continuing to be gathered as a requirement of the Enforcement Order. The hydrologic conditions will be evaluated to obtain information concerning the flow dynamics and sediment deposition within the tributary of Deer Creek, Deer Creek and the wooded wetland area downgradient of the March 7, 1992 spill. These data will be utilized to evaluate the feasibility and potential ecological impacts of removing the dams. The scope of work presented below is in accordance with our Dam Removal Assessment and Feasibility Evaluation dated August 14, 1992.

A field survey of the creeks and wooded wetland areas will be conducted to assess:

- condition of the channel
- areas of erosion and deposition
- extent of observable petroleum hydrocarbons
- vegetation condition
- presence/absence and potential effects to wetland wildlife communities (this work will be conducted under the wetland determination/delineation and mitigation presented in Section 5.5.)

To assess flow conditions (i.e. velocities and quantities) in Deer Creek and tributary and the March 7, 1992 Spill Area, flow measurements will be obtained during storm flow using an open channel flow meter. The flow measurement procedures are outlined in Appendix A.

Surface water samples will be collected at the established surface water quality sampling locations as shown on Figure 20. The surface water sampling procedures are outlined in Appendix A. The proposed analytical program is outlined on Table 6.

The sediment sampling program includes sampling of bottom sediments in the tributary of Deer Creek (i.e, in the vicinity of Dam 2), Deer Creek (i.e., in the vicinity of Dam 3) and the March 7, 1992 spill area. Sediment samples will be collected at upgradient and downgradient locations in Deer Creek and in the Area of the March 7, 1992 spill. In the tributary to Deer Creek, upgradient samples will be collected from a section of the drainage ditch which has not to have been affected by site operations. Samples will be collected according to the procedures outlined in Appendix A. The proposed sampling locations are shown on Figure 20. The proposed sediment sampling analytical program is summarized on Table 6.

5.4 GROUND WATER INVESTIGATION

The overall objectives of the ground water sampling and characterization program are outlined in Table 5. In order to further evaluate the current condition and potential future migration of contaminants in the ground water, additional investigation of hydrogeologic site characteristic will be conducted. The hydraulic relationships between the shallow saturated zone and the deeper aquifer will be evaluated further. Additional information is necessary to understand contaminant transport in the shallow saturated zone.

The selected components of the ground water sampling and characterization include:

- installation of additional shallow monitoring wells
- collection of additional water level data
- hydraulic testing (estimation of specific capacity and hydraulic conductivity)
- ground water sampling and analysis at existing and newly installed monitoring wells.

The techniques and procedures to be used during the ground water sampling and characterization are discussed below.

Ground water quality and hydrogeologic characteristics will be evaluated on a site wide basis through resampling of existing wells, installation and sampling of new shallow wells, and measurement of water levels. This program includes the installation of additional shallow ground water monitoring wells within the general areas of Study Unit 1 and 2 (Figure 22). The rationale behind the new monitoring well locations is summarized on Table 7.

Construction of monitoring wells will be conducted in conjunction with the soils investigation and selected soil borings will be completed as shallow wells. If ground water is not detected in the soil samples collected during the drilling of the well boring, the boring will be allowed to sit for a period of 1 to 3 hours to assess if ground water is present in the area. In some cases the boring will be allowed to remain open over night and measured in the morning to see if any ground water accumulation has occurred. Monitoring wells will not be installed at the proposed locations if ground water is not detected using the methods mentioned above. Well construction will be in conformance with WAC 173-160 and is detailed in Appendix A. In general, the wells will be constructed so that the well screen intersects the water table surface. Wells will be constructed of 10 to 15 feet of 2 inch diameter 0.001 inch slotted PVC screen and PVC riser to the surface. Sand filter pack material will be placed in the annular space between the well and

borehole extending 2 to 3 feet above the top of the screen. A 2 foot bentonite seal will be place over the sand pack, and the remaining annular space filled with bentonite/cement grout to the surface. The well will be completed with a locking protective steel cover placed into a concrete collar at the surface.

Monitoring wells will be developed no sooner than 48 hours after installation to allow the grout time to cure. Prior to beginning development water levels will be measured (Appendix A). Details of the well development procedure are contained in Appendix A. An estimation of the specific capacity of each well will be measured during well development (Appendix A). Development will generally entail the purging of water from the well until generally low turbidity water is achieved. At least five well volumes of water will be removed, or development proceeds for one hour.

In situ permeability tests will be conducted at selected monitoring wells in accordance with the procedures outlined in Appendix A.

Monitoring well sampling procedures are detailed in Appendix A. Sampling will be conducted no sooner than one week from the time of installation. Prior to sample collection the water level will be measured. The well will then be purged of stagnant water by pumping or bailing approximately three well volumes of water. This will assure the collection of samples representative of the water bearing formation. If the well is bailed dry and exhibits slow recovery, purging will be ceased. The well will be sampled following time for sufficient water level recovery. Samples will be collected using a dedicated bottom filling bailer. The bailer will be lowered slowly into and out of the water column using dedicated nylon rope. Samples for volatile organic analysis (VOA) will be collected first by slowly filling VOA vials and assuring that no air bubbles are present. Samples for other organic and inorganic parameters will be collected following the VOA samples. Sample teams will be careful to avoid sample agitation during sampling to prevent the loss of any volatile or semivolatile organic compounds. Details of sample handling procedures after collection are provided in the QAPP (Appendix B).

5.5 WETLAND DETERMINATION/DELINEATION AND MITIGATION

5.5.1 Review Background Data

Dames & Moore biologists will review project background information such as the previous wetland delineation report for Areas 1 - 3 (Purnell & Assoc., Inc. 1991), relevant soils engineering analysis, and aerial photographs of the project area. In addition, public resource documents will be reviewed to determine relevant site characteristics and the potential for wetlands to occur. Public resource documents used in this regard include SCS County Soil Surveys, National Wetlands Inventory Maps, USGS quadrangle base maps, and Washington Natural Heritage Program data. These data will be used to prepare for field studies to evaluate additional data requirements for Areas 1, 2, and 3 which were affected by the January 1991 natural gas condensate leak (Figure 2). In addition, other areas of the site which have been, or are potentially affected by the station's operations, such as the March 1992 spill area, will be evaluated.

5.5.2 Site-Specific Evaluation

An on-site evaluation of vegetation, soils, and hydrology will be conducted in accordance with the intermediate methodology described in the *Corps of Engineers Wetlands Delineation Manual* developed by the Department of the Army Environmental Laboratory (1987) to comply with Federal permitting. Additionally, to comply with County and State wetland regulations, a concurrent on-site evaluation of vegetation, soils, and hydrology will be conducted in accordance with the intermediate methodology described in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* developed by the Federal Interagency Committee for Wetland Delineation (FICWD 1989). According to both of these methodologies, each of these three parameters should be present to establish an area as wetland. Thus, our field data collection for these two methodologies will be the same. However, conclusions from the collected data may differ between these methodologies, possibly resulting in two separate sets of wetland boundaries.

Sampling plots will be established in appropriate areas to determine the presence and extent of wetland characteristics. Each plot will be numbered and flagged in the field. A minimum of two plots will be sampled for each boundary determination including one placed in the wetland area and one in the non-wetland area. For difficult boundary determinations, a third plot will be sampled at the boundary. At each plot, a plant species list with the percent cover and wetland indicator status for each plant will be developed. Soil sampling holes will be excavated to a depth of 18 inches and soil characteristics noted. Signs of past or current hydrology will be recorded and a determination of wetland hydrology made. Wetland data sheets produced for each sample plot will be included in the wetland report (Appendix D).

Based on preliminary information and field study data collected, a determination of the presence and extent of wetlands according to the 1987 Corps and the 1989 FICWD methodologies will be made. Delineated wetlands will be inter-visibly flagged and accurately mapped on a large scale map or large scale aerial photograph. The flagged wetland boundaries and sample plots will be professionally surveyed and a survey map with wetland acreage produced. Project biologists will review the final wetland survey map to ensure its accuracy. The wetland map generated by this process will be incorporated into our report.

5.5.3 Wetland Determination/Delineation Report

A detailed wetland report will be produced discussing the background data review, methodology and results of site-specific sampling and delineation. All relevant delineation data will be included in the report. Habitats will be described by dominant and commonly occurring species of the wetlands and adjacent upland communities. Several maps will be incorporated into the report including a general location map utilizing the appropriate USGS quadrangle as a base map, a topographic map of the area, large scale site map showing wetland boundaries and numbered sample plots, an aerial photo with overlays displaying site property and wetland boundaries, National Wetland Inventory Maps showing site location, and an SCS County Soil Survey map of the area showing site location. Regulatory requirements associated with our delineation results will also be discussed. Additionally this report will include potential impact assessment and mitigation measures as discussed below. Soil series profile descriptions will be appended to the report, as will all completed field data sheets.

5.5.4 Compensatory Wetlands Mitigation Plan

5.5.4.1 Wetland Functions and Values

Dames & Moore biologists will assess impacts for affected wetlands on-site. Impacts will be both quantitatively and qualitatively addressed, and a thorough ecological assessment of wetland functional values will be preformed. The functions and values of the impacted wetlands will be compared to those proposed for the created, restored, or enhanced wetland. Wetland functions include water quality improvement, floodflow moderation, biological support, ground water recharge and discharge, and recreational and aesthetic values. Functional values will be assessed through observations of specific wetland features at each wetland which effect wetland functions and values. These functions and values will be determined using the Washington State Wetlands Rating System for Western Washington (Washington State Department of Ecology 1991) will be completed for each delineated wetland. Impact descriptions will be incorporated into our delineation report.

Mitigation plans for creation, restoration or enhancement of wetlands will be proposed, if necessary, which should compensate for lost functions and values. Wetlands will be designed as persistent features in the landscape through creation of a permanent, consistent water source and successful revegetation by non-invasive plant species. The location of the wetland in the landscape will be considered during design of mitigation wetlands.

5.5.4.2 Wetland Mitigation Plan

Wetland delineation results may indicate impacts to wetlands on-site. If impacts are observed, the lead agency may require mitigation to compensate. If necessary, mitigation will be addressed initially in a conceptual plan which will be finalized upon agency approval.

Conceptual mitigation measures which emphasize impact avoidance, reduction, and compensation, in that order, will be discussed, based on guidelines established by the State and County, and any other agency guidelines. Once this conceptual mitigation plan is approved by the appropriate agencies, a final mitigation report and design will be prepared. This will be a comprehensive report which will discuss in detail the mitigation concepts previously agreed upon by the agencies.

The mitigation plan will include environmental goals and objectives, and performance standards with specific criteria for measuring project success. The plan will also include detailed construction and revegetation plans. The final mitigation design will be produced by our landscape architect on a map showing drainages and topography to two-foot intervals. A final construction specification drawing will be prepared and will accompany the final mitigation report. Included in this design will be a mitigation plan overview and details of specific implementation measures. A planting plan, including vegetation to be used, size and density of plantings, planting zones, and planting schedule will be included for each mitigation area, including the associated buffer.

Construction management of the wetland mitigation projects will be preformed by a wetland biologist. Functioning as a mitigation construction manager, the wetland biologist will ensure that the general contractor correctly implements the mitigation design. Specifically, the biologist will ensure erosion control

measures are used properly during construction, natural contouring and proper elevations are constructed, plantings include only native species with invasive species controlled, and fertilization and irrigation of plantings occurs as needed to increase plant survival. The construction manager's tasks will include conducting pre- and post-construction meetings with the general contractor and agency inspector, and where unforeseen site conditions require modification to the final mitigation design, the construction manager will see that proper plan adjustments are made. The construction manager will also authorize plant substitutions when specified materials are not available.

Post-construction monitoring of the wetland mitigation project will be conducted by wetland biologists for five-years. The monitoring program will evaluate the success of mitigation plans, in accordance with specifications of the agencies. Survivorship of plantings, percentage plant cover, wildlife use, and permanent photographic points will be monitored immediately after planting (to record baseline conditions), then twice a year during subsequent years. Other parameters may be monitored as required by the agencies. Annual reports will be produced for client and agency review. The final report will summarize the success of the overall project.

Should the monitoring biologist and agency personnel conclude upon review of monitoring reports that the desired mitigation goal (as specified in the performance standards) is not being achieved, a determination by the agencies involved may be made to implement contingency measures.

5.6 BASELINE ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT

To evaluate the impact or potential impact of releases of hazardous substances at the site, a site specific ecological and human health risk assessment plan has been developed and is presented in Appendix E.

6.0 SCHEDULE

It is anticipated that the execution of the RI/FS, evaluation of data and submittal of the RI/FS Report will take approximately 34 weeks from the date of the Work Plan approval and authorization to proceed. The proposed schedule is presented on Figure 25.

7.0 PROJECT MANAGEMENT AND STAFFING

Field and office staff for the project will be drawn primarily from the Seattle offices of Dames and Moore. Subcontractors will be retained to perform specific services such as drilling, surveyor and laboratory analysis. Key staff are listed below:

Project Director	Roy W. Elliott
Project Manager	David Raubvogel
FS Task Manager	Tom Hanson
QA/QC Manager	Melody Allen
Office Safety Manager	Will Winslow

8.0 REPORTING

An RI/FS Report will be submitted to Ecology for review and approval. The report will follow the EPA suggested RI/FS format.

TABLES

Table 1

Surface Water (SW) Laboratory Results

Laurel Station, Trans Mountain Oil Pipe Line Corp.

Sample ID	Sample Date	BETX 602/8020 BENZENE	ETHYLBENZENE	TOLUENE	TOTAL XYLENES	Modified TPH418.1 TPH as OIL	WTPH-G Total Gas Range Hydrocarbons Conc.	ID	WTPH-D Diesel Range Hydrocarbons Conc.	ID
SW-1-031092	3/10/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-031192	3/11/92	NA	NA	NA	NA	1 U	NA		NA	
SW-1-2	3/11/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-3	3/12/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-3-DUP	3/12/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA	
SW-1-4	3/13/92	0.001 U	0.001 U	0.001 U	0.002 U	1.1	NA		NA	
SW-1-4-DUP	3/13/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA	
SW-1-5	3/14/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-6	3/15/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-7	3/16/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-8	3/17/92	0.0294 U	0.0294 U	0.0294 U	0.0588 U	1 U	NA		NA	
SW-1-9	3/18/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-1-10	4/28/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	0.25 U	NO	NA	
SW-2-031092	3/10/92	0.0054	0.0021	0.014	0.022	1 U	NA		NA	
SW-2-2	3/11/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-1	3/12/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-2	3/13/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-3	3/14/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-3-DUP	3/14/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA	
SW-3-4	3/15/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-5	3/16/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-6	3/17/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-6-DUP	3/17/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA	
SW-3-7	3/18/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-8	3/19/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-8-DUP	3/19/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA	
SW-3-9	3/20/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-10	3/24/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-12	4/1/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-13	4/8/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-14	4/15/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-15	4/22/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	0.25 U	NO	NA	
SW-3-16	4/28/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	0.25 U	NO	NA	
SW-3-17	5/7/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	0.25 U	NO	NA	
SW-3-18	5/13/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-19-052092	5/20/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	
SW-3-20	5/27/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA	
SW-3-19-071592	7/15/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	0.25 U	NO	0.25 U	NO

Note : Units are PPM.

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

NA - Not Analyzed.

SW-1 : 15 M downgradient of dam built for 3-7-92 spill.

SW-2 : Side arm of spill, midway between dam and start of the spill.

SW-3 : 5 M downgradient of SW-1..

Table 1 (Continued)

Storm Water Run-Off (SWRO) Laboratory Results

Laurel Station, Trans Mountain Oil Pipe Line Corp.

Sample ID	Sample Date	BETX 602/8020 BENZENE	ETHYLBENZENE	TOLUENE	TOTAL XYLENES	Modified TPH 418.1 TPH as OIL	WTPH-HCID Petroleum Hydrocarbons Conc.	ID	WTPH-G Total Gas Range Hydrocarbons Conc.	ID	WTPH-D Diesel Range Hydrocarbons Conc.	ID
SWRO-C1	12/11/91	0.002	0.001 U	0.0022	0.0017 J	1 U	NA		NA		NA	
SWRO-C2	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C3	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C4	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C5	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C6	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C7	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C8	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C9	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C11	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		NA	
SWRO-C11-DUP	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C13	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C15	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C17	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C19	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-C20	12/13/91	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.5 U	NO	NA	
SWRO-C20-DUP	12/13/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C22	12/13/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-C26	12/17/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-C27	12/18/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-C28	12/24/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-C29	1/2/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.5 U	NO	NA	
SWRO-C29-DUP	1/2/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	1 U	NO	NA		NA	
SWRO-C30	1/8/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C31	1/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C31-DUP	1/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C32	1/22/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C32-DUP	1/22/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C33	1/29/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C33-DUP	1/29/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-X-C33	1/29/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C34	2/6/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C34-DUP	2/6/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C35	2/12/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C35-DUP	2/12/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C36	2/20/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C37	2/26/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C38	3/3/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C38-DUP	3/3/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C39	3/11/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-C40	3/18/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C41	3/25/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C41-DUP	3/25/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-C42	4/1/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-C43	4/8/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-C44	4/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-C45	4/22/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-C46	4/28/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	0.25 U	
SWRO-C47	5/7/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	3 U	NO	0.25 U	NO	NA	
SWRO-C48	5/13/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	3 U	NO	NA		NA	
SWRO-C48-DUP	5/13/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	
SWRO-C49-052092	5/20/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		0.25 U	
SWRO-C49-DUP	5/20/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-C49-071592	7/15/92	0.001 U	0.001 U	0.00064 J	0.002 U	1 U	NA		0.25 U	NO	0.25 U	
SWRO-C50	7/22/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.25 U	NO	NA	
SWRO-C50-DUP	7/22/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	

Note : Units are PPM.

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

NA - Not Analyzed.

SWRO-C : Culvert adjacent to Smith Rd.

SWRO-D1 : Dam # 1

SWRO-D2 : Dam # 2

SWRO-D3 : Dam # 3

Table 1 (Continued)

Storm Water Run-Off (SWRO) Laboratory Results

Laurel Station, Trans Mountain Oil Pipe Line Corp.

Sample ID	Sample Date	BETX 602/8020 BENZENE	ETHYLBENZENE	TOLUENE	TOTAL XYLENES	Modified TPH 418.1 TPH as OIL	WTPH-HCID Petroleum Hydrocarbons Conc.	ID	WTPH-G Total Gas Range Hydrocarbons Conc.	ID	WTPH-D Diesel Range Hydrocarbons Conc.	ID
SWRO-D1	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D2-2	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D2-3	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D2-4	12/13/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D2-5	12/14/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D2-6	12/15/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D2-7	12/17/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D2-8	12/18/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D2-9	12/24/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D2-9-DUP	12/24/91	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.5 U	NO	NA	
SWRO-D2-10	1/2/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D2-11	1/8/92	NA	NA	NA	NA	NA	1 U	NO	NA		NA	
SWRO-D2-12	1/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-13	1/22/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-14	1/29/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-15	2/6/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-16	2/12/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-17	2/20/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-17-DUP	2/20/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-18	2/26/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-19	3/3/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-20	3/11/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D2-21-031892	3/18/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-21-032592	3/25/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D2-23	4/1/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D2-24	4/1/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D2-25	4/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-D2-26	4/22/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D2-26-DUP	4/22/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-D2-27	4/28/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		0.25 U	NO
SWRO-D2-27-DUP	4/28/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	
SWRO-D2-28	5/7/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	3 U	NO	0.25 U	NO	NA	
SWRO-D2-29	5/13/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D2-29-DUP	5/13/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	0.25 U	
SWRO-D2-30-052092	5/20/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.25 U	NO	NA	
SWRO-D2-30-063092	6/30/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D2-30-DUP	6/30/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.25 U	NO	0.25 U	
SWRO-D2-31	7/22/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		0.25 U	
SWRO-D2-31-DUP	7/22/92	NA	NA	NA	NA	NA	NA					
SWRO-D3-1	12/11/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D3-2	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D3-3	12/12/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D3-4	12/13/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D3-4-DUP	12/13/91	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.5 U	NO	NA	
SWRO-D3-6	12/15/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D3-6-DUP	12/15/91	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		NA	
SWRO-D3-7	12/17/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		NA		NA	
SWRO-D3-8	12/18/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D3-8-DUP	12/18/91	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.5 U	NO	NA	
SWRO-D3-9	12/24/91	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D3-10	1/2/92	0.001 U	0.001 U	0.001 U	0.002 U	1 U	NA		0.5 U	NO	NA	
SWRO-D3-11	1/8/92	NA	NA	NA	NA	NA	1 U	NO	NA		NA	
SWRO-D3-12	1/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-13	1/22/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	

Note : Units are PPM.

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

NA - Not Analyzed.

SWRO-C : Culvert adjacent to Smith Rd.

SWRO-D1 : Dam # 1

SWRO-D2 : Dam # 2

SWRO-D3 : Dam # 3

Table 1 (Continued)

Storm Water Run-Off (SWRO) Laboratory Results
Laurel Station, Trans Mountain Oil Pipe Line Corp.

Sample ID	Sample Date	BETX 602/8020 BENZENE	ETHYLBENZENE	TOLUENE	TOTAL XYLENES	Modified TPH 418.1 TPH as OIL	WTPH-HCID Petroleum Hydrocarbons Conc.	ID	WTPH-G Total Gas Range Hydrocarbons Conc.	ID	WTPH-D Diesel Range Hydrocarbons Conc.	ID
SWRO-D3-14	1/29/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-15	2/6/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-16	2/12/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-17	2/20/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-18	2/26/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-19	3/3/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-20	3/11/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D3-21-031892	3/18/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-21-032592	3/25/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-23	4/1/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D3-24	4/8/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	NA	
SWRO-D3-25	4/15/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-D3-26	4/22/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		0.25 U	NO
SWRO-D3-26-DUP	4/22/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	0.25 U	NO
SWRO-D3-27	4/28/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO	0.25 U	
SWRO-D3-28	5/7/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		NA		0.25 U	
SWRO-D3-28-DUP	5/7/92	NA	NA	NA	NA	NA	NA		0.25 U	NO	NA	
SWRO-D3-29	5/13/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	3 U	NO	0.25 U	NO	0.25 U	
SWRO-D3-30	5/20/92	0.001 U	0.001 U	0.001 U	0.002 U	NA	NA		0.25 U	NO		

Note : Units are PPM.
U - The material was analyzed for, but was not detected above the level of the associated value.
The associated value is either the sample quantitation limit or the sample detection limit.
NA - Not Analyzed.
SWRO-C : Culvert adjacent to Smith Rd.
SWRO-D1 : Dam # 1
SWRO-D2 : Dam # 2
SWRO-D3 : Dam # 3

TABLE 2
General Monitoring Well Information
Trans Mountain Oil Pipeline
Laurel Station

Monitoring Well I.D.	Screen Interval (feet bgs)	Ref. Elev. (Feet MSL)	Screen Elev. (Ft (MSL))	Area _____
SW-1 (TM-B2)	6 - 21	296.0	270 - 275	SU1 - Former Burn Pit and O/W Separator
SW-2 (TM-B3)	40 - 50	296.0	256 - 246	SU1 - Former Burn Pit and O/W Separator
SW-3 (TM-B5)	18 - 28	302.5	284.5 - 274.5	SU2 - Former Draintile
SW-4 (TM-B4)	22 - 32	298.5	276.5 - 266.5	SU1 - Oily Water Sump
SW-5 (TM-B16)	35 - 40	398.5	363.5 - 358.5	SU1 - Oily Water Sump
DW-1	186.5 - 226.5	320.5	134 - 94	SU2 - Bulk Storage Tanks
DW-2	153 - 173	289.5	136.5 - 116.5	SU1 - Southern Portion of Pump Station Operation Area
DW-3	146.5 - 165.5	282.5	134 - 114	SU1 - Northern Portion of PUmp Station Operation Area
DW-4	155.5 - 175.5	279.5	124 - 104	SU1 - Down gradient of 20" Main Product Line
DW-5	124 - 214	325.5	131.5 - 111.5	SU3 - Pressure Relief Tank Area

Note:

bgs - Below Ground Surface
SU - Study Unit
MSL - Above Mean Sea Level
Reference Elevation estimated ground surface

TABLE 3
Ground Water Level Measurements
Trans Mountain Oil Pipeline

	Reference Elevation	Depth to Water (Feet)	GW Elevation
DW-1	322.41	197.7	124.71
DW-2	291.8	168.86	122.94
DW-3	282.41	159.35	123.06
DW-4	281.42	157.16	124.26
DW-5	327.73	195.61	132.12
SW-1	296.09	6.06	290.03
SW-2	296.69	38.82	257.87
SW-3	304.79	33.56	271.23
SW-4	298.3	Dry	
SW-5	298.86	20.64	278.22

Notes:

Reference Elevation - Ft Above Mean Sea Level (TOC)
BGS - Feet below TOC
G.W. Measurement made 4-15-92 through 4-17-92

Table 4
Summary of Ground Water Laboratory Results (mg/l)
Laurel Station
Trans Mountain Oil Pipe Line Corp.

	Deep Wells				
Sample ID	DW-1	DW-2	DW-3	DW-4	DW-5
Lab ID	A523H	A501K	A501L	A501M	A501N
Sample Date	4/22/92	4/16/92	4/16/92	4/16/92	4/17/92
Sample Time	11:30	12:30	15:00	17:30	12:00
General Water Quality Parameters					
pH	8.23	7.67	7.81	7.7	7.93
TOTAL DISSOLVED SOLIDS	8,523	336	290	214	135
NITRITE	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
NITRATE	0.023	0.257	0.287	0.615	0.01 U
CHLORIDE	4.3	41.7	7.6	8.1	6.3
FLUORIDE	0.24	0.23	0.23	0.19	0.15
SULFATE	6.1	39.8	24.2	24.9	7.7
Metals					
ANTIMONY	0.003	0.001 UJ	0.002 J	0.001 UJ	0.002 J
ARSENIC	0.083	0.002 UJ	0.018 J	0.014 J	0.019 J
BERYLLIUM	0.001 U	0.006	0.001	0.001 U	0.001 U
CADMIUM	0.002 U	0.002 U	0.002 U	0.002	0.002 U
CHROMIUM	0.038	0.154	0.036	0.014	0.042
COPPER	0.01	0.209	0.08	0.017	0.041
LEAD	0.009 U	0.167	0.028	0.021	0.013
MERCURY	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U
NICKEL	0.03	0.08	0.03	0.02	0.05
SELENIUM	0.001 U	0.005 U	0.005 U	0.001 U	0.024
SILVER	0.003 U	0.003 U	0.003 U	0.003 U	0.003 U
THALLIUM	0.001 U	0.009	0.002	0.001 U	0.001 U
ZINC	0.028	0.243	0.218	0.045	0.079
Modified EPA Method 418.1					
TPH as OIL	1 U	1 U	1 U	1 U	1 U
Volatile Organics					
1,1,1-TRICHLOROETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
1,1,2,2-TETRACHLOROETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
1,1,2-TRICHLOROETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
1,1,2-TRICHLOROTRIFLUOROETHANE	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
1,1-DICHLOROETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
1,1-DICHLOROETHENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
1,2-DICHLOROETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
1,2-DICHLOROPROPANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
2-BUTANONE	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
2-CHLOROETHYLVINYLETHER	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
2-HEXANONE	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
4-METHYL-2-PENTANONE	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
ACETONE	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
BENZENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
BROMODICHLOROMETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
BROMOFORM	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
BROMOMETHANE	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
CARBON DISULFIDE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
CARBON TETRACHLORIDE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
CHLOROBENZENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
CHLOROETHANE	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
CHLOROFORM	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
CHLOROMETHANE	0.002 U	0.0016 J	0.002 U	0.002 U	0.002 U
CIS-1,2-DICHLOROETHENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
CIS-1,3-DICHLOROPROPENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
DIBROMOCHLOROMETHANE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
ETHYLBENZENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
METHYLENE CHLORIDE	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
STYRENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
TETRACHLOROETHENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
TOLUENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
TOTAL XYLENES	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
TRANS-1,2-DICHLOROETHENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
TRANS-1,3-DICHLOROPROPENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
TRICHLOROETHENE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
TRICHLOROFLUOROMETHANE	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
VINYL ACETATE	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
VINYL CHLORIDE	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U

Note : Units are PPM.

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

J - The associated value is an estimated quantity.

UJ - The material was analyzed for, but was not detected. The associated detection limit is an estimated quantity

NA - Not Analyzed.

Table 4 (Continued)

Summary of Ground Water Laboratory Results (mg/l)

Laurel Station

Trans Mountain Oil Pipe Line Corp.

	Shallow Wells					
Sample ID	SW-1	SW-1	SW-2	SW-2	SW-3	SW-5
Lab ID	A501E	A501G	A501F	A501H	A501I	A501J
Sample Date	4/15/92	4/15/92	4/15/92	4/15/92	4/15/92	4/15/92
Sample Time	11:30	16:00	12:00	16:00	15:30	17:00
General Water Quality Parameters						
pH	6.16	NA	8.03	NA	NA	6.7
TOTAL DISSOLVED SOLIDS	419	NA	253	NA	NA	561
NITRITE	0.01 U	NA	0.011	NA	NA	0.01 U
NITRATE	0.01 U	NA	0.323	NA	NA	0.01 U
CHLORIDE	2.7	NA	16.5	NA	NA	NA
FLUORIDE	0.43	NA	0.2	NA	NA	0.05
SULFATE	329.3	NA	18.3	NA	NA	58.7
Metals						
ANTIMONY	0.001 J	NA	0.003 J	NA	NA	NA
ARSENIC	0.007 J	NA	0.005 J	NA	NA	NA
BERYLLIUM	0.002	NA	0.004	NA	NA	NA
CADMIUM	0.002 U	NA	0.002 U	NA	NA	NA
CHROMIUM	0.179	NA	0.767	NA	NA	NA
COPPER	0.207	NA	0.523	NA	NA	NA
LEAD	0.031	NA	0.09	NA	NA	NA
MERCURY	0.001 U	NA	0.0002	NA	NA	NA
NICKEL	0.23	NA	0.6	NA	NA	NA
SELENIUM	0.005 U	NA	0.01 U	NA	NA	NA
SILVER	0.003 U	NA	0.003 U	NA	NA	NA
THALLIUM	0.005 U	NA	0.008	NA	NA	NA
ZINC	0.279	NA	1.03	NA	NA	NA
Modified EPA Method 418.1						
TPH as Oil	NA	1 U	NA	1 U	NA	18
Volatile Organics						
1,1,1-TRICHLOROETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.0057 J
1,1,2,2-TETRACHLOROETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
1,1,2-TRICHLOROETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
1,1,2-TRICHLOROTRIFLUOROETHANE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
1,1-DICHLOROETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.0012 J
1,1-DICHLOROETHENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
1,2-DICHLOROETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
1,2-DICHLOROPROPANE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
2-BUTANONE	0.005 U	NA	0.005 U	NA	0.005 U	0.01 UJ
2-CHLOROETHYLVINYLETHER	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
2-HEXANONE	0.005 U	NA	0.005 U	NA	0.005 U	0.01 UJ
4-METHYL-2-PENTANONE	0.005 U	NA	0.005 U	NA	0.005 U	0.01 UJ
ACETONE	0.005 U	NA	0.005 U	NA	0.005 U	0.01 UJ
BENZENE	0.001 U	NA	0.001 U	NA	0.001 U	0.0013 J
BROMODICHLOROMETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
BROMOFORM	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
BROMOMETHANE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
CARBON DISULFIDE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
CARBON TETRACHLORIDE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
CHLOROBENZENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
CHLOROETHANE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
CHLOROFORM	0.014	NA	0.001 U	NA	0.001 U	0.002 UJ
CHLOROMETHANE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
CIS-1,2-DICHLOROETHENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
CIS-1,3-DICHLOROPROPENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
DIBROMOCHLOROMETHANE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
ETHYLBENZENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
METHYLENE CHLORIDE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
STYRENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
TETRACHLOROETHENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
TOLUENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
TOTAL XYLENES	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
TRANS-1,2-DICHLOROETHENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
TRANS-1,3-DICHLOROPROPENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
TRICHLOROETHENE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
TRICHLOROFLUOROMETHANE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ
VINYL ACETATE	0.001 U	NA	0.001 U	NA	0.001 U	0.002 UJ
VINYL CHLORIDE	0.002 U	NA	0.002 U	NA	0.002 U	0.004 UJ

Note : Units are PPM.

U - The material was analyzed for, but was not detected above the level of the associated val
The associated value is either the sample quantitation limit or the sample detection limit.

J - The associated value is an estimated quantity.

UJ - The material was analyzed for, but was not detected.
The associated detection limit is an estimated quantity.

NA - Not Analyzed.

TABLE 5
RI/FS Objectives Summary
Trans Mountain Oil Pipe Line Corp
Laurel Station

Activity	Subsurface Soils	Ground Water	Surface Water	Sediment
Objectives:	To determine the nature and extent of contaminants in Study Units, to support Site characterization, risk assessment and Feasibility Study	To assess presence, nature and extent of contaminants of concern, evaluate hydrogeologic conditions, identify potential contaminant receptors, and assess human health risks.	Assess nature and extent of any contamination, evaluate hydrologic conditions and recharge/discharge relationships, assess potential exposure pathways, evaluate presence of upgradient sources, assess human health and ecological risk	Assess nature and extent of any contamination, assess potential exposure pathways, assess human health and ecological risk
Contaminants of Concern:	WTPH-HCID, VOC	WTPH (G, D and 418.1), VOC	BTEX, WTPH (G, D and 418.1), Bioassay, PAH (8310)	BTEX, WTPH-HCID Bioassay, PAH (8310)
Sample Locations:	Vertical profile samples	Water samples collected from wells completed in shallow saturated zone and deeper aquifer	All samples	All samples

Notes:

A: WTPH-HCID analysis followed by analysis of dominant hydrocarbon (i.e., WTPH-G, D or 418.1).

TABLE 6
Summary of RI/FS Sampling and Analysis Program
Trans Mountain Oil Pipe Line Corp.
Laurel Station

Study Unit/Area	Sampled Media	Study Unit Designation	Sample Location	Total Depth or Interval (ft bgs)	No. of Samples[a]	Laboratory Analysis					
						WTPH-HCID[b]	WTPH-418.1 WTPH-D and WTPH-G	BETX	VOC	Bioassay[c]	PAH[c]
Study Unit 1 - Pump Station Operation Area											
Former Pump Station Area	Soil	1A	B1A-1 through B1A-5	35	14	X					
Former Oily Water Sump	Soil	1B	B1B-1 through B1B-3	24	6	X			X		
Former Burn Pit	Soil	1C	B1C-1 through B1C-3	20	6	X			X		
Former Drain Line Between Oily Water Sump & Burn Pit	Soil	1D	B1D-1 + B1D-2	10	4	X			X		
Former Drain Tile & Ferndale 16-inch Product Line	Soil	1E	B1E-1 through B1E-5	15	10	X					
Former Waste Pit	Soil	1F	B1F-1 through B1F-3	20	6	X					
Former Oil/Water Separator	Soil	1G	B1G-1 through B1G-3	12	6	X					
Historical Spills	Soil	1H	B1H-1 through B1H-6	2	12	X					
Study Unit 2 - Oil Bulk Storage Tank Area	Soil	2	B2-1 through B2-6	15	12	X					
Study Unit 3 - Pressure Relief Tank Area	Soil	3	B3-1 through B3-4 B3-5 through B3-9	10 10	4 6	X					
Study Unit 4 - Boneyard Area	Soil	4	B4-1 through B4-7	3	6	X					
Study Unit 5 - Area North of Smith Rd. Spill	Soil	5	B5-1 through B5-2	5	4	X					
Study Unit 6 - 12/11/91 Spill Area	Soil	6	B6-1 through B6-2	0.3	2	X					
On-site and Off-site Sediment Study Areas	Sediment	SED	Deer Creek Tributary Deer Creek 3/7/92 Spill Area	0-2 in. 0-2 in. 0-2 in.	1 1 1	X X X				X X X	X X X
On-site and Off-site Surface Water Study Areas	Surface Water	SWS	Deer Creek Tributary Deer Creek 3/7/92 Spill Area		3 3 3		X X X	X X		X X X	X X X
Study Unit 1, 2 & 3	Ground Water	SW	Existing Shallow Wells SW-1 through 5	NA	5		X		X		
		SW	New Shallow Wells SW-6 through 10	NA	5		X		X		
		DW	Existing Deep Wells DW-1 through 5	NA	5		X		X		
		MW	Purnell Shallow Wells[d] MW-1, 2 & 3	NA	3		X		X		

(a) Number of analytical samples may vary based on field conditions.
(b) If TPH is detected, sample will be analyzed for the specific fraction identified (i.e. WPTH-G, D, 418.1 and BETX).
(c) Selected sediment and surface water samples at each area will have bioassay analysis performed.
(d) Shallow Monitoring Wells installed to 3.5 feet by Purnell & Associatesin February 1991.
BETX: Method 8240
VOC: Method 8240
PAH: Method 8310
Bioassay: EPA, 1986 (PSEP Protocols)

TABLE 7
Monitoring Well Installation Rationale and Plan
Trans Mountain Oil Pipe Line Corp
Laurel Station

Proposed Well #	Screened Unit	Location	Purpose
SW-6	Shallow saturated zone (45-55' bgs)	Adjacent to SW-5	° Evaluate vertical extent of shallow ground water contamination
SW-7	Shallow saturated zone (45-55' bgs)	Northwest of former burn pit, oil/water separator and drain tile	° Characterize hydrogeology ° Evaluate ground water quality
SW-8	Shallow saturated zone (45-55' bgs)	Northwest of former sump	° Characterize hydrogeology ° Evaluate ground water quality
SW-9	Shallow saturated zone (45-55' bgs)	Northwestern property corner, downgradient of SW-7 and Area 1	° Characterize hydrogeology ° Evaluate ground water quality
SW-10	Shallow saturated zone (45-55' bgs)	Northwest of product tanks and north of PCS stockpile	° Characterize hydrogeology ° Evaluate ground water quality

FIGURES

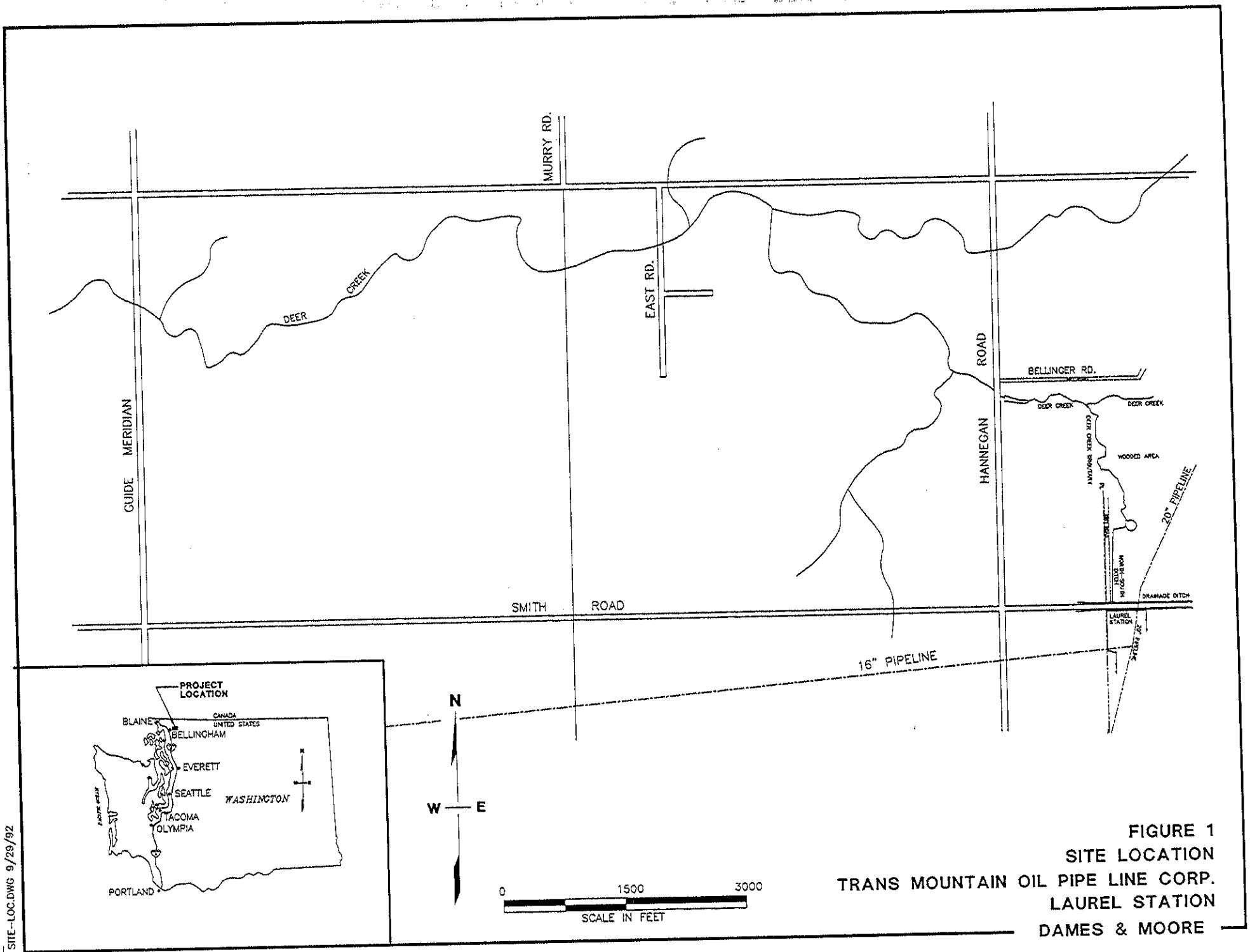


FIGURE 1
SITE LOCATION
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE

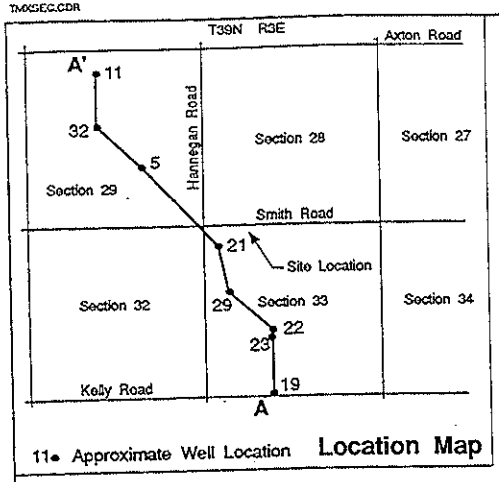
SITE-LOC.DWG 9/29/92

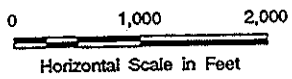
.34 ACRES
WATER AS

See .jpg file

FIGURE 2
SITE PLAN
N OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE

TM03SEC.CDR





Legend for Sedimentary Types:

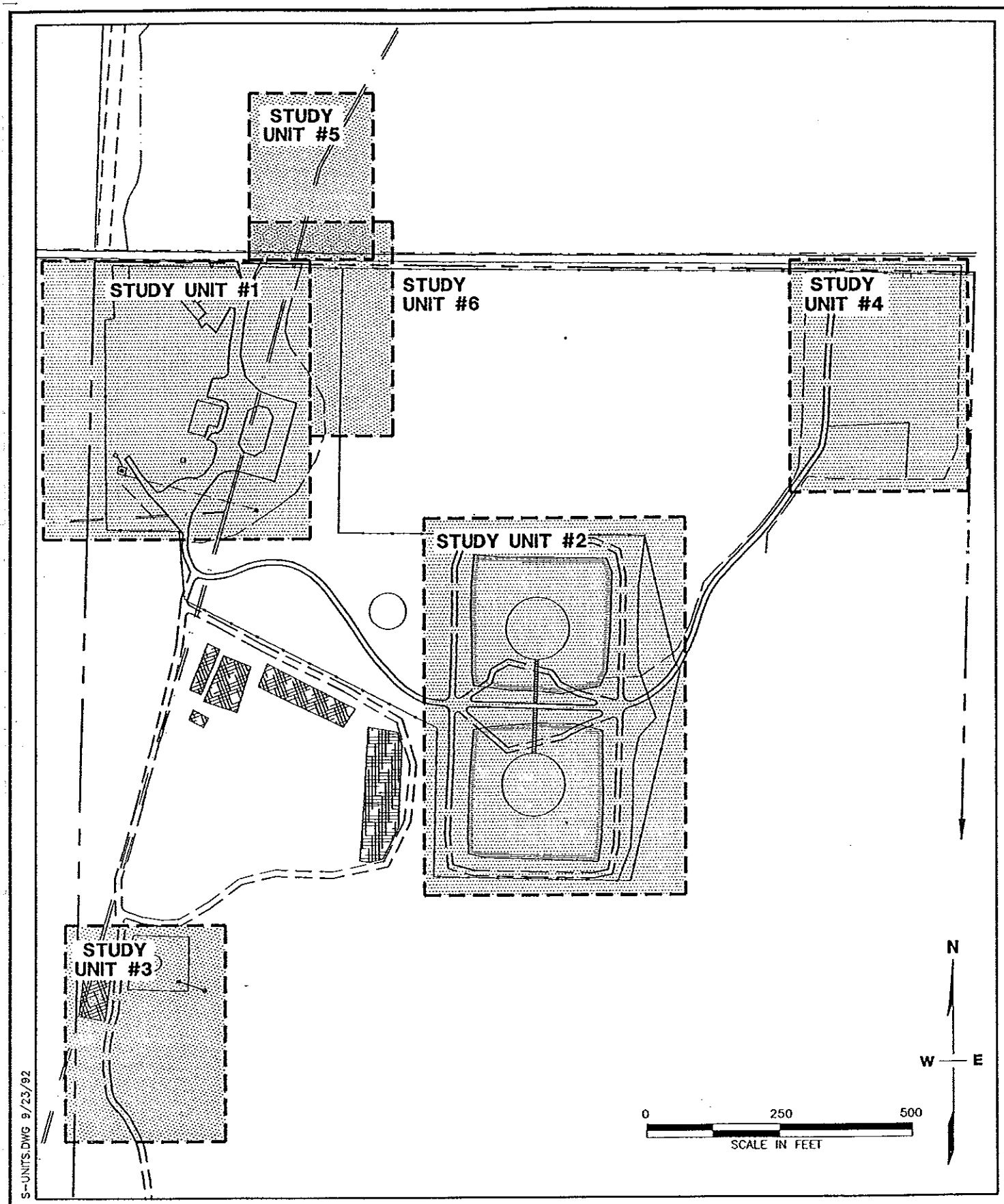
- Clay
- Gravel
- Sand
- Sand and Gravel
- Gravel and Clay
- Sand and Clay
- Sand, Gravel, and Clay (hardpan)
- Described on Log as "Oil Shale" (inferred Chuckanut Formation)

Reference: Figure by W. D. Purnell & Associates, Inc., 12-9-91, descriptions were provided on drillers logs.

Figure 3

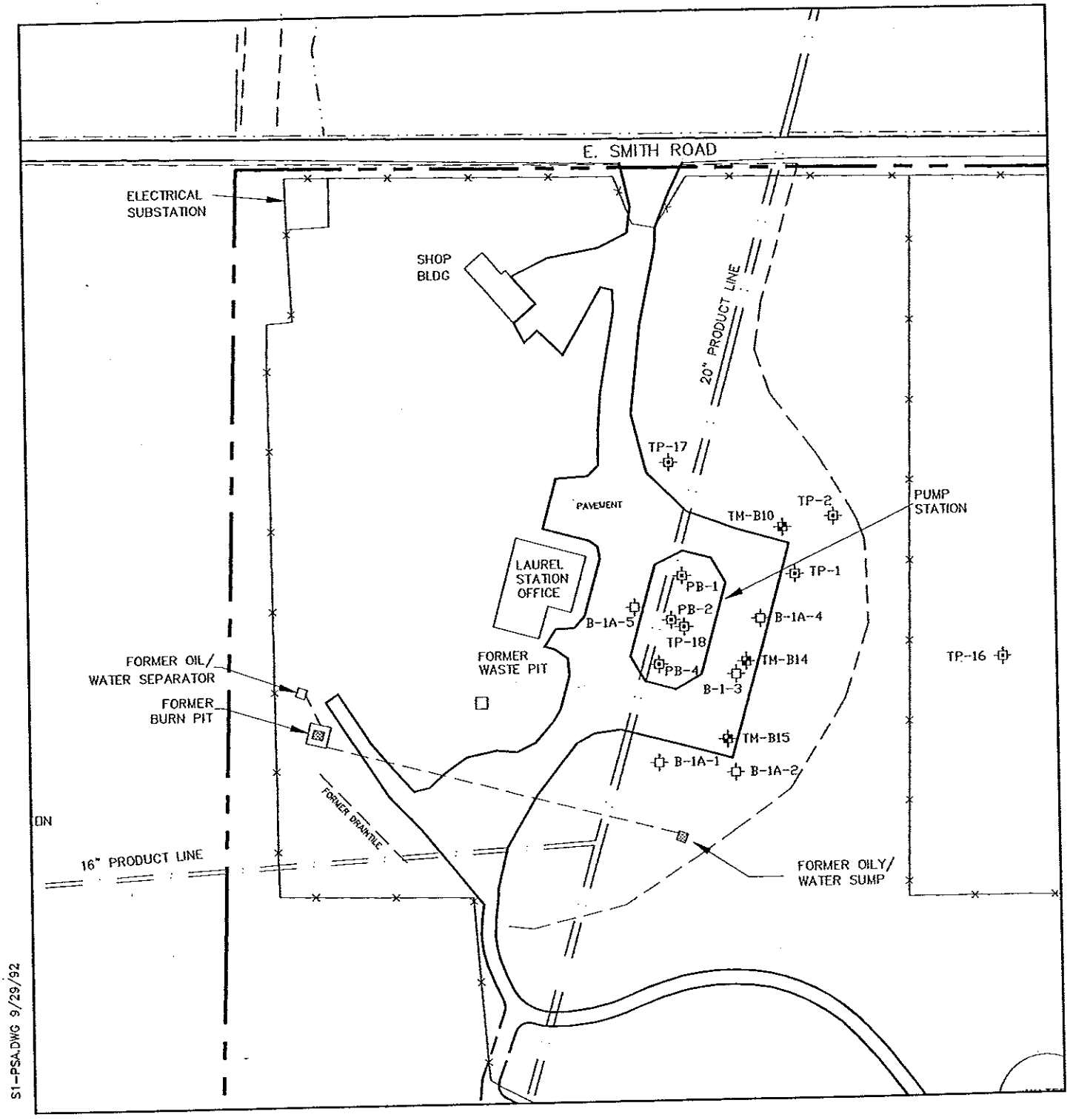
North to South Geologic Cross-Section
Trans Mountain Oil Pipe Line Corporation
Laurel Station
Dames & Moore

Job No. 21199-032-005



Study Unit #1 – Pump Station Operation Area
Study Unit #2 – Oil Bulk Storage Tank Area
Study Unit #3 – Pressure Relief Tank Area
Study Unit #4 – Boneyard Area
Study Unit #5 – Area North of Smith Rd. Spill
Study Unit #6 – December 11, 1991 Spill Area

FIGURE 4
STUDY UNIT INDEX
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE



N

W — E

LEGEND

- TM-B10 SOIL BORING LOCATION
- TP-1 TEST PIT LOCATION
- B-1A-1 PROPOSED BORING LOCATION

0 100 200

SCALE IN FEET

FIGURE 5

STUDY UNIT 1 - PUMP STATION AREA

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE

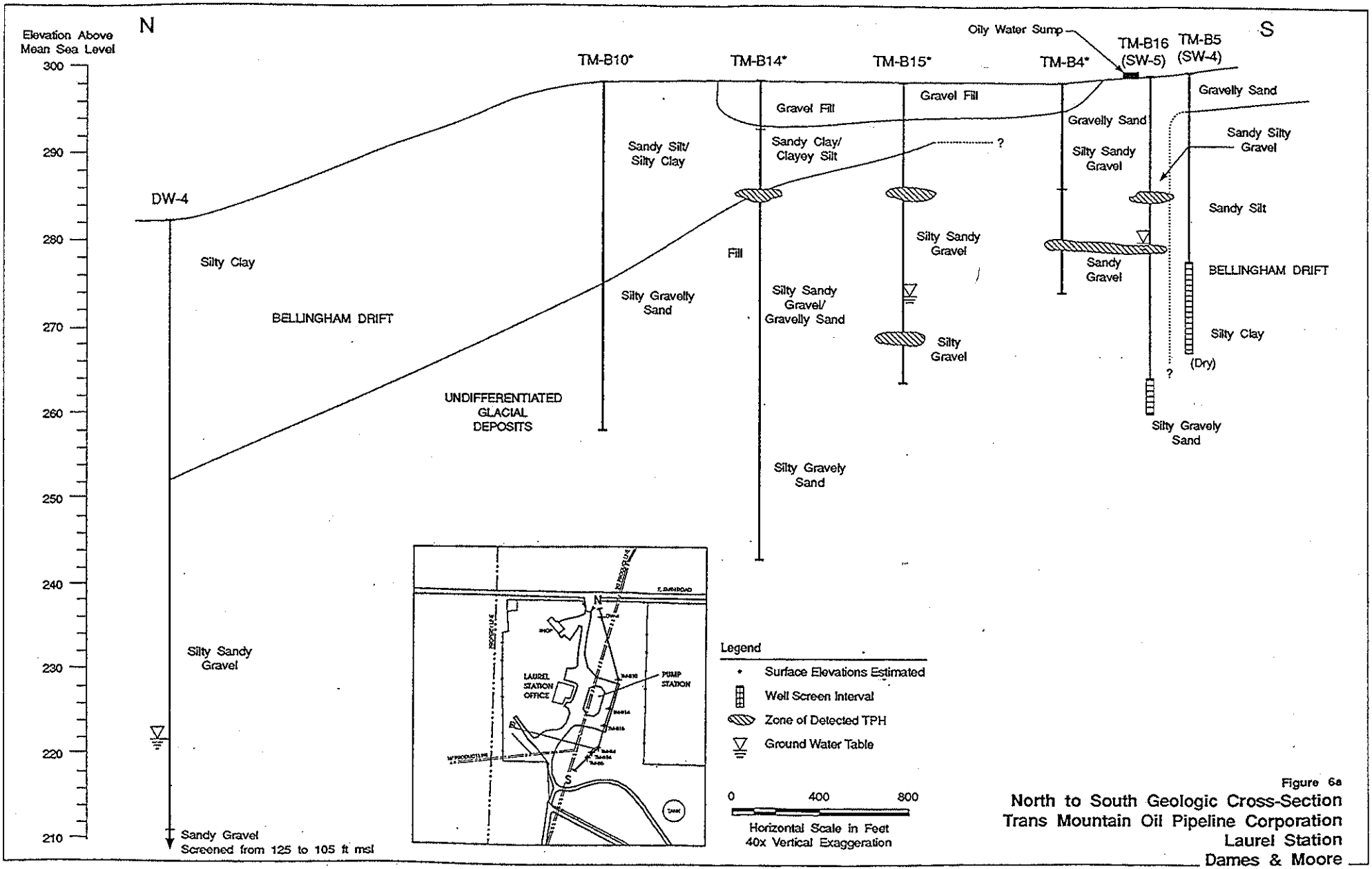


Figure 6a
North to South Geologic Cross-Section
Trans Mountain Oil Pipeline Corporation
Laurel Station
Dames & Moore

Job No. 21189-032-005

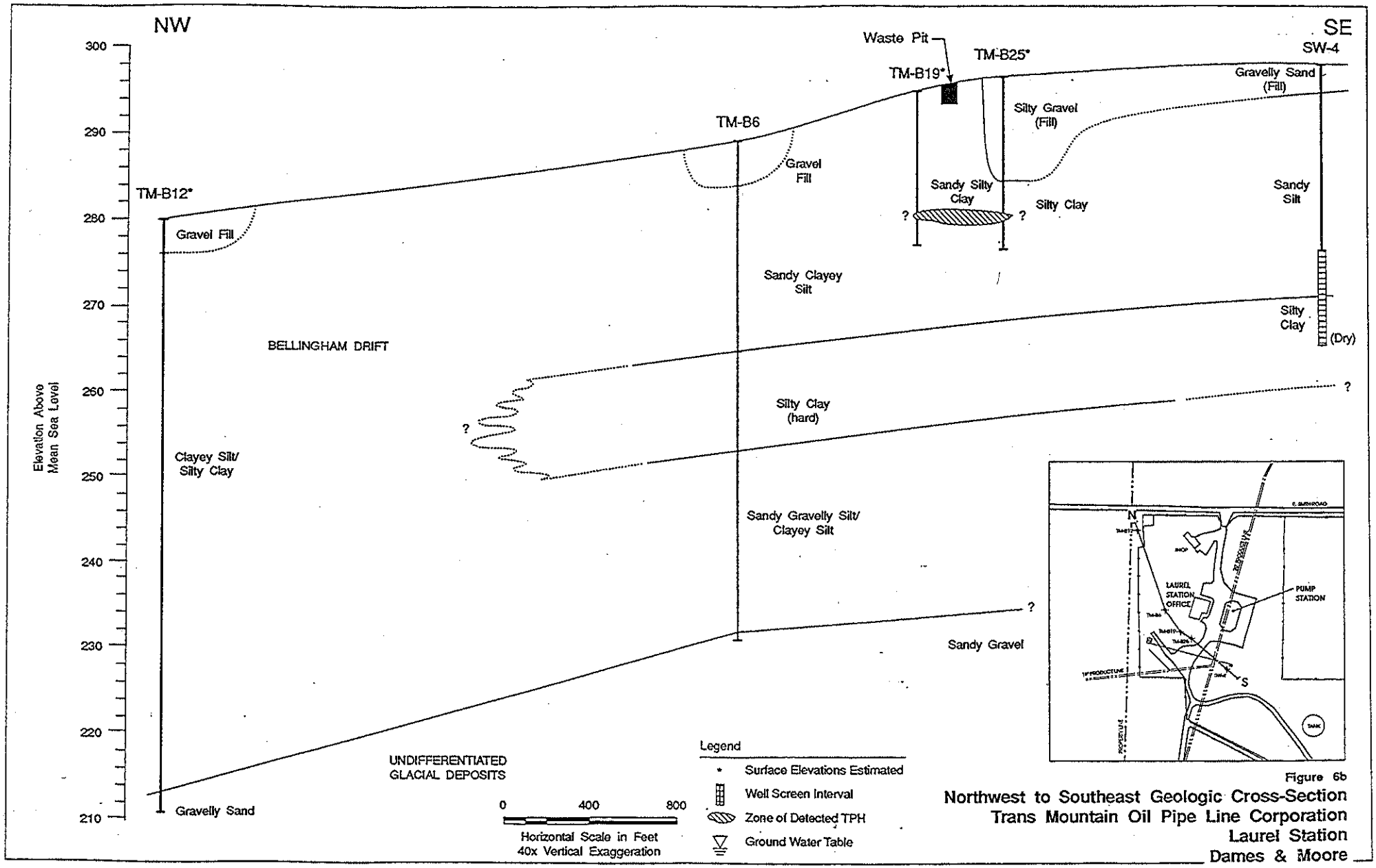


Figure 6b

Northwest to Southeast Geologic Cross-Section
Trans Mountain Oil Pipe Line Corporation
Laurel Station
Dames & Moore

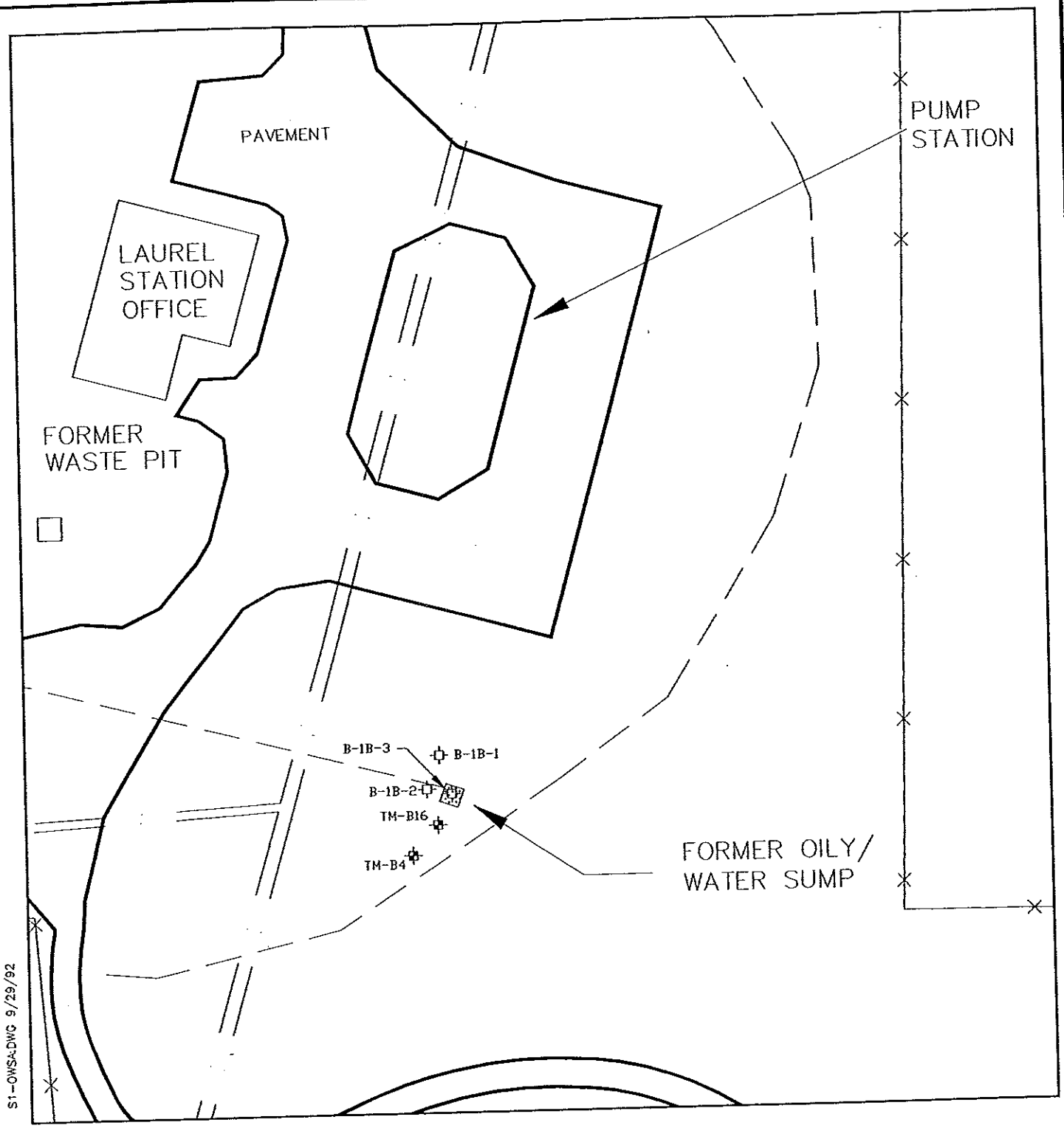


FIGURE 7

STUDY UNIT 1 - FORMER OILY WATER SUMP AREA

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE

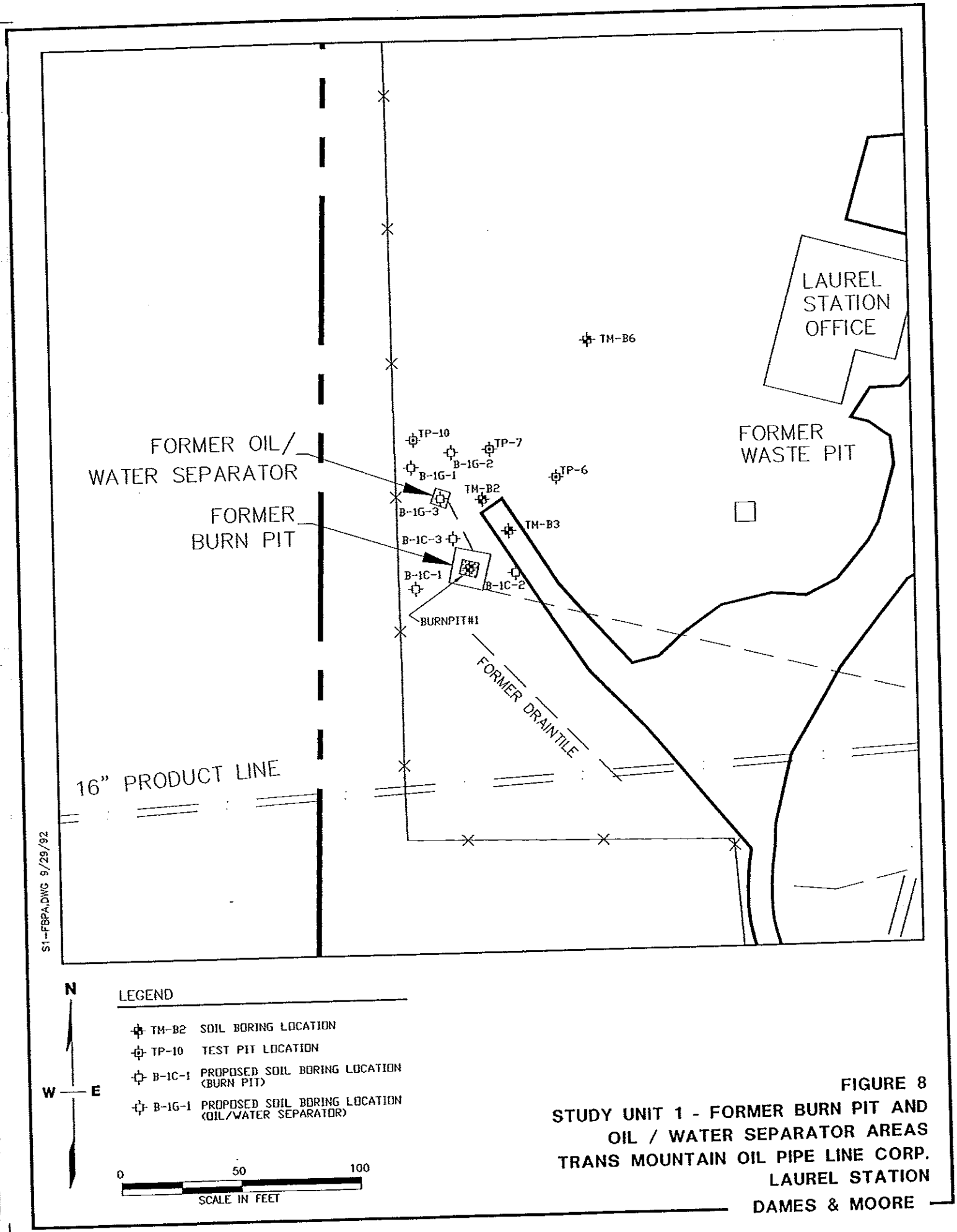


FIGURE 8
STUDY UNIT 1 - FORMER BURN PIT AND OIL / WATER SEPARATOR AREAS
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE

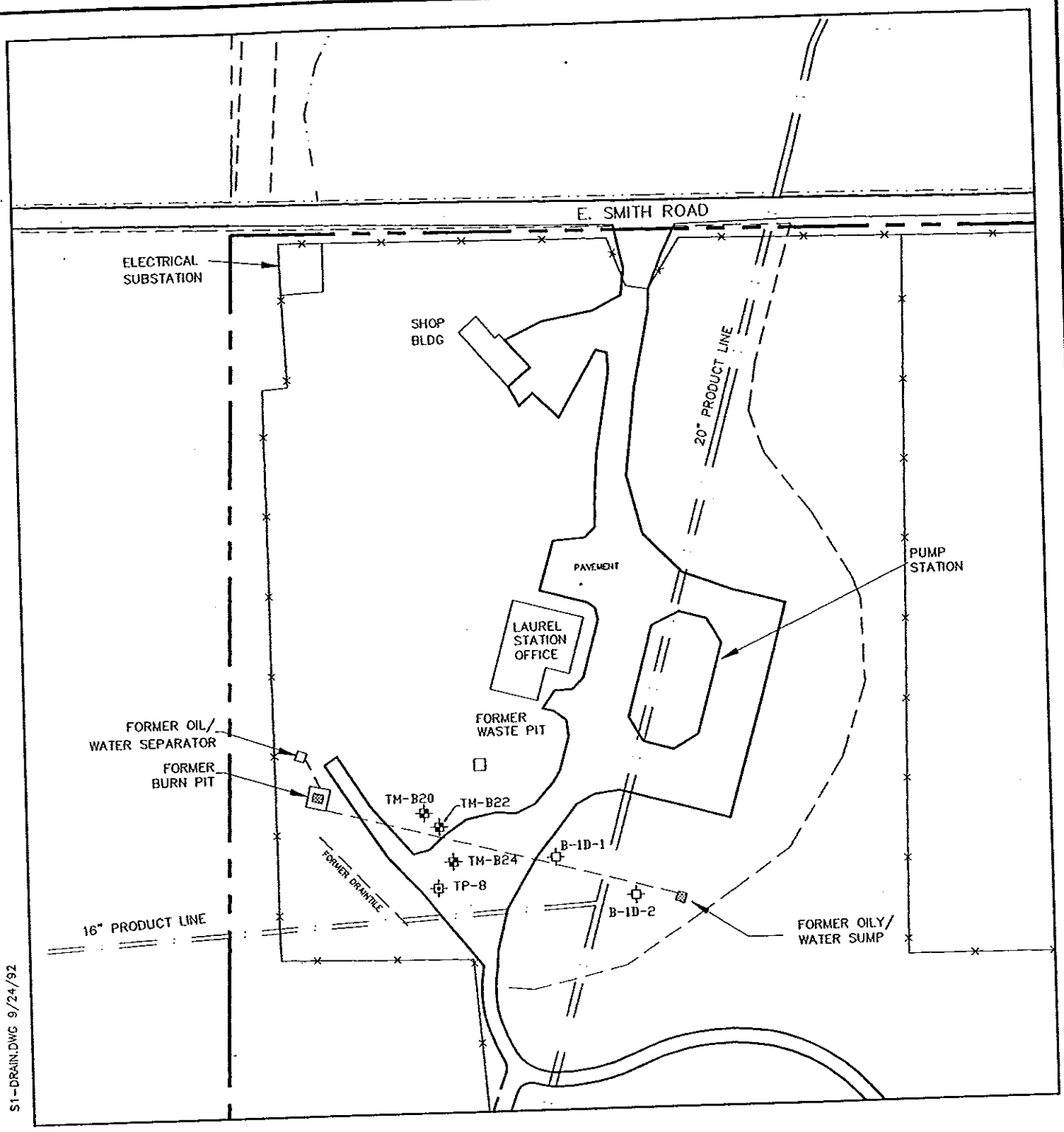


FIGURE 9
STUDY UNIT 1 - FORMER DRAINLINE BETWEEN OILY WATER SUMP AND BURN PIT AREA
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE

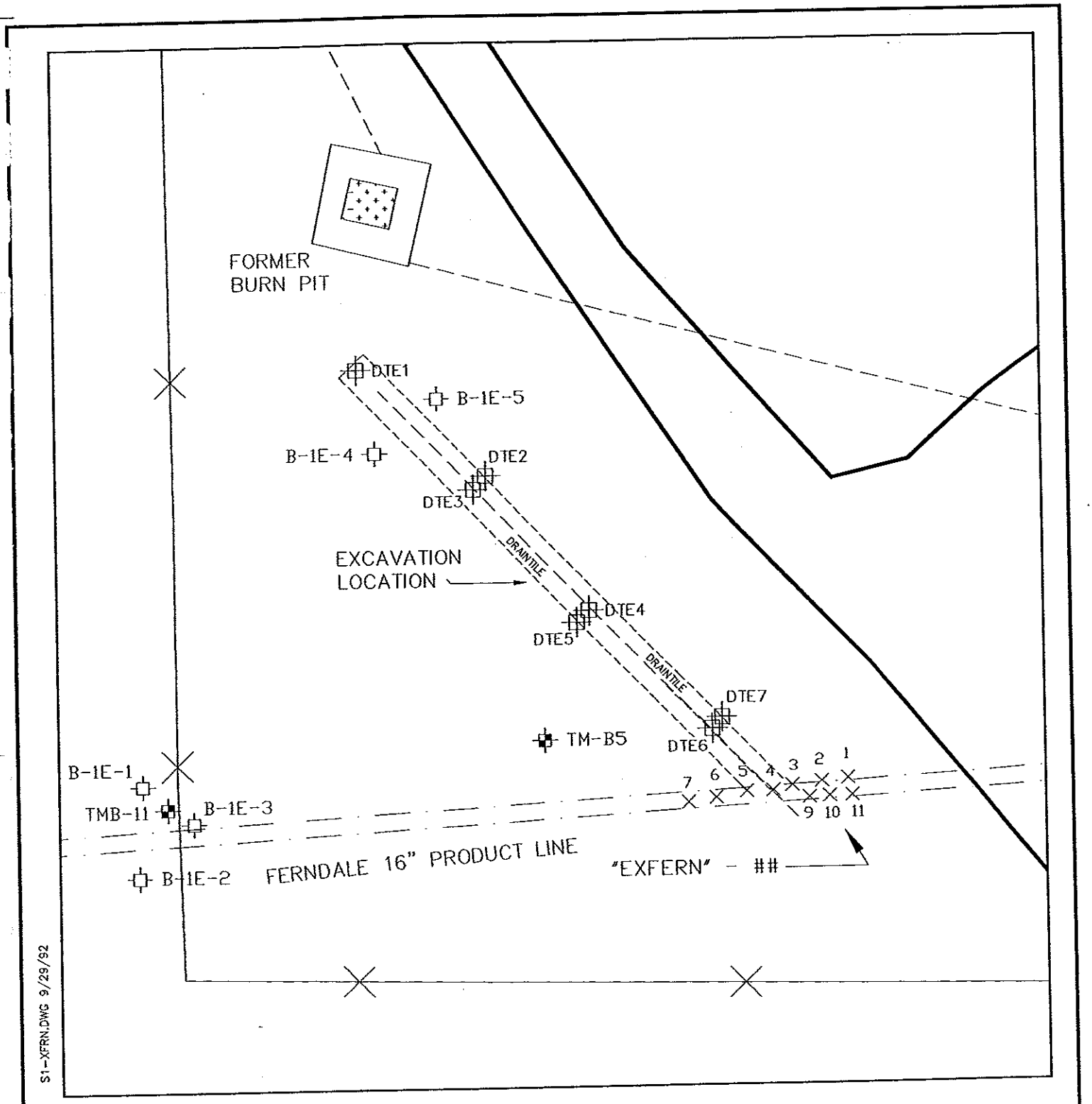
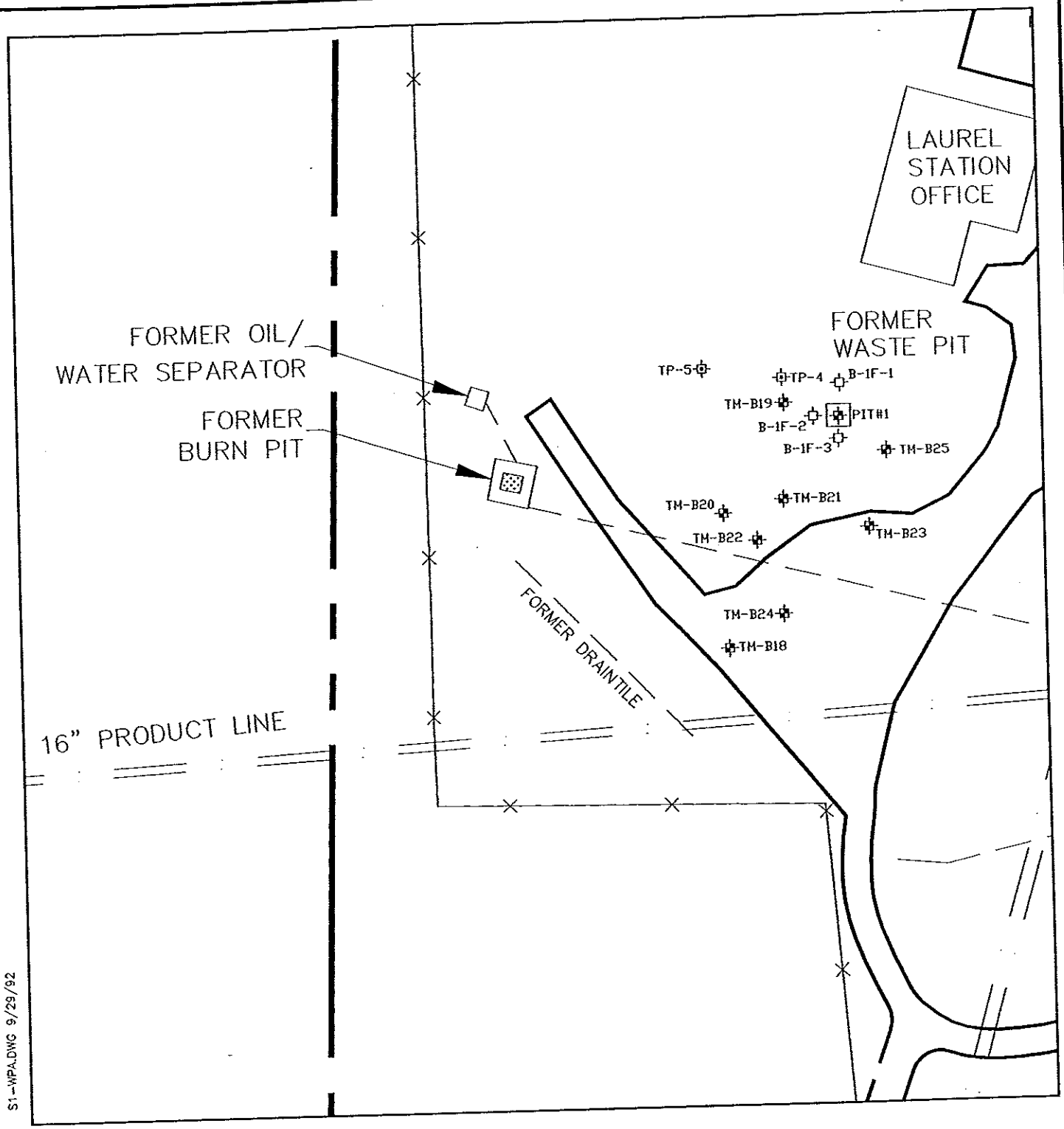


FIGURE 10
STUDY UNIT 1 - FORMER DRAINTILE AND FERNDALE 16" PRODUCT LINE AREA
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE



N

W — E

LEGEND

- TM-B2 SOIL BORING LOCATION
- TP-10 TEST PIT LOCATION
- B-1F-1 PROPOSED SOIL BORING LOCATION

0 100 200

SCALE IN FEET

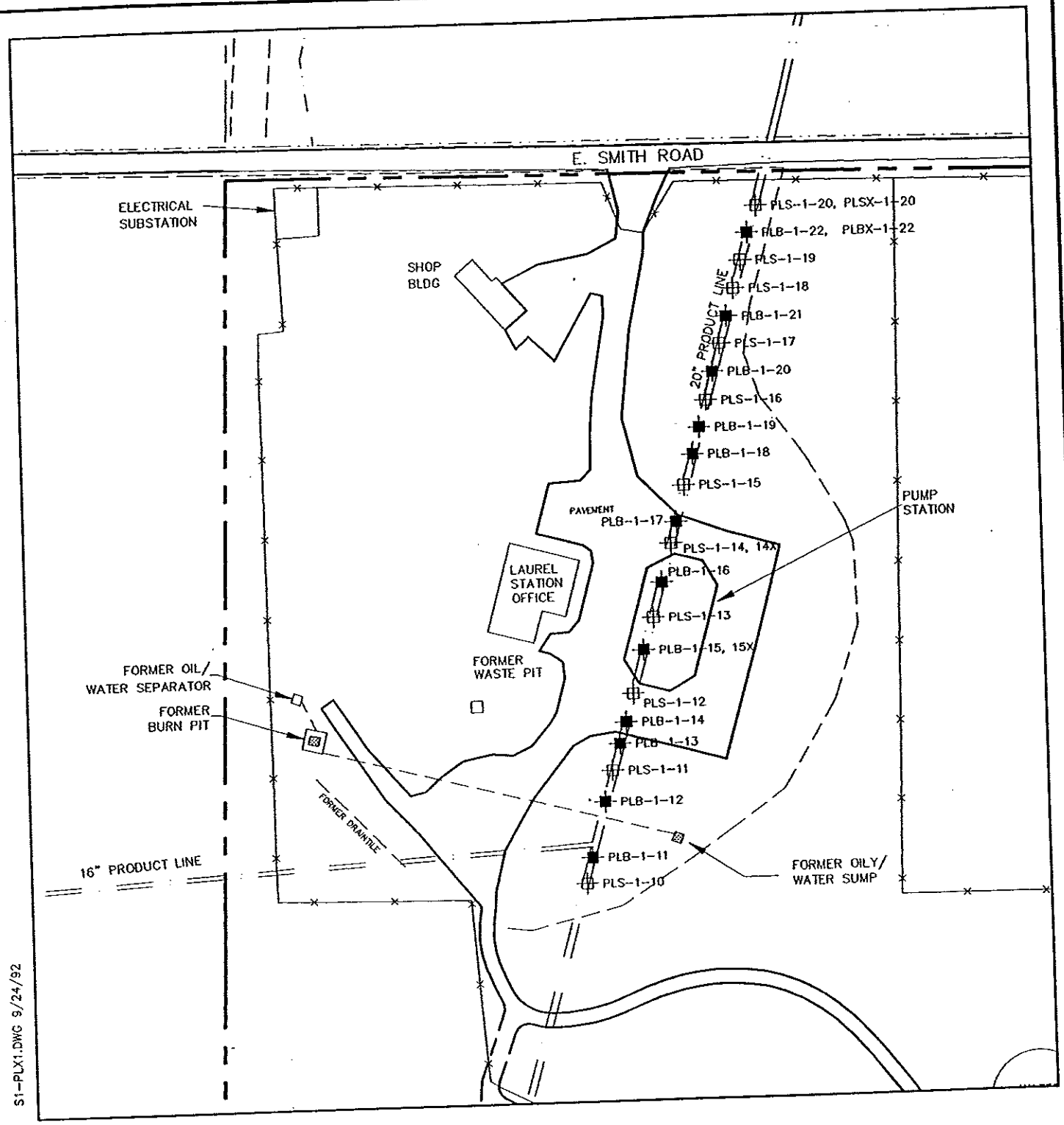
FIGURE 11

STUDY UNIT 1 - FORMER WASTE PIT AREA

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE



N

W — E

LEGEND

PLS-1-20 SOIL SAMPLE LOCATION PIPE LINE SIDE WALL

PLB-1-22 SOIL SAMPLE LOCATION PIPE LINE BASE

0 100 200

SCALE IN FEET

FIGURE 12A
STUDY UNIT 1 - MAIN 20" PRODUCT LINE
TRENCH EXCAVATION AREA - JAN. 17, 1992
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE

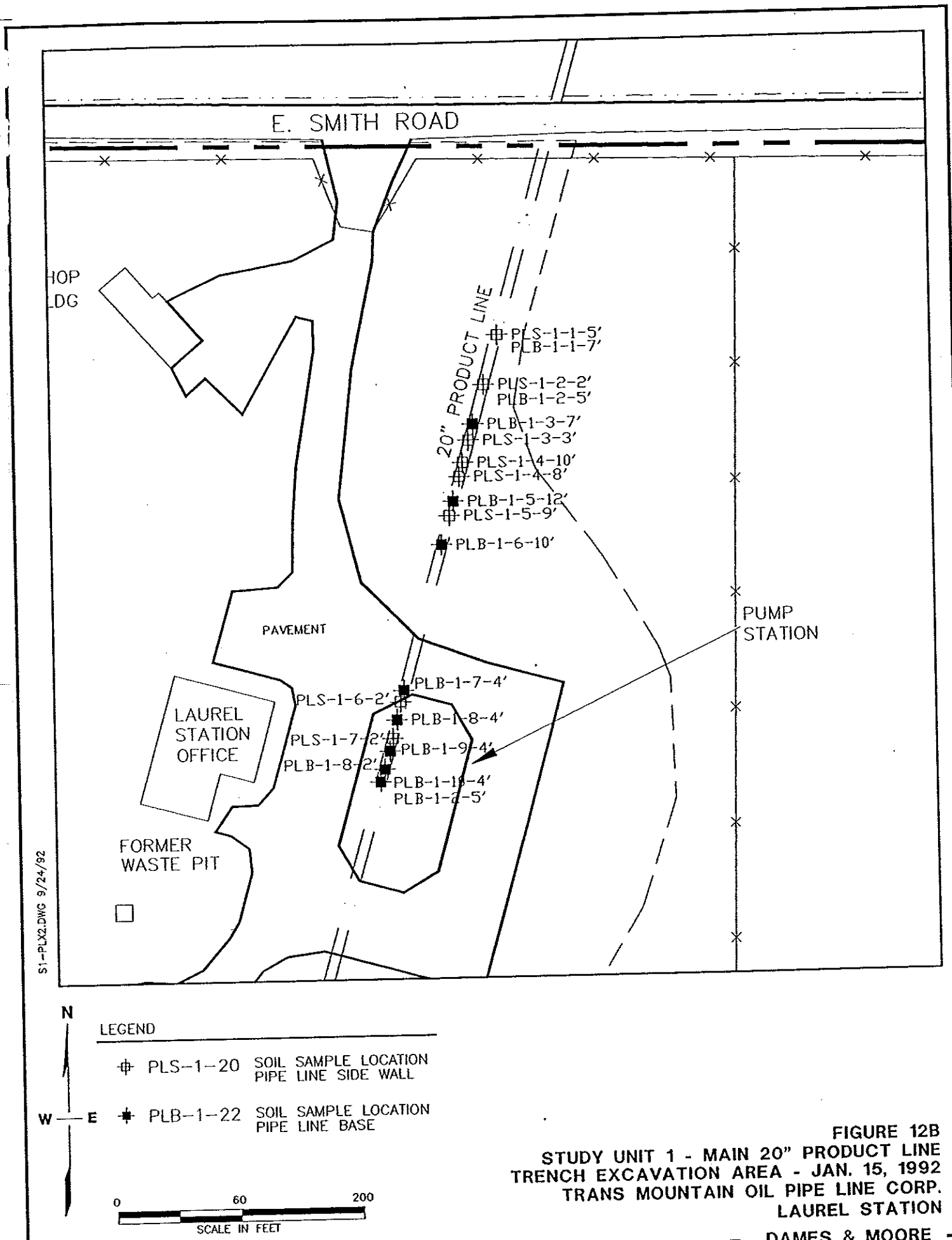
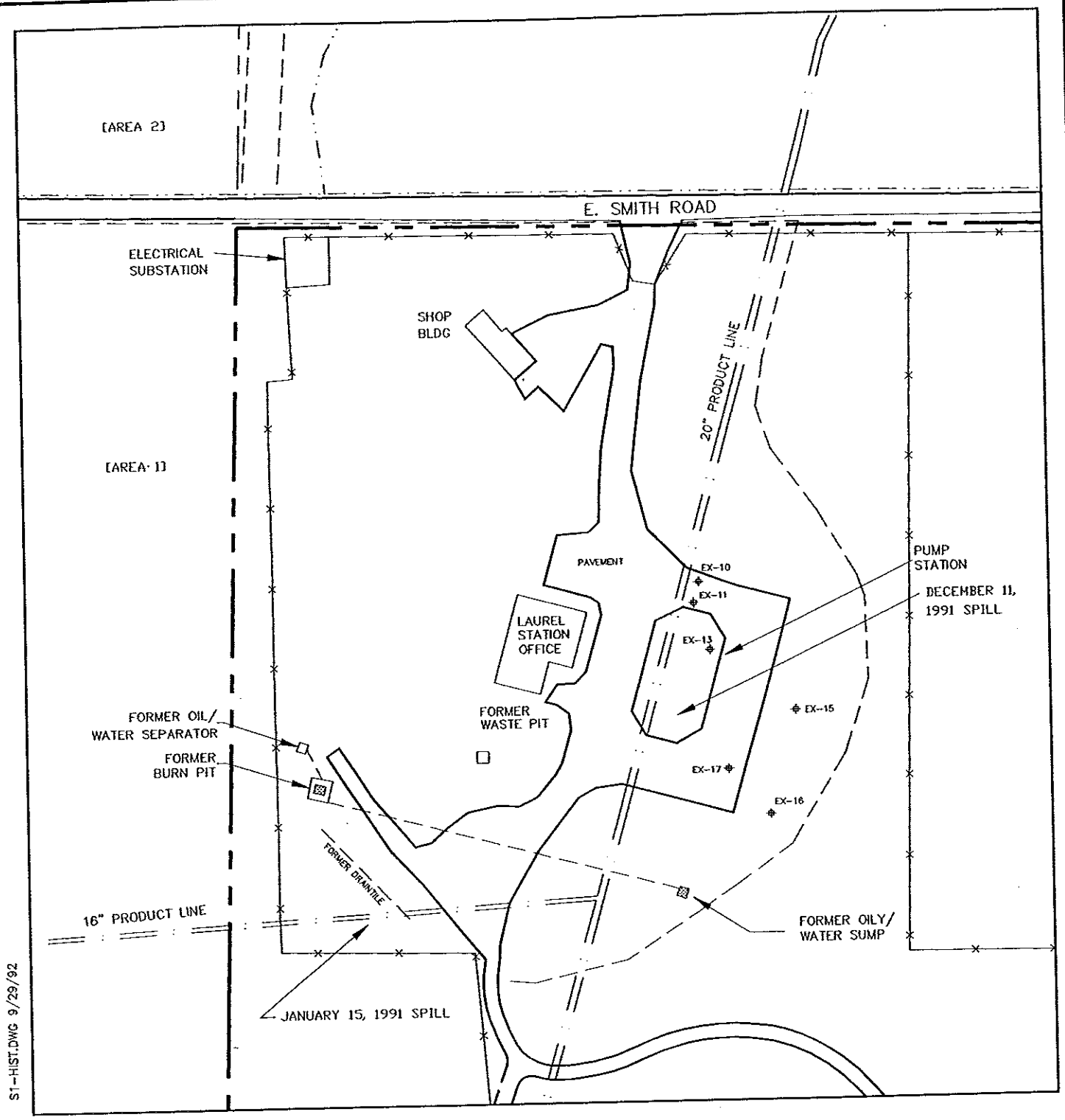


FIGURE 12B
STUDY UNIT 1 - MAIN 20" PRODUCT LINE
TRENCH EXCAVATION AREA - JAN. 15, 1992
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE



N

W — E

LEGEND

EX-10 EXCAVATION SAMPLE LOCATION

[AREA 1 & 2] OFF TRANS MOUNTAIN PROPERTY AS DEFINED IN THE ENFORCEMENT ORDER

0 100 200

SCALE IN FEET

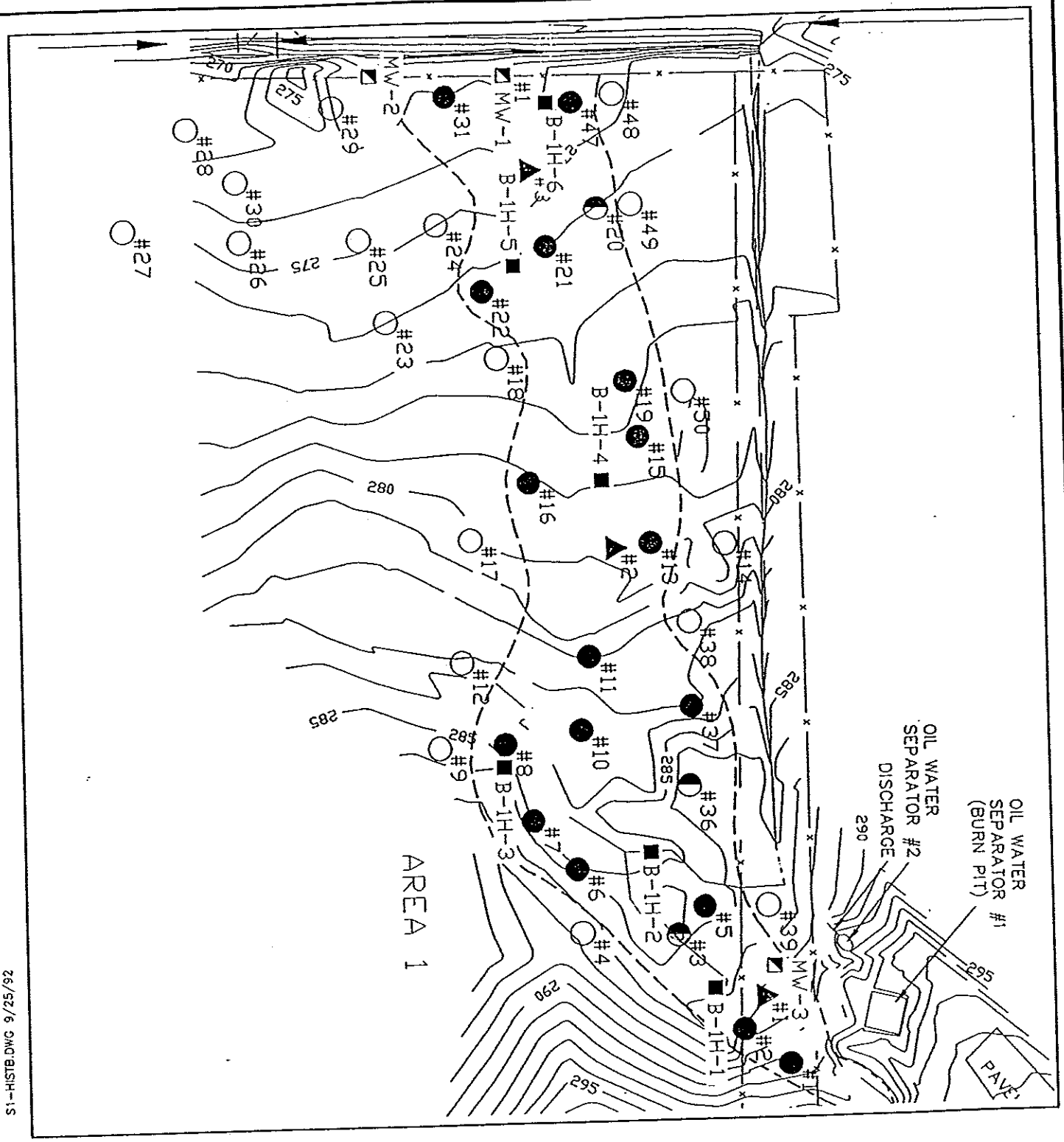
FIGURE 13A

STUDY UNIT 1 - HISTORICAL SPILLS

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE



LEGEND

- APPROX. SAMPLE LOCATION W/ LESS THAN 10ppm TPH (PURNELL, 1991)
- APPROX. SAMPLE LOCATION W/ GREATER THAN 100ppm TPH (PURNELL, 1991)
- APPROX. SAMPLE LOCATION W/ 1 TO 100ppm TPH (PURNELL, 1991)
- APPROX. PROPOSED SHALLOW SOIL BORING LOCATION (D&M)
- MONITORING WELL LOCATION (PURNELL, 1991)
- APPROX. LOCATION OF SHELBY TUBE SAMPLING POINTS (PURNELL, 1991)
- APPROX. EXTENT OF CONTAMINATION (VP. PURNELL, 1991)

N

W — E

From: Purnell & Associates, Inc., November 25, 1991.

0 60 200

APPROXIMATE SCALE IN FEET

FIGURE 13B

STUDY UNIT 1 - HISTORICAL SPILLS

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE

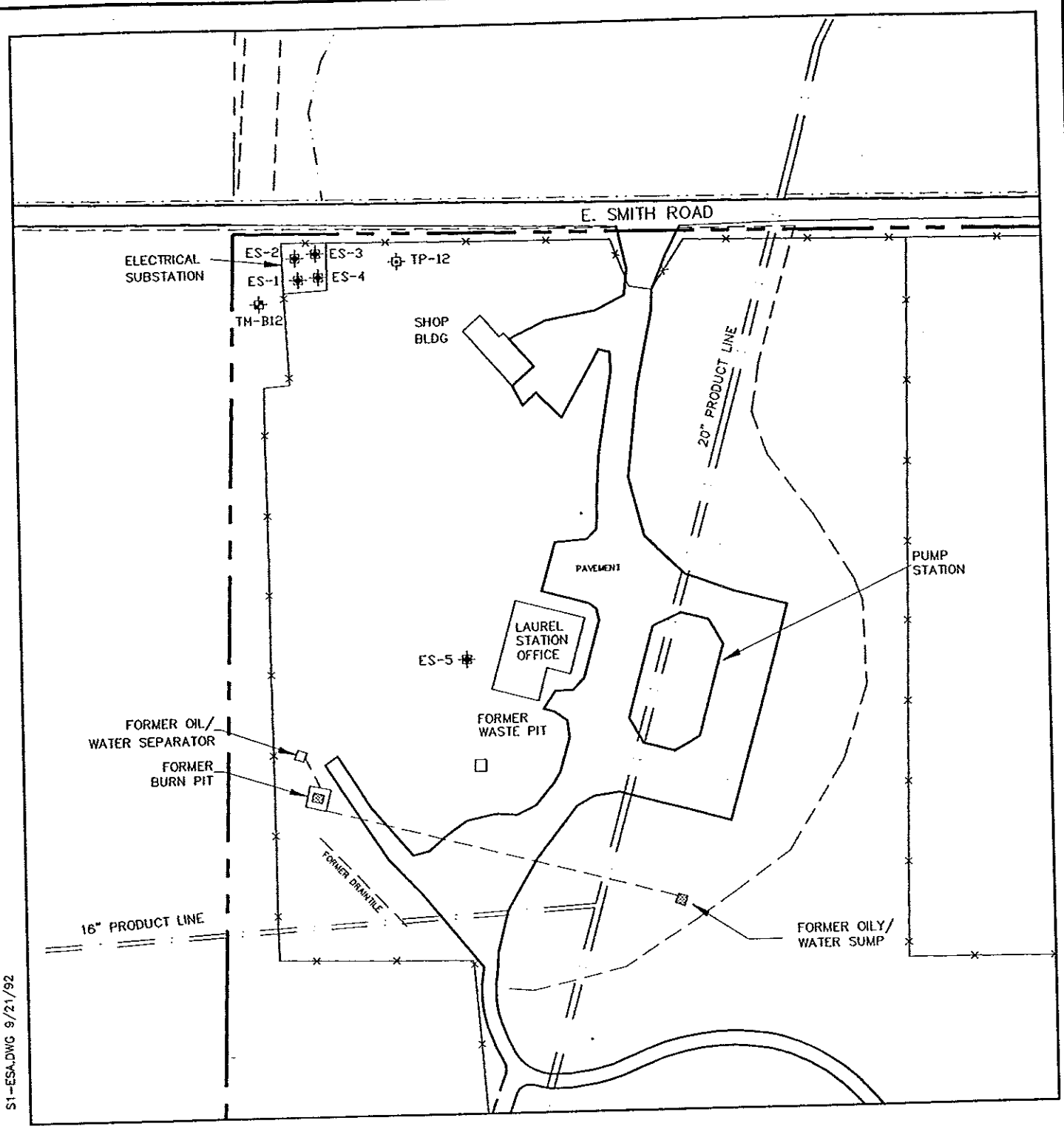


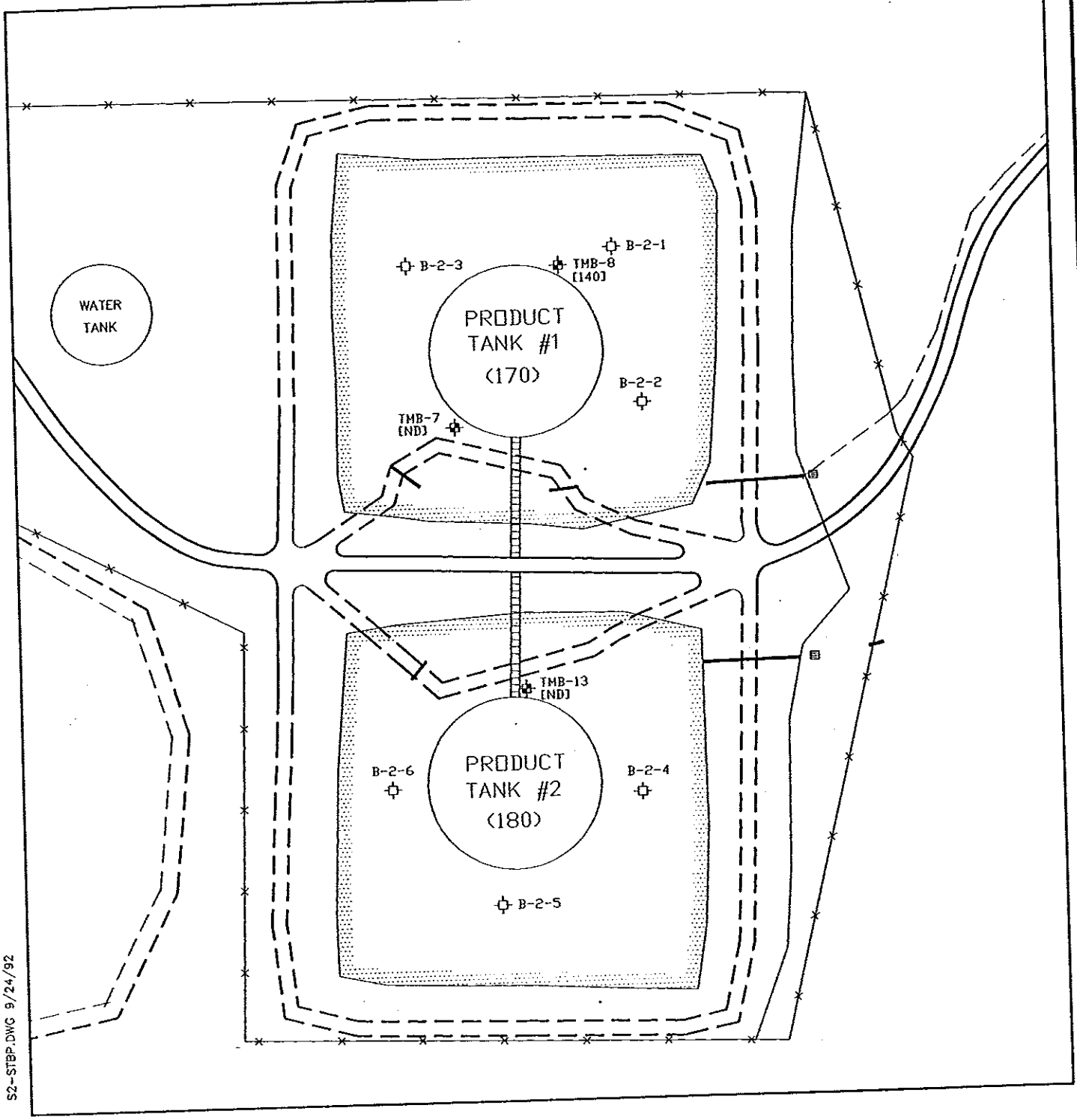
FIGURE 14

STUDY UNIT 1 - ELECTRICAL SUBSTATION AND TRANSFORMER AREA

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE



N

W — E

LEGEND

TMB-7 [ND] SOIL BORING LOCATION W/ TPH ANALYTICAL RESULTS (mg/kg)

B-2-1 PROPOSED SOIL BORING LOCATION

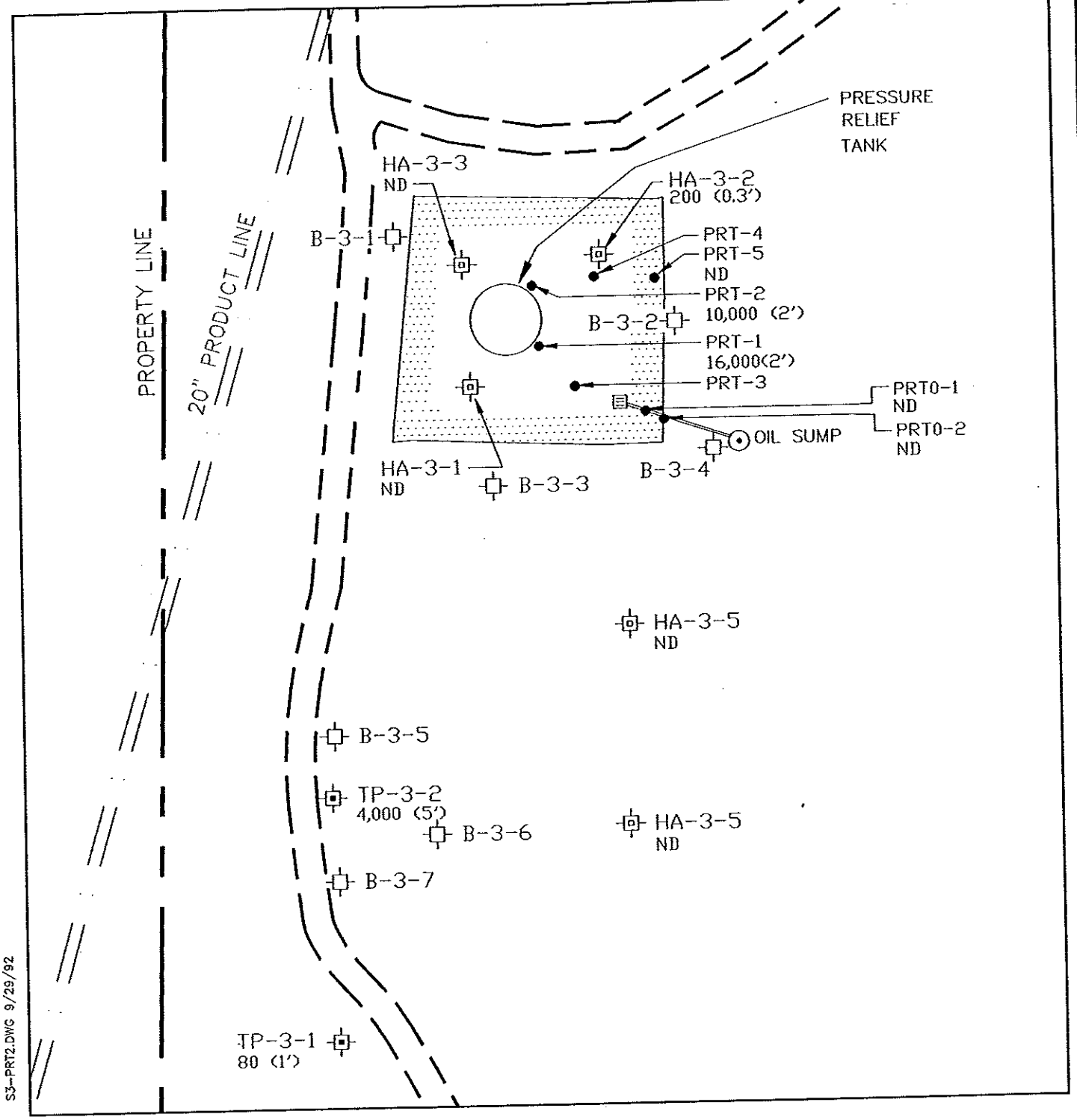
0 100 200

SCALE IN FEET

FIGURE 15

STUDY UNIT 2 - BULK PETROLEUM STORAGE TANKS
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE



LEGEND

- HA-3-5 ND — HAND AUGER LOCATION W\ TPH ANALYTICAL RESULTS (mg/kg)
- TP-3-1 80 (1') — TEST PIT LOCATION W\ TPH ANALYTICAL RESULTS (mg/kg)
- B-3-1 — PROPOSED BORING LOCATION
- PRT-1 — POST-SPILL EXCAVATION SAMPLE W\ TPH ANALYTICAL RESULTS (mg/kg)

ND NOT DETECTED
(1') SAMPLE DEPTH

N
W — E

0 60 120
SCALE IN FEET

FIGURE 16
STUDY UNIT 3 - PRESSURE RELIEF TANK AREA
SOIL BORING PROGRAM
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE

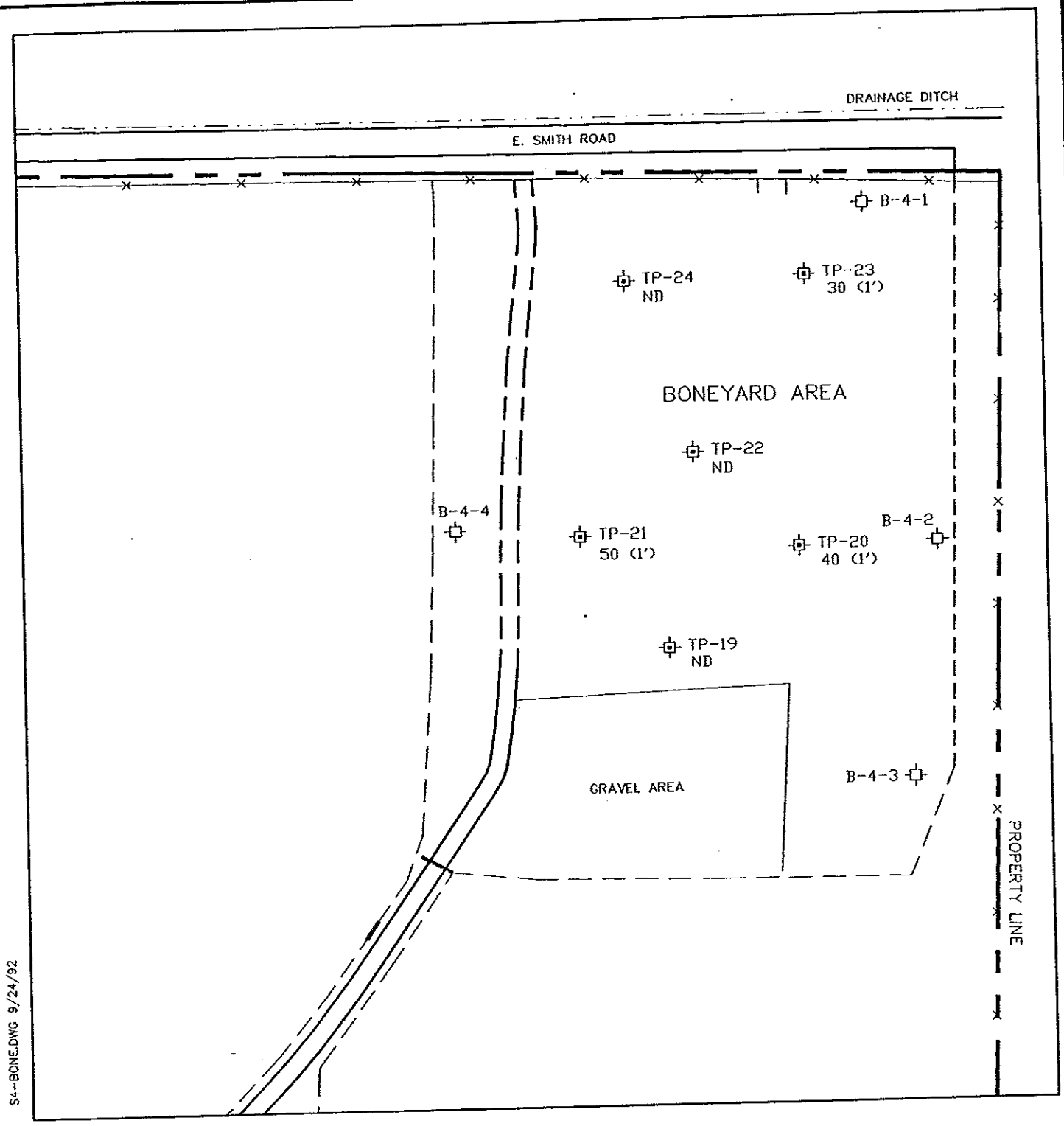
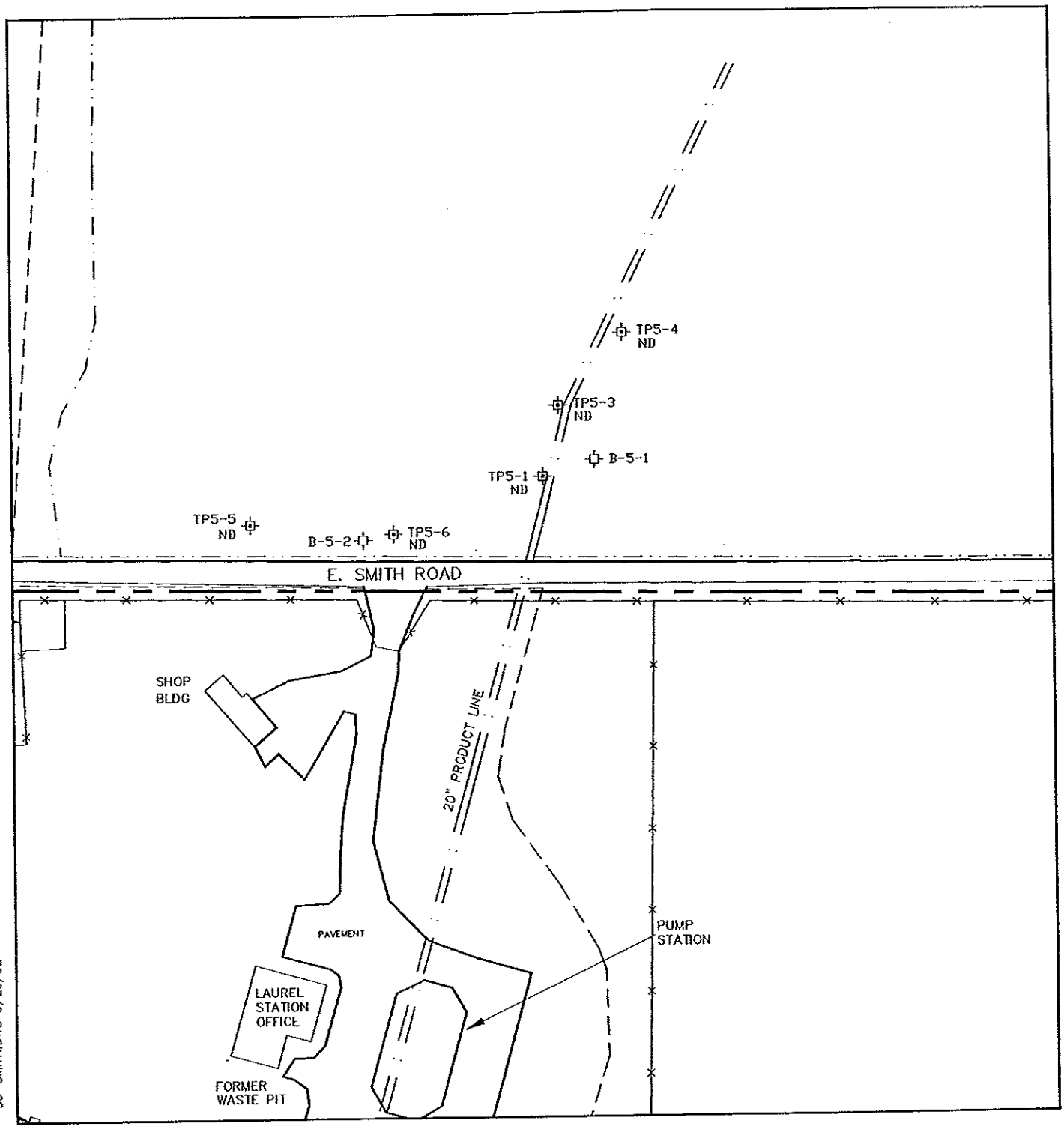


FIGURE 17
STUDY UNIT 4 - BONEYARD AREA
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE



N

W — E

LEGEND

TP5-1 TEST PIT LOCATION W\
ND TPH ANALYTICAL RESULTS (mg/kg)

B-5-1 PROPOSED BORING LOCATION

ND NOT DETECTED

0 100 200

SCALE IN FEET

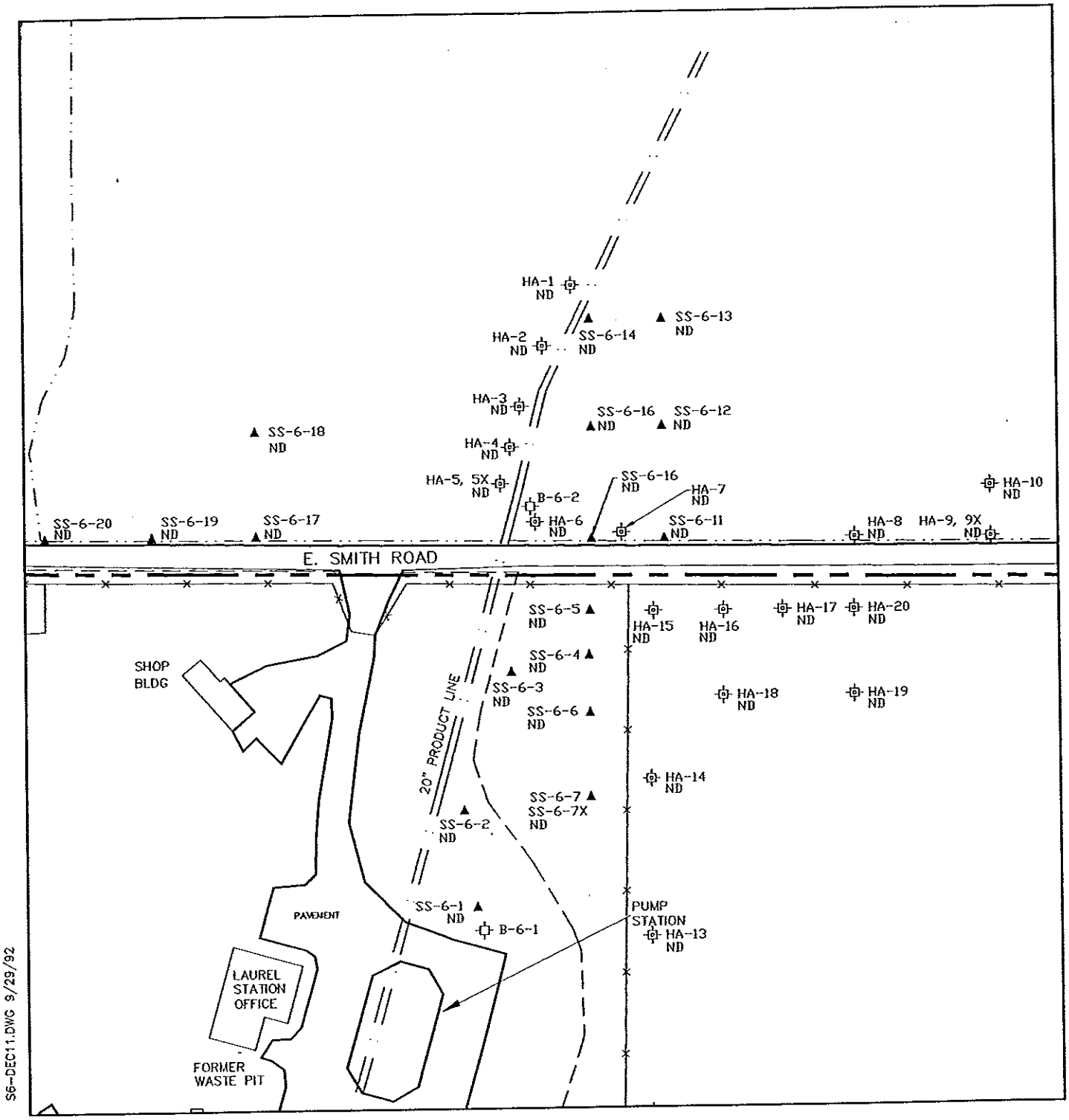
FIGURE 18

STUDY UNIT 5 - AREA NORTH OF SMITH ROAD SPILL

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE



N

W — E

LEGEND

- HA-1 / ND — HAND AUGER LOCATION W\ TPH ANALYTICAL RESULTS (mg/kg)
- SS-6-1 / ND — SURFACE SOIL LOCATION W\ TPH ANALYTICAL RESULTS (mg/kg)
- B-6-1 — PROPOSED SHALLOW SAMPLE LOCATION
- ND — NOT DETECTED

0 100 200

SCALE IN FEET

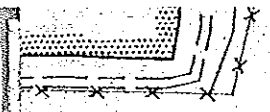
FIGURE 19

STUDY UNIT 6 - DECEMBER 11 SPILL AREA

TRANS MOUNTAIN OIL PIPE LINE CORP.

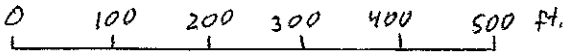
LAUREL STATION

DAMES & MOORE



EA

: 0.34 ACRES
IF WATER AS



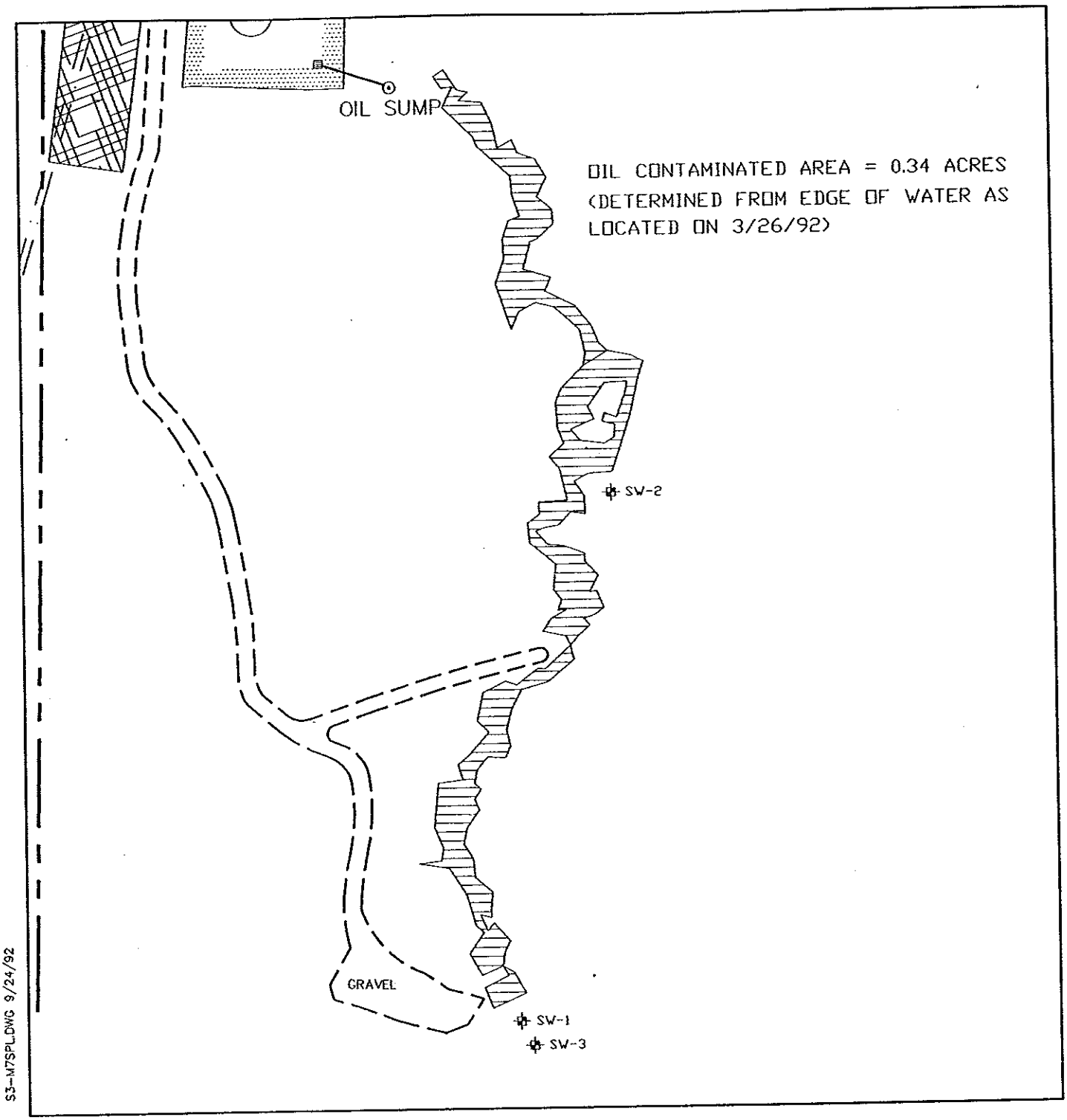
See dig. file

Sediment and Surface Water

FIGURE 20

ER SAMPLE LOCATIONS
IN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE



N

W — E

LEGEND

SW-3 SURFACE WATER SAMPLE LOCATION

0 100 200

SCALE IN FEET

FIGURE 21

MARCH 7, 1992 SPILL SURFACE WATER SAMPLE LOCATION

TRANS MOUNTAIN OIL PIPE LINE CORP.

LAUREL STATION

DAMES & MOORE

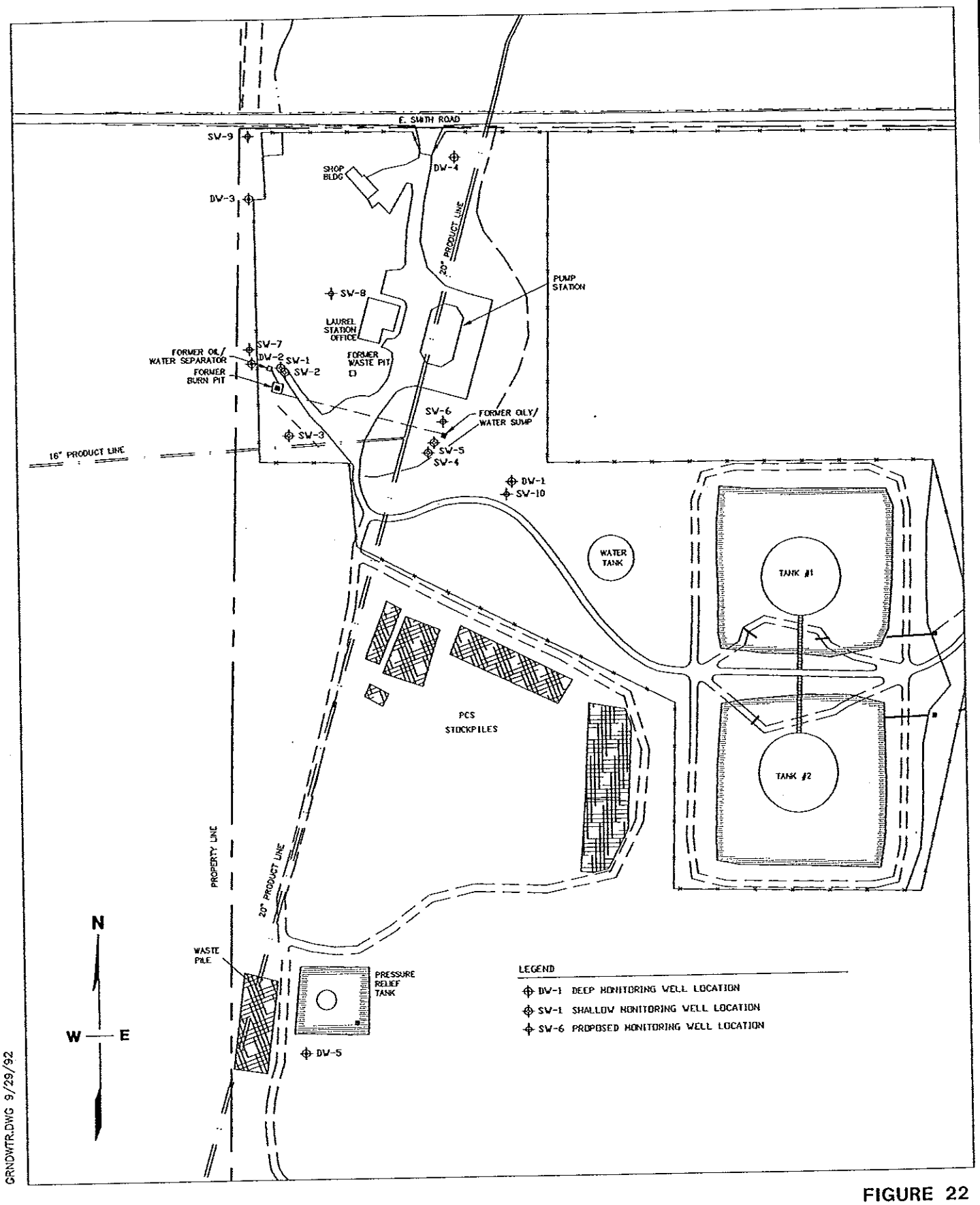


FIGURE 22
MONITORING WELL LOCATION
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION
DAMES & MOORE

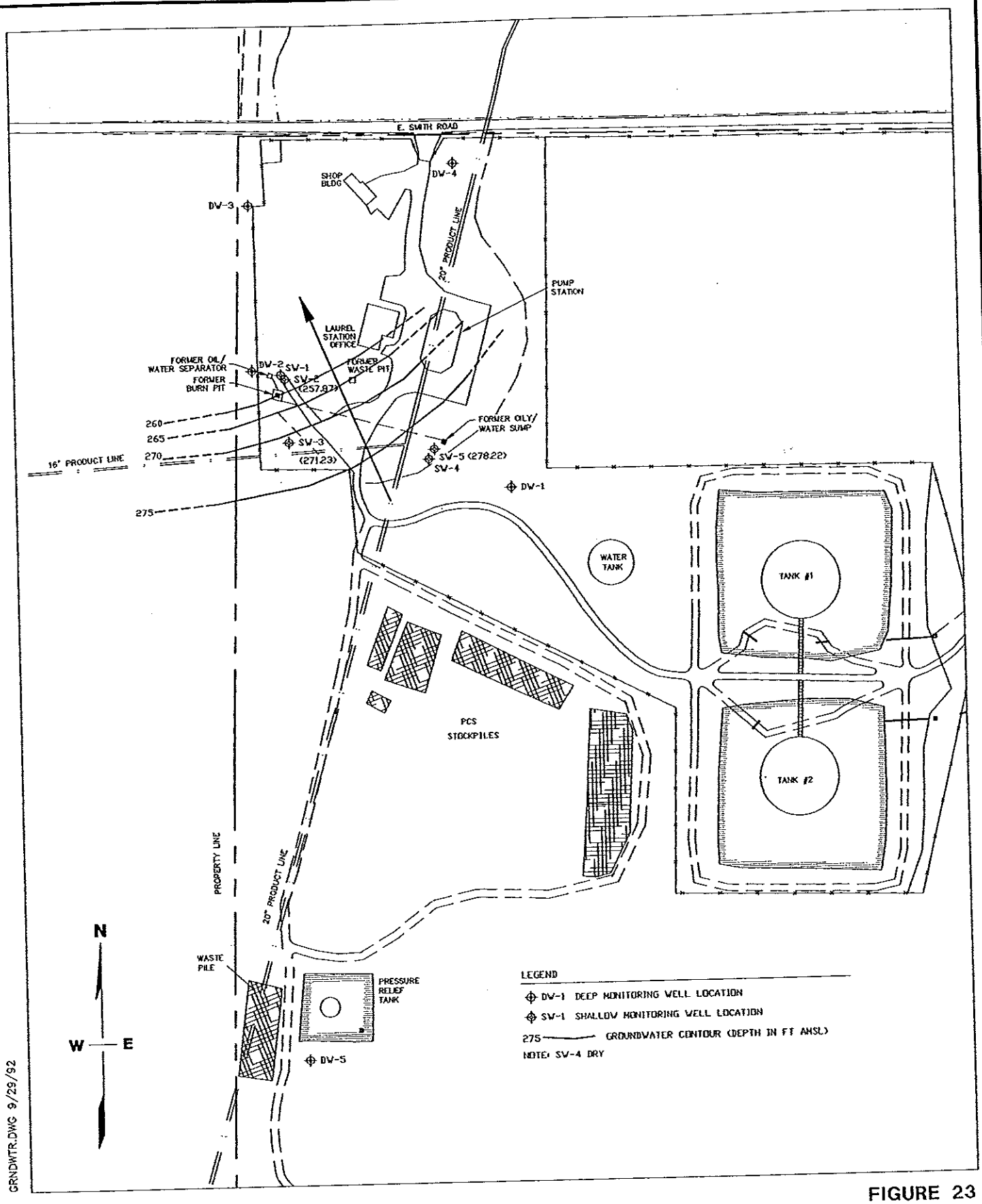


FIGURE 23
GROUNDWATER ELEVATION CONTOURS
SHALLOW SATURATED ZONE, APRIL 1992
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE

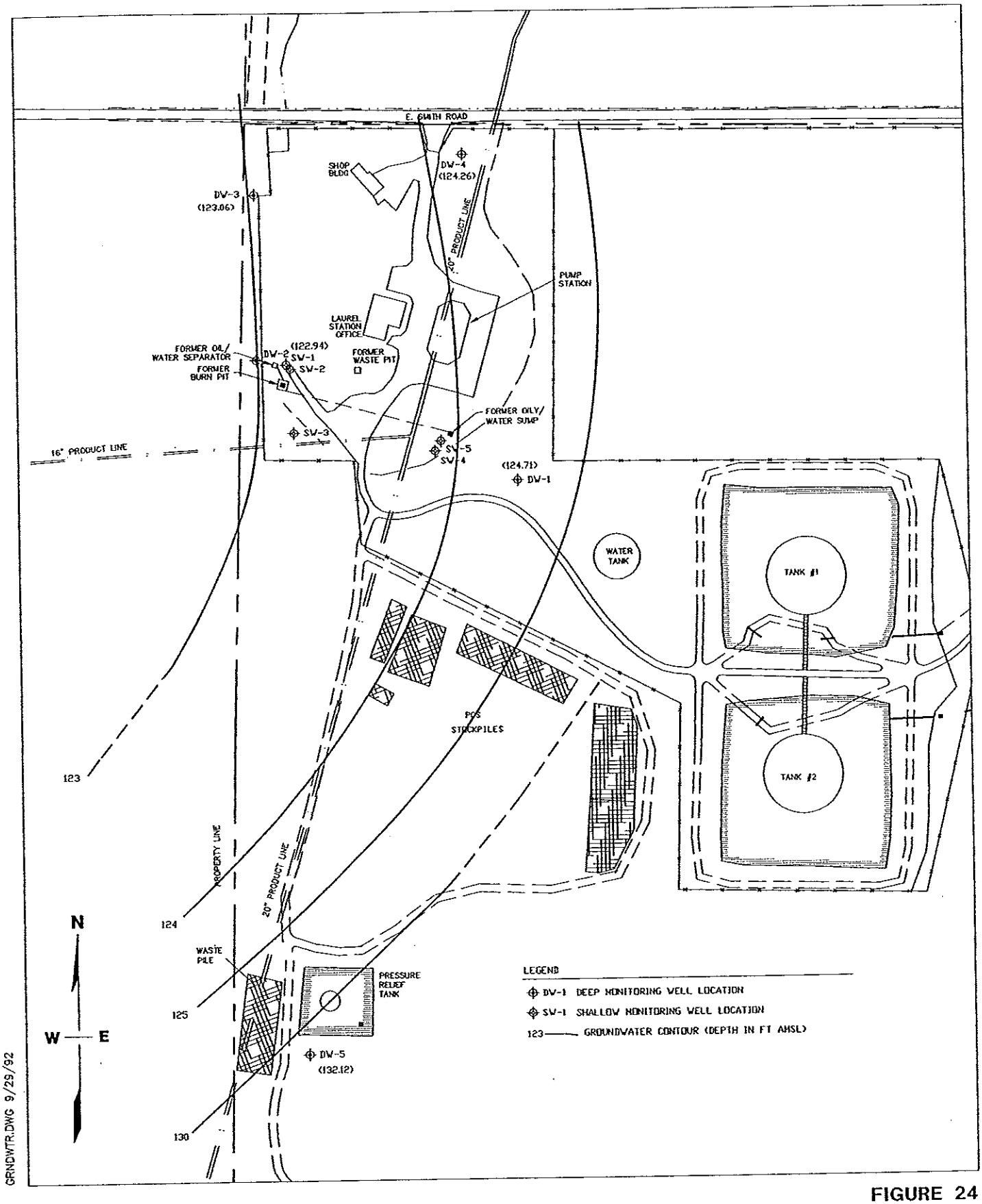
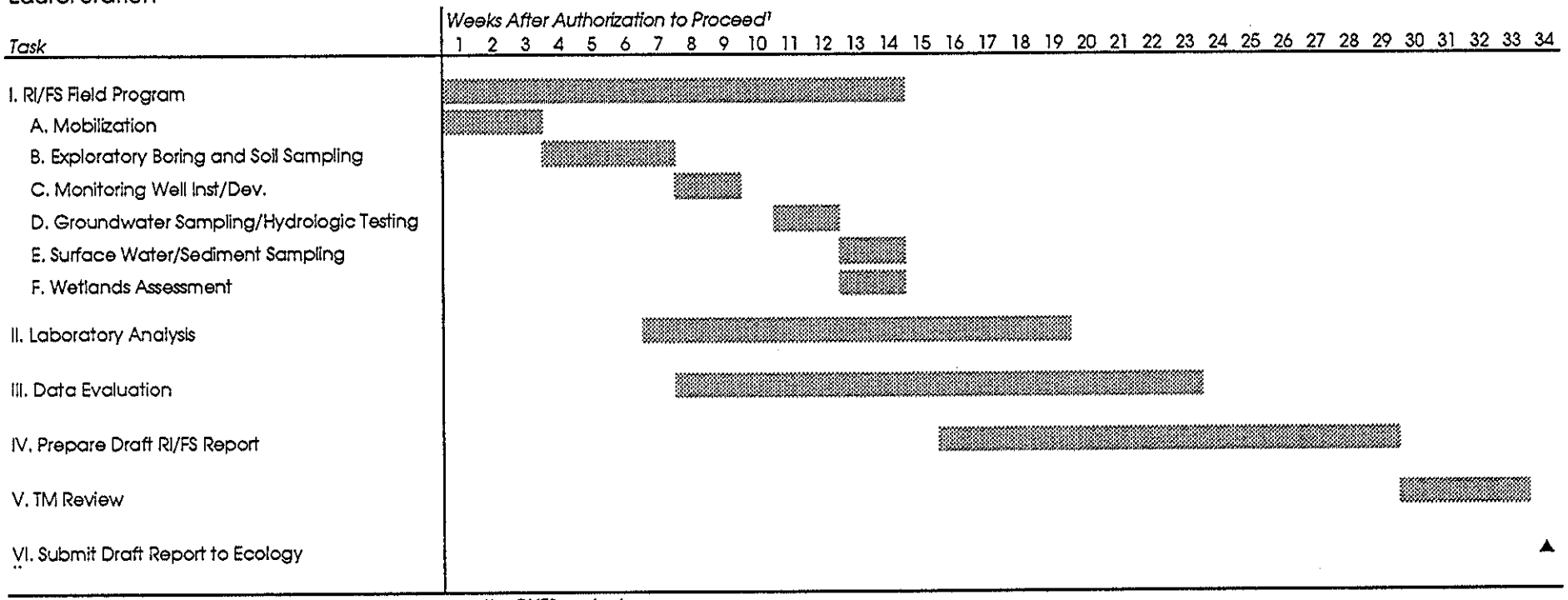


FIGURE 24
GROUNDWATER ELEVATION CONTOURS
DEEP AQUIFER, APRIL 1992
TRANS MOUNTAIN OIL PIPE LINE CORP.
LAUREL STATION

DAMES & MOORE

Figure 25
Scheduled RI/FS Activities
Trans Mountain Oil Pipeline Corp.
Laurel Station



[1] *Authorization corresponds to date Ecology approves the RI/FS work plan.*

Job No. 21199-032-005
File FIG_25.XLS | scd | 9/25/92

APPENDICES

A-D

(SEE FILE)

APPENDIX E

APPENDIX E

BASELINE ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT WORK PLAN
Laurel Station and Wetlands

BASELINE ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT WORK PLAN
Laurel Station and Wetlands

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

BASELINE ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT WORK PLAN
Laurel Station and Wetlands

1.0 INTRODUCTION AND RISK ASSESSMENT CONCEPTUAL SITE MODEL

The baseline risk assessment for the Laurel Station will be conducted for the purpose of evaluating the potential risk to ecological receptors and human health based on current and potential conditions in accordance with requirements of the National Contingency Plan (EPA 1990b) and in specific compliance with Enforcement Order DE 91-N192 and Ecology comments presented in their letter dated August 3, 1992. In addition, the risk assessment findings will also be used to evaluate the feasibility of removing the temporary dams as presented in the Dam Removal Assessment and Feasibility Evaluation dated August 14, 1992.

The risk assessment will be based on measured concentrations of chemical compounds, where available, on site-specific toxicity data which directly address potential effects upon ecological communities, and on model-generated estimates based on data collected during the Remedial Investigation phase of the project. Historical analytical data, where available, will also be incorporated into the analysis. The risk assessment will be conducted according to generally accepted state and federal guidance, including, but not limited to the EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (Vol. 1) and Environmental Evaluation Manual (Vol. 2) (EPA 1989a, 1989b).

The final product and output of the risk assessment will be to provide an estimate of potential risk to: (a) wildlife, both terrestrial and aquatic, inhabiting the Laurel Station or its immediate environs, and (b) residential receptors. In so doing, risk assessment results will identify compounds, compound mixtures, receptors, and pathways of potential concern to the site. These findings will be designed to allow for risk-based determination of remedial design and cleanup, if necessary. This Work Plan provides an overview of the specific assumptions and general approach adopted to conduct the risk assessment.

The risk assessment conceptual site model (Figure E-1) is developed to delineate sources of potential hazard to on-site or off-site ecological communities or other receptors resulting from exposure to compounds or compound mixtures of potential concern to the Laurel Station and the potentially affected surrounding area. This approach is useful for identifying locations on or around the site where additional sampling is necessary, and thus contributes to the data needs assessment (Section 2.2 of this Appendix). The conceptual site model was developed based on both available and anticipated site information (following the rationale presented in the data needs assessment). Key elements of the site model include:

- chemical contaminants or contaminant mixtures known from previous site sampling or believed to potentially contribute to ecological effects;
- environmental media potentially affected by site contaminants including surface water, sediment, soil, groundwater, and biota;
- potential exposure pathways for wildlife communities or human populations living on or near the site;

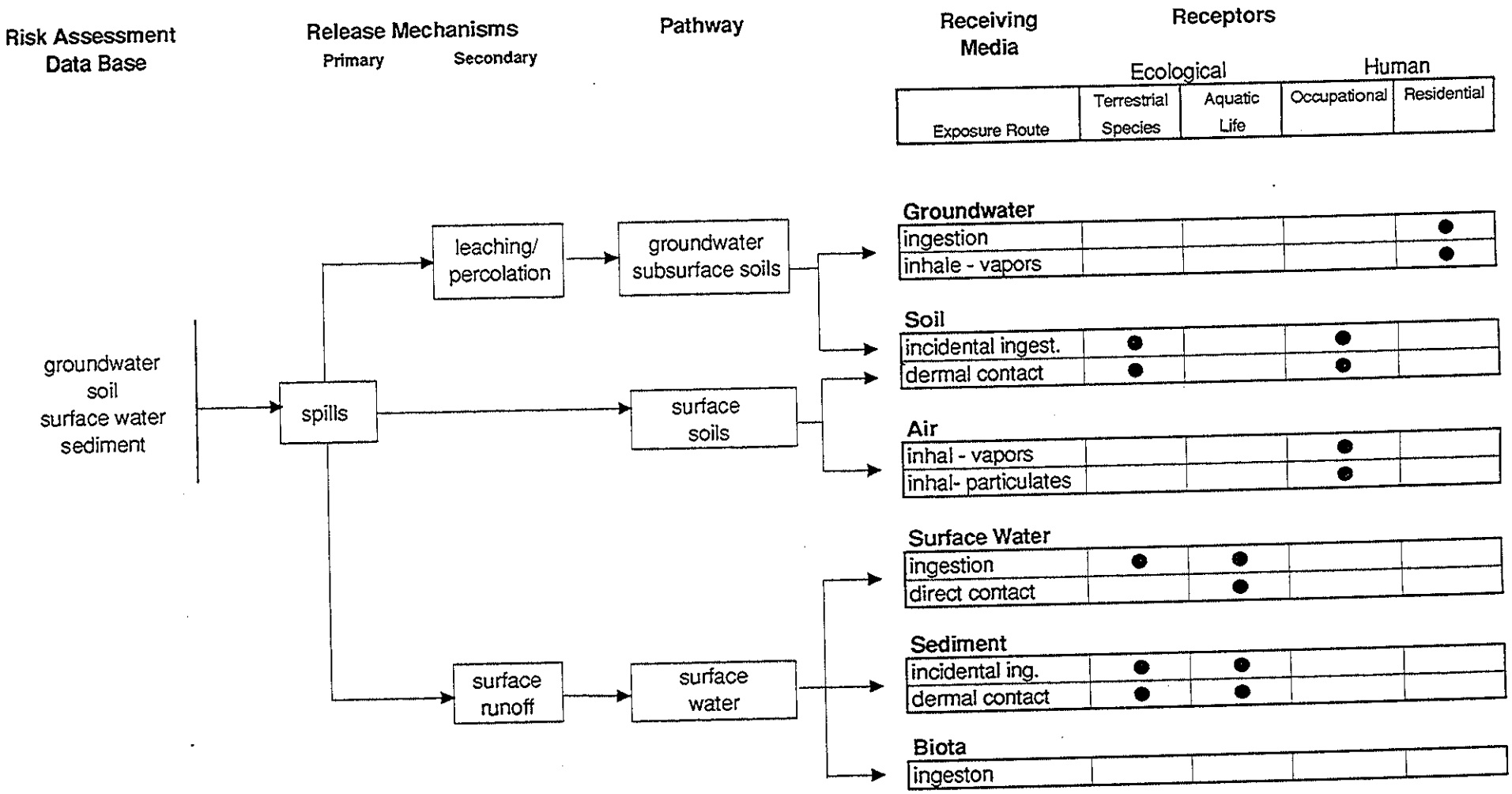


Figure E-1
Conceptual Site Exposure Pathway Model
Trans Mountain Oil Pipe Line Corporation
Laurel Station

- potentially affected wildlife species, including aquatic life and/or Threatened and Endangered species, inhabiting the site or its environs; and

- potential human receptor populations, to include residential populations living within range of potential exposure to the site, and on-site workers.

These components will be incorporated into the risk assessment to quantitatively evaluate: (a) potential ecological risk associated with Station contaminants, and (b) potential human health risk occurring on- or off-site.

Figure E-1 presents the potential sources of contaminant exposure and related pathways addressed in the conceptual site model. This figure represents a broad description of the types of potential exposures expected to occur from the site, shown as release processes and exposure pathways associated with the site. Figure E-1 also shows the specific environmental and human receptors associated with each receiving medium. The discussion emphasizes potential off-site transport associated with specific release events, including subsequent potential exposures to contaminated sediment, surface water, or other media.

An important part of the risk assessment conseptual site model is the delineation of risk-based concentrations for key compounds of potential concern for the purpose of ensuring that analytical detection limits are reflective of toxicological (both ecological and human) threshold values. Derivation of these values and selection of key compounds of potential concern are discussed in Section 2.1.

1.1 SITE HISTORY AND DESCRIPTION

Section 2.0 of the RI/FS Work Plan discussed the general history and past activities of the Laurel Station. Section 3.0 presents a summary of past sampling activities at the site, including types of samples collected, specific objectives, and units of study within the site. These data will be incorporated into the risk assessment database.

2.0 DATA EVALUATION

The risk assessment database will quantitatively incorporate data from several data sets developed during the field program, including analytical data, bioassay data, and other ongoing (monitoring) data where available. Specific data sets, each of which provides information on a specific aspect of the risk assessment, are expected to include:

- sediment and limited surface water chemistry data;

- site-specific sediment and surface water bioassay data;

- on-site and off-site surface/subsurface soil data; and

- ground-water data.

The following subsections discuss important elements of the data evaluation, including the approach adopted to select compounds of potential concern (Section 2.1), evaluate the need for further data (Section 2.2), statistically evaluate the database (Section 2.3), determine analytical methods and detection limits, and address QA/QC concerns (Section 2.4).

2.1 SELECTION OF COMPOUNDS OF POTENTIAL CONCERN

For the purpose of the risk assessment conceptual site model, specific contaminants of concern will be based on those compounds discussed and identified by current or previously conducted sampling efforts. The risk assessment will also address potentially significnat individual compounds believed to be present within contaminant mixtures (i.e., crude product or related materials) for which the effects of the release are under evaluation. Additional compounds will be added as new data are obtained from the additional sediment sampling.

All analytically detected compounds will be incorporated as compounds of potential concern into the database unless data qualifiers indicate that data are suspect or unusable. Compounds found to be below quantitation limits for a specific medium will not be addressed in the risk assessment. The use of this data base for risk assessment purposes will be in accordance with current EPA policy as defined in EPA (1989a).

Compounds of potential concern were selected based on those detected in surface water, sediment, soil, or groundwater, as appropriate, including both historical or current analytical data if they are of sufficient quality (e.g., data from Dames and Moore 1992a and 1992b). Anticipated additional data will be incorporated into this data base when validated.

All data will be subjected to a formalized screening procedure recommended by EPA Region 10 for inclusion as compounds of potential concern into a risk assessment, with complex contaminant mixtures addressed in the same manner. This procedure involves comparison of the maximum medium-specific concentration of each chemical with respective ecological or human health risk-based concentrations (see Tables E-2 and E-3). This process is less formalized for delineation of compounds of ecological concern (see Table E-1).

Compounds of potential concern to human health, for example, may be eliminated from further analysis if the maximum value detected is either less than 10^{-6} (or 0.1 Hazard Quotient (HQ)) for drinking water, or less than 10^{-7} (or 0.1 HQ) for soil. Lower "risk range" target risk values, as defined by the National Contingency Plan (EPA 1990b), are used in this manner to allow for additivity among compounds with similar modes of toxic action via more than one exposure pathway.

TABLE E-1
RISK-BASED SCREENING CONCENTRATIONS FOR AQUATIC LIFE IN SURFACE WATER

Compound	Maximum Detected Conc. (ug/L)	AWQC Final Chronic Value (ug/L)
benzene	5.4	212 (a,b)
ethylbenzene	2.1	1,280 (a,b)
toluene	14	700 (a,b)
xylene	22	21.4 (c)
TPH	1,100	1,000 (d)

Footnotes
(a) Value represents acute criteria divided by an Acute-to Chronic Ratio of 25 because of lack of chronic data.
(b) Value estimated based on a LOEL because of insufficient data to develop criteria.
(c) Value based on draft Advisory Concentration (EPA 1991d).
(d) MTCA (Wash. Dept. of Ecology 1991b) value for TPH in groundwater used for lack of available ambient water quality criteria (AWQC).

TABLE E-2

RISK-BASED SCREENING CONCENTRATIONS FOR SOIL AND SEDIMENT

Soil (mg/kg)			Sediment (mg/kg OC)	
Detected Compound	Max value	Risk-Based Conc.(a)	Compound	Most Appropriate Numerical Guidance (b)
benzene	0.015	2	benzene	11,000 (c)
chrysene	0.098	2.6 (d)	chrysene	90
ethylbenzene	0.72	3,000	ethylbenzene	11,000
fluorene/ fluoranthene	0.19	1,000	fluorene/ fluoranthene	1,216
TPH	1,700	100 (e)	TPH (PAH)	2 (DW)
toluene	0.45	5,000	toluene	5,250
trichlorotri-fluoroethane	0.59	$>10^5$ (f)	chloroform	2.7
Petroleum hydrocarbons	3,500	100 (e)	lead	31 (DW)
xylene	2.4	50,000	1,1,1-TCA	
naphthalenes	1.3	100 (g)	xylene	
phenanthrene	0.4	286 (f)	naphthalenes	1,240
pyrene	0.077	800	zinc	120 (DW)

Footnotes

DW = dry weight

(a) Value at 10-7 risk, 0.1 HQ for soils and 10-6 risk, 0.1 HQ or MCL for water. All values based on human health concerns because of the absence of data to evaluate ecological concerns. Values taken from EPA (1991a) unless otherwise indicated.

(b) The most appropriate criteria were used based on a summary of sediment data compiled by Ecology using mg/kg organic carbon (1991b). These values address ecological concerns.

(c) Value for ethylbenzene used for benzene for lack of specific data. Value based on equilibrium partitioning method.

(d) Chrysene value calculated using SF for benzo(a)pyrene and equivalency factors (only carcinogenic PAH detected).

(e) Value for TPH taken from MTCA guidance.

(f) Value estimated based on the toxicity (RfD or slope value) and EPA calculations.

(g) RfD not available for phenanthrene, naphthalene RfD used in the concentration calculations.

TABLE E-3
RISK-BASED SCREENING CONCENTRATIONS FOR GROUNDWATER

Groundwater (ug/L)			
Detected Compound	Max Conc. (Deep)	Max. Conc. (Shallow)	RBC Conc.
arsenic	83	9	50
benzene	ND	1.3	5
chromium	154	767	100
copper	209	523	1,300
chloromethane	1.6	ND	2
1,1-dichloroethane	ND	1.2	5 (b)
chloroform	ND	14	100
lead	167	88	5
1,1,1-trichloroethane	ND	5.7	200
TPH	ND	18	(b)
zinc	243	1,030	700

Footnotes
(a) Value at 10-6 risk, 0.1 HQ or MCL for water. Values taken from EPA (1991a) unless otherwise indicated.
(b) Value estimated based on the toxicity (RfD or slope value) and EPA calculations.

2.2 DATA NEEDS ASSESSMENT

As noted in previous reports (Dames & Moore 1992a, 1992b), analytical data collected to date are adequate for groundwater and, to a lesser extent, for surface water as well, although limited additional sampling will be conducted to characterize specific compounds within these key media. Additional limited chemical data from sediment and soils will contribute to overall chemical characterization of these media. Sediment and surface water bioassay data will also contribute to a database which is "effects-based" rather than based on chemical concentrations alone. Each of these data types directly supports the quantitative risk assessment in that it contributes information concerning the nature and extent of contaminants or the potential effects of these contaminants.

Proposed sediment, soil and surface water sampling locations are shown on Figures 5 through 22 in the RI/FS Work Plan. Surface sampling from each sediment sampling location will be conducted for the upper 5 cm (2 inches), a standardized depth believed to most effectively represent potential aquatic exposures to benthic organisms. In addition, hand augers or comparable equipment will be used to sample sediments to a depth of up to 1.5 ft. in two locations only, in order to determine whether petroleum hydrocarbon residues could have migrated vertically following release of these compounds.

Sediment sampling. The eight sediment samples will be collected from Station SED-1 to Station SED-8, as shown on Figure 20. Cores will be sampled from two stations, SED-C5 and SED-C8 at a depth of one foot. In addition to the chemical samples, five stations (SED-2,3,C5,7,C8) will be sampled for sediment bioassay, for the purpose of attempting to correlate sediment chemistry data with bioassay data.

Surface water sampling. Six surface water stations, Station SWS-1 to SWS-6, will be sampled for specific chemical analytes to correspond with the sediment chemistry data, while five surface water stations will be sampled for bioassay to correspond with the sediment bioassay stations. This sampling is intended to address the issue of whether petroleum hydrocarbon contaminants are bioavailable within the water column, which could thereby cause toxicity to aquatic life.

It is noted that both sediment and surface water samples taken for chemistry and bioassays include a station located upstream of the temporary dams to serve as "reference" stations (shown on Figure 20, as station SED-3). These stations are designed to indicate which effects could be associated with effects on aquatic life as a result of exposure to petroleum-based mixtures. Table E-4 summarizes the additional sampling required to conduct the risk assessment.

Approximately 40 surface and subsurface soil samples will be collected and analyzed for on-site petroleum hydrocarbons, which will complement the extensive on-site RI soil data. The proposed sampling locations are presented in the RI/FS Work Plan. These samples, along with the existing data, will contribute to characterization of site soils, necessary to support conclusions generated in the risk assessment.

Air monitoring. Initial screening to determine whether vapors are a viable concern at the site will be accomplished through personal monitoring (refer to Appendix C for details).

2.3 STATISTICAL EVALUATION OF CONTAMINANT DATABASE

An integral portion of the baseline risk assessment is the statistical approach used to evaluate the various data sets, including contaminant chemistry data, bioassay data, and other types of information incorporated into the risk assessment, including numerical exposure parameters, and geological/biological field data. The statistical approach and subsequent analysis to be used for the contaminant data base will generally follow accepted practice for baseline risk assessment; regulatory guidance has been developed by Ecology and EPA (both headquarters and within Region 10). The statistical approach to be adopted for data evaluation in support of the risk assessment is briefly summarized below.

Definition of the statistical distribution for individual data sets (e.g., contaminant data, exposure factor data, etc.) is useful for characterizing uncertainty in any risk assessment. Assumption of statistical normality (i.e., a normal mode of distribution) is common practice for smaller data sets and recommended by EPA (1990a), although data distribution testing, including goodness-of-fit, or t-tests may be appropriate to evaluate distribution mode for individual data sets (Gilbert 1987, EPA 1989d). Arithmetic or geometric summary statistics, as appropriate (i.e., mean and 95% upper confidence limit (UCL)), will be provided for each data set to represent nature and extent of contamination specific to a given medium. Where sample size is sufficient (i.e., greater than $n = 10$), the standard deviation about the mean will be adequate to estimate the 95% UCL value needed for risk assessment.

The 95% UCL value is generally adopted in the risk assessment when the number of individual samples within a data set exceed 10; the maximum concentration is used when the sample size is less than 10. This is in keeping with EPA guidance for estimating the Reasonable Maximum Exposure (RME) scenario, developed for the purpose of estimating exposure potential to support a quantitative risk assessment. The exposure assessment will be conducted based on measured field data.

Table E-4
Summary of Data Needs for Risk Assessment
Trans Mountain Oil Pipeline Corp.
Laurel Station

Media of Concern	Chemistry (a)					Bioassay				
	Deer Creek No. samples/ Stations		Wetland Area No. samples/ Stations		Total Samples	Deer Creek No. samples/ Stations		Wetland Area No. samples/ Stations		Total Samples
sediments	6	SED-1 to 6	2	SED-7 to C8	8	3	SED-2,3,C5	2	SED-7 to 8	5 (b)
sediment cores	1	SED-C5	1	SED-C8	2	0		0		0
surface water	4	SWS-1 to 4	2	SWS-5 to 6	6	3	SWS-1 to 3	2	SWS-5 to 6	5 (c)

Footnotes

(a) Sediment chemistry includes one field blank.

(b) Sediment bioassay samples will be tested using a 10-day subchronic test using H. azteca.

(c) Water bioassays will be conducted using the 7-day life-cycle test using C. dubia.

In addition to the mean, standard deviation, and UCL (or maximum) contaminant values from each data set, pending sufficient sample size and distribution mode, the frequency of detection, sample size for each contaminant within a medium-specific data set, and maximum identified concentrations will be summarized. This statistical summary information is important for the purposes of uncertainty analysis.

2.4 ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QA/QC

2.4.1 Analytical Methods and Detection Limits

The additional samples to be analyzed, as outlined in this Work Plan, will better define the individual hydrocarbon components present within the TPH mixture.

Analytical methods. Sediment and surface water samples will be analyzed by method WTPH-HCID, using a fixed laboratory, as an initial screening for the presence of hydrocarbons. Detection limits for this method are presented in the QAPP for gas, diesel and oil. Samples from which hydrocarbons are detected will then be analyzed quantitatively (i.e., by individual PAH component) using EPA method 8310 (for sediment, soil and water). This method uses lower analytical detection limits than standard BNA analyses, and should be adequate to characterize PAH concentrations in sediment or soil if present within the wetland or creek areas.

Previous analyses have indicated that heavier hydrocarbon components were more frequently identified; therefore, analysis for lighter (gas fraction) components is not recommended. The RI investigation used the WTPH-HCID method, which can be compared with the screening for this proposed phase of analysis.

The EPA method attains a lower detection limit (10 ug/kg soil, and 0.1 ug/L for water for 8310) than the screening method and should be adequate to characterize hydrocarbon components and concentrations when detected in the screening process. These analyses will supplement the data collected during the RI and improve correlations between screening and actual compound concentrations for incorporation into the risk assessment.

Previous analyses at the site were conducted for BETX by 8020, volatiles by 8240, BNAs by 8270, WTPH-HCID, TPH by 418.1 and priority pollutant metals for selected soil samples. Most samples were analyzed by 418.1 for TPH with a 1 to 10 ppm detection limit. Groundwater was analyzed for priority pollutant metals, volatiles by 8240, TPH by 418.1, pH, TDS and major ions. Surface water was analyzed for BETX and TPH only. Analyses were performed through field screening (with additional QA/QC) and by a state-certified laboratory.

To complement the chemical analyses, bioassay analyses will also be conducted for both surface water and sediment. The tests to be performed include the *Ceriodaphnia dubia* 7-day life-cycle test for water, and the *Hyalella azteca* 10-day test for sediment. These two tests will be conducted according to established protocols, including NAS (1990), ASTM (1990) and EPA (1986b, 1989d). Test endpoints for *C. dubia* include mortality and reproduction, while the *H. azteca* test uses mortality and growth.

Risk-based concentrations. The objective of this section is to develop general guidance for establishing analytical detection limits which are protective of all receptors evaluated in the risk assessment (i.e., to establish detection limits which do not exceed recognized toxicity thresholds).

Although the primary concern at the site is the ecological receptors, well established risk-based soil guidance for soils, developed for human health protection, will represent terrestrial receptors as well. Risk-based concentrations were derived based on three principal sources:

- federal guidance for Ambient Water Quality Criteria from EPA (1992e) for protection of aquatic life;

- draft guidance from EPA Region 10 developed for the purpose of human health risk-based concentrations in soils and groundwater (EPA 1990c), and

- Cleanup regulations from the Washington Department of Ecology (Ecology) Model Toxics Control Act for soils and groundwater (human health-based).

As recommended by these sources of guidance, risk-based concentrations were derived on the basis of a hypothetical lifetime cancer risk of 1×10^{-6} and Hazard Index of 1.0. Hypothetical risk-based concentrations were derived for compounds where chronic reference dose (RfD) or carcinogenic potency slope factor (SF) values have been verified by EPA, or which have been proposed as interim values. The general source for such values included the EPA Integrated Risk Information System and Health Effects Assessment Summary Tables (EPA 1992d). Where RfD values or slope factors are unavailable, risk-based concentrations were estimated based on dose-response information (both ecological and human receptors).

3.0 RECEPTOR SPECIES, BIOLOGICAL COMMUNITIES AND POTENTIAL EXPOSURE PATHWAYS

3.1 HABITAT CHARACTERIZATION AND RESOURCE INVENTORY

Characterization of the biological habitat occurring at the site and its environs in order to determine which species of potentially affected plants or animals could be present at the site. Following is a brief discussion on the approach used to evaluate the "resource inventory", including biological habitat and ecological receptors, as part of the ecological portion of the risk assessment.

Wetland areas. While terrestrial habitat at the site is limited, a wetland area is located south of the site and adjacent to the location of the March 1992 spill. Immediately west of the site is a wooded area which is periodically wet as well. These areas are inhabited by various species of plants and animals.

Deer Creek. A Deer Creek tributary, ultimately flowing into the Nooksack River, flows north from the site and receives surface water runoff from the site through a intermittent drainage ditch along Smith Road (lying east-west). Temporary dams have been installed along stream, designed to prevent migration of spilled product into the lower watershed. Aquatic areas created by these temporary dams potentially create habitats and therefore represent areas potentially affected by spilled product.

The wetland and creeks will be investigated to identify potential receptors for characterization in the risk assessment. The analysis of the site will also consider species expected to be at the site, based on favorable habitats, but which have not been identified during past site reconnaissance. A retrospective evaluation of species observed at the site will be performed to determine whether species currently absent have historically been present at the site.

3.2 IDENTIFICATION OF POTENTIAL EXPOSURE PATHWAYS

Exposure pathways are used to evaluate the nature of specific exposures to site-generated contaminants. Terrestrial, aquatic, and human exposure pathways considered for the site are discussed by medium below. Following primary release, soils are expected to serve as the potential secondary contaminant source (noted on Figure E-1). Contaminants harbored in soils could then be transported to groundwater, surface water, sediment and subsequently offsite.

3.2.1 Surface Water

Surface waters adjoining the Laurel Station, with particular reference to the areas where recent spill events have occurred, may represent pathways by which wildlife receptor populations could be exposed to site contaminants. Human populations, including site workers and adjoining residents, are not expected to be exposed via this route; key pathways of potential concern are expected to include aquatic organisms (fish and invertebrates) in addition to terrestrial wildlife drinking from, feeding, or otherwise contacting these surface waters. Accordingly, human exposures to surface water will not be evaluated as part of the risk assessment.

Potential exposures for the surface water pathway will be based upon chemical and toxicological data from the field sampling and monitoring programs. Combined field data documenting contaminant residue levels and potential effects to aquatic organisms (based on bioassay data) will yield an effective data base for determining the potential for adverse effects to aquatic organisms.

The water column-dwelling organism to be tested using bioassay is *Ceriodaphnia dubia*, a very sensitive invertebrate. If petroleum hydrocarbon residues are evident based on chemistry data this does not necessarily indicate that harmful effects are occurring within the aquatic system. This is an important point because of the well known characteristics of petroleum hydrocarbon residues; namely, that they are relatively insoluble in water and readily sorb and persist within stream bed sediments. In other words, the mere presence of petroleum hydrocarbon residues does not constitute a harmful effect. If results from bioassay testing indicate no evidence of effects on survival or reproduction of the test organism, this would represent evidence that no effects would be apparent within the water column.

Aquatic and terrestrial species could be potentially exposed to contaminated surface water through ingestion and by other forms of direct contact (i.e., dermal contact and respiration via gills). Although the contaminants of potential concern are not expected to bioaccumulate to a substantial extent within organisms inhabiting the surface waters, this medium could represent the focus of the evaluation if bioaccumulation were to represent an issue of concern.

The areas which could contribute to the surface transport of contaminants off-site via direct surface runoff could include the drainage ditch next to Smith Road (north of the site), and the channel within the wetland area (south of the site). These two conduits may have carried product from past releases into nearby sediments and surface water.

3.2.2 Sediments

Sediments may represent the most important potential exposure pathway for ecological receptors because many of the components of crude oil or condensate could persist within bed sediment. These materials generally do not readily dissolve in water, and as such could represent harmful exposures to organisms inhabiting the stream bottoms. Consequently, organisms potentially affected by such residues could in turn be ingested by predators, which could have implications for the entire food web. On the other hand, the petroleum hydrocarbon residues most toxic to aquatic life are also the least bioavailable in that they tightly sorb (attach) to bed sediments and may not be readily taken up by benthic organisms. This issue has been very well studied by numerous investigators and is a relatively well understood process.

Sediments may act as a reservoir for contaminants which could at some time be dissolved or resuspended in association with particulates and become potentially bioavailable to aquatic organisms through exposure through surface water (usually via the sediment interstitial water).

As with surface water, sediments, with regard to areas where recent spill events have occurred, may represent pathways by which wildlife receptor populations could be exposed to site contaminants. Human

populations, including site workers and adjoining residents, are not expected to be exposed via this route; key pathways of potential concern are expected to include aquatic organisms (fish and invertebrates) in addition to terrestrial wildlife drinking from, feeding, or otherwise contacting sediments. Human exposures to sediments will therefore not be evaluated as part of the risk assessment.

To evaluate potential exposures to contaminated sediments, site-specific chemistry and bioassay data will be collected to characterize sediment from both the Deer Creek tributary and the wetland area. As with surface water, the combined chemical and toxicological data bases will serve to provide two independent "lines of evidence" concerning whether adverse effects to benthic life could be occurring within the benthic environment. This data base, in conjunction with the surface water monitoring and calculated data as discussed above, will also be useful to evaluate the potential for harmful exposures carried through the food web. Sediments, when contaminated, may facilitate direct exposure to aquatic or other wildlife, especially when these organisms are in direct contact with or ingest sediments. The potential for bioaccumulation of sediment contaminants will also be considered as part of this pathway.

The sediment-dwelling organism to be tested using bioassay is *Hyallela azteca*, also a sensitive and well tested invertebrate (amphipod). If petroleum hydrocarbon residues are evident in sediment based on chemistry data, this does not necessarily indicate that harmful effects are occurring within the sediments. If results from the amphipod testing indicate no evidence of effects on survival or growth during the ten day testing period, this represents evidence that no effects may be in evidence associated with petroleum hydrocarbons in sediments.

3.2.3 Air/Wind

Wind is the primary vector for potential airborne contaminant transport of soil-associated contaminants as: (a) vapors, and (b) suspended particulates. For the purpose of this risk assessment, the air pathway for human and terrestrial receptors will be qualitatively characterized with respect to soil concentrations or simple air monitoring. Air transport of mist from the December 1991 spill could be evaluated as a transport pathway if measured soil concentrations of product at locations where spills occurred are significant.

3.2.4 Surface and Subsurface Soil

Potential receptors may be directly exposed to contaminants present in soils via direct contact (e.g., associated with burrowing or feeding) or incidental ingestion of surface soils. Contaminated soils may also serve as a conduit to other media of concern such as surface water or grounwater.

Potential exposures to soils will be addressed in the risk assessment for both ecological and human receptors. Potential exposures to wildlife will be addressed based on available exposure and chemical-specific toxicity information for the selected receptors and compounds of potential concern in soil.

It is also possible that exposures to contaminated subsurface soils could occur, especially if such soils were to be disturbed and exposed as surface soils during future years. The primary receptors of concern would be workers active on the site. The data base to be used for this analysis includes on-site and off-site surface and subsurface soil data according to the locations, frequency, and approach presented in Section 4.2 of the RI. Additional (surface and subsurface) soil samples are planned for sampling and analysis, representing the areas to be characterized in the risk assessment.

Pathways involved with soil contamination include direct infiltration and percolation to ground water from underground storage tanks. This is expected to involve subsurface soils as a secondary source via release to groundwater. In contrast, other on-site source areas involve containerized waste materials or other forms of storage for which surface water and/or surface soil may be expected to serve as the secondary source. Under such conditions, air (i.e., via dust generation) and surface water (i.e., via runoff) may provide

a means for off-site transport and subsequent potential exposures in off-site areas (e.g., to surface water, sediment, etc.).

3.2.5 Groundwater

The potential for direct exposure of workers or adjoining residents to contaminated ground water via ingestion, inhalation, or other routes will be addressed as part of the risk assessment. Although groundwater from the shallow unit may enter the creeks via seeps and springs, etc., this will be addressed as a surface water pathway based on surface water and sediment monitoring information. Potential exposures to groundwater will be based on monitoring data, although the extent of potential ground-water contamination in the area is not well known.

Exposure potential for ground water, partially determined by depth, is expected to be greatest where infiltration and percolation of contaminants to groundwater potentially occurs. For the purposes of risk assessment, drinking water is assumed to be taken from the deep aquifer, corresponding to the deep well samples. The shallow unit does not produce sufficient water flow and is therefore a less likely source of exposure.

3.2.6 Fish/Aquatic Life

The necessity for evaluating potential effects associated with ingestion of aquatic biota will be determined based on findings from the sediment and surface water data bases. In other words, if levels of contamination are found to be high and if bioassay results indicate evidence of potential effects associated with contaminants in surface water and sediment, this pathway could constitute some concern. However, this is not expected to be an important issue, because the petroleum hydrocarbons of potential concern generally do not bioaccumulate and would therefore not be expected to be transmitted elsewhere within the food web. Aquatic organisms ingested by mammals (including humans), larger fish, or raptors would therefore not be expected to be affected by such consumption.

If analytical and bioassay data indicate that food chain relationships could be a significant route of exposure to wildlife and/or humans, additional data could be necessary for quantitative evaluation of this exposure route. Such additional data could include monitoring of fish or other aquatic biota for site-specific contaminants.

3.3 IDENTIFICATION OF INDICATOR PLANT/ANIMAL RECEPTORS, INCLUDING THREATENED OR ENDANGERED SPECIES

In order to evaluate potential terrestrial effects, one or more "indicator" species will be selected to represent similar species at the site in evaluating potential wildlife hazards in the area. Indicator species will be selected according to the following criteria: a) species which are of particular concern (e.g., they are rare or of concern to the public); b) ecologically dominant species which are important for the organization and function of ecological communities at the site; c) species of economic importance (e.g., game species); and d) species known to be sensitive to contaminants at the site.

Threatened and endangered species inhabiting the site, as specified under the federal Endangered Species Act or by the state of Washington, will also be identified and addressed as part of the ecological risk assessment.

Toxicity of petroleum hydrocarbons to terrestrial or wetland plant species or communities (i.e., as receptors) has been studied to a far lesser extent than has toxicity to animals. The approach adopted for the risk assessment will include a brief literature survey to determine whether plant toxicity is likely to be as significant as animal toxicity based on available information. If animal toxicity data, which are more

available, indicate that they would adequately represent the potential for plant toxicity, no separate effort would be made to evaluate potential effects to plants or plant communities.

No indicator species are necessary to evaluate potential effects to aquatic life, because the toxicological evaluation will be performed on an extensive aquatic data base which considers the range or "spectrum" of sensitivity by diverse aquatic life to petroleum hydrocarbons and related compounds.

3.4 EVALUATION OF HUMAN RECEPTORS

Human receptors will be evaluated as necessary according to the above potential pathways. Residential and occupational receptors will represent populations potentially at risk according to the respective scenarios (e.g., drinking water exposures to residents, soil exposures to workers). Specific numerical exposure factors to be used in the exposure assessment are discussed below.

3.5 DELINEATION OF EXPOSURE FACTORS

Exposure factors used for the ecological and human health exposure assessments, will be based on guidance from EPA (1989a, 1989b, 1989c, 1990a, and 1992b), or the open literature, as appropriate. Ecological exposure factors are derived primarily from known biological characteristics as documented in the literature, and by recommendations from expert biologists (e.g., ingestion rate, foraging behavior, etc.).

Exposure factors include evaluations of environmental fate and transport of specific contaminants, as appropriate for the exposure assessment. For example, an important part of evaluating potential exposures to sediment-sorbed petroleum hydrocarbons is understanding something about the tendency to biodegrade, be transported, or to bioaccumulate. These factors will be considered and incorporated into the quantitative exposure assessment.

Site-specific exposure factors will be incorporated where available (e.g., available habitat, amount of site use, etc.). Table E-5 presents a list of potential exposure pathways, both on- and off-site, to be quantified and briefly describes the rationale and basis for including or excluding the pathway.

4.0 EXPOSURE ASSESSMENT

The exposure assessment evaluates the magnitude and duration of potential exposure to site-generated contaminants based on pathways determined on a site-specific basis. The exposure pathways for the ecological and human receptors considered for the site are those identified graphically in the risk assessment conceptual site model (Section 1; Figure E-1) and described previously in Section 3.

Receptor populations located off site, potentially within the wetland or creeks, will be identified as part of the exposure assessment, on a site-specific basis to the extent possible. This process involves identification of potentially sensitive subgroups such as sensitive wildlife, valued game species which could affect human receptors, rare or endangered animals, or other groups which may be unusually sensitive to potential site-generated contaminants.

The exposure assessment will be conducted for specific compounds by individual potential exposure pathways for the site. These evaluations will be refined based on data planned for analysis, or upon model-generated estimates as appropriate.

4.1 CURRENT AND POTENTIAL FUTURE LAND USE

The site is currently being used as an oil distribution and storage facility. There will not be oil storage at this facility past April 16, 1993. There are no plans to change the land use pattern at the site in the foreseeable future. The baseline approach to evaluating hazard potential for the site, based on indicator ecological species and a human receptors at the site prior to any actions, will be conservative for the risk assessment and is expected to be protective of any future land use patterns as well. Human receptors evaluated at the site will conservatively represent potentially exposed human populations. Accordingly, no hypothetical future land-use scenarios will be evaluated as part of the risk assessment.

4.2 EXPOSURE POINT CONCENTRATIONS

Exposures to terrestrial receptors will be based on soil, sediment, and surface water contaminant data, while exposures to sediment and surface water will be based on measured field data. As noted above, where data are inadequate there are modeling procedures which would be adequate to estimate potential aquatic exposures.

The human health component of the risk assessment will be based primarily upon data from soils and groundwater. Exposure point concentrations may be estimated based on fate and transport will be made if field data are inadequate to conduct the exposure assessment.

4.3 ENVIRONMENTAL FATE AND TRANSPORT

The compounds of potential concern found at the site in soil, groundwater, surface water, or sediment may degrade, persist, or be transported to other media. These factors will influence the concentrations on the site because of volatility, weathering, and other environmental fate processes.

Because the compounds of potential concern have been well characterized with respect to environmental fate and degradation properties, these properties will be used to predict potential exposure point concentrations at a specific location of discharge or exposure at a downgradient (downstream) location, if applicable.

5.0 TOXICOLOGICAL ASSESSMENT

Acute effects to plants or animals could have occurred immediately after the spill events, either from physical toxicity (e.g., smothering, loss of feather insulating capacity, etc.), short-term loss of habitat, or chemical toxicity. Because of the direct and immediate action taken to prevent short-term environmental losses on a large scale, however, the risk assessment is not designed to focus on such short-term losses. The emphasis of the risk assessment, then, will be to determine potential chemical toxicity on a long-term (chronic) basis to ecological or human receptors, following the exposure pathways shown on Table E-5 and Section 3.2.

Compounds of potential concern will be selected based on those subjected to the screening procedure discussed in Section 2. In addition to these compounds, the risk assessment will address the cumulative toxicity potential of the complex mixture as it occurs in the environment.

The toxicological approach, then, will consist of elements of both the mixture (where chemical characterization may be adequate but toxicological data are sparse) and individual components within the mixture (where toxicological data may be adequate). The toxicity of several individual compounds has been well characterized, but may be inadequate to address the entire complex mixture.

Table E-5
Description and Selection of Potential Exposure Pathways by Receptor
Trans Mountain Oil Pipeline Corp.
Laurel Station

Potential Receptor	Route, Medium, and Point of Exposure	Selected for Quantitative Evaluation?	Basis for Selection or Exclusion On-site/Off-site?
Terrestrial Receptors	Incidental ingestion of soils	Yes	Assumes ingestion of potentially contaminanted on-site soils.
	Direct contact with soils	Yes	Assumes direct contact with potentially contaminanted on-site soils.
	Ingestion of contaminated biota	No	Pending results of sediment and soil exposure assessment.
	Ingestion of surface water	Yes	Assumes that surface water is exposed to surface soil run-off, windborne contaminants or groundwater discharge.
	Direct contact with surface water	No	Pathway not well defined for terrestrial receptors and considered unlikely.
	Incidental ingestion of sediment	Yes	Assumes that wildlife could ingest contaminated sediments.
	Direct contact with sediment	Yes	Assumes direct contact with potentially contaminanted on-site soils.
	Ingestion of fish/shellfish	No	Pathway considered unlikely
	Inhalation of wind-borne particulates from exposed surface soils	No	Pathway considered highly unlikely.
	Inhalation of vapor-phase chemicals emitted from site	No	Pathway considered highly unlikely.
Aquatic Organisms	Exposure to surface water and sediment	Yes	Considers ingestion, direct contact, and respiration.
	Ingestion of contaminated biota	No	Pending results of direct expose to sediments and surface water.
Human Receptors (Occupational/Residential)	Incidental ingestion of soils by workers	Yes	Assumes that soils could be contaminated via contaminant releases or direct waste disposal to soils.
	Dermal contact with soils during work activites	Yes	Assumes that soils could be contaminated via contaminant releases or direct waste disposal to soils.
	Ingestion of fruits and vegetables grown on site	No	Not addressed because no gardens on site.
	Incidental ingestion of surface water or sediment	No	Pathway considered highly unlikely
	Direct contact with surface water or sediment	No	Pathway considered highly unlikely

Table E-5
Description and Selection of Potential Exposure Pathways by Receptor
Trans Mountain Oil Pipeline Corp.
Laurel Station

Potential Receptor	Route, Medium, and Point of Exposure	Selected for Quantitative Evaluation?	Basis for Selection or Exclusion On-site/Off-site?
Human Receptors (cont.)	Ingestion of fish or invertebrates from creeks	No	Pathway considered highly unlikely
	Inhalation of particulates or vapor-phase contaminants from exposed soils to workers.	Yes	Based on personal monitoring results only.

FOOTNOTES
(a) Contaminant-specific information such as absorption coefficients for different routes, bioconcentration factors, and other exposure-related properties will will be incorporated into the exposure assessment, but are not presented in this table.

To evaluate human exposures to petroleum hydrocarbons it is appropriate to use reference dose (RfD) values for non-carcinogens and slope factors for carcinogens, but these factors do not exist for many compounds within these mixtures. Nevertheless, EPA has recommended an approach, which will be adopted (see discussion under Human Health below).

Petroleum hydrocarbon mixtures, representing the major contaminants at the site, consist of various hydrocarbons which have not been well defined toxicologically. However, studies regarding appropriate approaches to evaluating complex chemical mixtures have been recently compiled by EPA (1992c). Data are based on rodent studies, which may therefore be applicable to both terrestrial wildlife and human receptors.

5.1 TERRESTRIAL WILDLIFE

The sensitivity of terrestrial wildlife to site contaminants will be evaluated through analysis of dose-response data available for indicator species selected as part of the exposure assessment. These data will be used to develop toxicological benchmarks for compounds of potential concern to the site, following chemical analyses. These benchmarks will be derived based on current toxicological literature and in order to represent appropriate indicator species.

5.2 AQUATIC LIFE

Principal media of concern to the aquatic environment include surface water and sediment. Table E-1 presented risk-based concentrations for aquatic ecological receptors; these values also represent the most appropriate toxicological guidance for assessing potential aquatic hazards associated with several compounds of potential concern, developed by the EPA Office of Water Regulations and Standards (EPA 1992e), also promulgated within Washington as WAC 173-201.

Where no formal ambient criteria have been derived due to insufficient data, available toxicity information is used to address sensitivity to the compound. These values have been derived based on the most sensitive aquatic organisms tested, are conservative, and are useful as guidance.

Limited aquatic toxicity data are available to address sensitivity to complex hydrocarbon mixtures. In addition to the data cited above which emphasize individual compounds, mixture-specific data will be used to define hazardous exposures in the aquatic environment.

No formal numerical criteria for freshwater sediments have been promulgated within the state of Washington or anywhere in the United States. Available draft guidelines for freshwater sediments in other regions are available and may be used to address potentially harmful exposures within sediments. Among the groups active in the field, the Ecology Freshwater Sediment Unit (Wash. Dept. of Ecology 1991b) has compiled available information on this important subject.

The risk-based concentrations previously presented (Tables E-2 and E-3), believed representative of potential site contaminants in sediments for the purposes of determining analytical detection limits, may also be useful for determining aquatic toxicological benchmarks to be used in the risk assessment. While no formal criteria have been derived for freshwater sediments, the values shown are expected to represent toxicologically viable levels within an approximate order of magnitude.

5.3 HUMAN HEALTH

As noted above, compounds of potential concern will be selected based on compounds detected from water, soil, and sediment at the site. Toxicity factors have been developed for some of these compounds, and will be useful for the purpose of evaluating hazards to human health.

The Integrated Risk Information System (IRIS; EPA 1992d) will be the preferred source of human health related quantitative risk assessment values for carcinogens and non-carcinogens, as this source represents the greatest level of scientific review and consensus within EPA. The most recent scientific information will be incorporated into the toxicological assessment. Recently developed RfD and slope factors for hydrocarbon mixtures will be used when applicable (EPA 1992c). For each compound, the primary target organ, principal supporting study, level of uncertainty, and test animals (or epidemiologic data) will be presented. For potential human carcinogens, the overall weight-of-evidence, developed based on the entire compound data base, will be presented as well.

The most appropriate approach for addressing potential effects to human health for complex chemical mixtures is based on EPA's Guidelines for Health Risk Assessment of Chemical Mixtures (EPA 1986). This guidance uses subchronic or chronic health effects data on the mixtures of concern and adopts procedure similar to those used for single compounds. It is important to note, however, that dose-response models used for single compounds are often based on biological mechanisms of the toxicity of single compounds, and may not be as well justified when applied to the mixture as a whole. Also to be taken into account is the variable partitioning and degradation rates of the components.

EPA (1986a) therefore recommends a stepwise approach for assessing these chemical mixtures, including: assessment of data quality on interactions, health effects, and exposure; conducting risk assessment on the mixture of concern based on health effects data on the mixture; assessing the similarity of the mixture on which health effects data are available to the mixture of concern, with emphasis on differences in components or proportions of components, as well as the effects that such differences would have on biological activity; conducting risk assessment on the mixture of concern based on health effects data on the similar mixture; assessing available data on interactions of two or more components and conduct a risk assessment on an additivity approach for all compounds in the mixture. This approach will be generally be adopted for the human health component of the risk assessment, and modified to address terrestrial wildlife sensitivity as well.

6.0 RISK CHARACTERIZATION

Ecological. As noted above, risks for both ecological and human receptors will be characterized as part of the Laurel Station risk assessment. The two ecological components of the risk assessment, terrestrial and aquatic, will be characterized in different ways. This section briefly summarizes the approach to be taken to characterize both types of risks.

Terrestrial wildlife receptors (e.g., birds, mammals, etc.) will be characterized in much the same way as human receptors (see discussion below. In summary, this consists of developing exposure point concentrations which define pathways, contaminants/mixtures of concern, exposure duration, and indicator species. These exposure point concentrations are then compared with toxicological benchmark values (Section 5.0 of the Work Plan) and a ecological Hazard Quotient derived for each exposure scenario. The emphasis will be upon assessing the potential for chronic toxicity associated with exposure to these mixtures. If the Hazard Quotient value falls below one (1) it will be assumed that no ecological hazards are in evidence, and if it exceeds five (5) it will be assumed that some ecological hazards could occur. If it falls between the two levels, other factors (e.g., careful evaluation of field observations, additional data, etc.) will be considered to assist in developing conclusions concerning potential effects to terrestrial receptors. All efforts will be made to develop exposure concentrations and toxicological values which are accurate and site-specific rather than generic and overconservative.

As noted for aquatic life present within wetland areas or the Deer Creek tributary, the combined data from the chemistry and aquatic bioassay analyses will provide some independent evidence concerning whether deleterious effects could be occurring within the water column and sediment. In addition, exposure

point concentrations will be developed for both the water column and sediment in order to derive aquatic ecological Hazard Quotient values. The key difference in the two approaches (water column and sediment) is that the database is different for aquatic effects than for sediment effects; this difference will be carefully reflected in developing Hazard Quotient values for the two media of concern. As with the terrestrial portion of the risk assessment, when the aquatic Hazard Quotient value falls below one (1) it will be assumed that no hazards are in evidence, and if it exceeds five (5) it will be assumed that some ecological hazards could occur. If it falls between the two levels, other factors (e.g., careful evaluation of bioassay data, field observations, etc.) will be used to develop conclusions. All efforts will be made to develop exposure concentrations and aquatic/sediment toxicological information which are accurate and site-specific rather than generic and overconservative.

Human health. As discussed above, the two types of human health risk to be evaluated consist of potential occupational and off-site residential exposures (see also pathway discussion). The focus of the risk assessment will be upon chronic hazards.

Exposure pathways will be based on those identified in the exposure assessment, described previously in the risk assessment conceptual site model (Section 1). As with the ecological component of the risk assessment, potential risk of non-carcinogenic contaminants of potential concern will be estimated using Hazard Quotient values, while that for potential carcinogens will be estimated using a standardized probabilistic approach (i.e., linear multistage model).

Potential risks to occupationally-exposed workers will be conducted in much the same way as the assessment for residential populations, using standardized exposure assumptions (e.g., from EPA 1989c or 1988a). Site-specific exposure factors, where applicable, contribute to more realistic and therefore desirable exposure assessment values, and will be used wherever possible.

Results of the risk characterization will consider the primary anticipated sources of potential exposure and risk with respect to:

- principal contaminants and/or contaminant mixtures of potential concern;
- human receptors potentially at risk;
- age groups of potential concern (for non-carcinogens); and
- principal locations and routes (pathways) of potential concern.

If the risk of non-carcinogenic effects is found to be significant, it may also be necessary to present results of the non-carcinogenic risk characterization based on "critical effects" to major target organs, which may lend greater understanding to potential hazards. This may ultimately be important to establishment of remedial actions, if it determines the source of greatest potential concern to human health for the site.

6.1 SOURCES OF UNCERTAINTY

Considerable uncertainty is inherent in any risk assessment because the multiplicity of information is drawn from many types of information, some of which is less quantifiable than others. The important point, however, is that the risk assessment will be designed to "err" on the side of conservatism and protectiveness. The section briefly discusses the approach adopted to identify and evaluate the principal sources and relative magnitudes of uncertainty in the risk assessment.

The two primary sources of uncertainty in the analysis will consist of the exposure assessment (e.g., exposure factors, delineation of pathways, indicator species, duration, biological characteristics, environmental

fate properties), and toxicological considerations (extrapolation errors, errors in reporting, etc.). Each of these key sources is expected to contribute to uncertainty within the risk assessment.

Exposure Assessment Uncertainty. Indicator organisms used in the risk assessment are designed to represent the most sensitive, vulnerable, or exposed species or individuals within that species, and are therefore expected to be adequately protective. It is therefore unlikely that any individual organism would be present at the site of application more frequently than specified or that behaviors contributing to exposure would lead to greater exposures than those estimated. This is true for the human exposure assessment as well. All are expected, however, to be adequately protective against adverse non-target effects.

Toxicological Uncertainty. Considerable uncertainty exists in the toxicological benchmark values derived to quantify potential risk to both humans and wildlife although in general toxicological information is less uncertain than exposure information because many of the compounds of concern are well studied. Uncertainty may arise from both from the studies themselves (e.g., concentrations/doses tested, accuracy of observations, etc.) and in the application of uncertainty factors to derive benchmark values. The latter source is expected to contribute substantially to overall uncertainty.

Uncertainty factors such as those applied to individual studies to derive benchmark values have been standardized and rigorously reviewed for protection of human health and aquatic life, a process which has not yet been standardized for protection of wildlife. In general, toxicological assumptions were intended to be conservative, not expected to underestimate potential acute or chronic toxicity.

6.2 UNCERTAINTY ANALYSIS

Uncertainty in the risk assessment process will be conducted on a quantitative or semi-quantitative basis. The intent of the analysis is to evaluate the relative significance of sources of uncertainty within the analysis, including the extent to which project data accurately represent the nature and extent of contamination; the exposure assessment, including identification of receptor populations, exposure pathways, exposure factors, etc.; and the toxicological component, including identification of toxicological benchmark values in both the human health and ecological evaluations.

Uncertainties in individual data sets (normally expressed as the range between mean and upper-bound values) can be broken down into individual parameters using a first-order variance model, Monte Carlo simulations, or others as appropriate. These techiques will be used to determine ranking of individual sources of uncertainties. This in turn often leads to refinement of conclusions.

7.0 RISK-BASED CLEANUP OBJECTIVES

The principal value of the risk assessment is that it can be instrumental in determining cleanup objectives. Findings from both the ecological and human health elements of the risk assessment will be used to develop such objectives, which will delineate:

- areas of potential concern;
- receptors of potential concern;
- contaminants/mixtures of potential concern;
- ultimate feasibility of removing temporary dams 2, 3 and March 7, 1992 spill dam.

These calculated objectives will be based on site-specific conditions and calculated for a range of risks based on the model (exposure and toxicity assumptions) used in the risk assessment.

8.0 REFERENCES

American Society of Testing and Materials (ASTM). 1990. Standard Guide for Conducting Sediment Toxicity Tests with Freshwater Invertebrates. Designation: E 1383-90.

Dames & Moore. 1992a. **Report with surface water data.....** August 1992.

Dames & Moore. 1992b. Remedial Investigation Report, Laurel Station, Bellingham, WA. Prepared for Trans Mountain Oil Pipe Line Corporation. Job No. 21199-032-005. 12 June 1992.

EPA. 1986a. Guidelines for the Health Risk Assessment of Chemical Mixtures. EPA Office of Environmental Criteria and Assessment. FRL-2984-2. FR 51(185): 34014-34025.

EPA. 1986b. "Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments. Prepared by Tetra Tech, Inc., Bellevue, WA. In: Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. U.S. Environmental Protection Agency, Region 10, Seattle WA. (Looseleaf).

EPA. 1988a. Guidance for conducting Remedial Investigations and Feasibility Studies under CERCLA. Office of Emergency and Remedial Response, Washington, D.C. OSWER Directive 9355.3-01.

EPA. 1989a. Risk Assessment Guidance for Superfund; Vol. I: Human Health Evaluation Manual. Office of Emergency and Remedial Response. EPA/540/1-89/001 correct no.

EPA. 1989b. Risk Assessment Guidance for Superfund; Vol. II: Environmental Evaluation Manual. Office of Emergency and Remedial Response. EPA/540/1-89/001.

EPA. 1989c. Exposure Factors Handbook. Office of Health and Environmental Assessment. EPA/600/8-89/043.

EPA. 1989d. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Environmental Monitoring Systems. EPA/600/4-89-001.

EPA. 1990a. Statement of Work for Conducting RI/FS Risk Assessment. Region 10, Seattle, WA. 31 January 1990.

EPA. 1990b. Revised National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule, 40 CFR 300, Fed. Teg. 8 March 1990; 55(46): 8666-8865.

EPA. 1990c. Region 10 Memorandum: "Detection Limits for Human Health Risk Assessment." From P. Cirone to Superfund Remedial Project Managers and On-Scene Coordinators, July.

EPA. 1991a. Region 10 Memorandum: "Supplemental Guidance for Superfund Risk Assessments in Region 10". From P. Cirone. Region 10, Seattle, WA. Aug. 23, 1991.

EPA. 1991b. Region 10 Memorandum: "Use of Standard Default Exposure Factors". From P. Cirone. Region 10, Seattle, WA. April 18, 1991.

EPA. 1991c. Health Effects Assessment Summary Tables. Annual FY 1991. OERR 9200.6-303 (91).

EPA. 1991d. Draft Xylene Advisory Acute Value and Concentration.

EPA. 1992a. Drinking Water Regulations and Health Advisories. Office of Water. April 1992.

EPA. 1992b. Dermal Exposure Assessment: Principles and Applications. Office of Health and Environmental Assessment. EPA 600/8-91/011B.

EPA. 1992c. Oral reference doses and oral slope factors for JP-4, JP-5, diesel fuel, and gasoline. Memorandum from J. Dollarhide. Environmental Criteria and Assessment Office. March 24, 1992.

EPA. 1992d. Integrated Risk Information System (IRIS). Online. Office of Health and Environmental Assessment. Cincinnati, OH.

EPA. 1992e. Quality Criteria for Water. Office of Science and Technology. Health and Ecological Criteria Division.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold: New York.

Northwestern Aquatic Sciences (NAS). 1990. Freshwater amphipod, Hyalella azteca, 10-day sediment toxicity test. Protocol No. NAS-XXX-HA4, Revision 2 (5/30/92).

Washington Department of Ecology. 1991a. The Model Toxics Control Act Control Regulation and Proposal Amendments, WAC 173-340.

Washington Department of Ecology. 1991b. Summary of Criteria and Guidelines for Contaminated Freshwater Sediments. Sediment Management Unit. Sept. 1991.