TEXACO HARBOR ISLAND TERMINAL

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Final Remedial Investigation Report
Volume 1

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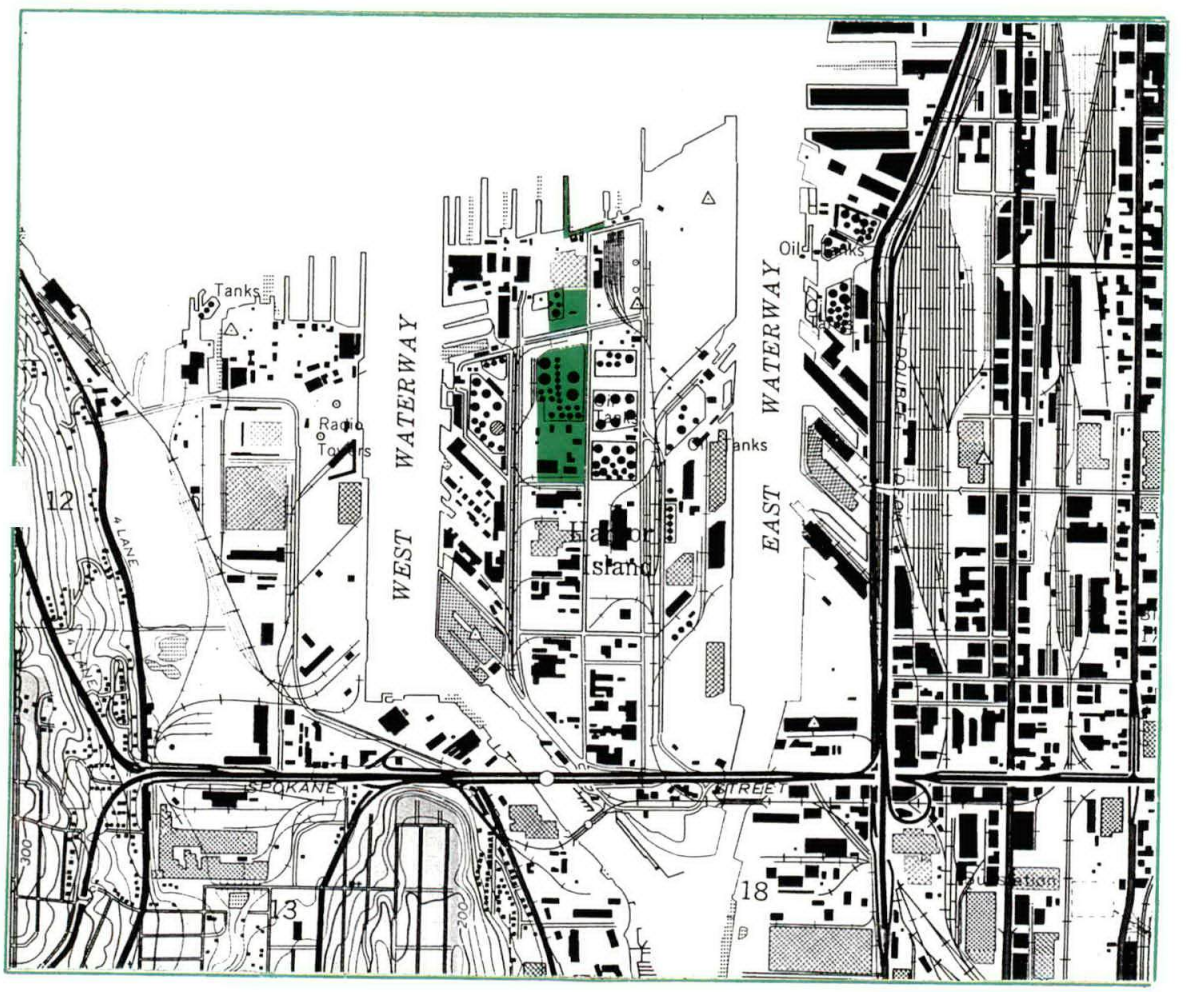

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Prepared by

EMCON

FINAL

REMEDIAL INVESTIGATION REPORT
TEXACO HARBOR ISLAND TERMINAL
Seattle, Washington

Volume 1

Submitted to

Washington State Department of Ecology

Submitted by

Texaco Refining and Marketing Inc.

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(revised)

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EXECUTIVE SUMMARY

Texaco Refining and Marketing Inc. (Texaco), is implementing an Agreed Order entered into with the Washington State Department of Ecology (Ecology) to conduct a Remedial Investigation/Feasibility Study at the Texaco Harbor Island Terminal (Terminal) in Seattle, Washington. The Harbor Island Superfund Site has been divided by the United States Environmental Protection Agency (USEPA) into four operable units. Operable Unit (O.U.) No. 1 includes the ARCO, Shell, and Texaco bulk fuel terminals. Ecology is the lead regulatory agency for O.U. No. 1. O.U. No. 2 consists of the marine sediments surrounding the island, and O.U. No. 3 consists of the Lockheed Shipyard. O.U. No. 4 includes the soil and groundwater on the remainder of the island. The USEPA is the lead regulatory agency for O.U.s No. 2, 3, and 4.

This report summarizes the remedial investigation (RI) work performed at the Terminal and presents the data obtained. The Terminal comprises 20.5 acres of land on the north central part of Harbor Island, located in Elliott Bay at the mouth of the Duwamish River. The Terminal includes three parcels: the main terminal and tank farm, the north tank farm, and the shoreline manifold area and dock. Following is a summary of the site investigations performed, the subsurface exploration results, the soil and groundwater laboratory results, the conceptual site model, and the potential for contaminant migration.

Site Investigations

During the Texaco RI, forty-four shallow soil borings, nine surface soil samples, and twenty-one monitoring well boreholes were drilled for soil identification and collection of soil samples for chemical and physical analyses. Seventeen shallow (approximately 15 feet deep) and four deep (approximately 50 feet deep) monitoring wells were installed within the boreholes. Aquifer characterization studies included two tidal response studies, hydraulic conductivity tests, monthly water level measurements, and groundwater sampling. The results of sixteen USEPA RI surface soil samples and seven USEPA RI monitoring wells were also included in the Texaco RI.

Up to three soil samples were collected from each of the soil borings and monitoring well boreholes for chemical analysis. Nearly all soil samples were analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and for total petroleum hydrocarbons as gasoline (TPH-G), as diesel (TPH-D), and as oil (TPH-O). In addition, most of the samples were analyzed for eight metals. Select soil samples were also analyzed for

carcinogenic polycyclic aromatic hydrocarbons (cPAHs), polychlorinated biphenyls (PCBs), and total organic carbon (TOC). Grain size, porosity, and vertical hydraulic conductivity tests were performed on several soil samples from the site. Nine surface soil samples were collected between the depths of 0 and 0.5 feet. The surface soil samples were analyzed for lead and arsenic.

Four quarterly rounds of groundwater samples were collected from nineteen new monitoring wells and nine existing monitoring wells. One round of groundwater samples was collected from two new monitoring wells. All groundwater samples were analyzed for BTEX, TPH-G, TPH-D, TPH-O, total dissolved metals, total suspended solids, and total dissolved solids. During the first groundwater sampling round, samples were also collected for analysis of cPAHs, TOC, ammonia, and nitrate/nitrite. Groundwater samples collected during the fourth sampling round were also analyzed for 1,2-dibromoethane (ethylene dibromide, EDB), 1,2-dichloroethane (ethylene dichloride, EDC), and methyl tertiary butyl ether (MTBE). Groundwater samples collected from two new monitoring wells were also analyzed for cPAHs, EDB, EDC, and MTBE.

Results of Subsurface Explorations

Soil underlying the site consists of man-emplaced grade fill and dredge fill overlying native estuarine deposits. The uppermost grade fill unit consists of coarse-grained fill varying from less than 1 to approximately 2 feet thick. The dredge fill unit originated from estuarine deposits near the site; therefore, delineation of the contact between the two units is difficult. The dredge fill appears to vary from approximately 8 to 20 feet thick at the site. It consists of fine- to medium-grained sand, with some gravel. Native estuarine deposits underlie the dredge fill at depths of approximately 9 to 20 feet. These deposits are composed primarily of fine- to medium-grained sand with thin silt interbeds.

Groundwater occurs as a thin lens of fresh water overlying brackish water at depth. The grade fill is permeable and was unsaturated during the investigation. The water table occurs within the dredge fill at depths of 4 to 8 feet below ground surface. Groundwater within the dredge fill unit occurs under unconfined conditions. The north tank farm and main terminal areas generally are unaffected by tides; at the shoreline manifold area, groundwater quality and elevations within this unit are affected by surface water tidal fluctuations. The native estuarine deposits are fully saturated and unconfined. Water quality and water elevations within this unit are influenced by surrounding surface water bodies and associated tidal fluctuations. Groundwater within the shallower monitoring zone at the site is estimated to flow both to the north and to the south from a potentiometric high located within the main tank farm area. Based on the average groundwater elevations obtained during the tidal response study, groundwater flow within the deeper monitoring zone is estimated to flow to the west. Data collected during the Texaco RI support the USEPA conceptual hydrologic model of the island.

Results of Soil and Groundwater Analyses

For preliminary screening purposes, the soil and groundwater data were compared to screening levels. The soil screening levels are based either on the USEPA risk assessment for O.U. No. 4 or the MTCA Method A cleanup levels for industrial soil. The groundwater screening levels are based on the protection of marine organisms or the protection of human health from the consumption of marine organisms.

Surface Soil

During the Texaco RI, nine surface soil samples were analyzed for arsenic and lead. Sixteen surface soil samples were analyzed for a full suite of metals during the USEPA RI. The surface soil screening level for arsenic was exceeded in 6 samples (24 percent), and the soil screening level for lead was exceeded in 13 samples (52 percent). One USEPA surface soil sample slightly exceeded the soil mercury screening level. However, the data were anomalous. The soil screening levels were not exceeded for other metals.

Subsurface Soil

During the Texaco RI, 102 samples were analyzed for arsenic, cadmium, chromium, copper, mercury, nickel, and zinc, and 111 samples were analyzed for lead. Five subsurface soil samples slightly exceeded the soil mercury screening level. However, the data were anomalous. No other subsurface soil samples exceeded metals screening levels.

One hundred fifty-seven soil samples were analyzed for BTEX, TPH-G, TPH-D, and TPH-O. Eight samples (5 percent) exceeded the soil screening level for benzene, three samples (2 percent) exceeded the soil screening level for ethylbenzene, and six samples (4 percent) exceeded the soil screening level for xylenes. The soil toluene screening level was not exceeded.

The soil screening level for TPH-G was exceeded by 23 samples (15 percent). The TPH-D screening level was exceeded by 30 samples (19 percent), and the TPH-O screening level was exceeded by 25 samples (16 percent).

Fifty-two soil samples were analyzed for cPAHs. The subsurface soil cPAH screening level was not exceeded. PCBs were not detected above the screening level in any of the seven Texaco RI soil samples analyzed. VOCs, SVOCs, PCBs, and pesticides were not detected above the surface or subsurface soil screening levels in any of the five USEPA RI samples analyzed.

Groundwater

One-hundred eleven groundwater samples were analyzed. The groundwater screening levels for cadmium and dissolved mercury were not exceeded. The groundwater screening level for arsenic was exceeded by total and dissolved arsenic concentrations in three samples (3 percent). The groundwater screening level for copper was exceeded by total or dissolved copper concentrations in 30 samples (27 percent). The groundwater screening level for lead was exceeded by total or dissolved lead concentrations in 15 samples (14 percent). The groundwater screening level for mercury was exceeded by a total mercury concentration in one sample (1 percent); however, particulate matter in the sample may have affected the results. The groundwater screening level for nickel was exceeded by total or dissolved nickel concentrations in four samples (4 percent). The groundwater screening level for zinc was exceeded by total or dissolved zinc concentrations in two samples (2 percent). The groundwater screening level for benzene was exceeded by 19 samples (17 percent) from eight wells, the groundwater screening level for ethylbenzene was exceeded by 4 samples (4 percent), and the groundwater screening level for toluene was exceeded by 2 samples (2 percent). The groundwater screening levels for four cPAHs were exceeded by results from one sample (1 percent); however, particulate matter in the sample may have affected the results.

Floating product was found periodically in two on-site wells and in two off-site wells during the RI. Product was only found during November 1993, December 1993, June 1994, and September 1994. Apparent product thicknesses ranged from trace (less than 0.01 feet) to 0.5 feet. Product was removed from one on-site well.

Conceptual Site Model and Contaminant Migration

Primary potential contaminant sources at the Terminal include 1) the main tank farm/western railcar unloading area, 2) the lubricants tank farms and oil/water separator, 3) the employee building/pumphouse area, 4) the loading racks, 5) former and existing underground storage tanks, 6) the north tank farm/dock area, 7) adjacent facilities, and 8) the former off-site lead smelter. A constituent was classified as a potential indicator hazardous substance (potential IHS) if results exceeded the screening levels. A constituent was classified as a preliminary IHS if it was also associated with former or existing Texaco Terminal operations. IHSs will be refined during the feasibility study. Arsenic and copper were retained as potential IHSs. Benzene, toluene, ethylbenzene, xylenes, TPH-G, TPH-D, TPH-O, cPAHs, and lead were retained as preliminary IHSs for the site. Benzene was detected above the soil or groundwater screening levels in the six primary potential source areas on site. Toluene was detected above the soil or groundwater screening levels in one primary potential source area on site. Ethylbenzene and xylenes were detected above the soil or groundwater screening levels in three and four primary potential source areas on site, respectively. TPH-G, TPH-D, and TPH-O were

detected above the soil screening levels in five, six, and six primary potential source areas on site, respectively. cPAHs were detected above the groundwater screening levels in one primary potential source area on site. Lead was detected above the soil or groundwater screening levels in five of the six primary potential source areas on site. Benzene and the more volatile petroleum hydrocarbons tend to be the more mobile indicator hazardous substances. Migration pathways for the indicator hazardous substances include air (for lead only), soil, groundwater, and surface water.

The USEPA groundwater flow and transport model results were used in the Texaco RI because the site-specific data collected during the Texaco RI are similar to the island-wide data collected by the USEPA. Three wells monitored during the Texaco RI were used as source wells for pathlines that were included in the transport model. Using both the USEPA and Texaco RI groundwater quality data and the modelling scenario preferred by the USEPA, the USEPA model estimated that no groundwater cleanup goal would be exceeded within a time period of 50 years at the ends of the pathlines originating at the three wells monitored during the Texaco RI.

Benzene was observed in subsurface soil and groundwater. However, benzene does not pose adverse environmental impacts to surface water at the perimeter of the island since groundwater beneath the central portion of the island, including the southern part of the Terminal, discharges to sinks in the central part of the island. Additionally, the USEPA groundwater model predicted that concentrations of benzene in groundwater from beneath the northern part of the Terminal will not exceed the groundwater cleanup goal at the perimeter of the island within a time period of 50 years. Soil TPH contamination was found at depth in localized areas of the Terminal. Petroleum hydrocarbon product has migrated to groundwater via soil in the southern part of the site. However, migration to surface water is limited by the direction of groundwater flow beneath the southern part of the site. Product was only found periodically in four wells during the RI. Lead contamination is limited primarily to the surface soil, except for a localized area in the southeastern part of the Terminal. Based on the location and depth of soil samples containing elevated lead concentrations and historic air sampling, the lead in shallow soil appears to be due to airborne discharges from the former smelter located immediately south of the Terminal.

Supplemental Remedial Investigation

Additional field investigations were performed during the supplemental RI to delineate hot spots, fill in data gaps, and provide additional groundwater level and product measuring points. Twenty-seven soil borings were drilled to investigate three areas in the main terminal and the shoreline manifold area. Seven piezometers were installed north of the warehouse, one monitoring well was installed at the shoreline manifold area, two rounds of groundwater levels were measured, and groundwater samples were collected at the

shoreline manifold area. The results of these investigations are included in Appendix J. Based on the supplemental RI investigations, mercury was not retained as a potential IHS in soil or groundwater; the vertical and horizontal extents of soil with TPH above 10,000 mg/kg were better delineated on the east side of the warehouse, on the north side of the main tank farm, and at the shoreline manifold area; and the contaminant transport evaluation showed that benzene concentrations at the shoreline end of the modeled pathlines do not exceed the surface water quality standard due to transport from the Texaco Terminal.

1 INTRODUCTION

1.1 Purpose of Report

Texaco Refining and Marketing Inc. (Texaco), has entered into an Agreed Order with the Washington State Department of Ecology (Ecology) to conduct a Remedial Investigation/Feasibility Study at the Texaco Harbor Island Terminal (Terminal) in Seattle, Washington (Figure 1-1). The Agreed Order Number DE 92 TC-N160 (Order), pursuant to the authority of the Revised Code of Washington (RCW) 70.105D.050(1), identified the tasks to be completed for this project. An outline and a schedule of the tasks to be performed to complete the Remedial Investigation/Feasibility Study (RI/FS) Program at the Terminal were presented in the March 16, 1992, Scope of Work (Texaco, 1992). The first deliverable listed in the Scope of Work, the *Background Summary Report* for the Terminal (EMCON, 1992), was approved by Ecology on September 24, 1992. The second deliverable, the *Remedial Investigation Work Plan* for the Terminal (EMCON, 1993), was approved by Ecology on January 29, 1993. The third deliverable, the *Interim Remedial Investigation Report* (EMCON, 1993b), was submitted to Ecology on July 28, 1993.

This report summarizes the RI work performed and presents the results of the data obtained. Results presented herein include soil laboratory data, aquifer characterization test results, 12 rounds of water level measurements, and 4 rounds of groundwater quality data.

1.2 Project Objectives

The RI was performed to provide information on soil and groundwater quality, as well as soil and aquifer characteristics which may affect fate and transport of constituents of concern. The objectives of the soil investigation were as follows:

- Explore the nature and extent of potential surface and subsurface soil contamination from historic activities at the terminal and surrounding facilities.
- Identify the extent of soil contaminated by lead (from non-Texaco, off-site operations) for potential remediation.

- Characterize the physical parameters (e.g., soil types, grain size, porosity, total organic carbon, and permeability) of potentially contaminated soil.

Groundwater investigations were performed to supplement hydrogeologic and water quality data collected during previous investigations and to meet RI requirements. The objectives of the groundwater investigation included the following:

- Explore the nature and extent of potential groundwater contamination at the Terminal resulting from historic activities at the Terminal and surrounding facilities.

- Further characterize the site hydrogeology (occurrence of groundwater, flow direction, velocity, and hydraulic conductivity).

- Determine the potential for on- and off-site migration.

1.3 Report Organization

This report is organized into nine sections. Following are brief descriptions of each section.

- **Section 2 – Site Background.** A description of the Texaco facility and historical and current operations at the facility are provided. Chemical management, waste management spill response planning, regulatory status, facility permits and registrations are described. A summary of the environmental history of the facility is presented, including known spills and associated cleanups and investigations.

- **Section 3 – Environmental Setting.** General descriptions of the regional climate, surface water hydrology, geology, hydrogeology, and land use are provided.

- **Section 4 – Study Area Investigation.** Descriptions of the field investigations undertaken as a part of this RI are provided. Sampling locations, techniques, and laboratory methods are described for soil, groundwater, and aquifer characterization investigations.

- **Section 5 – Subsurface Exploration Results.** Data obtained during drilling, hydraulic conductivity testing, tidal response study testing, and soil physical testing are evaluated and used to define the site-specific geology and hydrogeology. The conceptual hydrologic model of the island is discussed.

- **Section 6 – Nature and Extent of Soil Contamination.** The results of chemical analyses of soil samples are presented and compared to soil screening levels.

- **Section 7 – Nature and Extent of Groundwater Contamination.** The results of chemical analyses of groundwater samples are presented. The concentrations of constituents detected and the frequency of detection are summarized. The data are compared to the groundwater screening levels. Groundwater quality trends are discussed.

- **Section 8 – Conceptual Site Model and Contaminant Migration.** The soil and groundwater data are used to present a conceptual model of the site. Potential source areas, indicator hazardous substances, fate and transport properties, migration pathways, and groundwater flow and transport are discussed. Based on these factors, the potential for contaminant migration from the site is discussed.

- **Section 9 - Figures.** All figures referenced in the RI report are presented in Section 9. Figures are numbered according to the section in which they are discussed.

Data collected during the investigation are presented in Appendices A through H, as follows, and include the following: **Appendix A**—sampling alteration checklists; **Appendix B**—lithologic logs and well development data; **Appendix C**—summaries of sample analyses for soil, groundwater, and physical soil; **Appendix D**—soil analyses data; **Appendix E**—groundwater analyses data; **Appendix F**—groundwater levels and tidal response study graphs; **Appendix G**—hydraulic conductivity test results; **Appendix H**— data validation reports; and **Appendix I**—underground storage tank replacement report.

2 SITE BACKGROUND

A detailed description of the site, its history, operations, environmental concerns, and previous investigations, was presented in the report entitled *Final Background Summary Report, Texaco Refining and Marketing Inc, Harbor Island Terminal* (EMCON, 1992). This section summarizes site background information provided in that report and operational and facility changes that have occurred since 1992.

2.1 Site Description

The Texaco Harbor Island Terminal comprises 20.5 acres of land on the north central part of the island (Figure 2-1). The facility is divided into three parcels: the main terminal and tank farm (2555 13th Avenue SW), the north tank farm (1835 13th Avenue SW), and the shoreline manifold area and dock (1711 13th Avenue SW). Terminal operations are split among Texaco Lubricants Company (TLC) and Texaco Refining and Marketing Inc (TRMI), serving the lubricants and light oil (fuel) side of the business, respectively.

The main terminal and tank farm are located on 17.5 acres lying west of 13th Avenue SW, south of SW Florida Street, east of 16th Avenue SW, and north of SW Lander Street. The main facility consists of 2 office buildings, a warehouse, a bottle filling building, a blending building, a light oil truck loading rack, a lube oil truck loading rack, pipeline receipt facilities, rail receipt facilities, 1 regulated underground storage tank, 6 unregulated underground tanks (process tanks and heating oil tanks), 83 aboveground product storage tanks, piping, pumps, a boiler, and a garage. The main terminal receives primarily light oils (fuels) via the Olympic Pipe Line from Anacortes and lube oils by truck and rail. Lube operations include storage and distribution.

The north tank farm comprises 2.5 acres immediately northwest of the intersection of 13th Avenue SW and SW Florida Street. The tank farm contains two aboveground storage tanks, both about 1,500,000 gallons in size, which currently store diesel fuel. The tanks receive product by pipelines from the Olympic Pipe Line, the main tank farm, and the dock. Product from these two tanks is also transferred to both the main terminal and the dock.

The shoreline manifold area and dock lie on 0.5 acres of land on the north side of the intersection of 13th Avenue SW and SW Massachusetts Street. Elliott Bay is adjacent

to the north edge of the shoreline manifold area. The area contains manifolds controlling the flow of product between the tank farms and the dock. The dock lies 250 feet to the west of the shoreline manifold area and extends 590 feet into Elliott Bay.

2.2 Historical and Current Operations

The main tank farm and shoreline manifold parcels were purchased by the Texas Company (now known as Texaco) on February 14, 1942. The north tank farm was purchased from Mobil Oil on December 23, 1968. Product is received via the Olympic Pipe Line, barge or ship, railcar, and truck. Product is stored and distributed off site via truck, drums, bins, and packages, and, formerly, by rail. Historical and current operational areas at the Texaco Harbor Island Terminal include the dock, aboveground tank farms, railcar unloading area, piping systems, drum storage areas, blending building, filling building, warehouse, barrel refurbishing and paint pit area, laboratory, maintenance operations, loading rack, boiler, oil/water separator, and underground storage tanks. Current operational area locations are shown on Figures 2-2 and 2-3.

2.2.1 Main Terminal

The main terminal and tank farm were built in 1947. The main terminal consists of three smaller tank farms in addition to the main tank farm: the southeast tank farm, the southwest tank farm, and the west tank farm. Other operational areas within the main terminal consist of piping systems, railcar unloading areas, the blending building, the filling building, the warehouse, drum storage areas, barrel refurbishing, the laboratory, maintenance operations, loading racks, refueling stations, a boiler, an oil/water separator, and underground storage tanks.

Railcar Unloading Areas. Two railcar unloading areas exist at the Texaco Harbor Island Terminal, one on the west side of the main tank farm and one between the warehouse and the southwest tank farm. The western railcar unloading area was constructed in 1947 and consists of two railroad tracks with a loading/unloading rack between the tracks. Catch basins beneath this area drain to the oil/water separator. The tracks are underlain by gravel. Products received at the west railcar unloading area consist of base lubricating oils and fuel additives. Light oils were loaded at this location through the mid-1970s. An ethanol containment and recovery system was installed at the western railcar unloading area in 1993.

The south railcar unloading area near the warehouse was constructed in 1947 and paved in approximately 1980. Permanent drip pans were installed at one bulk unloading spot, between rails and at hose connections, and were connected to an oil/water separator in 1984. Two storm drains are used for spill containment at two of the four loading

locations. Products received at the south railcar unloading area consist of base lubricating oils and lubricant additives. Motor oil was loaded at this location through the mid-1970s.

Blending and Filling Buildings. The lubricating oil blending building, located south of the warehouse between the southeast and southwest tank farms, was constructed in 1947 and contains several large kettles that until recently were used to blend lubricating oils. Any spillage within the blending building is collected and reprocessed or drained to the oil/water separator. The filling building is in the southeast portion of the main terminal; any spillage within the filling building is drained to an aboveground tank on the west side of the building. A 1,000-gallon underground storage tank formerly was used to contain spillage from the filling building. Before 1969, Texaco refurbished 55-gallon drums in the current bottle filling building.

Warehouse. The warehouse, located in the southwest part of the main terminal, was originally constructed with the main terminal in 1947. In 1991, the 20,000-square-foot warehouse was expanded to 46,000 square feet. The warehouse contains storage space, an office, a bottle conveyor leading to the filling building, a temperature-controlled room ("hot room") used to heat 55-gallon drums of viscous oils, a drum and pail filling machine, and a pelletizing machine. All package filling was discontinued by August 1, 1993.

Laboratory. The laboratory originally occupied space in the office building on the west side of the main terminal. The laboratory was moved in the early 1960s and currently is located in the office building in the southeast portion of the main terminal. Only limited testing was performed in the laboratory until the early 1970s when the facilities were upgraded. The laboratory currently is used for quality control of products Texaco stores and distributes at the terminal. Before installation of a laboratory waste tank in 1974, all laboratory waste drained to the storm drain system and the oil/water separator. In 1991, the laboratory waste tank was removed, and different wastes were handled separately. Currently, eight sinks located in the laboratory are used for disposal of fuel oils, lubricating oils, non-chlorinated and chlorinated solvents, and waste water. Each sink is dedicated to a specific waste type.

Maintenance Operations. Product delivery trucks are maintained in the garage and truck wash located north of the light oil truck loading rack. The garage was built with the main terminal in 1947 and included three service bays and two office spaces. Sumps in the center of each service bay drained to the oil/water separator. The building currently contains a covered drive-through truck wash in the north end of the building, one covered service bay in the center of the building, and office space in the south end. The truck wash bay drains to the Metro sewer. Waste oil is stored in two aboveground tanks on the west side of the garage. The former sumps have been plugged.

Truck-loading Racks. The main terminal currently contains two truck-loading racks, one for light fuel oils and one for lubricating oils. The light oil loading rack is located south of the garage and was constructed in 1981. The original loading rack, constructed in 1947, was located immediately east of the current rack. Both racks were constructed with a canopy, a concrete pad, dedicated product-loading arms, and underground pipelines delivering fuel to the rack. Spill containment at the former light oil loading rack consisted of curbed concrete pavement and drains that led directly to the oil/water separator. The current light oil loading rack is equipped with a vapor recovery system, a concrete pad, concrete curbs, and a series of strip drains that lead to a 10,000-gallon underground tank. The current lubricating oil truck-loading rack was built in 1987 and is located immediately north of the northeast corner of the filling building.

Oil/Water Separators. Three oil/water separators are located at the main terminal. The main oil/water separator is in the southeast corner of the main terminal, and a smaller oil/water separator, constructed in 1991, is located north of the warehouse addition, and drains to the city storm drain line. A third oil/water separator, consisting of a baffled underground storage tank is located south of the light oil truck-loading rack. The main oil/water separator was constructed in 1947. Historically, all storm water drains at the main terminal, except for one catch basin near the STAT office, have drained to this oil/water separator. Wastewater from the laboratory, wash water from truck washing, drainage from four septic tanks on site, spillage in the garage, and wash water and spills from the light oil truck-loading rack also historically drained to the main oil/water separator. Currently, most surface drainage at the main terminal drains to the main oil/water separator. The truck wash bay currently drains to the Metro sewer.

Underground Storage Tanks. Seven underground storage tanks, numbered U4, and U11 through U16, currently exist at the facility. Tank U4 (estimated 100-gallon capacity), located on the north side of the boiler building, was installed about 1947 and is used as a pilot burner tank for the boiler. Tank U11 is a 10,000-gallon tank installed in the early 1980s. It is a commingle tank and has stored mixed gasoline, diesel, and kerosene products. This tank was recently replaced (see Appendix I). Tank U12 is a 10,000-gallon containment/process (oil/water separator) tank that receives spillage from the light oil truck load rack. Tank U13 is a 1,000-gallon vapor recovery tank located at the vapor recovery unit. This tank was recently closed and replaced (see Appendix I). Tanks U14, U15, and U16 are 1,000-gallon fiberglass heating oil tanks installed in 1984 to replace two existing 500- to 550-gallon steel tanks (U-2 and U3). Nine underground tanks (U1 to U3 and U5 through U10) at the terminal are no longer in use and have been removed from the site. Seven aboveground tanks (A1 through A7) at the terminal are used for storage of slop oil or waste oil before reuse or disposal.

Other Areas. Before 1991, drums were stored in the main terminal in several areas: along the western fence line south of the employees' building, west of the warehouse, west of the current laboratory, and on a gravel pad in the central area of the main terminal. A company refueling station is located in the main terminal yard south of the east manifold pit. Product is delivered to the refueling station from aboveground tanks in the main tank farm. The current refueling station was built in 1981. An earlier company vehicle refueling station was located immediately east of the employee building.

2.2.2 Main Terminal Tank Farms

Main Tank Farm. The original main tank farm consisted of 30 product storage tanks, containing both lube oils and fuels. The main tank farm currently has 39 product storage tanks ranging in size from 11,400 gallons to 4,700,000 gallons, and one flush-oil tank with a capacity of 11,000 gallons. Twenty-three tanks currently are dedicated to storing a wide variety of lube oils. Sixteen tanks currently store fuel and fuel additives, including bunker fuel, diesel, aviation gas, aviation jet fuel, and leaded and unleaded gasolines. The main tank farm, which covers approximately 8 acres, is unpaved with a gravel surface through which a significant portion of the precipitation infiltrates. All but three of the tanks in the tank farm are enclosed by an 11-foot-high concrete firewall. Storm water runoff is collected in a series of catch basins which drain to the oil/water separator. Water drains from the tanks are connected to the oil/water separator.

All product pipelines and valves in the main tank farm are steel, are aboveground, and are dedicated to specific products. Product pipes from the dock enter the tank farm in the northeast corner of the firewall and run parallel to the north wall before bending south down the corridors between the tanks. Product pipelines from the Olympic Pipe Line enter the tank farm midway along the east side of the firewall, network through a manifold, and run to specific storage tanks. Product pipelines exit the tank farm under the firewall on the south side of the tank farm.

Southeast Tank Farm. The 6,500-square-foot southeast tank farm is located east of the blending building and south of the filling building. The tank farm was constructed in 1959, with the installation of two tanks for blending lube oils and storing aircraft engine oil. Additional tanks were added over the years. Twelve storage tanks currently are present in the tank farm. The tanks range in size from 10,000 gallons to 55,700 gallons and contain a variety of lube products. All the tanks are enclosed by a 2.5-foot-high concrete containment wall. The tank farm was paved with concrete in 1991, with four catch basins to collect storm water runoff. The catch basins drain to the oil/water separator. All product pipelines and valves are steel, are aboveground or overhead, and are dedicated to specific tanks. Product pipelines enter the tank farm on the west side and exit back to the blending building, go underground from the blending building to the filling building, and then to the rack.

Southwest Tank Farm. The 3,400-square-foot southwest tank farm, located immediately west of the blending building, was constructed along with the main terminal in 1947. The tank farm included eight tanks. Additional tanks were added over time. The tanks have been used to store or blend lube oils. The southwest tank farm currently contains 13 storage tanks ranging in size from 5,200 gallons to 10,700 gallons which are used to store additives and a variety of lube products. All of the tanks are enclosed by a 3-foot-high concrete containment wall. Before 1991, the tank farm was covered with gravel. In 1991, the tank farm was paved with concrete. One catch basin is used to collect storm water and to route it to the oil/water separator. All product pipelines and valves are steel, are aboveground or overhead, and are dedicated to specific tanks. Product pipelines enter the tank farm on the east side and exit back to the blending building, go underground from the blending building to the filling building, and then to the rack.

West Tank Farm. The 5,000-square-foot west tank farm is located west of the warehouse, adjacent to 16th Avenue SW. The west tank farm was constructed in 1969 with the installation of two lube oil storage tanks. Additional tanks were added over time. The tank farm currently includes 19 storage tanks, 16 of which have a capacity of 20,100 gallons and 3 of which hold 28,000 gallons. The tanks are used to store finished product. All of the tanks are enclosed by a 1.5-foot-high concrete containment wall. The ground surface in the tank farm was gravel until 1991, when it was paved. Two catch basins collect storm water runoff and drain to the oil/water separator. All product pipelines and valves are steel, are aboveground or overhead, and are dedicated to specific tanks. Product pipelines enter and exit the tank farm on the south side.

2.2.3 North Tank Farm/Dock Area

The north tank farm was constructed by Mobil Oil in 1936. The tank farm initially consisted of 14 product storage tanks and 1 blending tank, and was part of a larger storage and distribution terminal located to the north. The north tank farm originally stored both lube oils and fuels in two separate containment areas. Product pipelines entered and exited the 1-acre west containment area through the northeast corner of the firewall. Tanks in the 0.4-acre east containment area were serviced by pipelines through the north and east firewalls.

Texaco purchased the north tank farm from Mobil in 1968. Ten of the original lube oil tanks were moved to the main and southeast tank farms. Three other tanks were later removed from the site. The north tank farm currently contains two fuel storage tanks, both approximately 1,500,000 gallons in size. Both tanks currently store diesel fuel. The north tank farm is enclosed by a concrete firewall up to 14 feet in height. The tank farm is unpaved and has a sandy surface through which all precipitation infiltrates. No catch basins are located in the north tank farm. Water is drained from the bottom of each tank into portable containers which are transported to the oil/water separator. All product pipes and valves are steel and are aboveground. Product pipelines from the dock

and the Olympic Pipe Line enter the tank farm through the east firewall. The pipes run through a manifold adjacent to the east firewall prior to entering the tank farm. Product pipelines exit the tank farm under the firewall on the south side.

The shoreline manifold area and dock were constructed with the main terminal in 1947. Texaco is responsible for maintenance of the dock, with Mobil splitting the cost of maintenance. Mobil and Texaco are each responsible for maintaining their own piping, pumps, valves, and other operational equipment on the dock. The dock is constructed of treated wood timbers set on treated wood pilings. The surface of the dock is finished with concrete. One approximately 100-gallon steel tank is located several feet below the dock to provide storm water and spill collection during unloading. The product from this collection tank is pumped to a nearby aboveground tank.

Texaco's dock loading/unloading facilities consist of a system of pipes and valves, each dedicated to a specific product. Thirteen 6-inch-diameter to 12-inch-diameter steel pipes run along the east side of the dock from the loading/unloading area (located about 450 feet from shore) to the shoreline. Eleven of the pipes used to transfer diesel, AvGas, cutter diesel #2, jet fuel, unleaded premium, leaded regular, and unleaded run primarily above the dock, and two bunker oil pipes run under the dock. The pipes bend east at the shoreline and proceed underground 250 feet to the shoreline manifold area. The pipes run south from the shoreline manifold area along the east side of 13th Avenue SW to SW Florida Street, where they bend southwest into the northeast corner of the main tank farm.

2.3 Chemical Management

Texaco handles and manages petroleum products and chemicals at the Terminal. The general categories of chemicals that the Texaco Harbor Island Terminal manages include petroleum products, additives, and laboratory chemicals.

2.3.1 Petroleum Products

The Texaco Harbor Island Terminal handles two main types of petroleum products: light oils and lubricating oils. Light oils include three grades of motor gasoline, aviation gasoline, jet fuel, and middle distillates (e.g., diesel #2). The Texaco Harbor Island Terminal also stores residual fuel oils (e.g., #6 bunker fuel). The facility has provided Texaco Harbor Island terminaling services (i.e., management of other companies' products), Texaco product storage, and product distribution for light oil products since the Texaco Harbor Island Terminal opened in 1948.

Bulk lubricating oils are received as several grades of base stock (e.g., solvent neutral oils and pale oils). These base oils consist of naphthenic and/or paraffinic, light to heavy, petroleum distillates. The facility has performed blending, distributing, and

packaging of lubricating products since 1948. Blending of lubricating products ceased in March 1994. Hard greases are received prepackaged and distributed by the Texaco Harbor Island Terminal.

Base oils are received by truck and rail, blended and packed on-site into products, and distributed via truck. Light oils are received via the Olympic Pipe Line, marine tanker or barge, stored on site, and shipped via truck or marine vessel, tanker, or barge. Historically, they were also shipped via rail. Historically, lubricating base oils have also been shipped via rail. The material safety data sheets (MSDSs) for these materials are enclosed in the Background Summary Report (EMCON, 1992).

2.3.2 Additives

The Texaco Harbor Island Terminal uses numerous additives in the blending of both light oil and lubricating oil products. These additives are generally detergents, anti-rust compounds, lubricants, viscosity index improvers, anti-foaming agents, and gasoline additives. Chemicals in gasoline additives used at the facility include lead and methyl t-butyl ether (MTBE).

2.3.3 Laboratory Chemicals

The Texaco Harbor Island Terminal operates a small laboratory on site that is used primarily for product quality assurance and quality control purposes. During routine analytical testing procedures, this laboratory uses a wide variety of chemicals in small quantities. The chemicals that were used by or stored in the laboratory as of 1990 included 1,1,1-trichloroethane, acetic acid, acetone, aluminum potassium sulfate, ammonium hydroxide, chlorobenzene, chloroform, cyclosol-53, hexane, hydrochloric acid, isopropyl alcohol, methanol, methyl isobutyl ketone, petroleum ether, potassium hydroxide, silver nitrate, Stoddard solvent, sulfuric acid, toluene, tritylmono methyl ammonium chloride, and xylene.

2.4 Waste Management

The types of wastes generated at the Texaco Harbor Island Terminal include wastewater, oil/water separator wastes, tank bottoms, laboratory wastes (non-wastewater), paint wastes/sandblasting grit, spill residuals, off-specification or waste oils, and general solid waste.

The Texaco Harbor Island Terminal is classified as a Hazardous Waste Generator. The Texaco Harbor Island Terminal does not treat or dispose of hazardous waste on site; the on-site storage of hazardous waste is conducted in accordance with Section 40 CFR 262.34 (WAC 173-303-200). Labeling and tracking of hazardous waste is handled by the respective departments within the Texaco Harbor Island Terminal

(e.g., laboratory, maintenance). Hazardous wastes generated include primarily laboratory wastes or wastes generated as part of operations cleanup (e.g., oil/water separator tanks). A waste profile and manifest is prepared for each waste stream. Wastes or recycled materials generated at the Texaco Harbor Island Terminal include Safety-Kleen® (waste petroleum naphtha), waste antifreeze, waste gasoline, tank bottom sludge, tank scale, and diesel-contaminated absorbent pads. Generator Annual Dangerous Waste reports are prepared by Texaco and submitted to Ecology listing the dangerous waste generated over the past year. It should be noted that no dangerous wastes have been generated in some years (i.e., 1984, 1985, 1987).

2.5 Spill Response Planning

The current Spill Prevention and Countermeasure Control (SPCC) Plan is dated November 1993 and describes spill prevention and a contingency plan to follow in the event of a spill. The SPCC Plan was prepared in compliance with USEPA regulations (40 CFR Part 112 [WAC 173-180, 173-181, and 173-182]) and includes:

- Facility information including types of facility, address, maximum storage capacity, and average daily thruput
- A record of spill events
- Physical description of the facility, topography, and potential spill sources
- Drainage at the site from diked storage areas, water treatment units, and undiked areas
- Secondary containment, protection, operating procedures, and inspections of bulk storage tanks
- Intro-facility transfer operations including buried lines, out-of-service lines, pipe supports, and overhead pipelines
- Maintenance and loading procedures for tank truck and tank car loading racks
- Inspections and records for tanks and basins
- Security for tanks truck and tank car loading racks, tank farm areas, fences and gates, and marine docks
- Personnel training and spill prevention procedures

- Contingency plan including general operating procedures, responsibilities and equipment requirements, and specific plans from potential spill sources

- Laws and regulations on oil pollution prevention

The SPCC Plan lists emergency response telephone numbers including plant supervisors, oil cleanup companies, government agencies, local agencies, and other Texaco personnel. An emergency number for the National Response Center for the U.S. Coast Guard is also listed.

2.6 Regulatory Status

USEPA notified Texaco on July 31, 1986, that it was a potentially responsible party (PRP) for taking response actions at the Harbor Island Superfund site in Seattle, Washington (Findley, July 31, 1986). The USEPA divided the Harbor Island Superfund site into four operable units. Operable unit (O.U.) No. 1 includes the ARCO, Shell, and Texaco bulk fuel terminals. O.U. No. 2 consists of the marine sediments surrounding the island, and O.U. No. 3 consists of the Lockheed Shipyard. O.U. No. 4 includes the soil and groundwater on the remainder of the island. A Phase I and Phase II Remedial Investigation/Feasibility Study (RI/FS) has been completed by USEPA for O.U. No. 4. Surface soil samples and groundwater quality data were collected on Texaco's property as part of the USEPA RI/FS. A Record of Decision (ROD) was signed for O.U. No. 4 in September 1993.

On May 21, 1990, Ecology formally notified Texaco that the Texaco Harbor Island Terminal is a potentially liable party (PLP) under Section 4 of the MTCA, as applied to the "facility" known as Texaco Harbor Island Terminal located at 2555 13th Avenue Southwest, Seattle, Washington (Dorigan, May 21, 1990). On December 3, 1990, USEPA Region 10 stated that "USEPA and Ecology have agreed that Ecology will be the primary enforcement agency for the remedial investigation and cleanup of petroleum and hazardous substances on all the tank farms on Harbor Island. Only after the tank farm facilities are cleaned up in compliance with the MTCA regulations will the tank farm owners be removed from USEPA's PRP list (Rose, December 3, 1990)."

On June 6, 1991, Ecology notified Texaco that they would begin the formal negotiations process to finalize the Agreed Order and Scope of Work for the Texaco Harbor Island RI/FS (Turvey, June 6, 1991). The Scope of Work, dated March 16, 1992, and Proposed Agreed Order have been agreed to by Texaco and Ecology (Texaco, March 16, 1992). The Agreed Order was approved on July 15, 1992, with no objections from the public concerning the contents of the Agreed Order and Scope of Work (Madakor, July 15, 1992). This remedial investigation is being conducted in accord with the Agreed Order and Scope of Work.

2.7 Facility Permits and Registrations

Air

The Texaco facility has no air discharge permit, but the terminal vapor recovery unit is registered with PSAPCA Registration No. 16003, and is in compliance with the PSAPCA requirements for continuous emission monitoring systems.

NPDES

The Texaco Harbor Island Terminal has an NPDES waste discharge permit. Metro issued a waste discharge permit (No. 1971) to Texaco to discharge up to 3,780 gallons per day to the Duwamish River for the period of September 6, 1963, to September 6, 1968. The permit conditions cover total volume, pH, total oils, discharge effluent from barrel washing, truck washing, and paint stripping to the sanitary sewer, discharge yard drainage to the Duwamish River after passing through an oil/water separator, discharge sanitary sewage to the city sewer system, city requirements and ordinances, and pollution control commission notification in the event of equipment breakdown. A brief summary of the permit history is provided below. Specific permit requirements can be found in the respective permits.

A waste discharge permit (No. 3236) was issued for the period from November 13, 1969, to November 13, 1974. The permit conditions were the same as the previous permit, with the following additions:

- No visible oil in effluent.
- Do not dispose chemical sludges, sludges containing oils, or sludges with a high or low pH to a state waterway.

An NPDES waste discharge permit (No. WA-000179-1) was issued for the period from March 29, 1974, to March 29, 1979. Permit conditions were added for inspection and observation, monitoring, data submission, sampling, and reporting.

The NPDES waste discharge permit (No. WA-000179-1) was renewed for the period from April 20, 1979, to April 16, 1984. There were no changes in the permit conditions from the previous permit.

The NPDES waste discharge permit (No. WA-000179-1) was renewed for the period from December 13, 1983, to December 13, 1988. Changes in permit conditions addressed the frequency of effluent flow monitoring, effluent pH monitoring, ensuring that leachate from solid waste material would not enter the Duwamish Waterway.

On June 30, 1988, Texaco received an extension of their NPDES permit until 1992 (Ecology, 1988).

The NPDES waste discharge permit (No. WA-000179-1) was renewed in April 1992. The permit conditions covered oil and grease daily average and daily maximum effluent limits, total suspended solids effluent limits, daily maximum effluent limits for benzene and ethylbenzene, pH, flow measurements, monitoring of oil and grease, TPH, BTEX, TSS, lead, zinc, priority pollutants, and biomonitoring.

2.8 Previous Investigations

A summary of previous environmental investigations is provided in Table 2-1. In addition to investigations performed for Texaco, remedial investigations of the entire Harbor Island area performed for the USEPA are also listed. A summary of releases greater than 10 gallons, when they occurred, causes, and actions taken, is provided in Table 2-2.

2.9 Interim Measures

Interim remedial measures have not been implemented at the Texaco Harbor Island Terminal. However, the following activities have occurred at the site in the course of Terminal operations.

1. Sandblasting and Repainting Aboveground Storage Tanks: Tanks in the southwest tank farm were tented, sandblasted, and repainted in the fall of 1992. Sandblast grit was removed from the concrete containment area and disposed off site.

2. Track Addition at the Western Railcar Unloading Area: A second track was added to the west of the rack in the fall of 1992. Excavated petroleum-impacted soil was disposed off site.

3. Underground Storage Tank Replacement: Underground storage tanks U11 and U13 were replaced as described in Appendix I in December 1993. Excavated petroleum-impacted soil was disposed of off site.

4. Pumphouse Spill Cleanup: Product and soil from a December 1992 pale oil spill at the pumphouse were cleaned up. A total of 5,950 gallons of the 6,000 gallons of oil spilled were recovered. About 50 cubic yards of petroleum-impacted soil were excavated and disposed off site.

5. Pier 15 Spill Cleanups: September 1993 and March 1994 diesel spills were cleaned up with booms and absorbent pads.

Table 2-1

Texaco Harbor Island Terminal
Remedial Investigation Report
Previous Investigations

Investigation	Date	Performed by	Comments
Geotechnical Investigation	1981	Earth Consultants	Explored subsurface conditions in a portion of the Texaco main terminal area.
Phase 1 Superfund RI	1989	Ebasco Services, Inc.	Performed RI for USEPA; included all of Harbor Island.
Geotechnical Investigation	1991	Earth Consultants	Conducted a geotechnical engineering study for an additional storage tank installation in the Texaco main terminal area.
Underground Storage Tank Investigation	1991	SEACOR	Investigated soil in the vicinity of two underground storage tanks.
North Tank Farm Investigation	1991	Groundwater Technology, Inc.	Investigated surface and near-surface soils in the Texaco north tank farm area.
Soil Investigation in Main Tank Farm	1992	SEACOR	Investigated soil at a proposed location for an additional aboveground storage tank in the main tank farm.
Phase 2 Superfund RI	1993	Roy F. Weston	Performed RI for USEPA; included all of Harbor Island.
Underground Storage Tank Replacement	1993	EMCON Northwest, Inc.	Investigated soil in the vicinity of two underground storage tanks.

Table 2-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Known Spills to the Environment

No.	Date of Spill	Volume (gallons)	Product Type	Spill Location	Cause of Spill	Cleanup Action/Volume Recovered
1	1960s	50,000	Bunker oil	Near Tank 8501	Tank overfilled	Soil and product removed by Texaco.
2	09/19/69	<50	Oil	Dock (Pier 15)	Product transfer line from Texaco facility failed	Unknown.
3	06/29/71	50	Fuel oil	Dock (Pier 15)	Pinhole in 6" line	Boom and absorbent pads; 30 to 40 gal recovered.
4	01/07/75	Unknown	Lube oil	Tank 1308	Leak in tank bottoms; weld failed	"Contained."
5	Mid-1970s	≈50	75/80 pale oil	Near Tank 1312	NA	Soil and product removed by Texaco.
6	05/17/78	21,900	Aviation jet fuel (Avjet A)	Tank 31470	Improper valve operation	Vacuum truck; 8,800 gal recovered; 200 gal oil mop; 4,500 gal evaporated.
7	08/24/80	6,000	#2 diesel	Light oil truck loading rack	Line failure	60% recovered at time of spill (3,600 gal); soil removal.
8	06/03/82	Unknown	Unknown	Tank 8500	Tank bottom leaked	Removed contaminated sand; repaired tank bottom.
9	≈1982	≈800	Rando HD32	Tank 317	Tank overfilled	Product and soil removed by contractor.
10	02/29/84	2,050	Diesel	Near employees' building	Line leak	Product recovery well; 7,000 gal by 7/86.
11	12/24/85	>2,500	#2 diesel	Olympic Pipe Line adjacent to north tank farm	Flange rupture	Shallow recovery well and vacuum truck; 2,550 gal recovered by 2/10/86.
12	≈1987	≈200	10/40W oil	BL-1	NA	Product and soil removed by contractor.
13	12/29/90	10	Cutter stock	Dock (Pier 15)	Pipe failure	Boom and absorbent pads, vacuum truck; 1,100 gal of oily water recovered.

Table 2-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Known Spills to the Environment

No.	Date of Spill	Volume (gallons)	Product Type	Spill Location	Cause of Spill	Cleanup Action/Volume Recovered
14	01/11/91	200	#2 diesel	Shoreline manifold area	Pinhole leak in product line	Boom and absorbent pads (10 gal recovered), vacuum truck (900 gal diesel and water recovered) 10 cy soil excavated and stockpiled.
15	08/31/91	3,000	Diesel	North tank farm	Improper valve operation	Vacuum truck; 3,052 gal recovered; removed 40 cy stained soil for off-site treatment.
16	06/26/92	1,000	30W oil	Main tank farm	Valve malfunction	750 gallons recovered; soil excavated and cleaned up.
17	12/19/92	6,000	Pale oil	Pumphouse	Valve leak	5,950 gallons recovered; soil excavated and cleaned up.
18	02/03/93	100	Lube oil additive	Railcar unloading rack	Faulty hose connection	100 gallons removed, area steam-cleaned, water recovered by vacuum truck.
19	09/27/93	10 - 25	Diesel	Dock (Pier 15)	Pinhole leak in product line	Boom and absorbent pads.
20	03/08/94	5	Diesel	Dock (Pier 15)	Equipment failure (pressure gauge), thermal expansion	Boom and absorbent material.

NOTE: NA = not available.

Table 2-2
Texaco Harbor Island Terminal
Focused FS Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Toluene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
Screening Level		32.6[a]	0.5[b]	40[b]	20[b]	1,000[a]	100[b]	200[b]	200[b]	20[b]
SB-120	0.5	—	—	—	—	—	—	—	550	—
SB-122	1.0	—	—	—	—	—	190	280 J	970 J	—
SB-122	2.5	—	—	—	—	—	2,800	1,800 J	10,000 J	—
SB-122	4.5	NA	2.4 J	—	35 J	NA	12,000 J	6,600	52,000	99 J
SB-123	2.0	—	—	—	—	—	—	250	3,800	—
SB-123	4.0	NA	—	—	—	NA	—	360 J	3,000 J	—
SB-127	2.5	—	—	—	—	—	250 J	—	—	—
SB-128	4.5	NA	0.62	—	—	—	1,300 J	450	430	—
SB-131	0.0	—	—	—	—	1,400	—	—	—	—
SB-131	4.0	NA	—	—	—	—	430 J	—	630	—
SB-134	6.0	—	—	—	—	—	—	18,500	—	—
SB-135	2.5	—	4.5	—	40	—	—	1,200	—	150
SB-135	4.5	—	27	—	51	—	—	15,400	—	200
SB-135	6.0	—	180	66	250	—	—	31,500	—	990
SB-135	8.0	—	4.9	—	—	—	—	1,040	—	—
SB-136	2.5	—	—	—	—	—	—	13,700	—	—
SB-136	4.5	—	—	—	—	—	—	33,500	—	—
SB-136	6.5	—	—	—	—	—	—	583	—	—
SB-137	2.5	—	—	—	—	—	—	8,260	—	—
SB-137	4.5	—	—	—	—	—	—	20,000	—	—
SB-137	6.5	—	—	—	—	—	—	18,300	—	—
SB-138	7.0	—	1.4	—	—	—	—	543	—	—
SB-138	9.5	—	0.62	—	—	—	—	—	—	—

Table 2-2
Texaco Harbor Island Terminal
Focused FS Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Toluene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
Screening Level		32.6[a]	0.5[b]	40[b]	20[b]	1,000[a]	100[b]	200[b]	200[b]	20[b]
SB-139	2.0	—	—	—	—	—	—	4,870	—	—
SB-139	4.0	—	—	—	—	—	—	14,000	—	—
SB-139	6.0	—	—	—	—	—	—	7,430	—	—
SB-140	4.0	—	—	—	—	—	—	6,360	—	—
SB-140	6.0	—	—	—	—	—	—	4,720	—	—
SB-141	2.0	—	—	—	—	—	—	1,180	—	—
SB-141	4.0	—	—	—	—	—	—	11,000	—	—
SB-141	6.0	—	—	—	—	—	—	11,600	—	—
SB-142	2.0	—	—	—	—	—	—	2,050	—	—
SB-142	4.0	—	—	—	—	—	—	23,800	—	—
SB-142	6.0	—	—	—	—	—	—	11,100	—	—
SB-143	2.0	—	—	—	—	—	—	493	—	—
SB-143	4.0	—	—	—	—	—	—	22,000	—	—
SB-143	6.0	—	—	—	—	—	—	3,800	—	—
SB-143	8.0	—	—	—	—	—	—	890	—	—
SB-144	4.0	—	—	—	—	—	—	17,600	—	—
SB-144	6.0	—	—	—	—	—	—	2,500	—	—
SB-146	0.0	—	—	—	—	—	194	—	—	—
SB-147	2.0	—	—	—	—	—	—	1,300	—	—
SB-147	4.0	—	—	—	—	—	—	3,000	—	—
SB-147	6.0	—	—	—	—	—	—	686	—	—
SB-148	4.0	—	—	—	—	—	—	293	—	—
SB-148	6.0	—	—	—	—	—	—	6,740	—	—

Table 2-2
Texaco Harbor Island Terminal
Focused FS Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Toluene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
Screening Level		32.6[a]	0.5[b]	40[b]	20[b]	1,000[a]	100[b]	200[b]	200[b]	20[b]
SB-201	4.4	NA	1.6 J	—	—	NA	9,100 J	13,000 J	—	—
SB-202	0.5	—	—	—	—	—	—	1,100	12,000	—
SB-203	4.0	NA	—	—	—	NA	2,500	2,300 J	—	—
SB-204	1.0	—	—	—	—	—	—	370	4,800	—
SB-204	2.5	—	—	—	—	—	—	—	2,400	—
SB-206	2.0	—	0.53	—	—	—	4,200	14,000 J	1,600 J	22 J
SB-208	4.0	NA	—	—	—	—	3,500 J	6,200	740	—
SB-208	6.5	NA	1.3 J	—	—	NA	2,200 J	14,000	—	—
SB-210	6.5	NA	—	—	—	—	2,500 J	3,300	—	—
SB-211	2.0	NA	1.0 J	—	—	—	1,400 J	3,900	1,400	23 J
SB-211	4.0	NA	—	—	—	NA	180	—	—	—
SB-212	2.0	NA	—	—	—	—	—	640	—	—
SB-213	9.0	—	—	—	—	—	—	267	—	—
SB-213	11.5	—	—	—	—	—	—	403	—	—
SB-214	0.5	—	—	—	—	—	—	5,850	2,740	—
SB-214	2.0	—	—	—	—	—	—	11,300	370	—
SB-214	4.0	—	—	—	—	—	—	40,500	—	—
SB-214	6.5	—	—	—	—	—	—	2,690	—	—
SB-214	8.0	—	—	—	—	—	—	3,120	—	—
SB-215	2.0	—	—	—	—	—	—	5,900	—	—
SB-215	4.0	—	—	—	—	—	—	12,100	—	—
SB-215	6.5	—	—	—	—	—	—	16,800	—	—
SB-216	2.0	—	—	—	—	—	—	626	—	—

Table 2-2
Texaco Harbor Island Terminal
Focused FS Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Toluene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
Screening Level		**32.6[a]**	**0.5[b]**	**40[b]**	**20[b]**	**1,000[a]**	**100[b]**	**200[b]**	**200[b]**	**20[b]**
SB-216	4.0	—	—	—	—	—	—	13,000	—	—
SB-216	6.5	—	—	—	—	—	—	3,920	—	—
SB-216	8.0	—	—	—	—	—	—	1,240	—	—
(1) SB-217	4.0	—	—	—	—	—	—	4,950	—	—
SB-217	6.0	—	—	—	—	—	—	20,200	—	—
SB-218	4.0	—	—	—	—	—	—	8,890	—	—
SB-218	6.0	—	—	—	—	—	—	6,260	—	—
(2) SB-219	4.0	—	—	—	—	—	—	1,590	—	—
SB-219	6.0	—	—	—	—	—	—	27,300	—	—
SB-219	8.0	—	—	—	—	—	—	17,200	—	—
SB-220	4.0	—	—	—	—	—	—	4,740	—	—
SB-220	6.0	—	—	—	—	—	—	6,460	—	—
SB-220	8.0	—	—	—	—	—	—	1,250	—	—
(3) SB-221	4.0	—	—	—	—	—	—	1,350	—	—
SB-221	6.0	—	—	—	—	—	—	19,100	—	—
SB-221	8.0	—	—	—	—	—	—	1,760	—	—
(4) SB-222	4.0	—	—	—	—	—	—	5,620	—	—
SB-222	6.0	—	—	—	—	—	—	23,900	—	—
SS-106	0.0	44	NA	—	NA	1,600	NA	NA	NA	NA
SS-110	0.0	NA	NA	NA	NA	1,400	NA	NA	NA	NA
SS-111	0.0	NA	NA	NA	NA	1,800	NA	NA	NA	NA
SS-112	0.0	NA	NA	NA	NA	1,700	NA	NA	NA	NA
SS-113	0.0	NA	NA	NA	NA	1,700	NA	NA	NA	NA

3 ENVIRONMENTAL SETTING

Harbor Island is a man-made island located in Elliott Bay at the mouth of the Duwamish River, approximately 1 mile southwest of downtown Seattle. The 430-acre island was created between 1903 and 1905 (Benoit, 1979) by filling the site with sediment dredged from the Duwamish River. Dredging during this time period also created the waterways on the east and west sides of Harbor Island. The Texaco facility occupies approximately 20.5 acres in the northcentral portion of the island.

3.1 Climate

The climate in the Puget Sound area is temperate with moderate precipitation and temperatures. The area is characterized by a long rainy season and short dry season. The rainy season extends from October to March, while the driest months are July and August. Winter temperatures are typically in the 30s and 40s (°F), and summer temperatures commonly range from the 50s to 70s (°F). Extreme temperatures range from the 90s (°F) in the summer to as low as 5°F in the winter. The average annual precipitation ranges from approximately 35 to 39 inches (Galaster and Laprade, 1991; NOAA, 1983). Most of the precipitation falls as rain; snow accumulations are rare.

Prevailing winds are from the south. North-south trending hills on the east and the west sides of the Duwamish River valley frequently result in relatively stagnant air conditions in the valley (City of Seattle, 1986).

3.2 Surface Water Hydrology

Harbor Island is surrounded by the surface waters of Elliott Bay and the East and West Waterways of the Duwamish River. The bay and the river are directly connected to Puget Sound and, thus, are tidally influenced. No surface water bodies exist on the island itself. Precipitation on the island either runs off through a storm water system to the waterways and Elliott Bay or infiltrates into the ground. Most of the island is paved; thus much of the precipitation falling on the island runs off through the storm water system. Significant unpaved areas remain, however, along roadways, in tank farms, and in metal recycling yards through which precipitation infiltration can occur.

3.3 Regional Geology

The Seattle area lies within the Puget Sound Lowland, a north-south trending trough extending from Oregon to southwestern British Colombia. This trough is characterized by relatively thick accumulations of post-glacial and glacial deposits overlying Tertiary sedimentary and igneous rocks. The area has been influenced by at least five major advances and several lesser advances of Pleistocene continental ice (Galaster and Laprade, 1991). Glacial deposits consist of a complex sequence of lacustrine deposits, advance outwash, drift, till, and recessional deposits. A variety of river deposits characterizes the interglacial periods. The Quaternary glacial and interglacial deposits range in thickness from 0 to 3,700 feet. The underlying bedrock consists primarily of Tertiary sedimentary and volcanic rocks.

Harbor Island lies at the mouth of the Duwamish river valley in an estuarine depositional environment. The closest glacial deposits to Harbor Island lie on the uplands to the west and south. Bedrock outcrops on Alki Point to the west of the island and in the southern Duwamish valley.

Three main geologic units have been identified beneath Harbor Island in the depths explored to date: aggregate or grade fill, dredge fill, and estuarine deposits (Ebasco, 1990; Weston, 1993). Details of the lithology observed during this RI field investigation are presented in Section 5.1.

3.4 Hydrogeology

Groundwater at Harbor Island occurs as a thin lens of fresh water overlying brackish water at depth. Groundwater is hydraulically connected to the surrounding Elliott Bay and East and West Waterways. Groundwater, particularly at depth, is tidally affected. Recharge of shallow groundwater is through infiltration of precipitation. As previously mentioned, infiltration is variable over the island due to the extensive paved area.

Four hydrostratigraphic units have been identified beneath Harbor Island in the depths explored to date: unsaturated fill, saturated fill and shallow deltaic or estuarine sediment, saturated clay interbeds, and saturated deeper deltaic or estuarine sediment. The lower three units have been poorly defined because the clay interbeds are only partly continuous beneath the island (Ebasco, 1990; Weston, 1993). Clay occurrence was reported to increase considerably at depths greater than 45 feet (Weston, 1993). The deeper estuarine sediments may be partially confined. Details of the site area hydrogeology, as determined during this RI investigation, are presented in Section 5.2.

3.5 Land Use

3.5.1 Industrial and Commercial Uses

Historically, Harbor Island has been used for industrial and commercial purposes. Relatively little activity occurred on the island until World War II. Petroleum storage and distribution facilities, shipyards, and warehouses were the principal operations in the World War II era. Much of the additional development occurred in the late 1940s and early 1950s. Principal historical operations have included petroleum storage and distribution facilities, a secondary lead smelter, metal fabricators, metal recycling facilities, shipbuilding operations, warehouses, port facilities, and a flour mill.

Harbor Island is currently zoned exclusively as "General Industrial," except for a 200-foot shoreline zone designated as "Urban Industrial" (Weston, 1993; City of Seattle, 1987). Most commercial uses are permitted within the General Industrial Zone, with the exception of schools and churches (Weston, 1993; City of Seattle, 1988). The island presently is occupied by a variety of enterprises, mainly consisting of petroleum storage and distribution facilities, metal fabricators, a metal recycling facility, shipbuilding operations, warehouses, port facilities, and a flour mill. Some smaller businesses support industry and commerce on the island. They consist of retail and wholesale establishments, offices, and restaurants. No hotels, other lodging establishments, or day care facilities are present on the island at this time (Weston, 1993).

Most of the eastern side of the island is occupied by the Port of Seattle's Terminal 18 Cargo container facility. Metal fabricators, a metal recycling facility, and petroleum company tank farms (Texaco, Shell, Mobil (Rainier Petroleum), and ARCO) are the principal operations in the interior of the island. Todd Shipyards occupies the northwest corner of the island, and Lockheed Corporation occupies a portion of the western side of the island, which was formerly used for shipbuilding.

3.5.2 Harbor Island Recreational and Residential Uses

Parks, playgrounds, and most private recreational facilities are permitted within the General Industrial Zone (Weston, 1993). Recreational marinas are permitted within the shoreline areas if they are determined not to interfere with commercial navigation and industrial use of the shorelines (City of Seattle, 1987). Harbor Island has limited recreational use, since recreational facilities generally are incompatible with heavy industry. A marina and a fishing pier are present on the southern end of the island.

Residential uses are prohibited within the General Industrial Zone of Harbor Island (Weston, 1993; City of Seattle, 1988). However, caretakers' quarters are allowed and may exist on the island.

3.5.3 Operations Adjacent to Texaco

The Texaco facility currently is surrounded by the following operations:

- **East:** The Shell Oil tank farm and distribution facility, the ARCO tank farm, and the Olympic Pipe Line operations
- **North:** Todd Shipyard and the Mobil Oil storage and distribution facility (currently operated by Rainier Petroleum)
- **West:** The ARCO storage and distribution facility and the Lockheed facility
- **South:** The Seafab (formerly Quemetco) metal fabrication facility

Shell Oil Company has been operating on the site to the east of Texaco since before 1946. The facility has been modified since its initial construction. The distribution center was constructed in its present location in 1979 (Ebasco, 1990). A petroleum storage and distribution facility has been operating on property currently owned by ARCO since before 1936. Most of the facility adjacent to the West Waterway of the Duwamish River was, however, constructed in the late 1930s or early 1940s. Petroleum storage and distribution has occurred at the Mobil Oil site since before 1936. Most of the tank farm was demolished in the early 1970s. Todd Shipyards has operated at the same location on Harbor Island since 1918 (Ebasco, 1990) and purchased the main portion of the former Mobil Oil site in 1968. Lockheed and previous owners have operated a shipbuilding facility since the 1920s.

Seafab Metals has operated a metals fabrication facility since 1984. The Seafab site was previously used for battery recycling, secondary lead smelting, refining, and fabrication. The secondary lead smelter was constructed in 1937. Smelter operations continued until 1984 (Weston, 1993). The lead smelter is suspected of causing widespread lead contamination throughout Harbor Island. In 1983, the USEPA identified Harbor Island as a Superfund site due to lead contamination.

4 STUDY AREA INVESTIGATION

Field investigations of soil, groundwater, and aquifer characteristics began in March 1993. Forty-four shallow soil borings, 8 surface soil samples, and 21 monitoring well boreholes were drilled for soil identification and collection of soil samples for chemical and physical analyses (Drawing 1). Twenty-one single-completion monitoring wells were installed within the boreholes. Deep and shallow monitoring wells were installed at four locations, adjacent to one another, in separate boreholes. The new monitoring wells were developed and surveyed before collection of groundwater samples and measurement of water table elevations. In addition, 12 previously installed monitoring wells and 2 recovery wells were abandoned during the investigation. Four quarters of groundwater samples were collected from 21 on-site and 7 off-site monitoring wells. Groundwater samples were also collected once from two on-site monitoring wells.

Three existing on-site monitoring wells and 11 existing off-site monitoring wells were used to monitor groundwater levels or collect groundwater samples during the Texaco RI. All but one of these wells were installed by the USEPA or Shell Oil Company for other remedial investigations. USEPA surface soil data were also used in the Texaco RI. The USEPA collected 15 surface soil samples on Texaco property and 11 surface soil samples in the street right-of-way east and west of the site.

Aquifer characterization studies consisted of two 72-hour tidal response studies, six hydraulic conductivity (slug) tests, and monthly rounds of water level measurements. Geotechnical analyses, including grain size, porosity, and vertical hydraulic conductivity, were performed on several soil samples from the site.

Any deviations from the general sampling procedures were brought to the attention of the EMCON project manager, and a Sample Alteration Checklist was completed. Copies of the checklists are provided in Appendix A.

4.1 Soil

Soil samples were collected from shallow soil borings and monitoring well boreholes. Soil sampling locations are indicated on Drawing 1. Locations generally were selected based on historic on-site and off-site land uses, soil and groundwater quality data generated from the USEPA Phase 1 and 2 RIs, and the need to further characterize the

soil types and properties. The collection of soil samples was biased, as sample locations were generally selected in areas of known or suspected contamination.

A decontamination pad was constructed in the Texaco contractor's yard. All equipment steam cleaning took place over the lined pad. Steam cleaning and equipment washing water was collected and contained in 55-gallon drums. All down-hole drilling equipment was steam cleaned before drilling and between drilling locations. All well casings, screens, and centralizers were steam cleaned before installation. Soil sampling equipment was decontaminated either by steam cleaning or by using the following procedure: (1) tap water rinse, (2) hexane rinse (if visibly stained with product), (3) tap water rinse, (4) non-phosphatic detergent (Liquinox) and tap water wash, (5) tap water rinse, (6) dilute nitric acid rinse (pH <2) at the start of each day, and, if the split-spoon sampler was visibly rusty, and (7) distilled water rinse.

4.1.1 Surface Soil Samples

Nine surface soil samples were collected between depths of 0 and 0.5 foot bgs, in accordance with Addendum No. 1 to the work plan (December 2, 1993). The samples were collected to determine the extent of arsenic and lead in surface soil above the USEPA Harbor Island cleanup goal. Ten sample sites were identified in the addendum, but at one site location, SS-102, ponded water prevented the collection of a sample.

Surface soil samples were collected by placing an equal volume of soil from five sub-sites from within a 10-foot radius into a clean, stainless steel bowl, by using a clean, stainless steel spoon. The collected soil was homogenized, using the stainless steel spoon, before filling the various sample jars.

4.1.2 Soil Borings

Forty-four soil borings were drilled to approximately 5 feet below ground surface (bgs) (Drawing 1). Thirty-one shallow soil borings (SB-101 through SB-131) were drilled within the main terminal and tank farm areas. The remaining 13 soil borings (SB-201, SB-201b, and SB-202 through SB-212) were drilled within the north tank farm or shoreline manifold areas. The project work plan presented sampling of only 32 shallow soil borings; however, one additional location (SB-126) was included in the area of a recent lubricating oil spill. Eleven other borings were added, in accordance with Addendum No. 1 to the work plan (December 2, 1993), to: (a) further characterize and delineate the nature and extent of soil displaying TPH and mixed organic carcinogen laboratory results which exceeded the USEPA "hot spot" criteria (USEPA, September 1993); (b) investigate the extent of petroleum product found in well A-28; and (c) determine TCLP lead concentrations at TPH "hot spots" where subsurface total lead concentrations exceeded 100 mg/kg.

Each drilling location was checked for underground utilities before drilling. Several boring locations were moved (generally only a few feet) from their originally proposed locations due to underground or aboveground utilities, operational constraints, or access difficulties. The maximum distance for boring relocation was approximately 20 feet for soil boring SB-212, which was moved to avoid buried concrete within the area. All boring relocations were approved by the EMCON project manager, in accordance with the work plan.

Soil sampling was conducted between March 1 and 25, 1993, and between January 25 and February 4, 1994. Soil borings were advanced using either a 3.5-inch-diameter stainless-steel hand auger or a hollow-stem auger drill rig with nominal 4-inch-inside-diameter (i.d.) and nominal 7-inch outside-diameter (o.d.) auger flights. Soil samples typically were collected from depths of 0.5 to 1.5 feet, 2 to 3 feet, and 4 to 5.5 feet bgs to provide a vertical profile of lithology and to provide multiple samples from above the water table for chemical analysis. In a few locations at the shoreline manifold area, soil samples were collected from 6.5 to 8.0 feet bgs; at SB-131, a surface soil sample was collected from 0 to 1.5 feet bgs.

Hand auger refusal was encountered in 6 of the 33 soil borings (SB-101, SB-106, SB-107, SB-118, SB-119, and SB-121) at a depth of approximately 2 to 3 feet bgs. The five soil borings that could be reached by a drill rig (SB-106, SB-107, SB-118, SB-119, and SB-121) were redrilled using a hollow-stem auger drill rig. Severe caving problems were encountered due to wet soil in soil boring SB-207 at a depth of approximately 3.5 feet and in soil boring SB-212 at a depth of 2.5 feet. The 4 to 5 feet bgs sample in SB-207 was collected at the end of the summer. The 4 to 5 feet bgs sample could not be collected from SB-212 since it was drilled in February 1994. Soil sample depths had to be altered in a few locations due to obstructions (primarily large cobbles) in the borehole. Intervals sampled are indicated on the boring logs (Appendix B).

Soil samples from auger-rig drilled soil borings were collected using a 3-inch o.d., stainless steel split barrel sampler advanced ahead of the auger. Soil from each interval sampled was transferred from the hand-auger barrel or split barrel sampler to a clean, stainless steel bowl, with the exception of the sample for volatile petroleum hydrocarbons. To minimize volatilization of this sample, soil was collected from the approximate midpoint of the sampling interval and transferred directly from the auger barrel or sampler to the sample jar, using a stainless steel spoon. The remainder of the collected soil was homogenized using a clean, stainless steel spoon before filling the various sample jars.

A headspace analysis sample was collected from each sample interval, along with the sample for volatile organics analysis, before mixing. To perform a headspace analysis, a 4-ounce glass jar was filled approximately halfway with soil and sealed with aluminum foil. The jar was placed inside the field vehicle for at least 15 minutes to promote sample volatilization. The tip of a photoionization detector (PID) was then inserted

carefully through the foil to sample volatile constituents within the sample headspace. The PID reading was recorded on a boring log (Appendix B). The sample lithology was recorded on the boring log using classifications provided in ASTM D-2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).*

All sampling equipment and reusable materials that contacted the sample were decontaminated on site using a liquid soap and water wash and distilled water rinse. Soil borings completed to 5 feet were backfilled with bentonite chips to within 6 inches of ground surface, hydrated with an equal volume of potable water, and smoothed to grade using local surface sediment or concrete. Soil borings in which refusal was encountered (less than 3-feet-deep) were backfilled with removed material and smoothed to grade. All remaining drill cuttings were collected and handled according to the procedure described in Section 4.4. All soil boring locations were located horizontally by using a fiberglass survey tape to measure their positions with respect to nearby, permanent structures.

4.1.3 Monitoring Well Boreholes

Twenty-one monitoring wells were installed at the site: 17 shallow wells (approximately 15 feet bgs), and 4 deep wells (approximately 50 feet bgs). Twelve monitoring wells (MW-101 through MW-112) were installed within the main terminal and tank farm area (Drawing 1), including ten shallow wells and two deep wells (MW-103 and MW-108). Seven monitoring wells (MW-201 through MW-207) were installed within or near the north tank farm area, including six shallow wells and one deep well (MW-205). Shallow monitoring well MW-207 was installed within the roadway of 13th Avenue Southwest, to replace an older monitoring well (MW-5) at that location. One shallow (MW-208) and one deep (MW-209) monitoring well were installed in the shoreline manifold area.

Shallow monitoring well boreholes were drilled to depths of approximately 15 feet. The four deep monitoring wells were to be advanced until a fine-grained layer (silt or finer) at least 1-foot thick was encountered, or to a maximum of 50 feet bgs. As no fine-grained layer of appreciable thickness was encountered in any of the deep monitoring well boreholes, each boring was advanced to a depth of approximately 50 feet. Drilling and installation of the monitoring wells took place between March 15 and 26, 1993, and September 7 and 12, 1994. Fifteen of the 17 shallow monitoring wells were drilled and installed using a Mobile Drill Model B-61 hollow-stem auger drill rig equipped with nominal 6-inch i.d. and nominal 11-inch o.d. auger flights. Monitoring wells MW-201 and MW-202 were drilled and installed using a Mobile Drill® Model B-56 drill rig. These two wells were located in the north tank farm area within the concrete retaining wall. The B-56 rig, having a lower gross vehicle weight than the B-61, was lifted over the wall by using a large hydraulic crane. The four deep monitoring wells were drilled and installed by using a Fairbanks cable-tool drill rig.

Each deep monitoring well was installed adjacent to a shallow monitoring well. Soil samples for chemical analyses were collected from each shallow monitoring well borehole (except MW-208) from either the bottom two or all three of the following intervals: 0.5 to 1.5 feet, 2 to 3 feet, and 4 to 5.5 feet bgs. No soil samples were collected from the deep monitoring wells for chemical analyses.

Subsurface soil samples were collected at prescribed depths in advance of the drill bit using an 18-inch-long, 3-inch o.d., split-barrel sampler. Soil samples were collected for lithologic description every 2.5 feet from 6.5 feet bgs (below the last sample for chemical analysis) to the bottom of the boring in shallow monitoring well boreholes, and continuously in deep monitoring well boreholes. The sample lithology was recorded on a boring log using ASTM D-2488 classifications. Monitoring well borehole soil samples were handled the same as soil boring samples (see Section 4.1.1). Field PID readings were obtained on soil samples (from shallow and deep monitoring wells) to a total depth of approximately 15 feet bgs; results are noted on the boring logs (Appendix B).

Soil samples were also collected from eight monitoring well boreholes (MW-103, MW-106, MW-107, MW-108, MW-110, MW-112, MW-205, and MW-207) for physical analyses. Ten samples were collected for grain size analyses, three for Atterberg limits, three for porosity, and two for vertical hydraulic conductivity. Samples were selected to represent the distribution of soil properties encountered while drilling. Samples for grain size analysis were collected from split barrel samplers. Samples for testing vertical hydraulic conductivity, Atterberg limits, and porosity were collected by driving a ring sampler ahead of the drill bit into undisturbed soil. The rings were sealed with polyethylene caps at both ends and taped to minimize disturbance during handling.

Each of the monitoring well boreholes was completed as a monitoring well as described in Sections 4.2.1 (shallow wells) and 4.2.2 (deep wells).

4.1.4 Sample Analysis

Laboratory parameters were selected based on historic site activities and previously collected soil and groundwater data in the vicinity. A list of soil samples collected and analyses performed on each is provided in Table C-1 (Appendix C).

Petroleum Hydrocarbons

One hundred fifty-seven soil samples were submitted for the following analyses: benzene, toluene, ethylbenzene, and xylenes (BTEX) by USEPA Method 5030/8020, total petroleum hydrocarbons (TPH) as gasoline by the WTPH-G method, and TPH as diesel (TPH-D) and oil (TPH-O) by the WTPH-D extended method. TPH as gasoline (TPH-G) includes compounds within the range of C_7 to C_{12}. TPH-D includes compounds between C_{12} and C_{24}, while TPH-O includes the C_{24} to C_{34} range.

cPAHS

Fifty-two soil samples were analyzed for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) by USEPA Method 8310. cPAH analyses consisted of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Metals

One hundred seventy soil samples were collected for possible metals analyses. One hundred thirty-four samples were collected for possible arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc analyses using USEPA 6000 and 7000 Series methods. Of these, 101 samples initially were designated for analysis. An additional 33 samples, collected from 4 to 5 feet below grade, were archived for possible later analyses. These archived metals samples were to be analyzed only if both shallower samples from that location had elevated metals concentrations. Based on the results of the initial metals analyses, none of the archived metals samples was specified for analysis, but the laboratory provided results for one sample (SB-125-5). Twenty-eight other samples, collected near areas with TPH results above 10,000 mg/kg, were archived for possible lead analysis. The sample from each boring with the highest TPH-G concentration was analyzed for lead. Twelve of these 28 samples were subsequently analyzed for lead, and one sample was also analyzed for TCLP lead. An additional eight surface soil samples were submitted for analysis of arsenic and lead.

PCBs/Total Organic Carbon

Seven soil samples collected at 0.5 to 1.5 feet below grade were analyzed for polychlorinated biphenyls (PCBs) by USEPA Method 8080. Sixty-four soil samples were collected and archived for total organic carbon (TOC) analyses. Twenty-four of the archived soil samples (one sample collected from each of 24 borings) were submitted for TOC analysis by the PSEP method. The soil sample corresponding to the highest TPH results for each of the 24 borings was submitted for TOC analysis.

Physical Parameters

Ten soil samples were submitted for grain size analysis by ASTM Method D-422. Two samples were submitted for hydraulic conductivity testing. Although ASTM Method D-4511 was proposed in the work plan, Method D-2434 was used to analyze the sample hydraulic conductivity, since it is more appropriate for granular soils such as those encountered at the site. Three soil samples were submitted for porosity by ASTM Methods D-854 and D-2937. Although two samples were submitted for Atterberg Limits testing by ASTM Method D-4318, the samples were not fine-grained enough to warrant performing the test.

4.1.5 Sample Handling and Designation

Soil samples for chemical analysis were collected in the following order: 4-ounce jars for BTEX and TPH-G, 8-ounce jars for TPH-D, and TPH-O, cPAHs, PCBs, and metals. TOC samples were collected in separate 8-ounce jars pending identification of archived samples to be analyzed. Sample container labels were completed during sample collection. The labels included the following information: project name, project number, sample number, name of collector, date and time of collection, and analyses requested. Immediately after collection, the samples were placed on ice in a cooler. The samples were sent to Analytical Technologies, Inc., (ATI) at the end of each day of sample collection. All sample shipments were accompanied by a Chain-of-Custody/ Laboratory Analyses Request Form. Signed and dated chain-of-custody seals were placed on all shipping containers. Samples remained in the custody of EMCON personnel from the time of sample collection until they were relinquished to a courier for transport to the laboratory. Upon receipt of the samples at the laboratory, the chain-of-custody (C-O-C) form was signed by the laboratory representative taking possession, the shipping container seal condition was noted, and the sample condition was recorded.

Soil samples were identified by the boring or monitoring well from which they were collected. The following prefixes were used: "SB-" preceded all soil boring sample numbers; "SS-" preceded all surface soil sample numbers (except for the one collected at soil boring SB-131); and "MW-" preceded all monitoring well sample numbers. Samples were numbered according to the depth sampled. For example, MW-101-3 identifies the sample collected from the MW-101 borehole at a depth of 2 to 3 feet bgs.

4.1.6 QA/QC Samples

Quality Assurance (QA) samples consisted of duplicate samples, equipment rinsate samples, and trip blanks. Duplicate samples were collected at a frequency of 10 percent of the total number of samples. Duplicate sample collection locations were chosen to represent the anticipated range of soil types and contamination likely to be found at the site. Field equipment rinsate blanks were collected during drilling and sampling events. One rinsate sample was collected per week of sampling (at least one per sampling event). An equipment rinsate sample was collected by rinsing distilled water over decontaminated sampling equipment. At least one trip blank per week of sampling was prepared and submitted for analysis. In addition, since potable water was added to borings to control heaving conditions, a water sample was submitted for analysis.

Field duplicates and rinsate blanks were submitted to the laboratory blind (not identified as QA samples). The QA samples were given fictitious soil sample names (e.g., for a nonexistent boring or sampling location). Trip blanks were identified as such with a date suffix (TB-4-1-93) on the container. Extra samples collected for laboratory duplicates

and matrix spike and matrix spike duplicate (MS/MSD) analyses were identified with the same designation as the sample.

4.2 Groundwater

Monitoring well locations were selected based on historic on-site and off-site land uses, soil and groundwater quality data generated from previous studies, and the need to further characterize aquifer properties and groundwater quality. All monitoring wells were installed in accordance with the requirements of Chapter 173-160 WAC, Part 3, *Resource Protection Well Guidelines*. Several existing on- and off-site monitoring wells were included for groundwater sampling and water level monitoring. On-site monitoring wells included MW-101 through MW-112, MW-201 through MW-206, MW-208, MW-209, MW-05, MW-06, and TES-MW-1. Off-site monitoring wells included MW-207, A-23, A-28, AR-04, DP-06, MW-2, MW-6, SH-04, TD-05, TX-03, TX-04, and TX-06. Summaries of monitoring well construction details for the new and existing wells are provided in Tables 4-1 and 4-2, respectively.

4.2.1 Shallow Monitoring Well Installation

Seventeen shallow monitoring wells were installed to depths of approximately 15 feet bgs. The monitoring wells were constructed of 2-inch-diameter flush-threaded Schedule 40 PVC, including a threaded end plug. Each monitoring well was constructed using a 10-foot-long screen with machined 0.010-inch slots. Water table elevations encountered while drilling shallow monitoring wells ranged from approximately 4 to 8 feet bgs. Shallow monitoring well screens were placed across the water table to permit measurement of light nonaqueous phase liquid (LNAPL or floating product), if present. The wells generally were screened from approximately 4.5 to 14.5 feet bgs, to allow for seasonal variations in groundwater levels. At the time of installation, water levels in most wells should have been near the seasonal high.

The annular space around the screened zone of each monitoring well was backfilled with clean Colorado® 20-40 silica sand. The filter packs extended from 2 to 12 inches below the lowest slot to 1 to 3 feet above the uppermost slot. The annular space above the filter pack was sealed with 3/8-inch (medium) bentonite chips. The bentonite seal extended from the top of the filter pack to the base of aboveground surface security casings, or to within 6 inches of the base of flush-mounted security casings. All monitoring well security casings were cemented in place and secured with keyed padlocks.

All materials were placed concurrent with casing withdrawal. Bentonite chips placed above the water table were hydrated with an equal volume of potable water. As-built construction details, including the volumes of materials used to construct each well, were recorded in the field logbook and on boring logs (Appendix B). Monitoring well details

Table 4-1

Texaco Harbor Island Terminal
Remedial Investigation Report
New Monitoring Well Construction Details

Well Number	Date Drilled	Horizontal Coordinates[a]		Ground Elevation[b] (ft NGVD)	Top-of-Casing Elevation[b] (ft NGVD)	Total Depth[b] (ft bgs)	Screened Interval[b] (ft bgs)
		North	East				
MW-101	04/06/93	216513.97	1625248.36	9.96	15.14	15.0	5.0 - 14.5
MW-102	03/17/93	216541.64	1624924.84	9.64	12.51	15.0	5.0 - 14.5
MW-103	03/17/93	216552.89	1624925.49	9.51	12.34	49.5	39.5 - 49.0
MW-104	03/19/93	215796.13	1625250.42	10.44	10.22	15.0	5.0 - 14.5
MW-105	03/24/93	215730.60	1624975.86	9.46	9.05	15.0	5.0 - 14.5
MW-106	03/24/93	215768.13	1624914.24	9.82	9.39	15.0	5.0 - 14.5
MW-107	03/19/93	215707.12	1624875.12	10.11	13.09	15.0	5.0 - 14.5
MW-108	03/22/93	215694.78	1624875.41	10.18	12.86	50.5	40.5 - 50.0
MW-109	03/22/93	215639.53	1624921.64	8.17	8.01	15.0	5.0 - 14.5
MW-110	03/15/93	215339.22	1624871.10	8.84	8.46	15.0	5.0 - 14.5
MW-111	03/15/93	215495.53	1625228.68	8.98	8.61	15.0	5.0 - 14.5
MW-112	03/15/93	215300.95	1625227.80	10.51	9.98	15.5	5.5 - 15.0
MW-201	03/18/93	217289.30	1625137.03	10.21	17.07	15.0	5.0 - 14.5
MW-202	03/18/93	217103.96	1625182.42	9.97	16.77	15.0	5.0 - 14.5
MW-203	03/17/93	217157.23	1625294.18	11.33	11.04	15.0	5.0 - 14.5
MW-204	03/17/93	217308.88	1625251.33	11.63	14.21	15.0	5.0 - 14.5
MW-205	03/19/93	217308.77	1625258.62	11.70	14.10	48.5	38.5 - 48.0
MW-206	03/17/93	217060.84	1625420.05	11.28	10.75	15.0	5.0 - 14.5
MW-207	03/23/93	217110.96	1625471.08	10.63	10.38	15.0	5.0 - 14.5
MW-208	09/07/94	217959.56	1625518.70	9.00	8.61	16.5	5.0 - 14.5
MW-209	09/12/94	217958.74	1625513.08	8.95	8.87	50.5	39.5 - 49.0
Dock 1[c]	—	218512.55	1625282.64	13.05	—	—	—
Dock 2[d]	—	218512.51	1625267.76	13.14	—	—	—

NOTE: ft bgs = feet below ground surface.
[a] NAD 1927 = Washington Coordinate System, North Zone, 1927.
[b] ft NGVD = feet relative to the National Geodetic Vertical Datum of 1929.
[c] Reference point used 4/93 - 6/94.
[d] Reference point used 9/94.

Table 4-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Existing Monitoring Well Construction Details

Well Number	Date Drilled	Horizontal Coordinates		Top of Casing Elevation[a] (ft. NGVD)	Total Depth[b] (ft. bgs)	Screened Interval (ft bgs)	Well Diameter (in)	Use[c]	Installed By[d]
		North	East						
TES-MW-1	02/19/92	216723.41	1625407.10*	13.10* A	18	3-18	4	GW	Seacor
TX-03	08/13/91	216801.93	1625168.19*	9.58* F	16.0	6-16	2	GW	Weston
TX-04	08/12/91	216227.72	1625421.54*	14.36* A	16.0	6-16	2	GW	Weston
TX-06	09/27/91	216331.55	1624843.48	8.58 F	15.8	5.5-15.5	2	GW	Weston
MW-05	01/25/91	215812.38	1625390.58*	10.39* F	18.9	5-15	2	GW	Ebasco
MW-06	02/07/89	215798.84	1625389.96*	10.74* F	67.6	56-66	2	GW	Ebasco
SH-04	10/01/91	215577.61	1625413.77*	12.92 A	18.1	6-16	2	GW	Weston
DP-06	09/19/91	216240.27	1625421.41*	14.25* A	67.0	55-65	2	GW	Weston
MW-2	12/16/92	216211.3	1625510.8	11.36	13	3-13	4	WL	PEG
MW-6	12/16/92	215717.1	1625494.2	11.15	13	3-13	4	WL	PEG
A-23	11/07/91	NA	NA	10.68	14.5	5-14.5	4	WL	H-C
A-28	01/24/92	215328.76	1625408.73*	10.68* F	16.5	6-16	4	GW	H-C
AR-04	09/27/91	215880.7	1624627.4	11.26 A	17.7	5.5-15.5	2	WL	Weston
TD-05	08/12/91	216800.5	1624654.9	11.68 A	17.3	6-16	2	WL	Weston

NOTE: NA = not available.
ft NGVD = feet relative to the National Geodetic Vertical Datum of 1929.
ft bgs = feet below ground surface.

[a] A = aboveground completion.
F = flushmount completion.

[b] Total depth from top of casing.

[c] WL = used for monthly water level measurements only.
GW = used for quarterly groundwater monitoring and monthly water level measurements.

[d] PEG = Pacific Environmental Group, H-C = Hart Crowser.

* EMCON survey measurement.

are summarized in Table 4-1. The total depth of each boring and the placement depths of the filter pack, the bentonite seal, and the surface completion were measured to the nearest 0.1 foot, using a weighted fiberglass tape.

The top of each well was secured with a flush-mount (flush with grade) or an aboveground lockable security casing. A flush-mount security casing was installed over each well located in a paved area or as directed by the Texaco project manager. To allow any surface water entering the security casing to drain, the security casing was seated on silica sand, and the interior of the security casing vault was filled with silica sand. To minimize the potential for surface water entering the well annulus, the top of the surface casing was installed slightly (less than 1 inch) above surface grade. Aboveground security casings were cemented in place, with the surface of the cement sloping away from the security casing. To allow any surface water entering the aboveground security casings to drain, a hole was drilled above the level of concrete on the outside of the security casings. The inside of the aboveground security casings was filled with silica sand above the drain hole.

4.2.2 Deep Monitoring Well Installation

Four monitoring wells were installed to total depths of approximately 50 feet bgs within the deep monitoring well boreholes discussed in Section 4.1.2. A step casing technique was employed for drilling and installation of the deep monitoring wells. A 10-inch-diameter casing was advanced to 15 feet bgs. Following sampling of the soil immediately below the casing, the casing was filled with at least 2 feet of bentonite chips. The casing was retracted about 2 feet, and an additional 1 to 2 feet of bentonite were added to the casing. Potable water was added to hydrate the bentonite, as necessary. The bentonite was allowed to hydrate for at least 1 hour before drilling continued. The 10-inch casing was then advanced about 3 feet.

A 6-inch-diameter casing was advanced inside the 10-inch casing through the last sampled interval. Bentonite and soil within the 6-inch casing were bailed from the casing. Soil sampling and drilling within the 6-inch casing continued to the completion depth. Both casings were removed as the monitoring wells were installed. The 6-inch casing was removed first as well materials were added to the boring. The 10-inch casing was withdrawn following the removal of the 6-inch casing.

The monitoring wells were constructed of 2-inch-diameter, flush-threaded, Schedule 40 PVC, including a threaded end plug. Each deep monitoring well was constructed using a 10-foot-long screen with machined 0.010-inch slots. One stainless steel centralizer was placed near the bottom of each screen. The annular space around the screened zone of each monitoring well, and extending approximately 2 feet above the screen, was backfilled with clean Colorado® 20-40 silica sand. A layer of bentonite chips, approximately 3 feet thick, was placed above the sand. The remainder of the annulus was filled with bentonite grout. Three deep monitoring wells were completed using

aboveground lockable security casings and one was completed using a flush-mount lockable security casing, as described in Section 4.2.1. As-built construction details are provided on the boring logs (Appendix B). A summary of monitoring well details is provided in Table 4-1.

4.2.3 Well Development

All newly installed wells were developed by pumping, surging, and bailing. The water level in the well was measured to the nearest 0.01 foot (from a surveyed notch in the well casing) before development using an electric well probe. The total depth of each well was measured and recorded before and after development. The pore (casing) volume of the installation was determined using the measured water level and the as-built installation depth. Groundwater pH, specific conductance, temperature, and turbidity were measured repeatedly during development. A well was considered developed when (1) at least ten times the pore volume of water was removed from the well, (2) the color of the discharge water did not change with additional development, and (3) field measurements of groundwater pH, specific conductance, temperature, and turbidity stabilized to within ± 10 percent for three consecutive measurements collected at one-pore-volume intervals.

All development details, consisting of discharge volume, discharge rate, pH, specific conductance, temperature, turbidity, and appearance, were recorded on field logs and are summarized in Table B-1 (Appendix B). All development water was handled as described in Section 4.4.

4.2.4 Surveying

The locations of the existing and new monitoring wells were surveyed by a registered surveyor. Each location was surveyed for ground surface elevation (to the nearest 0.1 foot), well casing rim (to the nearest 0.01 foot), and horizontal position (to the nearest 1.0 foot). A small notch was filed into the well casing rim indicating the surveyed point. Vertical surveys were of third-order accuracy. The horizontal datum was the Washington State Plane Coordinate System, North Zone (NAD 1927), and the vertical datum was the National Geodetic Vertical Datum of 1929 (NGVD). Two locations on the Texaco dock were also surveyed to provide reference elevations for surface water measurements. Horizontal and vertical coordinates for the new monitoring wells and the dock are presented in Table 4-1. Soil boring locations were located horizontally by measuring positions respective to nearby permanent structures by using a survey tape.

4.2.5 Monitoring Well Abandonment

Twelve previously installed monitoring wells and two recovery wells were abandoned: six wells in the main terminal and tank farm (MW-4, MW-5, MW-9, MW-10, MW-14, and RW-1) and eight wells in the north tank farm area (MW-1 through MW-7, and RW). The monitoring wells were all shallow depths, ranging from approximately 12 to 22 feet bgs. The monitoring wells were abandoned because they did not meet current standards for monitoring well construction. Recovery well RW, located in the 13th Avenue SW road right-of-way near the north tank farm, was approximately 30 inches in diameter and 8 feet deep. Well RW was installed in 1986 for product recovery. Recovery well RW-1, located in the main terminal near the employee's building, was approximately 26 inches in diameter and 15 feet deep. RW-1 was installed for product recovery in 1984, following a spill of diesel fuel.

Wells MW-7 and MW-14 were abandoned by removing the concrete surface pad, pulling the PVC well casing, then grouting with bentonite slurry via a tremmie pipe. The rest of the monitoring wells were abandoned without pulling the PVC casing. For those wells located in areas of vehicular traffic (MW-5 and MW-6 in the north tank farm area and MW-4 and MW-5 in the main terminal area) the surface security casing was removed, the PVC well casing was pressure grouted with bentonite slurry, and the surface was sealed with concrete. For wells located in dirt or gravel areas (MW-1 through MW-4, MW-9, and MW-10), the cement pad was removed, the well casing was pressure grouted with bentonite slurry, and the site was smoothed to grade with dirt or gravel.

Recovery well RW was abandoned by cutting off the top 4 feet of corrugated casing (to a depth of 2 feet bgs) and filling the hole with bentonite chips up to 2 feet bgs. The chips were charged with potable water and allowed to hydrate overnight. The following day, the hole was filled with dirt and smoothed to grade with a gravel cap. Recovery well RW-1 was filled with bentonite grout to a depth of approximately 8 feet bgs, then with bentonite chips to approximately 2 feet bgs. The well was then capped with concrete. The manhole covering the well was left in place.

4.2.6 Water Level and Product Measurements

Water levels were measured monthly for 1 year in all but two monitoring wells installed as a part of this investigation. Monitoring wells MW-208 and MW-209 were installed after the year-long monitoring program was completed. During the monthly monitoring events, water levels in several, previously installed, monitoring wells on the site and on adjacent properties were monitored to provide further data. Water levels in all monitored wells were measured over as short a time period as possible at monthly intervals. Depth-to-water measurements and depth-to-product measurements (if present) were obtained using an oil/water interface probe. Depths were measured to the nearest 0.01 of a foot relative to a surveyed notch at the top of the well casing rim, then recorded in the field logbook. A surface water station was established in Elliott Bay, at the end of Pier 15.

Surface water elevation readings were obtained at the beginning and end of each round of water level measurements to document the amount of tidal fluctuation. An attempt was made to obtain water level measurements during periods of minimal tidal fluctuations, to minimize tidal effects on the measurements.

An additional groundwater level measurement event was performed in June 1994. Groundwater levels were measured in Texaco monitoring wells concurrent with groundwater level measurements at the Shell and ARCO facilities. During this event, water levels were measured at the Texaco facility in a similar fashion to the monthly monitoring events.

An oil/water interface probe was used to measure the depth to groundwater and to check for product in MW-208 and MW-209. These measurements were made before the wells were purged and sampled.

4.2.7 Groundwater Sampling and Analysis

Nineteen new and eight existing monitoring wells were sampled initially in early April 1993, after all the new wells had been installed and developed, in late June 1993, and in late September 1993. One additional, existing, off-site well was sampled in late June 1993 and in late September 1993. All but two of these 28 monitoring wells were also sampled in mid-December 1993. Two new monitoring wells that were installed in September 1994 (MW-208 and MW-209) were sampled in mid-September 1994.

During the first and second rounds of groundwater sampling, PID measurements were obtained in each well casing upon initial opening of the well. The probe of the PID was inserted into the well beneath the loosened well cap, and a measurement was made and recorded. While elevated PID readings were obtained from the casings of several of the wells, the breathing zone was not affected, and the measurements were not collected during the third and fourth sampling rounds.

Before purging, the depth to water in each monitoring well was measured to the nearest 0.01 of a foot, using an electric well probe or an oil/water interface probe. A transparent acrylic bailer was also dipped carefully into the well to check for the presence of floating product. If floating product was found, groundwater was not sampled in that well. During the second, third, and fourth rounds of sampling, acrylic bailers were also lowered to the bottom of each deep well to check for the presence of sinking product. No sinking product was found during the RI.

Each monitoring well was purged of at least three pore volumes of water, before sampling. Well purging was performed using a peristaltic pump fitted with new silicon and PVC tubing. During purging, field measurements of pH, specific conductance, temperature, dissolved oxygen, and turbidity were made and recorded after the removal of each well casing volume. The pH/conductivity meter, PID, turbidimeter, and

dissolved oxygen meter were calibrated before use each day and approximately every 4 hours thereafter. The field parameters were required to stabilize to within a ±10 percent difference between consecutive pore volume removals before obtaining a sample. During the initial round of sampling, an additional three replicate measurements of the field parameters were obtained from the last pore volume removed to check for variability in the field measurements. The readings were, however, found to be consistent, and this practice was discontinued for subsequent sampling rounds.

After stabilization of field parameters, groundwater samples were collected for the following analyses: BTEX and TPH-G by USEPA Method 5030/8020, TPH-D and TPH-O by the WTPH-D extended method, total and dissolved metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) by USEPA 200 series methods, total suspended solids (TSS) by USEPA Method 160.2, and total dissolved solids (TDS) by USEPA Method 160.1. In addition, during the first round of groundwater sampling only, samples were also collected for the following analyses: cPAHs by USEPA Method 8310, TOC by USEPA Method 415.1, ammonia nitrogen by USEPA Method 350.3, and nitrate/nitrite nitrogen by USEPA Method 353.2. During the fourth round of groundwater sampling, samples were also collected for the analysis of 1,2-dibromoethane (ethylene dibromide, EDB) and 1,2-dichloroethane (ethylene dichloride, EDC) by USEPA Method 8010, and methyl tertiary butyl ether (MTBE) by USEPA Method 8020. Groundwater samples collected from MW-208 and MW-209 were also analyzed for cPAHs, EDB, EDC, and MTBE by the USEPA methods previously noted. A list of groundwater samples collected and analyses performed on each is provided in Table C-2 (Appendix C).

Groundwater samples for metals, TDS, and TSS were collected from the discharge line of the peristaltic pump (before removal of the discharge line and after purging the well). Groundwater samples for BTEX, TPH, cPAHs, TOC, ammonia, and nitrate/nitrite were collected with a disposable bailer. Groundwater samples collected for dissolved metals testing were field filtered at the time of sample collection by using a disposable 0.45 micron, in-line filter. The disposable filters were attached directly to the discharge tube of a peristaltic pump. Each in-line filter was used only once. No other samples were filtered. All samples were transferred from the sampling equipment into a container prepared for the given parameters by the laboratory.

All reusable sampling equipment was decontaminated using the following procedure: (1) tap water rinse, (2) hexane rinse (if visibly stained with product), (3) tap water rinse, (4) Liquinox and tap water wash, (5) tap water rinse, and (6) distilled water rinse. The electric well probe was rinsed with distilled water between uses in different monitoring wells. Sampling personnel wore new neoprene or vinyl gloves at each sampling location. New bailer cord (monofilament nylon) and polyethylene tubing were used at each sampling location. Purge water and residual water and cleaning solutions from equipment decontamination were contained and managed as described in Section 4-4.

4.2.8 Floating Product Sampling, Analysis, and Removal

Floating product samples were collected from three monitoring wells, on-site monitoring well MW-6 (located on the northeast side of the employee building, see Drawing 1) and off-site monitoring wells A-28 and SH-04. Product samples (or product and water samples, if the amount of product in the well was insufficient for analysis) were collected with a disposable PVC bailer. The samples were handled consistent with the groundwater samples and were submitted to a laboratory for the analysis of total petroleum hydrocarbons by USEPA Method 8015 (modified) and lead by USEPA Method 7421. Product was removed from on-site monitoring well MW-6 using a clear PVC bailer or a peristaltic pump and was disposed of in an on-site storage tank.

4.2.9 Sample Handling and Designation

Samples were labeled, handled, and shipped using the procedure described in the work plan. Groundwater samples were labeled with the monitoring well designation and a date suffix, including month and year. For example, MW-101-493 represents the water sample collected from MW-101 in April 1993. Duplicate and rinsate blank samples were assigned fictitious groundwater sample names for submittal to the laboratory. Trip blanks were identified with a date suffix (i.e., TB-4-6-93). Samples were placed in a cooler on ice immediately after collection and were submitted to the laboratory within 24 hours. Sample custody was maintained until delivery to the laboratory.

4.2.10 QA/QC Samples

QA samples, including duplicates, equipment rinsate blanks, and trip blanks, were collected at the same frequency as for soil samples (Section 4.1.6). Duplicate samples were collected by alternately filling like containers until both containers were filled. Field rinsate blanks were collected by passing distilled water through the sampling equipment and collecting the rinsate blank using the same procedures as those used to collect the groundwater samples.

4.3 Aquifer Characterization

Aquifer characterization studies were performed in April and May 1993 and in September 1994. During both studies, Terra® pressure transducers and AquaStar® data loggers were used to measure and record water level changes. The data were downloaded using a portable personal computer (PC).

4.3.1 Tidal Response Studies

Two 72-hour tidal response studies were conducted. The first was conducted in April 1993, and the second was conducted in September 1994.

April 1993 Tidal Response Study. Nine monitoring wells and one point within Elliott Bay were used for a tidal response study conducted from April 27 to 30, 1993, over three complete tidal cycles. This time period had the greatest predicted range in tidal fluctuation for the month (over 12.5 feet). Nine monitoring wells were selected for the test; six shallow wells, including MW-102, MW-112, MW-202, MW-204, MW-206, and MW-05 (a previously installed USEPA monitoring well); and three deep wells, including MW-103, MW-205, and MW-06 (another monitoring well installed by USEPA). Several of the shallow monitoring well locations were selected based on their proximity to tidally affected surface water, while the remainder were selected to provide site-wide information. The deep monitoring wells were selected to provide site-wide information and to allow preparation of water level contour maps for the deeper portion of the aquifer at varying points during the tidal cycle.

Water levels within Elliott Bay were measured at the north (bay) end of Pier 15. A 6-inch-diameter, 14-foot length of slotted PVC pipe was secured to a ladder on the dock and served as a stilling well for the pressure transducer. A point was surveyed adjacent to the ladder directly above the stilling well; it served to calibrate transducer readings.

Before beginning the test, tide and groundwater elevations were measured to the nearest 0.01 of a foot with an electric well probe to allow correlation of the water levels. The water levels in Elliott Bay and in nine observation wells were measured and recorded every 10 minutes using pressure transducers and programmable electronic data loggers. The water level data were evaluated to determine the maximum elevation change in the aquifer and the attenuation and lag time of tidal response.

Upon analyzing the data, the output from the transducer employed to monitor well MW-103 was found to "drift" at a linear constant rate of about -0.2 of a foot per day. This transducer was redeployed with a "check" transducer in MW-103 to replicate the test conditions. The well response, along with the Elliott Bay tidal fluctuations, was monitored and recorded for an additional 2 days. The constant linear drift of the instrument was confirmed. The data were corrected for drift.

4.3.1 September 1994 Tidal Response Study

Four monitoring wells and one point within Elliott Bay were used for a tidal response study conducted from September 19 to 22, 1994. The test covered three complete tidal cycles and was timed to be performed as soon as possible after the installation of monitoring wells MW-208 and MW-209. The test was designed to determine the tidal influence on groundwater beneath the shoreline manifold area. Shallow monitoring wells

MW-206 and MW-208 and deep monitoring wells MW-205 and MW-209 were included in the test. Water levels in Elliott Bay were measured at the north (bay) end of Pier 15. A 1-inch-i.d., 20-foot length of PVC pipe was secured to a ladder on the dock and served as a stilling well for the pressure transducer. A surveyed point adjacent to the ladder served as an elevation reference.

Before beginning the test, tide and groundwater elevations were measured to the nearest 0.01 foot with an electric well probe to allow correction of the water levels. During the tidal response study, the water levels in Elliott Bay and in the monitoring wells were measured and recorded every 5 to 10 minutes using pressure transducers and programmable electronic data loggers. The water level data were evaluated to determine the maximum elevation change in the aquifer, the attenuation of tidal response, and the lag time of tidal response.

4.3.2 Hydraulic Conductivity Testing

The horizontal hydraulic conductivity of the aquifer was estimated by using a slug test method on selected monitoring wells. Six monitoring wells were selected, four shallow and two deep wells. The shallow monitoring wells used were MW-102, MW-109, MW-112, and MW-206. The deep monitoring wells used were MW-108 and MW-205. The wells were tested on May 3 and 13, 1993. The rising head slug test method, in which a slug of water is instantaneously removed from the well bore, was performed using either a new disposable PVC bailer, or a clean 10-foot section of 1-inch i.d. PVC pipe, capped and sealed on both ends and attached to monofilament line. The deep wells recovered so rapidly when using the disposable bailer that the PVC pipe was used to increase the drawdown, and hence the accuracy, of the slug test. The bailer displaced about 0.25 gallons, and the PVC slug-pipe displaced about 0.6 gallons.

The tests were conducted using the following procedure. The initial water level in the well was measured to the nearest 0.01 of a foot with an electronic well probe. A pressure transducer was placed in the well at a depth greater than that required for the complete submersion of the bailer or slug. The water level was monitored with the well probe, and the transducer reading was noted when the water level returned to its initial elevation. The bailer or slug was submerged in the well just below the surface, and the water level again was allowed to equilibrate. The electronic data logger was preprogrammed to take a reading every second for the first 3 minutes, every 2 seconds for the following 2 minutes, every 5 seconds for the following 3 minutes, every 10 seconds for the following 5 minutes, and every 30 seconds after that. The data logging sequence was started and allowed to run for about 15 seconds. The slug was removed from the well as quickly and as smoothly as possible to minimize disturbance. The transducer output was monitored on the screen of a portable PC until the water level recovered to at least 95 percent of the initial level. For most of the wells, this took less than 5 minutes. The test was then terminated, the data file verified with the PC, and the file saved to a floppy disk.

Due to the rapid recoveries observed, all wells were tested at least twice. The water level data were used to calculate hydraulic conductivity using methods described by Bouwer and Rice (1976).

4.4 Residuals Management

All drill cuttings and residual soil from hand auger drilling were contained in 55-gallon drums. Soils collected from 1.5 feet or less bgs were drummed separately from those collected from greater depths, due to the potential for elevated lead concentrations in shallow soil. Water generated during drilling, well development, sampling, and decontamination was kept separate, to the extent possible, from residual soil. Water was placed in separate 55-gallon drums. Hexane rinsate was collected separately during decontamination and allowed to evaporate on site in a shallow pan. Appropriate personal protective clothing was worn during residuals transfers because of potential skin contact and splash hazards. Disposable clothing and equipment items were placed in plastic bags and disposed of as solid waste.

The drums were sealed daily and moved to a fenced, on-site holding area located in the Texaco contractor's yard. The drums were labeled with the date filled, the sampling location, and a description of the contents. The drums were stored in the holding area until the contents were characterized, and the drums and contents were disposed.

5 SUBSURFACE EXPLORATION RESULTS

5.1 Site Geology

The sediment underlying the site consists of man-emplaced grade and dredge fill overlying natural estuarine deposits. A description of each material is provided below. Copies of the soil boring and monitoring well lithologic logs are included in Appendix B. Summaries of the results of physical soil analyses are presented in Table 5-1. Copies of the grain size distribution curves are included in Appendix D. Figure 5-1 presents a hydrogeologic cross section of the site. The location of the cross section is shown on Drawing 1.

5.1.1 Grade Fill

The uppermost unit occurring at the site is coarse-grained grade fill. This material was imported to provide a usable working surface or engineered subgrade. The grade fill varies from less than 1 foot to approximately 2 feet thick at the site; it consists of dark-brown to black medium-dense gravel or silty sandy gravel. Pieces of tile, asphalt, metal, and wood occasionally are found in the unit.

5.1.2 Dredge Fill

Hydraulically emplaced dredge fill underlies the grade fill throughout the site. The dredge fill, having originated from sediments in proximity to the site, closely resembles the underlying native estuarine deposits; therefore, delineation of the contact between the two units is difficult. Based on lithologic samples collected during drilling, the dredge fill appears to vary from approximately 8 to 20 feet thick at the site. The dredge fill typically consists of dark reddish- or grayish-brown, loose- to medium-dense, fine- to medium-grained sand, with trace to some gravel. Silt and silty sand interbeds occur within the unit. Results of grain size analysis of samples from this interval indicate that the fill included silty sand, poorly graded sand, and poorly graded sand with silt. In a number of drilling locations within the main tank farm and terminal, a gravel layer was encountered at a depth of approximately 2 feet bgs. This may represent a former grade fill layer, upon which additional fill was later added.

Table 5-1

Texaco Harbor Island Terminal
Remedial Investigation Report
Summary of Laboratory Analysis of Physical Soil Properties

Grain Size Analysis

Sample Number	Depth	Classificaiton	Description
MW-103-46	45.5-46	SM	Silty sand
MW-106-8	6.5-8	SP	Poorly graded sand
MW-107-12.5	12-12.5	SP-SM	Poorly graded sand with silt
MW-108-48	47-49	SP-SM	Poorly graded sand with silt
MW-110-8.0	6.5-8	SP	Poorly graded sand
MW-112-10.0	8.5-10	SP-SM	Poorly graded sand with silt
MW-112-14	15.25-16	SM	Silty sand
MW-205-7.0	5-7	SM	Silty sand
MW-205-50	49.5-50	ML	Silt with sand
MW-207-12.5	12-12.5	SM	Silty sand

Vertical Hydraulic Conductivity Values

Sample Number	Water Content (%)	Bulk Density		Hydraulic Conductivity (cm/sec)
		Wet (pcf)	Dry (pcf)	
MW-112-14	40	115	82	2×10^{-4}
MW-205-50	39	110	79	2×10^{-6}

Water Content, Bulk Density, and Porosity Values

Sample Number	Water Content (%)	Bulk Density		Porosity
		Wet (pcf)	Dry (pcf)	
MW-103-46	29	118	91	.46
MW-107-12.5	23	120	97	.42
MW-207-12.5	25	126	101	.40

Particle Density (Specific Gravity) Values

Sample Number	Specific Gravity
MW-106-8	2.69
MW-112-14	2.68
MW-205-50	2.64

5.1.3 Estuarine Deposits

Native estuarine deposits underlie the dredge fill at depths of approximately 9 to 15 feet. This unit extends to depths of more than 50 feet, the greatest depth explored as a part of this study. The estuarine deposits are composed primarily of sand with silt interbeds. Silt interbeds encountered during drilling ranged from less than 1 inch to approximately 6 inches thick. Organic matter was occasionally encountered up to the maximum depth explored. The fine- to medium-grained sand varies from dark reddish-brown to grayish-brown and is medium dense, poorly graded, and subrounded to subangular. Grain size analyses of samples collected from depths between 40 and 50 feet bgs indicated that the materials consisted of silty sand, poorly graded sand with silt, and silt with sand (from a thin silty layer in MW-205).

5.2 Site Hydrogeology

5.2.1 Hydrostratigraphic Units

Grade Fill. As described in Section 5.1.1, the site is underlain by fill material composed primarily of silty sandy gravel. The fill is permeable and allows precipitation to penetrate to deeper units. The grade fill unit was generally unsaturated during the RI. Following rainfall events, water ponded in a few low areas underlain by less permeable materials.

Dredge Fill. Dredge fill underlies the grade fill and occurs beneath the entire site. The unit is predominantly composed of fine- to medium-grained sand with silt interbeds. A geologic description is provided in Section 5.1.2. Groundwater in the dredge fill is unconfined. The water table occurs within the dredge fill at depths generally ranging from 4 to 8 feet bgs and, except in the shoreline manifold area, is generally unaffected by tides. Seventeen new monitoring wells were completed within the dredge fill and screened from depths of approximately 5 to 15 feet bgs. The dredge fill unit is recharged by surface infiltration of precipitation. The dredge fill unit discharges to the unit below and to the surrounding bay and waterways.

Estuarine Deposits. The natural estuarine deposits underlie the entire island and consist of fine- to medium-grained sand with silt interbeds, as described in Section 5.1.3. This unit generally occurs at a depth of approximately 15 feet under the Texaco site. The estuarine deposits are fully saturated and unconfined. Four monitoring wells were completed within this unit with screens extending from approximately 40 to 50 feet bgs. Water quality and water elevations within this unit are influenced by the surrounding Elliott Bay and East and West Waterways and by associated tidal fluctuations.

5.2.2 General Groundwater Chemistry

Texaco RI Field Parameters. Specific conductance, pH, temperature, and dissolved oxygen were measured during groundwater sampling. Groundwater from shallow monitoring wells screened within the dredge fill and the uppermost portion of the estuarine deposits generally had a considerably lower specific conductance than that from deep monitoring wells screened within the deeper portion of the estuarine deposits. Specific conductance measurements of groundwater samples collected in north tank farm and main terminal shallow monitoring wells generally ranged from 200 to 500 μS/cm. Specific conductance measurements of groundwater samples collected in north tank farm and main terminal deep monitoring wells for the same period generally ranged from 1,000 to 2000 μS/cm. The pH measurements of groundwater samples obtained from shallow monitoring wells were commonly less than the pH readings of groundwater samples taken from deep wells. Shallow monitoring well samples had pH readings ranging from 5.47 to 8.61, while the pH of samples from deep wells ranged from 7.19 to 9.13. In paired wells, the temperature of shallow groundwater samples was generally at or below the temperature of deep groundwater samples in the April and June 1993 sampling events; the temperature of shallow groundwater samples was above the temperature of deep groundwater samples in the September and December 1993 sampling events. The temperatures of shallow groundwater samples ranged from 10.1° C to 25° C. The temperatures of deep groundwater samples ranged from 12.8° C to 18.3° C. The groundwater samples dissolved oxygen measurements were all below 2.3 mg/L. The field water quality measurements are summarized in Table E-1 (Appendix E).

Major Ion Chemistry. The major ion chemistry was determined by the USEPA for groundwater samples collected from monitoring wells on and adjacent to the Texaco property in November 1991 and March/April 1992. The samples were collected from shallow monitoring wells MW-05, SH-04, TX-01, TX-02, TX-03, TX-04, and TX-06 and deep monitoring wells DP-01, DP-06, and MW-06. Trilinear (Piper) diagrams are often used to provide a convenient graphic presentation of large numbers of geochemical analyses. These analyses are typically performed in order to differentiate groundwaters originating from unique sources, or to define hydrogeochemical facies within an area (Freeze and Cherry, 1979). The method assumes that the geochemistry of the system is represented by major ion chemistry. Anions analyzed include alkalinity (carbonate and bicarbonate), chloride, and sulfate. Cations analyzed include calcium, magnesium, potassium, and sodium. Figures 5-2 and 5-3 present trilinear plots of the major ion chemistry.

For these analyses, the reported value for alkalinity was assumed to represent only bicarbonate, as it would be unusual to have significant carbonate in solution at the pHs reported for these samples. Samples were analyzed by computing the percent contribution of the listed cations and anions as milliequivalents per liter (meq/L), calculated from constituent concentrations reported as milligrams per liter (mg/L) or micrograms per liter (μg/L). Results have not been evaluated for potential analytical

variations. However, the charge balance for each sample was calculated. A charge balance error exceeding 5 percent indicates that either significant concentrations of ionic species other than those used for trilinear diagram presentation were present or an analytical error may have occurred. For the November 1991 samples, charge balance errors ranged from 1.4 to -63.2 percent. Only samples from DP-01 and TX-02 had charge balance errors of 5 percent or less. For the March/April 1992 samples, charge balance errors ranged from -1.4 to 34.9 percent. Only the sample from SH-04 had a charge balance error of 5 percent or less. The source of charge balance error(s) for these samples is unknown.

Results for shallow wells indicate that shallow groundwater sampled during both rounds was generally of the bicarbonate type. Either no cation dominated, or calcium or magnesium dominated. Seasonal variations were generally minor. The geochemistry of groundwater sampled from MW-05 during March/April 1992 was atypical of the shallow system in that significant sulfate (130 mg/L, or 3 meq/L) was detected. For this event, sulfate contributed 59 percent of the total calculated anions. The source of this variation is unknown. Potential causes include a localized sulfate source in the area or analytic error.

Results for deep wells indicate that deep groundwater sampled during both rounds was generally of the bicarbonate or chloride type. The contribution from chloride generally increased with proximity to the shoreline. Sodium and potassium were consistently dominant cations. Seasonal variations were generally minor. Deep groundwater samples consistently contained significantly higher concentrations of sodium and potassium than shallow groundwater samples.

5.2.3 Freshwater-Saltwater Interface

The interface between freshwater and saltwater is typically based on the groundwater salinity. Salinity can be represented by measurements of total dissolved solids (TDS), chloride, or specific conductance. Table 5-2 presents a widely used groundwater classification system based on salinity (Freeze and Cherry, 1979; Todd, 1980).

Table 5-2

Groundwater Classification

Groundwater Classification	Total Dissolved Solids (mg/L)
Fresh	0 - 1,000
Brackish	1,000 - 10,000
Saline	10,000 - 100,000
Brine	>100,000
Note: The TDS of seawater is about 35,000 mg/L (Freeze and Cherry, 1979).	

Since fresh groundwater is less dense than saline groundwater, fresh groundwater floats on top of saline groundwater. The thickness of the interface between freshwater and saline water (i.e., brackish water) can vary from less than 10 feet to over 300 feet (Todd, 1980) and depends on the amount of mixing between fresh and saline water.

The depth to the freshwater-saltwater interface can be estimated using the Ghyben-Herzberg relation (Freeze and Cherry, 1979; Todd, 1980). Assuming a fairly thin freshwater-saltwater interface, hydrostatic conditions, and a homogeneous, unconfined, coastal aquifer: $z = 40h$, where z is the depth below mean sea level of the freshwater-saltwater interface, and h is the elevation of the water table above mean sea level. The relation provides satisfactory estimates where groundwater flow is predominantly horizontal. Given the ranges in groundwater elevations presented in Section 5.2.4, the Ghyben-Herzberg relation estimates the depth to the freshwater-saltwater interface to be about 75 feet below the shoreline manifold area, from 90 to 170 feet below the north tank farm, from 120 to 200 feet below the northern part of the main terminal, and from 80 to 170 feet below the southern part of the main terminal.

The TDS results of all shallow monitoring wells in and around the main terminal and north tank farm were below 1,000 mg/L. The average TDS result in groundwater collected from MW-108 was also below 1,000 mg/L. Groundwater in these wells is thus classified as fresh. The TDS results of groundwater samples collected from shallow monitoring well MW-208 (located at the shoreline manifold area) and deep monitoring wells DP-06, MW-06, MW-103, MW-205, and MW-209 were between 1,000 and 5,000 mg/L. Groundwater in these wells is thus classified as brackish.

Figure 5-4 presents the salinity measured in shallow and deep monitoring well pairs during the Texaco RI and the salinity measured in deep monitoring wells adjacent to the Texaco site in the USEPA Phase II RI. During the Texaco RI, salinity was measured by analyzing groundwater samples from the completed wells for TDS. During the USEPA Phase II RI (Figure 5-4 plots of DP-01 and DP-06), the salinity of groundwater samples was measured with a meter during drilling of the wells. As shown on Figure 5-4, salinity generally increased with depth. The exception was the recently installed well pair MW-208 and MW-209. As the effects of drilling and installing these wells on groundwater quality parameters diminishes with time, the TDS of groundwater in these wells may change. As shown on Figure 5-4, it appears that the top of the interface between fresh and saline groundwater occurs between the depths of 30 and 50 feet. Only well DP-01 (located northwest of the north tank farm) penetrated the bottom of the freshwater-saltwater interface, at a depth between 75 and 80 feet. The thickness of the freshwater-saltwater interface at this location is about 35 feet.

5.2.4 Groundwater Elevations

Texaco RI groundwater level measurements obtained from April 1993 through March 1994 and in June and September 1994 are presented in Appendix F (Table F-1) and are summarized in Table 5-3. Groundwater level measurements obtained at the Shell and ARCO facilities in the June 1994 water level event are presented in Table F-2 (Appendix F). Depth to the unconfined groundwater surface ranged from approximately 7 to 9 feet bgs beneath the north tank farm, and from approximately 4.5 to 7 feet bgs beneath the main tank farm. Depth to groundwater was about 7 feet bgs in the shoreline manifold area in September 1994. Depth to groundwater was greater in the north tank farm due in part to the slightly higher ground elevations in that area.

During the period of measurement, water elevations within on-site wells monitoring the shallow dredge fill ranged from 1.64 (MW-208) to 4.87 (TX-06). Groundwater elevations are relative to the National Geodetic Vertical Datum of 1929 (NGVD), which is roughly equivalent to mean sea level. The highest groundwater elevations were in and around the main tank farm. The lowest groundwater elevations were in the shoreline manifold area, the northwest part of the north tank farm, and southeast portion of the site. Groundwater elevations in shallow monitoring well MW-109 were abnormally low throughout the monitoring period. The cause of the low elevations is not known. However, it is possible that buried sewer lines, drain lines, or the warehouse foundation is causing a groundwater low in this area.

Groundwater elevations in deep wells monitoring the estuarine deposits (at a depth of approximately 50 to 70 feet bgs) ranged from 1.09 (MW-209) to 4.38 (MW-06). Groundwater elevations in the deep wells were generally lower than those in the shallow wells, indicating a downward component of groundwater flow.

Appendix F provides hydrographs for monitoring wells on and adjacent to the terminal. As indicated on the hydrographs, groundwater elevations varied seasonally during the period of measurement. In general, groundwater elevations were highest in wells across the site in late spring and were lowest in late fall. The seasonal trends are likely due to the infiltration and percolation of winter precipitation. These trends were less pronounced in the deeper wells, which, as discussed below, were subject to the influence of tides.

5.2.5 Tidal Influence

April 1993 Tidal Response Study. One location in Elliott Bay, six shallow monitoring wells, and three deep monitoring wells were monitored for 3 days to observe tidally influenced groundwater fluctuations. During the period of the study, Elliott Bay maximum highs and lows were approximately -0.9 and +11.6 feet relative to the mean lower low water datum), respectively, with a measured tidal range of approximately 10 to 12 feet. Compared to published times for Seattle tides, measured water level maximums

Table 5-3

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Summary of Groundwater Levels (4/93-3/94)

Well	Depth to Groundwater Range	Groundwater Elevation Range	Month of Groundwater High	Month of Groundwater Low
Shallow Wells				
MW-101	12.14 - 10.32	3.00 - 4.82	05/93	12/93
MW-102	9.62 - 7.80	2.89 - 4.71	06/93	11/93
MW-104	7.26 - 5.85	2.96 - 4.37	06/93	11-12/93
MW-105	6.28 - 4.83	2.77 - 4.22	06/93	11/93
MW-106	6.53 - 4.98	2.86 - 4.41	06/93	11/93
MW-107	10.26 - 8.83	2.83 - 4.26	05/93	11/93
MW-109	6.21 - 4.95	1.80 - 3.06	04/93	11/93
MW-110	5.70 - 4.45	2.76 - 4.01	06/93	11/93
MW-111	5.97 - 4.84	2.64 - 3.77	06/93	11/93
MW-112	7.56 - 6.51	2.42 - 3.47	06/93	11/93
MW-201	15.03 - 12.53	2.04 - 4.54	04/94	11/93
MW-202	14.48 - 13.17	2.29 - 3.60	05/93	11/93
MW-203	8.65 - 7.31	2.39 - 3.73	05/93	11/93
MW-204	12.03 - 10.92	2.18 - 3.29	05/93	11/93
MW-206[a]	8.17 - 6.72	2.58 - 4.03	05/93	12/93
MW-207	7.78 - 6.38	2.60 - 4.00	05/93	12/93
MW-208	6.97[b]	1.64[b]	—	—
A-23[c]	8.42 - 7.29	2.26 - 3.39	01/94	11/93
A-28	8.50 - 7.54	2.18 - 3.14	03/94	10/93
AR-04[c]	8.28 - 6.49	2.98 - 4.77	06/93	11/93
MW-05	7.42 - 5.92	2.97 - 4.47	05/93	11/93
MW-2[c]	8.39 - 6.48	2.97 - 4.88	03/94	11/93
MW-6[c]	8.40 - 5.19	1.10 - 4.31	06/93	11/93
SH-04[c]	10.88 - 9.72	2.04 - 3.20	03/94	11/93
TD-05[c]	9.43 - 7.83	2.25 - 3.85	03/94	11/93
TES-MW-1	10.20 - 8.61	2.90 - 4.49	05/93, 03/94	11/93
TX-03	6.91 - 5.50	2.67 - 4.08	06/93	11/93
TX-04	11.51 - 9.74	2.85 - 4.62	03/94	11/93
TX-06[c]	5.54 - 3.71	3.04 - 4.87	06/93	11/93
Deep Wells				
MW-103	11.08 - 9.66	1.26 - 2.68	03/94	10/93
MW-108	11.46 - 9.98	1.40 - 2.88	03/94	10/93
MW-205	12.80 - 11.60	1.30 - 2.50	04/93	08/93
MW-209	7.78[b]	1.09[b]	—	—
DP-06	12.94 - 11.75	1.31 - 2.50	03/94	09/93
MW-06	9.11 - 6.36	1.63 - 4.38	02/94	07/93

NOTE: Depth relative to top of PVC, elevations relative to NGVD (1929).
[a] Not including 4/93 reading which was in error.
[b] Static water level measured once after well development.
[c] Missing at least 2 monthly water level measurements for the period April 1993 through March 1994.

ranged from about 30 to 50 minutes earlier, and minimums ranged from about 10 to 30 minutes earlier. Observed tide elevations were similar to those published for Seattle. The amplitude (half-range) of the tides within Elliott Bay fluctuated approximately 5.8 feet, on average, over a tidal cycle.

Observed fluctuations in groundwater elevations in the six shallow wells ranged from essentially nondetectable to about 0.07 of a foot. Discrete tidal cycles could not be observed in any of the shallow wells monitored during this study; therefore, further discussion of tidal effects is focused on data obtained from the deep monitoring wells.

Graphs of the water level data are included in Appendix F. A summary of the tidal response study results is presented in Table 5-4. Groundwater amplitudes in the deep monitoring wells varied from 0.09 of a foot to 0.31 feet. The amplitude of water level fluctuation over a tidal cycle in a well (groundwater amplitude) was divided by the amplitude of water level fluctuation over the same tidal cycle in Elliott Bay (tidal amplitude), to provide the tidal response or efficiency. The calculated tidal efficiencies ranged from a low of 1.7 percent in MW-205 to a high of 5.4 percent in MW-103. The observed time lags, or the time delay for well water level fluctuations with respect to tidal fluctuations, ranged from 240 to 404 minutes (4 to 7 hours) and generally increased with distance from the shoreline. Values for the distance from the shoreline divided by the lag time ranged from 1.8 feet per minute (ft/min) in MW-103 to 4 ft/min in MW-06.

September 1994 Tidal Response Study. One location in Elliott Bay, two shallow monitoring wells, and two deep monitoring wells were monitored for 3 days to observe tidally influenced groundwater fluctuations. Elliott Bay maximum highs and lows during the study were about +5.2 and -5.1 feet (NGVD), respectively. The measured tidal range was about 8 to 10 feet. The amplitude (half-range) of the tides within Elliott Bay fluctuated approximately 4.8 feet on average, over a tidal cycle.

Graphs of the water level data are included in Appendix F. A summary of the tidal response study results is presented in Table 5-4. The observed fluctuations in MW-206 groundwater levels ranged between 0.1 and 0.2 feet. Due to the small tidal response and the noise in the data, no correlation could be seen between the MW-206 tidal response curve and Elliott Bay tides. Groundwater amplitudes in the shallow monitoring well at the shoreline manifold area (MW-208) ranged from 0.14 to 0.17 feet. The tidal efficiencies in MW-208 varied from 2.9 to 3.7 percent. The observed time lag for MW-208 water level fluctuations with respect to tidal fluctuations ranged from 20 to 84 minutes. Values for the distance from shoreline divided by the lag time ranged from 0.25 to 1.05 ft/min.

Groundwater amplitudes in the two deep monitoring wells ranged from 0.06 to 0.09 feet in MW-205 and from 1.35 to 1.62 feet in MW-209. The tidal efficiencies varied from 1.3 to 1.9 percent in MW-205 and from 28 to 33 percent in MW-209. The observed time lag for water level fluctuations with respect to tidal fluctuations ranged from 218 to

Table 5-4

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Tidal Response Study Results

Tide Event	Well Number	Tidal Amplitude, Elliott Bay (ft)	Groundwater Amplitude, in Well (ft)	r (ft)	TE (%)	LAG (min)	r/LAG (ft/min)
April 27	MW-06	6.22	0.21	1,340	3.3	404	3.3
	MW-103		0.29	540	4.6	288	1.9
	MW-205		0.175	600	2.8	240	2.5
April 28	MW-06	5.72	0.175	1,340	3	371	3.6
	MW-103		0.31	540	5.4	292	1.8
	MW-205		0.16	600	2.8	289	2.1
April 29	MW-06	5.4	0.11	1,340	2	334	4
	MW-103		0.26	540	4.8	290	1.9
	MW-205		0.09	600	1.7	270	2.2
September 19	MW-205	4.93	0.09	600	1.9	240	2.5
	MW-208		0.17	21	3.5	73	0.29
	MW-209		1.62	22	32.8	63	0.35
September 20	MW-205	4.56	0.08	600	1.7	225	2.7
	MW-208		0.17	21	3.7	75	0.28
	MW-209		1.50	22	32.8	40	0.55
September 21	MW-205	4.79	0.06	600	1.3	218	2.8
	MW-208		0.15	21	3.0	20	1.05
	MW-209		1.35	22	28.2	15	1.47
September 22	MW-205	4.90	0.09	600	1.8	373	1.6
	MW-208		0.14	21	2.9	84	0.25
	M2-209		1.58	22	32.2	79	0.28

NOTE: r = Distance from shoreline.
TE = Apparent tidal efficiency; amplitude of water level fluctuation over a tidal cycle in a well, divided by amplitude of water level fluctuation over the same tidal cycle in Elliott Bay.
LAG = Time delay of water level fluctuation with respect to tidal fluctuation, in minutes.

373 minutes in MW-205 and from 15 to 79 minutes in MW-209. Values for the distance from shoreline divided by the lag time ranged from 1.6 to 2.8 ft/min in MW-205 and from 0.28 to 1.47 ft/min in MW-209. The average groundwater elevations in MW-208 and MW-209 during the tidal response study were 1.67 and 1.25 feet (NGVD), respectively.

The September 19, 1994, data were evaluated to determine the amount of groundwater flow at the shoreline manifold area due to tidal fluctuations. The September 19 data were put into two categories: (1) periods of the day in which the water elevation in Elliott Bay was greater than the groundwater elevation in MW-208 (about 13.3 hours) and (2) periods of the day in which the groundwater elevation in MW-208 was greater than the water elevation in Elliott Bay (about 10.8 hours). The average water elevations in Elliott Bay and MW-208 were calculated for each time period. In the analysis, it was conservatively assumed that the shoreline bulkhead did not affect groundwater flow. Based on an average aquifer hydraulic conductivity of 1×10^{-2} cm/sec, a porosity of 40 percent, and a distance of 21 feet between MW-208 and Elliott Bay, it was calculated that groundwater at the shoreline flowed 2.7 feet from Elliott Bay towards MW-208 during the 13.3 hours of September 19 that the water elevation was greater in Elliott Bay than in MW-208. Groundwater was estimated to flow 6.4 feet from MW-208 towards Elliott Bay during the 10.8 hours of September 19 that the water elevation was greater in MW-208 than in Elliott Bay.

5.2.6 Hydraulic Conductivity

The horizontal hydraulic conductivity of the dredge fill and estuarine sediments was estimated by use of short-term in situ rising head tests (slug tests). The vertical hydraulic conductivity of the dredge fill and estuarine sediments was measured from laboratory permeameter tests on undisturbed core samples. Graphs of slug test data and calculations used to estimate hydraulic conductivity are presented in Appendix G. Summaries of the vertical and horizontal hydraulic conductivity results are presented in Tables 5-1 and 5-5, respectively. Horizontal hydraulic conductivities for the tested wells fell within the range of expected values for sand and silty sand aquifers (Freeze and Cherry, 1979) and the range of values estimated from grain size curves and aquifer tests by the USEPA (Weston, 1993).

Dredge Fill. Slug tests were performed in four shallow monitoring wells: MW-102, MW-109, MW-112, and MW-206. The horizontal hydraulic conductivity estimated from the slug tests ranged from 2.5×10^{-3} to 3.8×10^{-2} centimeters per second (cm/sec), with an arithmetic mean of 1.9×10^{-2} cm/sec (Table 5-5). Laboratory vertical hydraulic conductivity measurements were obtained on one sample collected from the monitoring well MW-112 borehole at a depth of 14 feet bgs (within the screened interval). The laboratory-determined vertical hydraulic conductivity of this silty sand was 2×10^{-4} cm/sec. Based on the limited data available, the vertical hydraulic conductivity

Table 5-5

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Horizontal Hydraulic Conductivity Test Results

Well Number	Hydraulic Conductivity (cm/sec)	Average of Multiple Tests
Shallow Monitoring Wells		
MW-102	2.6×10^{-2} 2.8×10^{-2}	2.7×10^{-2}
MW-109	2.5×10^{-3} 2.9×10^{-3}	2.7×10^{-3}
MW-112	3.6×10^{-2} 3.8×10^{-2}	3.7×10^{-2}
MW-206	1.0×10^{-2} 1.0×10^{-2}	1.0×10^{-2}
Minimum	2.5×10^{-3}	
Maximum	3.8×10^{-2}	
Arithmetic Mean	1.9×10^{-2}	
Deep Monitoring Wells		
MW-108	4.4×10^{-2} 6.1×10^{-2}	5.2×10^{-2}
MW-205	1.6×10^{-2} 1.5×10^{-2}	1.6×10^{-2}
Minimum	1.5×10^{-2}	
Maximum	6.1×10^{-2}	
Arithmetic Mean	3.4×10^{-2}	

was found to be approximately two orders of magnitude lower than the horizontal hydraulic conductivity in the dredge fill unit.

Estuarine Deposits. The horizontal hydraulic conductivity within the estuarine deposits was estimated through performance of slug tests in deep monitoring wells MW-108 and MW-205. Horizontal hydraulic conductivity estimates ranged from 1.5×10^{-2} to 6.1×10^{-2} cm/sec, averaging 3.4×10^{-2} cm/sec (Table 5-5). Laboratory vertical hydraulic conductivity measurements were performed on one sample collected from the monitoring well MW-205 borehole at a depth of 50 feet (within the screened interval). The vertical hydraulic conductivity of this sandy silt was 2×10^{-6} cm/sec.

Transmissivity. Transmissivity, defined as the rate of water transmission through a unit width of aquifer under a unit hydraulic gradient, is calculated by multiplying the hydraulic conductivity by the thickness of the aquifer. The average hydraulic conductivity of the slug tests performed in the dredge fill and the estuarine deposits was 2.4×10^{-2} cm/sec, or 2.4×10^{-4} m/sec. Based on this average hydraulic conductivity and an estimated aquifer thickness beneath the site of 45 to 70 feet, the transmissivity of the aquifer is about 3.3×10^{-3} m^2/sec (286 m^2/day or 23,000 gallons/day/ft) to 5×10^{-3} m^2/sec (445 m^2/day or 35,800 gallons/day/ft).

5.2.7 Porosity

The porosity of three soil samples was determined by laboratory analysis. Two samples were from the screened zone of shallow monitoring wells (samples MW-107-12.5 and MW-207-12.5), and one was from the screened zone of a deep monitoring well (MW-103-46). Porosity results for the two shallow soil samples were 0.40 and 0.42. The porosity for the deep soil sample was 0.46. These values are on the higher end of published estimated porosity values for silty sand.

5.2.8 Groundwater Flow Directions

Drawings 2 and 3 present shallow groundwater contour maps using data obtained on June 10, 1993, and November 7, 1993 (Table F-1). The estimated shallow groundwater flow directions at the site were to the north-northwest and to the south-southeast from a water table high located around the main tank farm. Shallow groundwater contour maps prepared from data collected in other months of the monitoring period appear similar to those prepared from the June and November data. Estimated horizontal gradients from Drawings 2 and 3 are about 0.002 feet/foot to the north-northwest in the northern portion of the site, 0.001 to 0.003 feet/foot to the north and south near the main tank farm, and from 0.001 to 0.004 feet/foot to the south-southeast in the southern portion of the site. Near MW-109, inward horizontal gradients of up to 0.04 feet/foot are estimated. Estimates of shallow groundwater flow directions obtained from the Texaco RI are consistent with those reported by the USEPA (Weston, 1993).

Drawing 4 presents a shallow groundwater contour map using data collected on June 7, 1994, from the ARCO, Shell, and Texaco terminals. The general pattern of groundwater contours at the Texaco Terminal during this event was similar to previous groundwater level measurement events. The estimated shallow groundwater flow directions at the Texaco Terminal were to the north-northwest and to the south-southeast from a water table high located around the ARCO, Shell, and Texaco tank farms.

Drawing 5 presents a deep groundwater contour map based on the average groundwater elevations obtained during the tidal response study conducted between April 27 and April 30, 1993. A simple arithmetic average of data collected during the same time period was used. Groundwater elevations were averaged to remove the effect of tidal fluctuations and allow the comparison of groundwater elevations from different wells. For this period, the estimated deep horizontal flow direction was to the west, and the estimated horizontal gradient was 0.0008 feet/foot.

Maximum and minimum groundwater elevation differences between shallow and deep monitoring well pairs were as follows: 2.41 and 1.19 feet for MW-102/MW-103 on 5/93 and 11/93, respectively; 2.05 and 0.75 feet for MW-107/MW-108 on 8/93 and 12/93, respectively; 1.47 and 0.32 feet for MW-204/MW-205 on 8/93 and 12/93, respectively; 2.53 and -0.53 feet for MW-05/MW-06 on 7/93 and 2/94, respectively; and 2.23 and 1.06 feet for TX-04/DP-06 on 5/93 and 12/93, respectively. The average elevation difference in MW-208 and MW-209 during the September 1994 tidal response study was 0.42 feet. The downward hydraulic gradient varied from 0.009 to 0.069 feet/foot.

5.2.9 Conceptual Hydrologic Model

The USEPA (Weston, 1993) developed a conceptual hydrologic model for Harbor Island (Figure 5-5). The model and the related Texaco RI data are discussed below.

The USEPA model includes a freshwater lens of groundwater overlying saline groundwater. The thickness of the freshwater lens varies from greater than 85 feet in the center of the island to approximately 35 feet near the edge of the island. The freshwater/saltwater interface is generally less than 10 feet thick. Monitoring wells on and adjacent to the Texaco Terminal that were monitored during the Texaco RI are less than 70 feet deep. Groundwater specific conductances increased with depth in the Texaco RI wells, but the deeper Texaco RI monitoring wells did not penetrate the base of the freshwater/saltwater interface. Based on groundwater specific conductances from the Texaco monitoring wells, groundwater beneath the facility at the explored depth range is fresh to brackish.

The USEPA model indicates that groundwater elevations are highest near the center of the island and lowest near the island perimeter. Groundwater elevations measured during the Texaco RI were highest near the center (unpaved) part of the facility and lowest at

the shoreline manifold area, towards the northwest part of the north tank farm, and in the southeast part of the Texaco property.

According to the USEPA model, tidal fluctuations affect groundwater elevations near the edge of the island. The effects are greatest within approximately 200 to 500 feet of the shoreline. The only shallow monitoring well monitored during the Texaco RI that showed significant tidally-induced fluctuations was located in the shoreline manifold area, 21 feet from Elliott Bay. Tidal fluctuations were minimal in the north tank farm and main terminal shallow monitoring wells monitored during the Texaco RI, consistent with the USEPA hydrologic model.

Groundwater is recharged, according to the USEPA model, by the infiltration and percolation of rainfall through unpaved surfaces, most of which are located near the center of the island. The pattern of Texaco RI groundwater elevations discussed above is indicative of rainfall infiltration and percolation through the unpaved surfaces at the Texaco Terminal.

The USEPA model indicates that groundwater generally flows from the center of the island to the perimeter (Figure 5-6). However, about 30 percent of the island drains to a sink or sinks in the center part of the island. The groundwater flow directions inferred from the Texaco RI groundwater data were away from the main tank farm, consistent with the USEPA hydrologic model. Groundwater beneath the southeastern part of the Texaco Terminal flows towards the center part of the island, consistent with the existence of a sink or sinks in that area.

In summary, the data collected during the Texaco RI support the USEPA conceptual hydrologic model. The main components of the USEPA conceptual site model include a freshwater lens of groundwater overlying saline groundwater, localized tidal influences, groundwater recharge near the center of the island, and groundwater flow from the center of the island to either the island perimeter or sinks in the center of the island.

6 NATURE AND EXTENT OF SOIL CONTAMINATION

Soil samples for chemical analysis were collected from 9 surface soil locations, 44 soil borings (5 to 8 feet deep) and 16 shallow (15 feet deep) monitoring well boreholes, as described in Sections 4.1.1 and 4.1.2. Two to three soil samples were collected from each soil boring, typically from depths of 0.5 to 1.5 feet, 2 to 3 feet, 4 to 5 feet, or 6.5 to 8 feet. Two to three soil samples were collected from each monitoring well borehole from depths of 0.5 to 1.5 feet, 2 to 3 feet, or 4 to 5.5 feet. Almost all of the soil samples were analyzed for BTEX, TPH-G, TPH-D, and TPH-O. Most of the samples, with the exception of the deepest ones (obtained from the soil borings), were analyzed for metals. Select samples were also analyzed for cPAHs, PCBs, and TOC, as described in Section 4.1.4. Results of the analyses are presented in Tables D-1 through D-5 in Appendix D. Sixteen surface soil samples were collected on the Texaco Terminal during the USEPA RI. Five soil samples for chemical analysis were also collected from one shallow monitoring well boring (MW-05) during the USEPA RI. Results of the USEPA analyses are presented in Appendix D.

For ease of discussion, sampling depths are referred to as ranges of 0.5 to 1.5 feet bgs, 2 to 3 feet bgs, 4 to 5.5 feet bgs, and 6.5 to 8 feet bgs. Actual sampling intervals varied slightly from those ranges in some locations. The tops of the actual intervals sampled are reported in Tables D-1 through D-5 in Appendix D.

General detection limits for each parameter are provided in the following discussions. Sample detection limits were within the ranges noted, except for an occasional sample which required dilution or in which some interference was observed. Actual detection limits for each sample parameter not detected are listed in Appendix D. All soil sample data received from the laboratory were reviewed and validated, before entry into a computer database. A discussion of the procedures used is provided.

6.1 Data Validation and Management

All sample data received from the laboratory were reviewed to determine compliance with data quality objectives (DQOs) as specified in the Sampling and Analysis Plan (SAP). The data were reviewed according to procedures specified in the SAP, and following data validation guidelines in *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics and Organics Analyses* (USEPA, 1988a,b). Data that did not meet DQOs were assigned data qualifiers to restrict or modify appropriate uses. Details

on data validation are presented in the data validation report (Appendix H). The only laboratory-assigned data qualifier was a less than (<) symbol, indicating the analyte was not detected at the method detection limit shown. Data qualifiers assigned during data validation review were as follows:

- U—The material was analyzed for, but was not detected. The associated numerical value is the method detection limit.
- J—The associated value is an estimated quantity.
- R—The data are unusable; an analyte may or may not be present. Resampling and reanalysis are necessary for verification.
- UJ—The material was analyzed for, but was not detected. The associated numerical value is the estimated method detection limit.
- B—The analyte was also detected in the associated field blank. The concentration is an estimated quantity.

Data were judged to meet DQOs for precision, accuracy, representativeness, and comparability. All sample analyses except soil PCBs met the DQO for completeness of 99 percent. The completeness for soil PCB analyses was 88 percent due to the omission of the analysis of one of eight samples. The omission of the analysis of this sample was not judged to impact the RI conclusions adversely.

All data were entered into a personal-computer-compatible database after validation using standardized repeatable procedures. Most data were entered directly into the database from electronic deliverables. Some data were hand entered into the database. A 100 percent check for accuracy was performed on all data that were hand-entered into the database.

6.2 Surface Soil

Nine surface soil samples (SS-101, SS-103 through SS-108, SS-201, and SB-131-0) were collected and analyzed during the Texaco RI. Sixteen surface soil samples (BH-05, or MW-05, TX-01, TX-02, TX-06, TX-07, TX-10, TX-12, TX-14 through TX-18, TX-20, TX-22, TX-23, and TX-25) were collected and analyzed at the Texaco Terminal during the USEPA RI. Texaco RI surface soil samples were analyzed for arsenic and lead. USEPA surface soil samples were analyzed for a full suite of metals. One USEPA surface soil sample (MW-05) was also analyzed for semivolatile organic constituents (SVOCs) and pesticides/PCBs, and one USEPA surface soil sample (TX-20) was also analyzed for TPH-O, SVOCs, and pesticides/PCBs.

6.2.1 Inorganic Constituents

Aluminum was detected in all 16 USEPA RI samples. Concentrations of aluminum ranged from 4,140 (BH-05 or MW-05) to 38,800 mg/kg (TX-01 and TX-25). Antimony was detected in 9 of 16 USEPA RI samples, ranging from less than the detection limit of 6 mg/kg to 68 mg/kg (TX-17). Arsenic was detected in all but two samples and ranged from below a detection limit of 1 mg/kg (TX-22) to 92.5 mg/kg (TX-17) (Figure 6-1 shows the distribution of arsenic in surface soil). Barium was detected in 15 of 16 USEPA RI samples, ranging from less than the detection limit of 2 mg/kg (TX-25) to 453 mg/kg (TX-01). Beryllium was not detected in any of the 16 USEPA RI samples. The detection limit for beryllium was less than 1 mg/kg. Cadmium was detected in 15 of 16 USEPA RI samples, with detections ranging from 1 to 2 mg/kg.

Calcium, chromium, cobalt, and copper were detected in all 16 USEPA RI samples. Calcium concentrations ranged from 2,870 mg/kg (TX-20) to 52,300 mg/kg (TX-01), chromium concentrations varied from 5 mg/kg (MW-05) to 46 mg/kg (TX-01), cobalt concentrations ranged from 3 mg/kg (MW-05) to 36 mg/kg (TX-01), and copper concentrations varied from 14 mg/kg (TX-20) to 930 mg/kg (TX-01). Cyanide was not detected in any of the 16 USEPA RI samples. The detection limit for cyanide was below 1 mg/kg.

Lead was detected in all Texaco RI and USEPA RI samples. Lead concentrations ranged from 8 mg/kg at TX-25 to 3,910 mg/kg in TX-15 (Figure 6-2). Surface soil locations with low lead concentrations were historically paved, and surface soil locations with elevated lead concentrations were historically exposed to the air. Iron, magnesium, and manganese were detected in all 16 USEPA RI samples. Iron concentrations ranged from 7,980 mg/kg (TX-20) to 68,300 mg/kg (TX-01). Magnesium concentrations varied from 1,730 mg/kg (MW-05) to 19,300 mg/kg (TX-01). Manganese concentrations ranged from 79 mg/kg (MW-05) to 1,280 mg/kg (TX-01). Mercury was only detected in 1 of 16 USEPA RI samples, at a concentration of 1.6 mg/kg in MW-05. The mercury detection limit was less than 1 mg/kg.

Nickel and potassium were both detected in all 16 USEPA RI samples. Nickel concentrations ranged from 4 mg/kg (TX-20) to 46 mg/kg (TX-01), and potassium concentrations varied from 188 mg/kg (MW-05) to 1,780 mg/kg (TX-01). Selenium was not detected in any USEPA RI sample. The selenium detection limit ranged from less than 1 mg/kg to 4 mg/kg. Silver was detected in only one USEPA RI sample, at a concentration of 1 mg/kg (TX-12). The silver detection limit was less than 1 mg/kg. Sodium was detected in all 16 USEPA RI samples. Sodium concentrations ranged from 321 mg/kg (TX-20) to 7,060 mg/kg (TX-25).

Thallium was not detected in any USEPA RI sample. The thallium detection limit ranged from less than 1 mg/kg to 1 mg/kg. Tin was detected in 6 of 15 USEPA RI samples. Concentrations of tin ranged from less than a detection limit of 51 to 59 mg/kg

to 121 mg/kg (TX-01). Vanadium and zinc were both detected in all 16 USEPA RI samples. Vanadium concentrations ranged from 21 mg/kg (MW-05) to 171 mg/kg (TX-12), and zinc concentrations varied from 38 mg/kg (TX-23) to 456 mg/kg (TX-01).

6.2.2 Organic Constituents

At TX-20, TPH-O (as analyzed by USEPA Method 418.1) was detected at a concentration of 1,764 mg/kg, and N-Nitrosodiphenylamine was detected at a concentration of 140 μg/kg. No other organic constituents were detected at TX-20, and no organic constituents were detected at MW-05. SVOC detection limits typically ranged from 0.04 to 6 mg/kg, PCB detection limits typically varied from 0.08 to 0.34 mg/kg, and pesticide detection limits typically ranged from 0.01 to 0.7 mg/kg.

6.3 Subsurface Soil

6.3.1 Inorganic Constituents

A total of 113 soil samples was analyzed for metals during the Texaco RI: 36 from 0.5- to 1.5-foot depths, 52 from 2- to 3-foot depths, 23 from 4- to 5.5-foot depths, and 2 from 6.5- to 8-foot depths. One hundred two samples were analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc (Table D-1, Appendix D). Nine samples were analyzed for lead. TCLP lead was analyzed in one sample which was also tested for lead. Five subsurface soil samples were collected and analyzed from MW-05 during the USEPA RI, to a maximum depth of 15 feet. The samples were analyzed for a full suite of metals and cyanide.

Arsenic was detected in all but 1 of the 107 soil samples analyzed. Concentrations of arsenic ranged from below the detection limit (0.94 mg/kg) in sample MW-201-3 to a maximum of 10.6 mg/kg in soil sample BH05-4 (MW-05).

Cadmium was detected in only 10 of the 107 samples analyzed. Concentrations of cadmium ranged from below the detection limit to a maximum of 2.8 mg/kg in sample MW-107-3. The detection limit for cadmium generally ranged from 0.26 to 1.8 mg/kg.

Chromium was detected in all 107 samples analyzed. Chromium concentrations detected ranged from 3.7 mg/kg in sample MW-107-5.5 to 40 mg/kg in sample SB-202-1. Copper was detected in all but 3 of 107 samples analyzed. Copper concentrations ranged from 4.8 mg/kg in sample MW-201-3 to 90 mg/kg in sample SB-102-1.

Lead was detected in all but 2 of the 118 soil samples analyzed. Lead concentrations ranged from below the detection limit to a maximum of 700 mg/kg in soil sample SB-123-1. Lead concentrations decreased significantly with depth.

Mercury was detected in only 12 of the 107 soil samples analyzed. Concentrations of mercury reported ranged from below the detection limit to a maximum of 1.8 mg/kg in sample BH05-4. The detection limit for mercury generally ranged from 0.10 to 0.14 mg/kg.

Nickel was also detected in all but one of the 107 soil samples analyzed. Nickel concentrations ranged from less than 1.9 mg/kg in sample BH05-1 to 38 mg/kg in sample MW-201-5.5. Zinc was detected in all 107 samples analyzed. Zinc concentrations ranged from 11 mg/kg in sample SB-107-3 (reported in several samples) to 280 mg/kg in sample MW-107-3.

Aluminum was detected in all five USEPA RI samples. Concentrations of aluminum ranged from 3,410 to 5,920 mg/kg. Antimony was not detected in any USEPA RI sample. The detection limit was near 10 mg/kg. Barium was detected in all five USEPA RI samples, ranging from 12.1 to 23.1 mg/kg. Beryllium was not detected in any of the five USEPA RI samples. The detection limit for beryllium was about 0.5 mg/kg. Calcium concentrations ranged from 3,210 to 4,660 mg/kg. Cobalt concentrations ranged from 2.7 to 8.0 mg/kg. Cyanide was not detected in any of the five USEPA RI samples. The detection limit for cyanide was about 1.2 mg/kg.

Iron concentrations ranged from 5,960 to 10,600 mg/kg, magnesium concentrations varied from 1,570 to 2,530 mg/kg, manganese concentrations ranged from 54 to 113 mg/kg, potassium concentrations varied from 207 to 529 mg/kg. Selenium was not detected in any of the five USEPA RI samples. The selenium detection limit was about 0.5 mg/kg. Silver was detected in only two USEPA RI samples, at concentrations of 1.9 and 2.4 mg/kg. The silver detection limit was about 1.7 mg/kg. Sodium concentrations ranged from 1,110 to 1,550 mg/kg. Thallium was not detected in any USEPA RI sample. The thallium detection limit was about 1.2 mg/kg. Vanadium concentrations ranged from 18.2 to 29.5 mg/kg.

6.3.2 Organic Constituents

Petroleum Hydrocarbons. One hundred fifty-seven soil samples were analyzed for petroleum hydrocarbons during the Texaco RI: 42 from 0.5- to 1.5-foot depths, 56 from 2- to 3-foot depths, 56 from 4- to 5.5-foot depths, and 4 from 6.5- to 8-foot depths. The samples were analyzed for benzene, toluene, ethylbenzene, total xylenes, TPH-G, TPH-D, and TPH-O (Table D-2, Appendix D). Petroleum hydrocarbon compounds were detected in varying numbers of samples, ranging from a low of 20 samples with detectable benzene to a high of 76 samples with detectable TPH-D.

Benzene was detected in 20 samples at concentrations above the detection limit, which generally ranged from 0.021 to 0.030 mg/kg. The maximum concentration of benzene detected in soil was 38 mg/kg (estimated concentration) in sample SB-102-5. Benzene results for this sample were reported as estimated because the results were greater than

the method detection limit, but lower than the practical quantitation limit. Of the 20 benzene detections, 2 were in samples collected from the 0.5- to 1.5-foot interval, 3 were in samples collected from the 2- to 3-foot interval, 12 were in samples collected from the 4- to 5.5-foot interval, and 3 were in samples collected from the 6.5- to 8-foot interval (Figures 6-3 through 6-6).

Toluene was detected in 32 samples at concentrations above the detection limit, which generally ranged from 0.021 to 0.030 mg/kg. The maximum concentration detected was 15 mg/kg (estimated) in sample SB-102-5. Of the 32 toluene detections, 3 were in samples collected from the 0.5- to 1.5-foot interval, 9 were in samples collected from the 2- to 3-foot interval, 17 were in samples collected from the 4- to 5.5-foot interval, and 3 were in samples collected in the 6.5- to 8-foot interval.

Ethylbenzene was detected in 31 samples at concentrations above the detection limit, which generally ranged from 0.021 to 0.030 mg/kg. The maximum concentration of ethylbenzene detected in soil was 71 mg/kg (estimated) in sample SB-102-5. Of the 31 ethylbenzene detections, 3 were in a sample collected from the 0.5- to 1.5-foot interval, 7 were in samples collected from the 2- to 3-foot interval, 18 were in samples collected from the 4- to 5.5-foot interval, and 3 were in samples collected from the 6.5- to 8-foot interval (Figures 6-7 through 6-10).

Total xylenes were detected in 44 samples at concentrations above the detection limit, which generally ranged from 0.021 to 0.030 mg/kg. The maximum concentration of total xylenes detected was 160 mg/kg (estimated) in sample SB-102-5. Of the 44 total xylenes detections, 7 were in samples collected from the 0.5- to 1.5-foot interval, 10 were in samples collected from the 2- to 3-foot interval, 24 were in samples collected from the 4- to 5.5-foot interval, and 3 were in samples collected from the 6.5- to 8-foot interval (Figures 6-11 through 6-14).

TPH-G was detected in 45 samples at concentrations above the detection limit, which ranged from 5 to 8 mg/kg. Six of those samples were collected from the 0.5- to 1.5-foot depth, 10 were from the 2- to 3-foot depths, 26 from the 4- to 5.5-foot depths, and 3 were from the 6.5- to 8-foot depths. The maximum concentration of TPH-G detected in soil was 12,000 mg/kg (estimated) in sample SB-122-5. Figures 6-15 through 6-18 show the distribution of TPH-G in soil samples.

TPH-D was detected in 76 soil samples at concentrations above the detection limit, which generally ranged from 11 to 15 mg/kg. Eighteen of those samples were collected from the 0.5- to 1.5-foot depth, 22 were from the 2- to 3-foot depths, 33 were from the 4- to 5.5-foot depths, and 3 were from the 6.5- to 8-foot depths. The maximum concentration of TPH-D detected in soil was 14,000 mg/kg (estimated) in samples SB-206-3 and SB-208-6.5. Figures 6-19 through 6-22 show the distribution of TPH-D in soil samples.

TPH-O was reported in 40 soil samples at concentrations above the detection limit, which generally ranged from 40 to 60 mg/kg. Ten of the samples were collected from the 0.5- to 1.5-foot depth, 12 were from the 2- to 3-foot depths, 17 were from the 4- to 5.5-foot depths, and 1 was from the 6.5- to 8-foot depths. The maximum concentration of TPH-O detected in soil was 52,000 mg/kg in sample SB-122-5. Figures 6-23 through 6-26 show the distribution of TPH-O in soil samples.

Volatile Organic Constituents. Two USEPA RI subsurface soil samples were analyzed for volatile organic constituents (VOCs). Only two VOCs were detected in the samples. Methylene chloride was detected at a concentration of 0.7 μg/kg in BH05-1 and BH05-3. Chloroform was detected at concentrations of 2.0 and 9.0 μg/kg in BH05-1 and BH05-3, respectively. These low-level detections of methylene chloride and chloroform may have been to laboratory contamination. None of the other 32 VOCs were detected in either subsurface soil sample. VOC detection limits ranged from 5 to 12 μg/kg.

Polycyclic Aromatic Hydrocarbons. Fifty-two soil samples were analyzed for cPAHs during the Texaco RI. Twenty-three samples were collected from the 0.5- to 1.5-foot depth interval, 15 samples were from the 2- to 3-foot interval, 10 samples were from the 4- to 5.5 foot interval, and 4 samples were from the 6.5- to 8.5-foot interval. Analyses were performed for the following seven cPAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. One or more cPAH compounds were reported above the detection limit (0.011 to 0.013 mg/kg for each compound) in 13 samples (Table D-3, Appendix D). Four of the samples with cPAH detections were collected from the 0.5- to 1.5-foot interval, one was from the 2- to 3-foot interval, five were from the 4- to 5.5-foot interval, and three were from the 6.5- to 8-foot interval. The maximum total cPAH concentration detected in any sample was 2.64 mg/kg in sample SB-210-6.5.

Semivolatile Organic Constituents. Five USEPA RI subsurface soil samples were analyzed for semivolatile organic constituents (SVOCs). Only two SVOCs were detected in the samples. Phenol was detected at a concentration of 0.1 mg/kg in BH05-5, and N-Nitrosodiphenylamine was detected at a concentration of 0.11 mg/kg in BH05-1 and BH05-3. None of the other 63 SVOCs were detected in the 5 USEPA subsurface soil samples. SVOC detection limits, which were typically below 1 mg/kg, ranged from 0.71 to 4.3 mg/kg.

Pesticides and Polychlorinated Biphenyls. PCBs were reported above the detection limit (0.0054 to 0.04 mg/kg) in only one of the seven Texaco RI soil samples analyzed (Table D-4, Appendix D). Sample SB-205-1 contained 0.044 mg/kg of Arochlor 1254 and 0.032 mg/kg of Arochlor 1260. Soil boring SB-205 was located in the north tank farm area, near 13th Avenue Southwest. Pesticides and PCBs were not detected in any

of the five USEPA soil samples analyzed. Detection limits in the five BH05 samples ranged from below 0.01 mg/kg to about 0.25 mg/kg.

Total Organic Carbon. Twenty-four samples were analyzed for total organic carbon (TOC). As described in Section 4.1.3, TOC analyses were performed only on the sample with the highest TPH concentration from the boreholes selected. TOC was detected in all samples analyzed at concentrations ranging from 151 mg/kg in sample MW-110-5.5 to 12,700 mg/kg in sample MW-102-5.5 (Table D-5, Appendix D).

6.4 Discussion of Soil Results Above Screening Levels

Table 6-1 presents surface and subsurface soil screening levels. Analytical results were compared to the screening levels to identify potential and preliminary indicator hazardous substances. During the feasibility study, potential and preliminary indicator hazardous substances will be evaluated to determine whether or not they will be finalized as indicator hazardous substances. Results from both the Texaco RI and the USEPA RI are included in this discussion. Results were not compared to background levels because background samples were not available.

A range of surface soil screening levels is presented in Table 6-1 for antimony, arsenic, cPAHs, and PCBs. These screening level ranges are equivalent to the USEPA surface soil cleanup goals (USEPA, 1993). The USEPA cleanup goals were based on achieving a 1×10^{-5} excess cancer risk or a hazard index equal to 1 and were derived by distributing risk among the constituents contributing 90 percent of the surface soil risk (antimony, arsenic, cPAHs, and PCBs). The USEPA set the cleanup goals based on the percentage contributions of risk at individual sampling locations. Since the concentrations of these constituents varied spatially, a range of cleanup goals were determined. At sampling locations with all four constituents present, cleanup levels at the lower ends of the ranges would be selected; at sampling locations with only one constituent present, a cleanup level at the high end of the range would be selected. In the discussion below, surface soil data for antimony, arsenic, cPAHs, and PCBs on the Texaco site are compared to the upper end of the screening level ranges because elevated concentrations of these constituents do not occur at the same sampling locations.

Analyte concentrations for soil samples collected from 11 surface soil sampling locations, 17 soil borings, and 12 monitoring wells did not exceed the screening levels. Analyte concentrations for soil samples collected from 14 surface soil sampling locations, 27 soil borings, and 8 monitoring wells exceeded the screening levels (Table 6-2). The distribution of these constituents is presented in Figures 6-1 through 6-26.

Table 6-1

Texaco Harbor Island Terminal
Remedial Investigation Report
Potential Indicator Hazardous Substances Screening Levels in Soil

Analyte	Screening Level (mg/kg)[a]
Antimony (surface soil)	180 to 677[b]
Arsenic (surface soil)	3.60 to 32.6[b]
Arsenic (subsurface soil)	200
Benzene	0.5
Cadmium	10
Chromium	500
Ethylbenzene	20
Lead	1,000
Mercury	1.0
PAHs (carcinogenic, surface soil)	0.1 to 36.5[b]
PAHs (carcinogenic, subsurface soil)	20
PCBs (surface soil)	0.18 to 2.99[b]
PCBs (subsurface soil)	10
TPH (gasoline)	100
TPH (diesel)	200
TPH (oil)	200
Toluene	40
Xylenes	20

[a] Based on MTCA Method A for soil at industrial sites unless otherwise specified.
[b] Based on achieving a 1×10^{-5} excess cancer risk or Hazard Index equal to 1 (USEPA risk assessment for Operable Unit No. 4 on Harbor Island).

Table 6-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
	Screening Level[a]	32.6	0.5	20	1,000	100	200	200	20
MW-104	4.0	—	—	—	—	1,500	—	—	100 J
MW-109	2.0	—	—	—	—	—	1,700	—	—
MW-109	4.0	—	—	—	—	—	2,200	600	—
MW-111	4.0	—	—	—	—	130	650	—	—
MW-112	4.9	—	—	—	—	—	—	490	—
MW-201	4.0	—	—	—	—	—	370	—	—
MW-202	4.0	—	—	—	—	600 J	1,300	—	—
MW-203	4.0	—	—	—	—	550	1,100	1,700	—
MW-204	4.0	—	—	—	—	—	—	300	—
SB-102	4.0	NA	38 J	71 J	NA	5,400 J	5,200	—	160 J
SB-103	4.0	NA	—	—	NA	—	—	440	—
SB-106	2.0	—	—	—	—	—	—	220	—
SB-108	4.0	NA	—	—	NA	120	—	—	—
SB-109	0.5	—	—	—	—	—	—	230	—
SB-110	2.0	—	—	—	—	—	2,100	3,100	—
SB-110	4.0	NA	—	—	NA	—	980	1,900	—
SB-112	0.5	—	—	—	—	—	—	1,300	—
SB-115	4.3	NA	—	—	NA	—	5,100	—	—
SB-116	4.0	NA	—	—	NA	500	6,200	—	—
SB-117	1.0	—	—	—	—	—	—	13,000	—
SB-118	2.0	—	—	—	—	620	610	—	—

Table 6-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
	Screening Level[a]	32.6	0.5	20	1,000	100	200	200	20
SB-118	4.0	NA	1.4 J	21 J	NA	3,200	2,800	—	100 J
SB-119	4.0	NA	—	—	NA	—	590	—	—
SB-120	0.5	—	—	—	—	—	—	550	—
SB-122	1.0	—	—	—	—	190	280 J	970 J	—
SB-122	2.5	—	—	—	—	2,800	1,800 J	10,000 J	—
SB-122	4.5	NA	2.4 J	35 J	NA	12,000 J	6,600	52,000	99 J
SB-123	2.0	—	—	—	—	—	250	3,800	—
SB-123	4.0	NA	—	—	NA	—	360 J	3,000 J	—
SB-127	2.5	—	—	—	—	250 J	—	—	—
SB-128	4.5	NA	0.62 J	—	—	1,300 J	450	430	—
SB-131	0.0	—	—	—	1,400	—	—	—	—
SB-131	4.0	NA	—	—	—	430 J	—	630	—
SB-201	4.4	NA	1.6 J	—	NA	9,100 J	13,000 J	—	—
SB-202	0.5	—	—	—	—	—	1,100	12,000	—
SB-203	4.0	NA	—	—	NA	2,500	2,300 J	—	—
SB-204	1.0	—	—	—	—	—	370	4,800	—
SB-204	2.5	—	—	—	—	—	—	2,400	—
SB-206	2.0	—	0.53 J	—	—	4,200	14,000 J	1,600 J	22 J
SB-208	4.0	NA	—	—	—	3,500 J	6,200	740	—
SB-208	6.5	NA	1.3 J	—	NA	2,200 J	14,000	—	—
SB-210	6.5	NA	—	—	—	2,500 J	3,300	—	—

Table 6-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Soil Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Depth (feet)	Arsenic (surface soil)	Benzene	Ethylbenzene	Lead	TPH-G	TPH-D	TPH-O	Xylenes
	Screening Level[a]	32.6	0.5	20	1,000	100	200	200	20
SB-211	2.0	NA	1.0 J	—	—	1,400 J	3,900	1,400	23 J
SB-211	4.0	NA	—	—	NA	180	—	—	—
SB-212	2.0	NA	—	—	—	—	640	—	—
SS-106	0.0	44	NA	NA	1,600	NA	NA	NA	NA
TX-01[b]	0.0	—	NA	NA	1,050	NA	NA	NA	NA
TX-02[b]	0.0	—	NA	NA	1,050	NA	NA	NA	NA
TX-06[b]	0.0	—	NA	NA	1,050	NA	NA	NA	NA
TX-07[b]	0.0	65.9	NA	NA	2,180	NA	NA	NA	NA
TX-10[b]	0.0	79.6	NA	NA	2,550	NA	NA	NA	NA
TX-12[b]	0.0	59.2	NA	NA	3,730	NA	NA	NA	NA
TX-14[b]	0.0	—	NA	NA	3,910	NA	NA	NA	NA
TX-15[b]	0.0	65.6	NA	NA	3,910	NA	NA	NA	NA
TX-16[b]	0.0	—	NA	NA	1,540	NA	NA	NA	NA
TX-17[b]	0.0	92.5	NA	NA	3,880	NA	NA	NA	NA
TX-18[b]	0.0	—	NA	NA	1,210	NA	NA	NA	NA
TX-20[b]	0.0	—	—	—	—	—	—	1,764	—

NOTE: Results are in mg/kg.
NA = not analyzed.
— = Result below the screening level.

[a] See Table 6-1 for source of screening levels.

[b] Sample collected, analyzed, and reported by the USEPA (Weston, 1993).

6.4.1 Surface Soil

Inorganic Constituents. The surface soil data collected during the USEPA RI did not exceed the soil screening levels for antimony, cadmium, or chromium. The surface soil screening level for arsenic was exceeded in 6 samples, and the soil screening level for lead was exceeded in 13 surface soil samples. One USEPA surface soil sample (BH05-A) slightly exceeded the soil mercury screening level. Five USEPA subsurface soil samples (BH05-1 through BH05-5) collected at this location also slightly exceeded the soil mercury screening level. All six mercury results were anomalous (between 1.2 and 1.8 mg/kg). Given the anomalous mercury data, low mercury detections elsewhere, and the lack of a mercury source in the area, mercury is not included in Table 6-2 and will not be considered a potential indicator hazardous substance in surface soil.

Organic Constituents. Only one organic soil screening level was exceeded. The screening level for TPH-O was exceeded at TX-20.

6.4.2 Subsurface Soil

Inorganic Constituents. The subsurface soil data collected during the Texaco and USEPA RIs did not exceed the inorganic soil screening levels. Five subsurface soil samples (BH05-1 through BH05-5) slightly exceeded the soil mercury screening level. One USEPA surface soil sample (BH05-A) collected at this location also slightly exceeded the soil mercury screening level. All six mercury results were anomalous (between 1.2 and 1.8 mg/kg). Given the anomalous mercury data, low mercury detections elsewhere, and the lack of a mercury source in the area, mercury is not included in Table 6-2. However, mercury will be considered a potential indicator hazardous substance in subsurface soil.

Organic Constituents. The organic soil screening levels were not exceeded for toluene and cPAHs. Eight samples from eight different soil borings exceeded the benzene screening level. Two of the samples were collected in the 2 to 3-foot depth range, five of the samples were collected in the 4 to 5.5-foot depth range, and one sample was collected in the 6.5 to 8-foot depth range. Three samples from three different soil borings exceeded the ethylbenzene screening level. All three samples were collected in the 4 to 5.5-foot depth range. Six samples from six different soil borings exceeded the xylenes screening level. Two of the samples were collected in the 2 to 3-foot depth range, and four of the samples were collected in the 4 to 5.5-foot depth range.

Twenty-three samples from 4 monitoring wells and 14 soil borings exceeded the TPH-G screening level. One of the samples was collected in the 0.5 to 1.5-foot depth range, 6 of the samples were collected in the 2 to 3-foot depth range, 14 of the samples were

collected in the 4 to 5.5-foot depth range, and 2 samples were collected in the 6.5 to 8-foot depth range. Thirty samples from 5 monitoring wells and 18 soil borings exceeded the TPH-D screening level. Three of the samples were collected in the 0.5 to 1.5-foot depth range, 8 of the samples were collected in the 2 to 3-foot depth range, 17 of the samples were collected in the 4 to 5.5-foot depth range, and 2 samples were collected in the 6.5 to 8-foot depth range. Twenty-five samples from 4 monitoring wells and 16 soil borings exceeded the TPH-O screening level. Seven of the samples were collected in the 0.5 to 1.5-foot depth range, 7 of the samples were collected in the 2- to 3-foot depth range, and 11 of the samples were collected in the 4 to 5.5-foot depth range.

7 NATURE AND EXTENT OF GROUNDWATER CONTAMINATION

Groundwater samples for chemical analysis were collected from 24 shallow (about 15 feet deep) and 6 deep (49 to 67 feet deep) monitoring wells, as described in Sections 4.2.7 and 4.2.8. Groundwater samples were analyzed for BTEX, TPH-G, TPH-D, TPH-O, and total and dissolved metals. Select first round samples were also analyzed for cPAHs, TOC, ammonia as nitrogen, and nitrate and nitrite as nitrogen, as described in Section 4.2.7. All fourth round groundwater samples were also analyzed for EDB, EDC, and MTBE. Groundwater samples from MW-208 and MW-209 were also analyzed for cPAHs, EDB, EDC, and MTBE. Results of the analyses are presented in Tables E-1 through E-6 in Appendix E.

General detection limits for each parameter are provided in the following discussions. Sample detection limits varied occasionally due to sample dilution or matrix interference. Actual detection limits for each sample parameter not detected are listed in Appendix E.

7.1 Data Validation and Management

All sample data received from the laboratory were reviewed to determine compliance with data quality objectives (DQOs) as specified in the SAP. The data were reviewed following procedures specified in the SAP and data validation guidelines in *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics and Organics Analyses* (USEPA, 1988a,b). Data that did not meet DQOs were assigned data qualifiers to restrict or modify appropriate uses. Details on data validation are presented in the data validation report (Appendix H). The only laboratory assigned data qualifier was a less than (<) symbol, indicating the analyte was not detected at the method detection limit shown. Data qualifiers assigned during data validation review are as follows:

- U—The material was analyzed for, but was not detected. The associated numerical value is the method detection limit.
- J—The associated value is an estimated quantity.
- R—The data are unusable; analyte may or may not be present. Resampling and reanalysis are necessary for verification.

- UJ—The material was analyzed for, but was not detected. The associated numerical value is the estimated method detection limit.

- B—The analyte was also detected in the associated field blank. The concentration is an estimated quantity.

Data were judged to meet DQOs for precision, accuracy, representativeness, and comparability. All sample analyses met the DQO for completeness of 99 percent. All data were entered into a personal computer compatible database after validation, using standardized, repeatable procedures. A 100 percent check for accuracy was performed on all data that were hand-entered into the database. Most data were entered directly into the database from electronic deliverables. Some data were hand-entered into the database.

7.2 Inorganic Constituents

One hundred eleven groundwater samples were analyzed for total and dissolved metals (Table 7-1). The samples were analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc (Table E-2, Appendix E).

Total arsenic was detected in 58 percent of the samples analyzed and in 24 of the 30 wells (Figures 7-1 through 7-4). Concentrations of total arsenic ranged from below the detection limit (0.001 mg/L) to a maximum of 0.070 mg/L in sample TX-06-1293. Dissolved arsenic was detected in 51 percent of the samples analyzed and in 21 of the 30 wells. Concentrations of dissolved arsenic ranged from below the detection limit (0.001 mg/L) to a maximum of 0.058 mg/L in sample SH-04-0693.

Total cadmium was detected in only one sample, 0.006 mg/L in A-28-0493. Dissolved cadmium was not detected in any of the groundwater samples. The detection limit for cadmium was 0.003 mg/L.

Total chromium was detected in 17 percent of the samples analyzed and in 6 of the 30 wells. Dissolved chromium was detected in 15 percent of the samples analyzed and in 5 of the 30 wells. Concentrations of total and dissolved chromium ranged from below the detection limit (0.010 mg/L) to a maximum of 0.049 mg/L in sample MW-06-0493.

Total copper was detected in 50 percent of the samples analyzed and in 24 of the 30 wells (Figures 7-5 through 7-8). Concentrations of total copper ranged from below the detection limit (0.001 mg/L) to a maximum of 0.12 mg/L in sampler MW-208-0994. Dissolved copper was detected in 41 percent of the samples analyzed and in 21 of the 30 wells. Concentrations of dissolved copper ranged from below the

Table 7-1

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Groundwater Detections

Analyte	Samples Analyzed[a]	Sample Detections	Wells With Detections	Wells Without Detections	Detection Limits[b]	Minimum Detection	Maximum Detection
Total arsenic	111	64	24	6	0.001	0.001	0.070
Dissolved arsenic	111	57	21	9	0.001	0.001	0.058
Total cadmium	111	1	1	29	0.003	0.006	0.006
Dissolved cadmium	111	0	0	30	0.003	—	—
Total chromium	111	19	6	24	0.010	0.011	0.049
Dissolved chromium	111	17	5	28	0.010	0.0011	0.049
Total copper	111	56	24	6	0.001	0.001	0.12
Dissolved copper	111	45	21	9	0.001	0.0011	0.017
Total lead	111	38	20	10	0.001	0.0011	0.19
Dissolved lead	111	22	14	16	0.001	0.001	0.046
al mercury	111	1	1	29	0.0002	0.00056	0.00056
Dissolved mercury	111	0	0	28	0.0002	—	—
Total nickel	111	58	27	3	0.001	0.001	0.027
Dissolved nickel	111	42	19	11	0.001	0.001	0.028
Total zinc	111	10	7	23	0.020	0.035	0.540
Dissolved zinc	111	7	4	26	0.020	0.024	0.420
TPH-D	111	73	24	6	0.25	0.26	19
TPH-O	111	8	7	23	0.75	0.75	11
TPH-G	111	52	17	13	0.1	0.13	52
Benzene	111	57	18	12	0.0005	0.0012	8.4
Toluene	111	49	16	14	0.0005	0.0008	8.8
Ethylbenzene	111	44	16	14	0.0005	0.0011	2.4
Xylenes	111	58	20	10	0.0005	0.0005	13
Benzo(a)anthracene	24	2	2	22	0.0000091	0.0000095	0.000077
Benzo(a)pyrene	24	1	1	23	0.0000091	0.000050	0.000050
Benzo(b)fluoranthene	24	1	1	23	0.0000091	0.000052	0.000052
Benzo(k)fluoranthene	24	1	1	23	0.0000091	0.000029	0.000029

Table 7-1

Texaco Harbor Island Terminal
Remedial Investigation Report
Groundwater Detections

Analyte	Samples Analyzed[a]	Sample Detections	Wells With Detections	Wells Without Detections	Detection Limits[b]	Minimum Detection	Maximum Detection
Chrysene	24	4	4	20	0.0000094	0.000013	0.000043
Dibenzo(a,h)anthracene	24	1	1	23	0.0000091	0.0000093	0.0000093
Indeno(1,2,3-cd)pyrene	24	1	1	23	0.0000091	0.000022	0.000022
1,2-dibromoethane (EDB)	28	0	0	28	0.0005	—	—
1,2-dichloroethane (EDC)	28	5	5	23	0.0002	0.0002	0.0004
Methyl-t-butyl ether (MTBE)	28	4	4	24	0.0025	0.0032	0.120
Ammonia as N	14	13	13	1	0.03	0.07	3.20
Nitrate + Nitrite as N	14	3	3	11	0.06	0.46	1.40
Total Organic Carbon	14	12	12	2	1.0	2.8	51
Total Dissolved Solids	111	111	30	0	1.0	58	4,900
Total Suspended Solids	111	80	29	1	10	10	910

NOTE: All results are in mg/L.

[a] Four rounds of samples were analyzed from all wells but A-28 (three rounds), SH-04 (two rounds), and MW-208 and MW-209 (one round).

[b] The lowest detection limit of all samples is listed; detection limits were occasionally elevated due to matrix interferences.

detection limit (0.001 mg/L) to a maximum of 0.017 mg/L in samples MW-06-0993 and MW-108-0493.

Total lead was detected in 34 percent of the samples analyzed and in 20 of the 30 wells (Figures 7-9 through 7-12). Concentrations of total lead ranged from below the detection limit (0.001 mg/L) to a maximum of 0.19 mg/L in sample MW-208-0994. Dissolved lead was detected in 20 percent of the samples analyzed and in 14 of the 30 wells. Concentrations of dissolved lead ranged from below the detection limit (0.001 mg/L) to a maximum of 0.046 mg/L in sample SH-04-0693.

Total mercury was detected in only one sample, 0.00056 mg/L in MW-208-0994. Dissolved mercury were not detected in any of the groundwater samples. The detection limit for mercury was 0.0002 mg/L.

Total nickel was detected in 52 percent of the samples analyzed and in 27 of the 30 wells Figures 7-13 through 7-16). Dissolved nickel was detected in 38 percent of the samples analyzed and in 19 of the 30 wells. Concentrations of total and dissolved nickel ranged from below the detection limit (0.001 mg/L) to a maximum of 0.027 mg/L and 0.028 mg/L, respectively, in TES-MW-1.

Total zinc was detected in 9 percent of the samples analyzed and in 7 of the 30 wells (Figures 7-17 through 7-20). Dissolved zinc was detected in 6 percent of the samples analyzed and in 4 of the 30 wells. Concentrations of total and dissolved zinc ranged from below the detection limit (0.020 mg/L) to a maximum of 0.540 mg/L and 0.420 mg/L, respectively, in MW-204-0693.

The wells with the most frequent and highest metals detections included MW-06 and off-site wells A-28 and SH-04. In general, dissolved metals concentrations were slightly lower than the corresponding total metals concentrations. In addition, chromium and copper concentrations were generally higher in the deep monitoring wells than the shallow monitoring wells. The results from MW-208 and MW-209 may have been affected by the fact that the wells were developed and sampled on the same day. The TSS concentrations were elevated, indicating that particulate matter in the samples may have affected the results.

7.3 Organic Constituents

7.3.1 Petroleum Hydrocarbons

One hundred eleven samples were analyzed for petroleum hydrocarbons. The samples were analyzed for benzene, toluene, ethylbenzene, total xylenes, TPH-G, TPH-D, and TPH-O (Table E-3, Appendix E).

Benzene was detected in 51 percent of the samples analyzed and in 18 of the 30 wells (Figures 7-21 through 7-24). Concentrations of benzene ranged from below the detection limit (0.0005 mg/L) to a maximum of 8.4 mg/L in sample SH-04-0993. Toluene was detected in 44 percent of the samples analyzed and in 16 of the 30 wells (Figures 7-25 through 7-28). Toluene concentrations varied from below the detection limit (0.0005 mg/L) to a maximum of 8.8 mg/L in sample SH-04-0693. Ethylbenzene was detected in 40 percent of the samples analyzed and in 16 of the 30 wells (Figures 7-29 through 7-32). Concentrations of ethylbenzene ranged from below the detection limit (0.0005 mg/L) to a maximum of 2.4 mg/L in sample MW-104-0693. Xylenes were detected in 52 percent of the samples analyzed and in 20 of the 30 wells (Figures 7-33 through 7-36. Xylenes concentrations varied from below the detection limit (0.0005 mg/L) to a maximum of 13 mg/L in sample MW-104-0693.

TPH-G was detected in 47 percent of the samples analyzed and in 17 of the 30 wells. Concentrations of TPH-G varied from below the detection limit (0.1 mg/L) to a maximum of 52 mg/L in sample SH-04-0693 (Figures 7-37 through 7-40). TPH-D was detected in 66 percent of the samples analyzed and in 24 of the 30 wells. TPH-D concentrations ranged from below the detection limit (0.25 mg/L) to a maximum of 19 mg/L in sample MW-208-0994 (Figures 7-41 through 7-44). TPH-O was detected in 7 percent of the samples analyzed and in 7 of the 30 wells. Concentrations of TPH-O ranged from below the detection limit (0.75 mg/L) to a maximum of 11 mg/L, in sample MW-208-0994. (Figures 7-45 through 7-48).

The wells with the most frequent and the highest detections of TPH and BTEX included MW-104, MW-111, and off-site wells A-28 and SH-04. The results from MW-208 and MW-209 may have been affected by sampling the wells the same day that they were developed. The TSS concentrations were elevated, indicating that particulate matter in the samples may have affected the results.

7.3.2 Polycyclic Aromatic Hydrocarbons

Twenty-two groundwater samples were analyzed for cPAHs in the April 1993 sampling round. Two samples were analyzed for cPAHs in September 1994. Analyses were performed for the following seven cPAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were only detected in 1 of the 24 groundwater samples, MW-208-0994 (Table E-4, Appendix E). In MW-208-0994, benzo(a)pyrene was detected at 0.050 μg/L, benzo(b)fluoranthene was detected at 0.052 μg/L, benzo(k)fluoranthene was detected at 0.029 μg/L, dibenzo(a,h)anthracene was detected at 0.0093 μg/L, and indeno(1,2,3-cd)pyrene was detected at 0.022 μg/L. Benzo(a)anthracene was detected in two samples (0.0095 μg/L in A-28-0493 and 0.077 μg/L in MW-208-0994). Chrysene was detected in three samples (0.026 μg/L in A-28-0493, 0.015 μg/L in MW-201-0493, and 0.013 μg/L in

TX-03-0493). Method detection limits varied from 0.0091 to 0.017 μg/L for the cPAHs. The results from MW-208 may have been affected by sampling the well the same day that it was developed. The TSS concentration was elevated, indicating that particulate matter in the sample may have affected the results.

7.3.3 Additives

Twenty-six groundwater samples were analyzed for additives in the December 1993 sampling round. Two samples were analyzed for additives in September 1994. The additives included EDB, EDC, and MTBE. EDB was not detected in any of the 28 groundwater samples analyzed (Table E-5, Appendix E). The method detection limit for EDB was 0.0005 mg/L. EDC was detected in 5 of the 28 samples analyzed. EDC concentrations varied from below the detection limit (0.0002 mg/L) to a maximum of 0.0004 mg/L in sample MW-111-1293. MTBE was detected in 4 of the 28 samples analyzed. Concentrations of MTBE ranged from below the detection limit (0.0025 mg/L) to a maximum of 0.120 mg/L in sample MW-101-1293.

7.3.4 Conventional Laboratory Parameters

Fourteen samples were analyzed for ammonia as nitrogen, nitrate and nitrite as nitrogen, and TOC. Ammonia as nitrogen was detected in all but one sample, and ranged from below the method detection limit (0.03 mg/L) to 3.20 mg/L in sample MW-205-0493 (Table E-6, Appendix E). Nitrate and nitrite as nitrogen were detected in only 3 of 14 analyzed samples, varying from below the method detection limit (0.06 mg/L) to 1.40 mg/L in sample MW-201-0493. TOC was detected in all but two of samples, and ranged from below the detection limit (1.0 mg/L) to 51 mg/L in sample MW-205-0493.

One hundred eleven groundwater samples were analyzed for TDS and TSS. TDS was detected in all the samples analyzed. Concentrations of TDS varied from 58 to 4,900 mg/L in sample MW-208-0994. Except near the shoreline, TDS generally ranged from 100 to 500 mg/L in the shallow wells and from 600 to 1,900 mg/L in the deep wells. TSS was detected in 72 percent of the samples analyzed and in 29 of the 30 wells. TSS concentrations ranged from below the detection limit (10 mg/L) to a maximum of 910 mg/L in sample MW-208-0994.

7.4 Discussion of Groundwater Results Above Screening Levels

Table 7-2 presents groundwater screening levels. The screening levels represent surface water standards, based on the protection of marine organisms or human health from the consumption of marine organisms. The toluene and ethylbenzene screening levels represent the lowest observed effect levels published by the USEPA. The screening levels are used in this report to identify potential and preliminary indicator hazardous

Table 7-2

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Potential Indicator Hazardous Substances Screening Levels in Groundwater

Analyte	Screening Level (mg/L)
Arsenic	0.036 [a,b]
Benzene	0.071[b]
Benzo(a)anthracene	0.031[b]
Benzo(a)pyrene	0.031[b]
Benzo(b)fluoranthene	0.031[b]
Benzo(k)fluoranthene	0.031[b]
Cadmium	0.008 [a,b]
Chromium (VI)	0.050 [a,b]
Chrysene	0.031[b]
Copper	0.0029 [a,b]
Dibenzo(a,h)anthracene	0.031[b]
Ethylbenzene	0.43[b]
Indeno(1,2,3-cd)pyrene	0.031[b]
Lead	0.0058 [a,b]
Mercury	0.000025 [a,b]
Nickel	0.0079 [a,b]
Toluene	5.0[b]
Zinc	0.0766 [a,b]

[a] Based on Chapter 173-201 WAC, *Water Quality Standards for Surface Waters of the State of Washington.*
[b] Based on *Quality Criteria for Water*, EPA 440/5-86-001, May 1986. cPAH screening levels modified by Federal Register, Vol. 57, No. 246, December 22, 1992.

substances. Potential and preliminary indicator hazardous substances will be evaluated during the feasibility study to determine whether or not they will be finalized as indicator hazardous substances.

Analyte concentrations for groundwater collected from eight monitoring wells did not exceed the groundwater screening levels in any of the sampling events. Groundwater collected from 22 monitoring wells exceeded the groundwater screening levels for at least one analyte in at least one sampling event (Tables 7-3 and 7-4). The distribution of these constituents, BTEX, and TPH are presented in Figures 7-1 through 7-48. One hundred eleven samples were analyzed for the constituents discussed below.

7.4.1 Inorganic Constituents

The groundwater screening level was not exceeded for total or dissolved cadmium or for dissolved mercury. The groundwater screening level for arsenic was exceeded by total and dissolved arsenic concentrations in three samples. All three samples were collected from shallow monitoring wells, and two of the three were collected from the same well during different sampling events.

The groundwater screening level for copper was exceeded by total or dissolved copper concentrations in 30 samples from 8 shallow and 6 deep monitoring wells. Deep monitoring wells accounted for 21 of the 30 samples that exceeded the screening level. Both total and dissolved copper exceeded the groundwater screening level in 18 of the 30 samples which exceeded the screening level; either total or dissolved copper was below the screening level in the other 12 samples.

The groundwater screening level for lead was exceeded by total or dissolved lead concentrations in 15 samples from 7 shallow and 1 deep monitoring wells. Shallow monitoring wells accounted for 14 of the 15 samples that exceeded the screening level. Both total and dissolved lead exceeded the groundwater screening level in only 4 of the 14 samples which exceeded the screening level; either total or dissolved lead was below the screening level in the other 10 samples. The groundwater screening level for mercury was exceeded by total mercury in one sample, MW-208-0994. However, the results from MW-208 may have been affected by sampling the well the same day that it was developed. The TSS concentration of sample MW-208-0994 was elevated, indicating that particulate matter in the sample may have affected the results.

The groundwater screening level for nickel was exceeded by total or dissolved nickel concentrations in four samples from three shallow and one deep monitoring wells. Both total and dissolved nickel exceeded the groundwater screening level in one of the four samples which exceeded the screening level.

The groundwater screening level for zinc was exceeded by total and dissolved zinc concentrations in two samples. Both samples were collected from shallow monitoring

Table 7-3

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Inorganic Groundwater Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Date	Total Arsenic	Dissolved Arsenic	Total Copper	Dissolved Copper	Total Lead	Dissolved Lead	Total Mercury	Total Nickel	Dissolved Nickel	Total Zinc	Dissolved Zinc
Screening Level[a]		**0.036**	**0.036**	**0.0029**	**0.0029**	**0.0058**	**0.0058**	**0.000025**	**0.0079**	**0.0079**	**0.0766**	**0.0766**
A-28	04/07/93	—	—	—	—	0.0059 J	—	—	—	—	—	—
A-28	06/23/93	—	—	—	—	0.025	—	—	—	—	—	—
A-28	09/21/93	—	—	—	—	0.0078 J	—	—	—	—	—	—
DP-06	04/05/93	—	—	0.0075 B	0.0054	—	—	—	0.011	—	—	—
DP-06	06/23/93	—	—	0.0093	0.0091	—	—	—	—	—	—	—
DP-06	09/23/93	—	—	0.0086 J	0.0074	—	—	—	—	—	—	—
DP-06	12/14/93	—	—	—	0.0068	—	—	—	—	—	—	—
MW-06	04/05/93	—	—	0.018	0.015	—	—	—	—	—	—	—
MW-06	06/23/93	—	—	0.019	0.0095	—	—	—	—	—	—	—
MW-06	09/22/93	—	—	0.017	0.017	—	—	—	—	—	—	—
MW-06	12/15/93	—	—	0.018	0.014	—	—	—	—	—	—	—
MW-103	04/06/93	—	—	0.036 J	0.0044 J	—	—	—	—	—	—	—
MW-103	06/21/93	—	—	0.012	0.0061	—	—	—	—	—	—	—
MW-103	09/22/93	—	—	0.0049	0.0030	—	—	—	—	—	—	—
MW-103	12/13/93	—	—	0.0037	—	—	—	—	—	—	—	—
MW-104	06/22/93	—	—	—	—	—	0.0093	—	—	—	—	—
MW-104	09/22/93	—	—	—	—	0.0084	0.0089	—	—	—	—	—
MW-108	04/02/93	—	—	0.034	0.017	0.0065 J	—	—	—	—	—	—
MW-108	06/21/93	—	—	0.008	0.0073	—	—	—	—	—	—	—

Table 7-3

Texaco Harbor Island Terminal
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Inorganic Groundwater Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Date	Total Arsenic	Dissolved Arsenic	Total Copper	Dissolved Copper	Total Lead	Dissolved Lead	Total Mercury	Total Nickel	Dissolved Nickel	Total Zinc	Dissolved Zinc
Screening Level[a]		**0.036**	**0.036**	**0.0029**	**0.0029**	**0.0058**	**0.0058**	**0.000025**	**0.0079**	**0.0079**	**0.0766**	**0.0766**
MW-108	09/21/93	—	—	0.0091	0.0079 J	—	—	—	—	—	—	—
MW-108	12/16/93	—	—	0.0049	0.0059	—	—	—	—	—	—	—
MW-109	04/02/93	—	—	0.0047	—	0.0092 J	—	—	—	—	—	—
MW-109	09/21/93	—	—	0.012	—	0.022 J	—	—	—	—	—	—
MW-109	12/16/93	—	—	0.0063	—	0.012 J	—	—	—	—	—	—
MW-111	06/23/93	—	—	—	—	—	—	—	—	0.0094	—	—
MW-201	12/14/93	—	—	0.0031	—	—	—	—	—	—	—	—
MW-202	06/24/93	—	—	0.0034	—	0.010	0.0084	—	—	—	—	—
MW-203	12/14/93	—	—	—	—	0.0082 J	—	—	—	—	—	—
MW-204	06/21/93	—	—	0.0066	—	—	—	—	—	—	0.54	0.42
MW-205	04/01/93	—	—	0.013	0.0036	—	—	—	—	—	—	—
MW-205	06/21/93	—	—	0.0082	0.0066	—	—	—	—	—	—	—
MW-205	09/20/93	—	—	0.0062	0.0056	—	—	—	—	—	—	—
MW-205	12/13/93	—	—	0.0044	—	—	—	—	—	—	—	—
MW-208	09/14/94	—	—	0.12	—	0.19	—	0.00056	0.026	—	0.17	—
MW-209	09/14/94	—	—	0.012	—	—	—	—	—	—	—	—
SH-04	06/24/93	0.061	0.058	—	—	0.056	0.046	—	—	—	—	—
SH-04	09/23/93	—	—	—	—	0.027	0.016	—	—	—	—	—
TES-MW-1	12/13/93	—	—	0.0042	0.0050	—	—	—	0.027	0.028	—	—

Table 7-3

Texaco Harbor Island Terminal
Remedial Investigation Report
Inorganic Groundwater Results Above Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Date	Total Arsenic	Dissolved Arsenic	Total Copper	Dissolved Copper	Total Lead	Dissolved Lead	Total Mercury	Total Nickel	Dissolved Nickel	Total Zinc	Dissolved Zinc
Screening Level[a]		**0.036**	**0.036**	**0.0029**	**0.0029**	**0.0058**	**0.0058**	**0.000025**	**0.0079**	**0.0079**	**0.0766**	**0.0766**
TX-03	12/16/93	—	—	0.0092	—	—	—	—	—	—	—	—
TX-06	04/05/93	—	—	—	—	—	—	—	—	—	0.077	0.080
TX-06	09/23/93	0.058	0.053	—	—	—	—	—	—	—	—	—
TX-06	12/15/93	0.070	0.055	—	—	—	—	—	—	—	—	—

NOTE: Results are in mg/L.
— = Result below the screening level.
[a] See Table 7-2 for source of screening levels.

Table 7-4

Texaco Harbor Island Terminal
Remedial Investigation Report
Organic Groundwater Results Above
Potential Indicator Hazardous Substances Screening Levels

Sample Location	Sample Date	Benzene	Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Chrysene	Ethylbenzene	Toluene
Screening Level[a]		**0.071**	**0.000031**	**0.000031**	**0.000031**	**0.000031**	**0.43**	**5.0**
A-28	04/07/93	7.6	—	—	—	—	—	—
A-28	06/23/93	0.75	NA	NA	NA	NA	—	—
A-28	09/21/93	0.4	NA	NA	NA	NA	—	—
MW-101	06/18/93	0.12	NA	NA	NA	NA	—	—
MW-102	09/22/93	0.17	NA	NA	NA	NA	—	—
MW-104	06/22/93	0.12	NA	NA	NA	NA	2.4	—
MW-104	09/22/93	0.087	NA	NA	NA	NA	1.9	—
MW-108	04/02/93	0.28	—	—	—	—	—	—
MW-108	06/21/93	0.32	NA	NA	NA	NA	—	—
MW-108	09/21/93	0.26	NA	NA	NA	NA	—	—
MW-111	04/06/93	0.29	—	—	—	—	—	—
MW-111	06/23/93	0.41	NA	NA	NA	NA	—	—
MW-111	09/23/93	0.11	NA	NA	NA	NA	—	—
MW-208	09/14/94	—	0.000077	0.000050	0.000052	0.000043	—	—
SH-04	06/24/93	8.1	NA	NA	NA	NA	1.4	8.8
SH-04	09/23/93	8.4	NA	NA	NA	NA	2.2	6.3
TX-03	04/05/93	0.12	—	—	—	—	—	—
TX-03	06/22/93	0.16	NA	NA	NA	NA	—	—
TX-03	09/23/93	0.087	NA	NA	NA	NA	—	—
TX-03	12/16/93	0.36	NA	NA	NA	NA	—	—

NOTE: Results are in mg/L.
NA = not analyzed.
— = Result below the screening level.
[a] See Table 7-2 for source of screening levels.

wells. Total zinc also exceeded the groundwater screening level in one shallow monitoring well.

7.4.2 Organic Constituents

The groundwater screening level for benzene was exceeded in 19 samples from 7 shallow and 1 deep monitoring wells. Shallow monitoring wells accounted for 16 of the 19 samples that exceeded the screening level. The groundwater screening level for ethylbenzene was exceeded in four samples from two shallow monitoring wells. Two samples from one shallow monitoring well exceeded the groundwater screening level for toluene. The groundwater screening levels for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene were exceeded in one sample from shallow monitoring well MW-208. However, the results from MW-208 may have been affected by sampling the well the same day that it was developed. The TSS concentration of sample MW-208-0994 was elevated, indicating that particulate matter in the sample may have affected the results.

7.5 Groundwater Quality Trends

The groundwater chemistry data were evaluated to determine if temporal trends existed. Four quarters of laboratory analyses were performed for metals, TPH, BTEX, TDS, and TSS. Only a limited evaluation is possible with four quarters of data.

The metals, TPH, BTEX, TDS, and TSS data did not appear to correlate with a linear trend. For seasonal trend evaluation, the data were categorized as follows: metals, TPH and BTEX, and TDS and TSS. Table 7-5 lists the months that tended to have the highest and lowest constituent concentrations in each category. Overall, about half of the data showed no discernible seasonal pattern in a given category, due, in part, to the high number of nondetected values and similar concentrations between sampling events. When seasonal correlations were observed, the seasonal high concentrations tended to occur more often in April and June than in September or December. Approximately half of the time, seasonal trends were not related to groundwater level fluctuations.

7.6 Floating Product

Floating product was found in four monitoring wells: on-site monitoring well MW-6, located on the northeast side of the employee building, on-site monitoring well MW-204, and off-site monitoring wells A-28 and SH-04. Floating product ranged from trace (less than 0.01 feet) to an apparent thickness of 0.5 feet (Table 7-6).

Dark-brown floating product was encountered in two monitoring wells during the water level measurement round on November 5, 1993. The apparent thickness of floating product was 0.45 feet in on-site monitoring well MW-6 and 0.2 feet in off-site

Table 7-5

Texaco Harbor Island Terminal
Remedial Investigation Report
Seasonal Groundwater Quality Trends

Monitoring Well	Metals		TPH and BTEX		TDS and TSS	
	Yearly High[a]	Yearly Low[b]	Yearly High[a]	Yearly Low[b]	Yearly High[a]	Yearly Low[b]
A-28	June	—	April, June	September	—	September
DP-06	—	—	September	—	—	—
MW-05	—	—	June	December	December	June
MW-06	April	December	—	—	April	—
MW-101	September	—	June	December	—	—
MW-102	—	—	September	April, June	—	—
MW-103	April	September	—	—	April	September
MW-104	September	December	June	December	—	—
MW-105	—	—	—	—	—	—
MW-106	June	September	—	—	—	—
MW-107	—	—	—	—	—	—
MW-108	April	—	June	December	—	—
MW-109	September	June	April	December	September	—
MW-110	—	—	April	September	—	June
MW-111	June	—	June	December	—	—
MW-112	—	—	April	December	—	—
MW-201	April	—	April	—	September	December
MW-202	April	December	June	April	April	—
MW-203	—	—	June	December	April	December
MW-204	June	December	April	—	—	—
MW-205	April	December	—	—	April	—
MW-206	April, Sept.	June	—	—	September	—
MW-207	—	—	—	—	—	—
SH-04[c]	June	September	—	—	June	September
TES-MW-1	December	—	—	—	—	—
TX-03	December	—	December	April	—	—
TX-04	—	—	December	June	—	—
TX-06	April	September	September	—	—	—

NOTE: — = No discernible pattern or insufficient data to evaluate seasonal patterns.
[a] Month in which constituent concentrations were the highest.
[b] Month in which constituent concentrations were the lowest.
[c] Well not sampled in all four quarters.

Table 7-6

Texaco Harbor Island Terminal Remedial Investigation Report
Apparent Product Thickness in Wells with Detected Product

Date	Method of Measurement	A-28	MW-6	MW-204	SH-04
04/01/93	probe/bailer	—	—	NP	—
04/06/93	probe	NP	—	NP	—
04/07/93	probe/bailer	NP	—	—	—
05/13/93	probe	NP	—	NP	NP
06/10/93	probe	NP	—	NP	—
06/21/93	probe/bailer	—	—	NP	—
06/23/93	probe/bailer	NP	—	—	—
06/28/93	probe/bailer	—	—	—	NP
07/08/93	probe	NP	—	NP	NP
08/03/93	probe	NP	—	NP	NP
09/08/93	probe	NP	—	NP	NP
09/20/93	probe/bailer	—	—	NP	—
09/21/93	probe/bailer	NP	—	—	—
09/23/93	probe/bailer	—	—	—	NP
10/08/93	probe	NP	—	NP	NP
11/05/93	probe	0.20	0.45	NP	NP
11/12/93	probe	0.25	0.50*	—	—
12/03/93	probe	0.22	0.16*	NP	—
12/06/93	probe	—	NP	—	—
12/13/93	probe/bailer	—	—	NP	—
12/15/93	probe/bailer	trace	—	—	trace
12/16/93	probe/bailer	—	NP	—	—
01/05/94	probe	NP	NP	NP	NP
02/04/94	probe/bailer	NP	NP	NP	NP
03/01/94	probe	NP	NP	NP	NP
04/15/94	probe	—	NP	—	—
06/07/94	probe	NP	0.05*	NP	NP
09/14/94	probe	—	0.35	—	—
09/20/94	probe	—	0.35*	trace	—

NOTE: Product thickness in feet.
Probe = oil/water interface probe.
Bailer = clear PVC bailer.
NP = no product measured.
— = not measured.
Trace = product droplets or film, insufficient product to measure with an oil/water interface probe (less than 0.01 feet).

* Product removed from well with a bailer or peristaltic pump, approximately 2 to 10 gallons of water and product were removed on each date listed.

monitoring well A-28. On November 12, 1993, the apparent product thicknesses were verified (0.5 feet in MW-6 and 0.25 feet in A-28), and product samples were collected and submitted to a laboratory for analysis of total petroleum hydrocarbons and lead (Table 7-7). Product was also bailed from monitoring well MW-6 until the product thickness could be reduced no further (0.11 feet thick). Laboratory results showed that the product in MW-6 was primarily diesel, and that the product in A-28 was primarily gasoline.

During the December 3, 1993, groundwater level measurement event, the apparent floating product thickness was 0.16 feet in MW-6 and 0.22 feet in A-28. Floating product and water were removed from MW-6 with a peristaltic pump on December 3, 1993, until no product was visible in the pump discharge hose. On December 6 and 16, 1993, the floating product level was monitored by using an oil/water interface probe or a clear PVC bailer in MW-6. No floating product was found in MW-6 on either of these dates.

During the December 15, 1993, groundwater sampling round, floating product was found in A-28 and SH-04. Floating product in A-28 and SH-04 was not thick enough to be measured by the oil/water interface probe, but was visible in a clear PVC bailer. The product consisted of either dark brown droplets (SH-04) or a thick, but patchy, film (A-28 and SH-04). A sample of the floating product and stagnant well water in SH-04 was collected and submitted to a laboratory for analysis of total petroleum hydrocarbons and lead. Due to the presence of floating product in the wells, groundwater samples were not collected in either A-28 or SH-04 during this sampling round.

Floating product was not detected with an oil/water interface probe in MW-6, A-28, or SH-04 during the January, February, or March 1994 groundwater level measurement rounds. During the January and March rounds, an oil/water interface probe was used to check for the presence of floating product. A clear PVC bailer was also used to check for the presence of floating product in MW-6, A-28, and SH-04 in March 1994.

Floating product was measured in MW-6 in June and September 1994. The apparent product thickness was 0.05 feet on June 7, 1994, and 0.35 feet on September 14 and 20, 1994. Trace product (product thickness less than 0.01 feet) was found in MW-204 on September 20, 1994.

Table 7-7

Texaco Harbor Island Terminal
Remedial Investigation Report
Floating Product Laboratory Results

Well	Date Sampled	TPH-G (%)	TPH-D (%)	TPH-O (%)	Lead (mg/kg)
A-28	11/12/93	100	8.6	—[a]	360
MW-6	11/12/93	27	77	—[a]	<0.15
SH-04	12/15/93	—[b]	—[b]	—[b]	0.022[c]

NOTE: — = Not analyzed.

[a] Sample was not quantified against an oil standard, but an inspection of the chromatogram does not indicate a positive response in the oil range.

[b] Laboratory inadvertently did not analyze sample for TPH.

[c] Results reported in mg/L.

8 CONCEPTUAL SITE MODEL AND CONTAMINANT MIGRATION

8.1 Conceptual Site Model

A preliminary conceptual site model was developed for the Terminal based on operational history, data from isolated or preliminary studies, and preliminary data from USEPA's Phase II RI for Harbor Island. The preliminary model was submitted to Ecology as part of the Final Remedial Investigation Work Plan for the Terminal.

The preliminary model has been updated based on the findings and laboratory results from Texaco's RI. Potential pathways for exposure to contaminants at the site are identified on Figure 8-1. Exposure pathways typically consist of a source of chemical release into the environment, an environmental medium for transport of the chemical (i.e., air, groundwater, surface water, or soil), a receptor (either human, terrestrial, or aquatic), and an exposure route (i.e., inhalation, ingestion, or dermal contact).

Primary potential contaminant sources at the facility have been identified based on location and operations. A description of contaminant transport is provided below, by contaminant source area (Figures 2-2 and 2-3), as identified in Figure 8-1.

8.1.1 Main Tank Farm/Western Railcar Unloading Area

The main tank farm includes aboveground product storage tanks, aboveground pipelines, former tank bottoms disposal areas, and a storm water runoff system which consists of a series of catch basins draining to the main oil/water separator in the southeast corner of the site. The western railcar unloading area is located west of the main tank farm and includes catch basins which drain to the main oil/water separator. Potential primary release mechanisms in this area include spills or leaks to soil. Contaminated soil may act as a secondary source, with contaminant release to groundwater via infiltration/ percolation. Contaminants may migrate through soil or groundwater. Potential receptors for soil contamination include site workers, who may contact the contamination through ingestion or dermal contact.

8.1.2 Lubricants Tank Farms and Oil/water Separator

The lubricants tank farms include the southeast, southwest, and west tank farms, the southern railcar unloading area, the west and south sides of the warehouse, former drum storage areas, the blending building, the filling building (including the former barrel refurbishing/paint pit area), and the main oil/water separator (located at the southeast corner of the site). Potential primary release mechanisms in this area include spills or leaks to soil and leaks to groundwater. Contaminated soil may act as a secondary source, with contaminant release to groundwater. Contaminants may migrate through soil or groundwater. Potential receptors for soil contamination include site workers, who may contact the contamination through ingestion or dermal contact.

8.1.3 Employee Building/Pumphouse Area

This area includes the pumphouse, the north side of the warehouse, a small oil/water separator, the company vehicle fueling pad, former drum storage areas, and the boiler. Potential primary release mechanisms in this area include spills or leaks to soil. Contaminated soil may act as a secondary source, with contaminant release to groundwater. Contaminants may migrate through soil or groundwater. Site workers are the potential receptors for contaminated soil, via ingestion or dermal contact.

8.1.4 Loading Racks

The light oil loading rack, the lube oil loading rack, and the maintenance building, located in the southeast portion of the Terminal, are included in this area. Potential primary release mechanisms in this area include spills or leaks to soil. Potential receptors for soil contamination include site workers, who may contact the contamination through ingestion or dermal contact.

8.1.5 Former and Existing Underground Storage Tanks

Seven underground storage or process tanks currently exist at the facility, and nine underground storage tanks have been removed. Laboratory wastes were discharged to one of the tanks investigated in this area. Potential primary release mechanisms include spills or leaks to soil and groundwater. Contaminated soil may act as a secondary source, with contaminant release to groundwater. Contaminants may migrate through soil or groundwater. Potential receptors for soil contamination include site workers, who may contact the contamination through ingestion or dermal contact. Site workers also may have dermal contact with contaminated groundwater.

8.1.6 North Tank Farm/Dock Area

This area includes the north tank farm with two remaining aboveground storage tanks, former tank locations, former tank bottoms disposal areas, the shoreline manifold area, and the dock, along with associated pipelines (both above and below ground). Potential primary release mechanisms in this area include the following: spills or leaks to soil from storage tanks and aboveground pipelines; spills or leaks to surface water from nearby pipelines, valves, and during unloading of fuel at the dock; and leaks to groundwater from underground pipelines. Contaminated soil may act as a secondary source, with contaminant release to groundwater via infiltration/percolation. Contaminated groundwater may also act as a secondary source, flowing to surface water. Potential receptors for soil contamination include site workers, who may contact the contamination through ingestion or dermal contact. Site workers also may have dermal contact with contaminated surface water. Contaminated surface water may also impact area residents, via ingestion or dermal contact, and both terrestrial and aquatic biota, also via ingestion or dermal contact.

8.1.7 Adjacent Facilities

Adjacent facilities include the Shell Oil tank farm and distribution facility, the ARCO tank farm, and the Olympic Pipe Line operations to the east; Todd Shipyard and the Mobil Oil storage and distribution facility (operated by Rainier Petroleum) to the north; the ARCO storage and distribution facility and the Lockheed facility to the west; and the Seafab Metal fabrication facility (former smelter) to the south. The former smelter site is addressed separately below. Primary release mechanisms potentially affecting the Terminal site include off-site spills or leaks to groundwater. Off-site contaminated soil may act as a secondary source, with contaminant release to groundwater. Contaminants, including free product, may migrate through or on top of groundwater. Potential receptors include site workers, who may ingest or have dermal contact with soil, or have dermal contact with groundwater.

8.1.8 Former Off-site Lead Smelter

A secondary lead smelter was operated from 1937 through 1984 on property immediately south (across Lander Street) of the Texaco Terminal. During operation of the smelter, lead was reclaimed from automobile and industrial batteries by crushing the batteries, segregating the material, and sending the grit and lead paste through a secondary smelting furnace. The smelter was operated by a number of owners during its 47-year history. The former smelter property is currently owned by Seafab Metals. The island was listed as a Superfund site due to high soil lead concentrations from the smelter "as well as elevated concentrations of other hazardous substances" (USEPA, 1993).

The primary release mechanism at this site is airborne emissions from the former smelter (see Section 8.5.1). Soil, contaminated by deposition of lead-contaminated particulates, may act as a secondary source and may migrate further via wind-blown dust. Potential receptors for contaminated soil include site workers and terrestrial and aquatic biota, which may contact contaminated dust through inhalation.

8.2 Potential Indicator Hazardous Substances

Potential indicator hazardous substances were selected based on concentrations detected above screening levels and, for metals in groundwater, on frequency of detection. Screening levels are MTCA Method A cleanup levels, risk-based concentrations, and water quality criteria (Tables 8-1 and 8-2). Potential indicator hazardous substances are those substances that exceeded the screening levels and are not associated with former or existing Texaco Terminal operations. Preliminary indicator hazardous substances are those substances that exceeded the screening levels and are associated with former or existing Texaco Terminal operations. Indicator hazardous substances for the site will be refined based on frequency of detection and the presence of on-site sources, during the feasibility study. Because groundwater under Harbor Island is not considered a drinking water resource, the groundwater screening levels represent surface water quality criteria. These criteria are based on the protection of marine organisms or of human health from the consumption of marine organisms. Constituents detected at concentrations above the screening level are listed in Table 8-3. Constituents selected as potential indicator hazardous substances include arsenic and copper. Constituents selected as preliminary indicator hazardous substances include benzene, toluene, ethylbenzene, xylenes, TPH (including TPH-G, TPH-D, and TPH-O), cPAHs, and lead.

Following is a discussion of each of the constituents analyzed in soil and groundwater samples and the basis for inclusion or exclusion of each constituent as a potential indicator hazardous substance.

8.2.1 BTEX

All soil and groundwater samples were analyzed for BTEX constituents. Spills or releases associated with the fuels stored and transferred at the Terminal have contributed to BTEX contamination on site.

Benzene. Benzene was detected in 20 of 157 soil samples analyzed. Concentrations of benzene in soil ranged from below the detection limit to a maximum of 38 mg/kg in sample SB-102-5. More than 90 percent of the benzene results for soil samples were below or near the detection limit. The screening level for benzene (0.5 mg/kg) was exceeded in eight samples from eight borings; six of eight samples were collected at depths of 4 feet or more bgs. Benzene was detected in 51 percent of the groundwater samples analyzed and in 18 of the 30 wells sampled. The maximum concentration of

Table 8-1

Texaco Harbor Island Terminal
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Potential Indicator Hazardous Substances Screening Levels in Soil

Analyte	Screening Level (mg/kg)[a]
Antimony (surface soil)	180 to 677[b]
Arsenic (surface soil)	3.60 to 32.6[b]
Arsenic (subsurface soil)	200
Benzene	0.5
Cadmium	10
Chromium	500
Ethylbenzene	20
Lead	1,000
Mercury	1.0
PAHs (carcinogenic, surface soil)	0.1 to 36.5[b]
PAHs (carcinogenic, subsurface soil)	20
PCBs (surface soil)	0.18 to 2.99[b]
PCBs (subsurface soil)	10
TPH (gasoline)	100
TPH (diesel)	200
TPH (oil)	200
Toluene	40
Xylenes	20

[a] Based on MTCA Method A for soil at industrial sites unless otherwise specified.
[b] Based on achieving a 1×10^{-5} excess cancer risk or Hazard Index equal to 1 (USEPA risk assessment for Operable Unit No. 4 on Harbor Island).

Table 8-2

Texaco Harbor Island Terminal
Remedial Investigation Report
Potential Indicator Hazardous Substances Screening Levels in Groundwater

Analyte	Screening Level (mg/L)[a]
Arsenic	0.036 [a,b]
Benzene	0.071[b]
Benzo(a)anthracene	0.031[b]
Benzo(a)pyrene	0.031[b]
Benzo(b)fluoranthene	0.031[b]
Benzo(k)fluoranthene	0.031[b]
Cadmium	0.008 [a,b]
Chromium (VI)	0.050 [a,b]
Chrysene	0.031[b]
Copper	0.0029 [a,b]
Dibenzo(a,h)anthracene	0.031[b]
Ethylbenzene	0.43[b]
Indeno(1,2,3-cd)pyrene	0.031[b]
Lead	0.0058 [a,b]
Mercury	0.000025 [a,b]
Nickel	0.0079 [a,b]
Toluene	5.0[b]
Zinc	0.0766 [a,b]

[a] Based on Chapter 173-201 WAC, *Water Quality Standards for Surface Waters of the State of Washington* unless otherwise specified.

[b] Based on *Quality Criteria for Water*, EPA 440/5-86-001, May 1986. cPAH screening levels modified by Federal Register, Vol. 57, No. 246, December 22, 1992.

Table 8-3

Texaco Harbor Island Terminal
Remedial Investigation Report
Constituents Detected at Concentrations Above Screening Levels

Constituent	Soil	Groundwater
Benzene	X	X
Toluene		X
Ethylbenzene	X	X
Xylenes	X	NA
TPH-G	X	NA
TPH-D	X	NA
TPH-O	X	NA
Carcinogenic PAHs[a]		X
Arsenic	X	X
Cadmium		
Chromium		
Copper	NA	X
Lead	X	X
Mercury	X	X
Nickel	NA	X
Zinc	NA	X
PCBs		—
EDB	—	NA
EDC	—	NA
MTBE	—	NA

NOTE: NA = not applicable.
— = not analyzed.

[a] Includes benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno (1,2,3-cd)pyrene.

benzene detected in groundwater was 8.4 mg/L in off-site monitoring well SH-04. The screening of 0.071 mg/L for benzene was exceeded in 19 groundwater samples from seven shallow monitoring wells and one deep monitoring well. Benzene was retained as a preliminary indicator hazardous substance since there were detections above the soil and groundwater screening levels.

Toluene. Toluene was detected in 32 of 157 soil samples analyzed, with a maximum concentration of 15 mg/kg in sample SB-102-5. None of the soil samples exceeded the screening level (40 mg/kg) for toluene. Toluene was detected in 44 percent of the groundwater samples analyzed and in 16 of the 30 wells sampled. The maximum concentration of toluene detected in groundwater was 8.8 mg/L in sample SH-04-0693. The screening level of 5 mg/L was exceeded in two groundwater samples from SH-04. Toluene was retained as a preliminary indicator hazardous substance because there were detections above the groundwater screening level.

Ethylbenzene. Ethylbenzene was detected in 31 of 157 soil samples analyzed, with a maximum concentration of 71 mg/kg in sample SB-102-5. Three of the soil samples exceeded the screening level (20 mg/kg) for ethylbenzene. Ethylbenzene was detected in 40 percent of the groundwater samples analyzed and in 16 of the 30 wells. The maximum concentration of ethylbenzene detected in groundwater was 2.4 mg/L in sample MW-104-0693. The screening level of 0.43 mg/L was exceeded in four groundwater samples from two shallow wells. Ethylbenzene was retained as a preliminary indicator hazardous substance because detections did exceed the soil and groundwater screening levels.

Total xylenes. Total xylenes were detected in 44 of 157 soil samples analyzed. The maximum concentration of xylenes detected was 160 mg/kg in sample SB-102-5. Six soil samples contained xylenes at a concentration above the screening level (20 mg/kg). Xylenes were detected in 52 percent of the groundwater samples analyzed and in 20 of the 30 wells sampled. The maximum concentration of xylenes detected in groundwater was 13 mg/L in sample MW-104-0693. No screening level was established for xylenes (no surface water standard exists). Xylenes were retained as a preliminary indicator hazardous substance because detections did exceed the soil screening level.

8.2.2 TPH

Soil samples were analyzed for TPH-G, TPH-D, and TPH-O. Spills or releases associated with operations by Texaco, by prior property owners, or by off-site facilities have contributed to TPH contamination on site.

TPH-G. TPH-G was detected in 45 of 157 soil samples, with a maximum concentration of 12,000 mg/kg in sample SB-122-5. The screening level for TPH-G (100 mg/kg) was exceeded in 23 soil samples from 14 soil borings and 4 monitoring well boreholes. TPH-G was detected in 47 percent of the groundwater samples analyzed and in 17 of the 30 wells sampled. The maximum concentration of TPH-G detected in groundwater was 52 mg/L in sample SH-04-0693. No screening level was established for TPH-G (no surface water standard exists). TPH-G was retained as a preliminary indicator hazardous substance because detections did exceed the soil screening level.

TPH-D. TPH-D was detected in 76 of 157 soil samples, with a maximum concentration of 14,000 mg/kg in samples SB-206-3 and SB-208-6.5. The screening level for TPH-D (200 mg/kg) was exceeded in 30 soil samples collected from 18 soil borings and 5 monitoring well boreholes. TPH-D was detected in 66 percent of the groundwater samples analyzed and in 24 of the 30 wells sampled. The maximum concentration of TPH-D in groundwater was 19 mg/L in sample MW-208-0994. No screening level was established for TPH-D (no surface water standard exists). TPH-D was retained as a preliminary indicator hazardous substance because detections did exceed the soil screening level.

TPH-O. TPH-O was detected in 40 of 157 soil samples, with a maximum concentration of 52,000 mg/kg in sample SB-122-5. The screening level for TPH-O (200 mg/kg) was exceeded in 25 samples from 16 soil borings and 4 monitoring well boreholes. TPH-O was detected in 7 percent of the groundwater samples analyzed and in 7 of the 30 wells sampled. The maximum concentration of TPH-O in groundwater was 11 mg/L in sample MW-208-0994. No screening level was established for TPH-O (no surface water standard exists). TPH-O was retained as a preliminary indicator hazardous substance because detections did exceed the soil screening level.

8.2.3 Carcinogenic PAHs

Concentrations of cPAHs may be associated with petroleum products stored and transferred at the site. Concentrations of cPAHs were detected in 13 of 52 soil samples analyzed. In soil, cPAH detections ranged from below the detection limit to 0.66 mg/kg. The maximum total cPAH concentration detected in any soil sample was 2.64 mg/kg in sample SB-210-6.5. None of the cPAH concentrations detected in soil samples exceeded the surface soil screening level (36.5 mg/kg) and the subsurface soil screening level (20 mg/kg). Concentrations of cPAHs were detected in groundwater samples from four monitoring wells: on-site wells MW-201 and MW-208 and off-site wells A-28 and TX-03. Four groundwater samples in one well (MW-208) exceeded the screening level of 0.031 μg/L (per individual cPAH). cPAHs were retained as preliminary indicator hazardous substances because detections exceeded the screening level at MW-208.

8.2.4 Metals

Soil samples were analyzed for eight metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. In addition, the USEPA also collected surface soil samples and analyzed for aluminum, antimony, barium, beryllium, calcium, cobalt, cyanide, iron, magnesium, manganese, potassium, selenium, silver, sodium, thallium, and vanadium as part of the island-wide remedial investigation. Potential on-site sources of metals include petroleum products stored and transferred at the site and sandblast grit from tank repainting.

Arsenic. Arsenic was detected in all but 3 of the 132 soil samples analyzed. The maximum concentration of arsenic detected was 92.5 mg/kg in surface soil sample TX-17. Six surface soil samples exceeded the surface soil screening level (32.6 mg/kg). No samples exceed the subsurface soil screening level of 200 mg/kg. Total arsenic was detected in 58 percent of the groundwater samples analyzed and in 24 of the 30 wells sampled. Dissolved arsenic was detected in 51 percent of the groundwater samples analyzed and in 21 of the 30 wells. The maximum concentrations of total and dissolved arsenic were 0.070 mg/L (TX-06-1293) and 0.058 mg/L (SH-04-0693), respectively. Total and dissolved arsenic were detected at concentrations above the screening level (0.036 mg/L) in three groundwater samples collected from two off-site wells: SH-04 and TX-06. Arsenic was retained as a potential indicator hazardous substance because detections exceeded the surface soil and groundwater screening levels.

Cadmium. Cadmium was detected in 25 of the 123 soil samples analyzed, with a maximum concentration of 2.8 mg/kg in sample MW-107-3. None of the soil samples contained cadmium concentrations above the screening level of 10 mg/kg. Total cadmium was detected in only one groundwater sample: 0.006 mg/L in sample A-28-0493. Dissolved cadmium was not detected in any groundwater sample. None of the groundwater samples contained cadmium concentrations above the screening level of 0.008 mg/L. Cadmium was not retained as a potential indicator hazardous substance since no screening level was exceeded.

Chromium. Chromium was detected in all 123 soil samples analyzed. The maximum chromium concentration was 46 mg/kg in surface soil sample TX-01. None of the soil samples contained chromium concentrations above the screening level of 500 mg/kg. Total chromium was detected in 17 percent of the groundwater samples analyzed and in 5 of the 28 wells sampled. Dissolved chromium was detected in 16 percent of the samples analyzed and in 6 of the 30 wells. The maximum concentrations of total and dissolved chromium were 0.049 mg/L in sample MW-06-0493. None of the groundwater samples contained chromium concentrations above the screening level of 0.050 mg/L. Chromium was not retained as a potential indicator hazardous substance since no screening levels were exceeded.

Copper. Copper was detected in all but 3 of 123 soil samples analyzed, with a maximum concentration of 930 mg/kg in surface sample TX-01. No screening level was established for copper in soil. Total copper was detected in 50 percent of the groundwater samples analyzed and in 24 of the 30 wells sampled. Dissolved copper was detected in 41 percent of the groundwater samples analyzed and in 21 of the 30 wells sampled. Maximum concentrations of total and dissolved copper detected were 0.12 mg/L (MW-208-0994) and 0.017 mg/L (MW-06-0993 and MW-108-0493), respectively. The screening level for copper in groundwater (0.0029 mg/L) was exceeded by total or dissolved copper concentrations in 30 samples from 8 shallow and 6 deep monitoring wells. Twenty-one of the 30 groundwater samples that exceeded the screening level for either total or dissolved copper were collected from deep monitoring wells. Copper was retained as a potential indicator hazardous substance because detections exceeded the groundwater screening level.

Lead. Lead was detected in all but 2 of the 143 soil samples analyzed. Elevated lead concentrations were observed primarily in the surface soil (0 to 0.5 feet). Concentrations decreased significantly with depth. Lead concentrations in surface soil collected during the Texaco RI ranged from 8.7 mg/kg to 1,600 mg/kg. USEPA's on-site surface soil analyses for lead ranged from 8 mg/kg to 3,910 mg/kg. USEPA's surface soil analyses for lead in samples taken near the Terminal ranged from 345 mg/kg to 13,000 mg/kg. Fourteen on-site soil samples contained lead concentrations at levels above the screening level of 1,000 mg/kg. Higher concentrations of lead in surface soil were observed in the portion of the Terminal closer to the former smelter operation, especially in unpaved areas or in areas that were unpaved during operation of the smelter.

Total lead was detected in 34 percent of the groundwater samples analyzed and in 20 of the 30 wells sampled. Dissolved lead was detected in 20 percent of the samples analyzed and in 14 of the 30 wells. Maximum concentrations of total lead and dissolved lead detected were 0.19 mg/L and 0.046 mg/L, respectively. The screening level for lead (0.0058 mg/L) was exceeded by total or dissolved lead concentrations in 15 groundwater samples from 7 shallow and 1 deep monitoring wells. Fourteen of the 15 samples that exceeded the screening level were collected from shallow monitoring wells.

The primary source of lead at the Terminal appears to be an off-site facility. However, lead was retained as a preliminary indicator hazardous substance because detections exceeded the soil and groundwater screening levels.

Mercury. Mercury was detected in only 13 of the 123 soil samples analyzed, with a maximum concentration of 1.8 mg/kg in sample BH05-4. Six of the mercury concentrations in soil samples, all from BH-05, exceeded the screening level of 1.0 mg/kg. One groundwater sample in one well exceeded the screening level of 0.025 μg/L. Due to the one-time anomalous detections in soil and groundwater, mercury was retained as a potential indicator hazardous substance.

Nickel. Nickel was detected in all but one of 123 soil samples analyzed, with a maximum concentration of 46 mg/kg in surface sample TX-01. No screening level was established for nickel in soil. Total nickel was detected in 52 percent of the groundwater samples analyzed and in 27 of the 30 wells sampled. Dissolved nickel was detected in 38 percent of the samples analyzed and in 19 of the 30 wells. Maximum concentrations of total and dissolved nickel were 0.027 mg/L and 0.028 mg/L, respectively (both in TES-MW-1). Total nickel and dissolved nickel each were detected in three groundwater samples (from three wells) at concentrations above the screening level of 0.0079 mg/L. Due to the lack of an on-site nickel source and the minimal number of groundwater detections above the screening level, nickel was not retained as a potential indicator hazardous substance at the site.

Zinc. Zinc was detected in all 123 soil samples analyzed, with a maximum concentration of 456 mg/kg in surface sample TX-01. No screening level was established for zinc in soil. Total zinc was detected in 8 percent of the groundwater samples analyzed and in 6 of the 28 wells sampled. Dissolved zinc was detected in 6 percent of the groundwater samples analyzed and in 4 of the 28 wells. Maximum concentrations of total and dissolved zinc were 0.540 mg/L and 0.420 mg/L, respectively (both in sample MW-204-0693). Total and dissolved zinc were detected in two groundwater samples at concentrations above the screening level of 0.0766 mg/L. Although zinc was ubiquitous in soil at the site, due to the low number of zinc detections in groundwater and the minimal number of detections above the screening level, zinc was not retained as a potential indicator hazardous substance.

8.2.5 PCBs

Only soil was analyzed for PCBs. Of the nine soil samples analyzed, PCBs were detected in one sample (0.076 mg/kg total PCBs in SB-205-1). None of the soil samples exceeded the screening level for PCBs in soil (ranging from 0.18 to 2.99 mg/kg). Because there is no on-site PCB source, PCBs were detected in only one sample, and the detected PCB concentration was below the screening level, PCBs were not retained as a potential indicator hazardous substance.

8.2.6 Fuel Additives

MTBE has been used as a product additive, but it is not known whether EDB and EDC were used as product additives on site. Groundwater samples were analyzed for EDB, EDC, and MTBE during one sampling round. EDB was not detected in any of the 28 groundwater samples analyzed. EDC was detected in 5 of 28 groundwater samples analyzed, with a maximum concentration of 0.0004 mg/L (just over the detection limit). MTBE was detected in 3 of 28 groundwater samples analyzed, with a maximum concentration of 0.120 mg/L. No screening levels were established for any of these constituents. Due to the limited number of detections and the low concentrations

detected, EDB, EDC, and MTBE were not retained as potential indicator hazardous substances.

8.3 Preliminary Indicator Hazardous Substances and Potential Source Areas

As discussed in Section 8.2, potential indicator hazardous substances are those substances that exceeded screening levels. Preliminary indicator hazardous substances are those potential indicator hazardous substances that are associated with former or existing Texaco Terminal operations and include benzene, toluene, ethylbenzene, xylenes, TPH-G, TPH-D, TPH-O, cPAHs, and lead. Table 8-4 presents the primary potential source areas at and adjacent to the Terminal, the sampling locations within or adjacent to the source areas, and the preliminary indicator hazardous substances detected at the Terminal above the screening levels. Summarized below are the preliminary indicator hazardous substances screening level exceedances (Tables 6-2, 7-3, and 7-4) by potential source area at the Terminal.

8.3.1 Main Tank Farm/Western Railcar Unloading Area

Forty-five soil samples were collected for chemical analysis from this area during the Texaco RI. Seven surface soil samples collected by the USEPA (Weston, 1993) in this area (TX-06, TX-07, TX-10, TX-12, TX-14, TX-15, and TX-16) exceeded the screening level for lead (Figure 6-2). One soil sample from SB-102, SB-103, SB-106, SB-108, SB-109, and SB-110 exceeded the screening levels for benzene, ethylbenzene, xylenes, TPH-G, TPH-D, or TPH-O. TPH-D and TPH-O concentrations in two soil samples from SB-110 exceeded the screening levels.

Thirty-two groundwater samples were collected for chemical analysis from this area during the Texaco RI. One sample each from monitoring wells MW-101 and MW-102 and four samples from off-site monitoring well TX-03 exceeded the groundwater screening level for benzene.

8.3.2 Lubricants Tank Farm and Oil/Water Separator

Twenty-one soil samples were collected for chemical analysis from this area during the Texaco RI. One surface soil sample at SB-131 exceeded the screening level for lead. One soil sample from MW-112 exceeded the screening level for TPH-D, and three soil samples from two borings (SB-123 and SB-131) exceeded the cleanup goals for TPH-G, TPH-D, or TPH-O.

Eleven groundwater samples were collected for chemical analysis from this area during the Texaco RI. Three samples from off-site monitoring well A-28 exceeded the groundwater screening levels for benzene and lead (total).

Table 8-4

Texaco Harbor Island Terminal
Remedial Investigation Report
Primary Potential Sources and Preliminary Indicator Hazardous Substances

Primary Potential Source Area	Sampling Locations within or Adjacent to Source Area	IHS Detected Above Soil Screening Level	IHS Detected Above Groundwater Screening Level
Main Tank Farm/Western Railcar Unloading Area	Surface soil sampling locations TX-06, TX-07, TX-10, TX-12, TX-14, TX-15, and TX-16; SB-101 through SB-114, MW-101 through MW-103, TES-MW-1; and off-site wells TX-03, TX-04, TX-06, and DP-06	Benzene, Ethylbenzene, Xylenes, TPH-G, TPH-D, TPH-O, and Lead	Benzene
Lubricants Tank Farm and Oil/Water Separator	Surface soil sampling locations SS-103, TX-22 and TX-25; SB-121, SB-123 through SB-125, SB-131, MW-110, MW-112; and off-site well A-28	TPH-G, TPH-D, TPH-O, and Lead	Benzene and Lead (total)
Employee Building/Pumphouse Area	Surface soil sampling locations SS-104 through SS-108, TX-17 and TX-18; SB-115, SB-126, and MW-105 through MW-109	TPH-D, TPH-O, and Lead	Benzene and Lead (total)
Loading Racks	Surface soil sampling locations SS-101 and TX-20; SB-117 through SB-120, MW-104, MW-05, MW-06; and off-site well SH-04	Benzene, Ethylbenzene, Xylenes, TPH-G, TPH-D, and TPH-O	Benzene, Ethylbenzene, Toluene, and Lead (total and dissolved)
Former and Existing Underground Storage Tanks	Surface soil sampling location TX-23; SB-116, SB-122, SB-127 through SB-130, and MW-111	Benzene, Ethylbenzene, Xylenes, TPH-G, TPH-D, and TPH-O	Benzene
North Tank Farm/Dock Area	Surface soil sampling locations SS-201, TX-01 and TX-02; SB-201, SB-201b, SB-202 through SB-212, MW-201 through MW-209	Benzene, Xylenes, TPH-G, TPH-D, and TPH-O	Lead (total and dissolved) and cPAHs
Adjacent Facilities	Off-site sampling locations	Benzene, TPH, and Lead	Benzene, Toluene, Ethylbenzene, and Lead
Former Off-site Lead Smelter	Off-site sampling locations	Lead	Lead

NOTE: IHS = indicator hazardous substance.

8.3.3 Employee Building/Pumphouse Area

Twenty-two soil samples were collected for chemical analysis from this area during the Texaco RI. One surface soil sample collected during the Texaco RI (SS-106) and two surface soil samples collected by the USEPA (Weston, 1993) in the area (TX-17 and TX-18) exceeded the screening level for lead. Three soil samples from one soil boring (SB-115) and one monitoring well (MW-109) exceeded the TPH-D and TPH-O screening levels.

Twenty groundwater samples were collected for chemical analysis from this area during the Texaco RI. Three samples from monitoring well MW-108 exceeded the groundwater screening level for benzene. One sample from MW-108 and three samples from MW-109 exceeded the groundwater screening level for lead (total).

8.3.4 Loading Racks

Fifteen soil samples were collected for chemical analysis from this area during the Texaco RI. One surface soil sample (TX-20) exceeded the TPH-O screening level. Two soil samples from SB-118 and MW-104 exceeded the screening levels for benzene, ethylbenzene, or xylenes. Six soil samples from four soil borings (SB-117 through SB-120) and one monitoring well (MW-104) exceeded the cleanup goals for TPH-G, TPH-D, or TPH-O.

Fourteen groundwater samples were collected for chemical analysis from this area during the Texaco RI. Two samples each from monitoring well MW-104 and off-site monitoring well SH-04 exceeded the groundwater screening level for benzene and lead (total or dissolved). Two samples from MW-104 also exceeded the ethylbenzene screening level, and two samples from SH-04 exceeded the ethylbenzene and toluene screening levels.

8.3.5 Former And Existing Underground Storage Tanks

Twenty soil samples were collected for chemical analysis from this area during the Texaco RI. Two soil samples from (SB-122 and SB-128) exceeded the screening levels for benzene, ethylbenzene, or xylenes. Seven soil samples from four soil borings (SB-116, SB-122, SB-127, and SB-128) and one monitoring well (MW-111) exceeded the screening levels for TPH-G, TPH-D, or TPH-O.

Four groundwater samples were collected for chemical analysis from this area during the Texaco RI. Three samples from monitoring well MW-111 exceeded the groundwater screening level for benzene.

8.3.6 North Tank Farm/Dock Area

Forty-six soil samples were collected for chemical analysis from this area during the Texaco RI. Four soil samples (SB-201, SB-206, SB-208, and SB-211) exceeded the cleanup goal for benzene or xylenes. Sixteen soil samples from nine soil borings (SB-201, SB-202, SB-203, SB-204, SB-206, SB-208, SB-210, SB-211, and SB-212) and four monitoring wells (MW-201 through MW-204) exceeded the screening levels for TPH-G, TPH-D, or TPH-O. A number of those samples were collected to supplement data collected during the early part of the RI, e.g., a localized area at the shoreline manifold.

Thirty groundwater samples were collected for chemical analysis in or adjacent to this area during the Texaco RI. One sample each from monitoring wells MW-202, MW-203, and MW-208 exceeded the groundwater screening level for lead (total or dissolved). One sample (from MW-208) exceeded the groundwater screening levels for four cPAHs.

8.4 Fate and Transport Properties

The fate and transport of chemicals in the environment depends on the physical and chemical characteristics of the contaminant, the physical characteristics of the site (e.g., underground utilities, pavement), and the physical and chemical characteristics of site soils, surface water, and groundwater. Reduction of contaminant concentrations by chemical breakdown (biodegradation, photolysis, or hydrolysis), chemical isolation (bioconcentration or soil adsorption), and mass transfer (volatilization or precipitation) are all expected to occur at the site to some degree, although rates or significance of these processes have not been evaluated. A general discussion of site contaminant fate and transport is provided below.

BTEX. BTEX compounds released to soil tends to volatilize due to its high vapor pressure. Benzene can leach through sandy soil to reach groundwater, where it can migrate rapidly due to its relatively high water solubility. Dissolved benzene in groundwater may move toward surface water by advection; however, transport rates are expected to be lower than groundwater flow velocities due to sorption to organic carbon and degradation by biologic and physical processes.

TPH and cPAHs. TPH is an analytical method or collection of methods designed to quantify a mixture of petroleum hydrocarbon constituents. TPH includes a wide variety of constituents, ranging from very volatile and soluble compounds, such as the BTEX constituents, to heavy molecular weight hydrocarbons with characteristically low solubility and vapor pressure and a high affinity for sorption to organic material (e.g., cPAHs). TPH-G constituents have fate and transport properties similar to benzene, as discussed above. The TPH-G constituents are the most mobile of the TPH compounds and are expected to migrate through soil to groundwater, as well as through

groundwater to surface water. TPH-D constituents tend to be less volatile and less soluble than TPH-G constituents and are more likely to absorb to organic matter. TPH-O constituents and cPAHs include the heavier molecular weight compounds which tend to have lower volatility, lower solubility, and a higher affinity for organic matter than TPH-D. TPH-O constituents and cPAHs are the least mobile of the TPH compounds and are not expected to significantly migrate either through soil or through groundwater. However, where lighter molecular weight TPH constituents occur and are mixed with heavier weight TPH constituents, the mobility of the heavier TPH constituents tends to increase.

Metals. The transport of metals is influenced by a number of chemical characteristics. They include pH, ionic strength of the groundwater and unsaturated pore water, and the organic and clay content of the soil. Metals are persistent in the environment, but low water solubility and the tendency to sorb to clay and organic particles in soil generally retards transport in groundwater. The mobility of metals tends to increase as the pH decreases. Lead, having a relatively high adsorption coefficient, tends to adsorb to soil.

8.5 Migration Pathways

8.5.1 Air

Historical operations from a former smelter located just south of the Terminal produced airborne emissions of lead dust/particles. Due to dust transport via wind, lead has adhered to surface soil on the Texaco property.

PSAPCA has monitored air quality on Harbor Island since 1977. Monitoring performed during operation of the lead smelter indicated that the smelter was the main contributor to elevated island-wide lead levels in air (Weston, 1993). Weston (1991) also reported that (1) the smelter was the major point source of air emissions on the island, (2) lead levels in air dropped significantly after the smelter closed, and (3) lead levels in air met the national ambient air quality standards after the smelter closed.

During the years when the lead smelter was operated, Texaco employees noted smoke and sharp odor emissions from the smelter and reported respiratory irritation. Physical evidence of the smelter emissions included a grayish discoloration of painted surfaces, especially those closest to the lead smelter, and a permanent grayish film on the windows nearest the lead smelter. Sampling performed for Texaco during operation of the lead smelter (in 1976, 1977, and 1979) indicated elevated concentrations of lead at Terminal sampling stations relative to those south of the smelter when the wind was from the south (National Loss Control Service Corporation, 1977; AM Test, 1979). Prevailing winds in the Harbor Island area are primarily (48 percent of the time) from the south-southwest, south, or south-southeast (Weston, 1993). Therefore, particulate emissions from the

adjacent smelter were directed primarily over the Texaco Terminal property, allowing deposition of airborne lead (and other metals) on exposed surfaces.

8.5.2 Soil

Terminal facilities include the main tank farm, the western railcar unloading area, lubricants tank farms, the warehouse and filling building, the oil/water separator, the employee building and pumphouse area, the loading racks, the former and existing underground storage tanks, the north tank farm, and the dock area. During the course of the Terminal's operation, releases or spills to the soil have occurred. Product recovery and soil cleanup were initiated immediately upon discovery. Soil beneath the site consists of grade fill composed primarily of silty sandy gravel and dredge fill composed of fine-to-medium sand. These types of soil can allow hazardous substances (associated with petroleum products) which spill onto soil to infiltrate and percolate through to groundwater beneath the site.

8.5.3 Groundwater

Due to the shallow depth to groundwater at the site (ranging from 4 to 8 feet bgs), hazardous substances can travel to groundwater through the soil or directly via releases from former underground storage tanks or pipelines. Petroleum product spilled at adjacent facilities can migrate to the site on the groundwater surface or dissolved in groundwater. Boring logs and static water level data show no significant confining layer in the depths monitored to date. Therefore, one aquifer exists below the site. Specific conductance data indicate that the aquifer below a depth of about 35 feet generally shows a specific conductance of 13,000 to 18,000 μmhos/cm. The aquifer is saline and, according to WAC 173-340-720(1)(a)(ii)(B), is not of practical use for drinking water. Ecology has identified Harbor Island as a site with an extremely low probability that groundwater would be classified as a potential future source of drinking water. Groundwater beneath the site eventually will flow to surface water at the perimeter of Harbor Island.

8.5.4 Surface Water

Hazardous substances from the site could have entered surface water directly via spills or releases occurring at the Pier 15 dock area and the manifold area or indirectly from groundwater. The modelling results presenting contaminant transport from the Terminal to the perimeter of Harbor Island are presented in Section 8.6.

8.6 Groundwater Flow and Transport

The USEPA groundwater modelling results for Harbor Island have been used to evaluate contaminant transport from groundwater beneath the Terminal to surface water at the edge of the island. The USEPA groundwater model results were used because the site-specific data collected during the Texaco RI are similar to the island-wide data collected by the USEPA. Data that are similar include geology, hydrostratigraphy, groundwater contours, tidal response study results, and hydraulic conductivities. Additionally, as discussed in Section 5.2.7, the data collected during the Texaco RI support the USEPA conceptual hydrologic model.

8.6.1 Modelling Methodology

The USEPA groundwater flow and transport model consisted of a combination of a steady state, two-dimensional, finite-difference flow and pathline model (FLOWPATH) with an analytical one-dimensional transport model. The shallow aquifer was assumed to be homogeneous and isotropic for purposes of the flow and transport model. Groundwater levels collected on September 24, 1992, were used to create a groundwater elevation grid. The grid, in turn, served as input to FLOWPATH, which estimated aquifer discharge to surface water and flow paths. Travel times and contaminant breakthrough curves were calculated by using the FLOWPATH output and retardation factors obtained from the literature. Deep groundwater was not considered, and future remediation scenarios cannot be evaluated using the model.

Forty-five pathlines were used in transport modelling. Each pathline was assigned a point of origin at a monitoring well. Four wells monitored during the Texaco RI were used as source wells for modelled pathlines: MW-05, and off-site wells TX-03, TX-04, and TX-06. Off-site monitoring well TX-02, located to the northwest of Texaco's North Tank Farm, also was used as a source well for a modelled pathline. The contaminant concentration at each well was assigned the higher of the two concentrations detected in that well during the two rounds of groundwater sampling and was assumed to be constant over time for purposes of the transport model. Biodegradation was not considered by the model.

8.6.2 Modelling Results

The groundwater contour map generated by the USEPA groundwater elevation grid for the Terminal is similar to the shallow groundwater contour maps generated during the Texaco RI. The groundwater elevations are the highest in the main tank farm and lowest in the northwest and southeast parts of the Terminal. The USEPA flow model estimated that 25 percent of groundwater discharge at the island is into an internal sink in the middle of the island. The cause of the sink is unknown. The southern portion of the Texaco main terminal is included in the region of the sink discharge. Pathlines within

the area of the internal sink, including the MW-05 pathline, were not included in the particle transport modelling.

With USEPA groundwater quality data and the modelling scenario preferred by the USEPA (a horizontal hydraulic conductivity of 0.003 cm/sec and metals retardation factors significantly greater than a value of one), the USEPA model estimated more than 1,000 years for time to exceedance of the metals groundwater cleanup goals (USEPA, 1993) at the ends of the pathlines starting at TX-03, TX-04, and TX-06. The ends of the pathlines are at the points of compliance at the perimeter of the island. Since the benzene concentrations, measured during the USEPA RI, in off-site monitoring wells TX-03, TX-04, and TX-06 did not exceed the groundwater cleanup goal, and the concentrations are assumed to remain constant at the well for the purposes of transport modelling, benzene was not estimated to exceed the groundwater cleanup goal for these pathlines.

The average metals and benzene concentrations from the four rounds of Texaco RI sampling in TX-04 and TX-06 were lower than the USEPA O.U. No. 4 groundwater cleanup goals. Therefore, the metals and benzene concentrations are estimated not to exceed the groundwater cleanup goals for these pathlines. Since the metals concentrations measured during the USEPA RI in TX-03 did not exceed the groundwater cleanup goals, metals are estimated not to exceed the USEPA O.U. No. 4 groundwater cleanup goal for this pathline. The average benzene concentration in TX-03 from the four rounds of Texaco RI sampling was 182 μg/L. Using the pathlines and breakthrough curves generated by the USEPA groundwater model and the average concentration of benzene in TX-03, the USEPA model estimated 70 years for time to exceedance of the groundwater cleanup goal at the end of this pathline. Since vertical flow and biodegradation were not considered in the model, the estimate for time to exceedance is extremely conservative.

8.7 Contaminant Migration

8.7.1 Benzene

Benzene and other BTEX compounds were detected in soil at depth in a number of locations. Benzene is the most mobile and toxic of the BTEX compounds and may be quickly volatilized from surface soil. Benzene can migrate from soil to groundwater. Benzene in petroleum product spilled at adjacent facilities can also migrate to the site on the groundwater surface. Although benzene was observed in groundwater beneath the site, there is no impact to surface water since groundwater beneath the central portion of the island, including the southern part of the Terminal, discharges to sinks in the central part of the island. The USEPA model predicted that concentrations of benzene in groundwater from beneath the northern part of the Terminal will not exceed the groundwater cleanup goal (surface water quality criteria) at the perimeter of the island.

8.7.2 Petroleum Hydrocarbons

TPH (an indicator of petroleum hydrocarbons) was observed in subsurface soil in localized areas of the main terminal, north tank farm and manifold area. TPH contamination has been found in areas within the main tank farm/western railcar unloading area (SB-102 and SB-110), north tank farm (SB-206 and SB-211), dock/shoreline manifold area (SB-201, SB-206, and SB-210), former underground storage tank sites (SB-122), the employee building/pumphouse area (MW-109 and SB-115), and lubricants tank farm (SB-123). The mobility of TPH in soil is largely a function of viscosity and volatility of the specific compound and the organic content of the soil. Lighter TPH compounds (e.g., gasoline) typically migrate readily through permeable soil as liquid and vapor phases. Heavier TPH compounds (e.g., lubricants or Bunker C) are much more viscous and less soluble, and are less likely to migrate.

TPH compounds, especially gasoline, are susceptible to biodegradation, volatilization, and adsorption, which will reduce the concentration of these contaminants over time. Gasoline and diesel are less dense than water and will collect and float on the water table, and move downgradient with groundwater flow. TPH as gasoline and/or diesel was observed in groundwater from on-site monitoring wells MW-101, MW-104, MW-110, MW-111, and MW-204 and off-site monitoring wells A-28, SH-04, and TX-04. Free product (up to 0.5 feet thick) has been detected in three monitoring wells: on-site well MW-6 and off-site wells A-28 and SH-04. However, no floating product was detected in any wells during the last three monthly rounds of product/water level monitoring. Petroleum product in off-site wells A-28 and SH-04 may have migrated to the area from adjacent facilities.

The detection of TPH in groundwater beneath the site indicates a pathway from soil to groundwater. Dissolved TPH in groundwater will move advectively, but is also subject to retardation by sorption to organic carbon and degradation by biologic and physical processes. Although TPH was observed in groundwater beneath the site, no impact to surface water is anticipated, because groundwater beneath the southern part of the Terminal discharges to sinks in the central part of the island. As previously mentioned, the USEPA model predicted that concentrations of benzene (a mobile constituent of petroleum hydrocarbons) will not exceed the groundwater cleanup goal at the perimeter of the island. Therefore, TPH poses no adverse impacts to surface water.

8.7.3 Lead

Elevated concentrations of lead were observed primarily in surface soil (0 to 0.5 feet bgs) and decreased significantly with depth. Higher concentrations of lead in surface soil were observed in the portion of the Terminal closer to the former smelter operation, especially in unpaved areas or in areas that were unpaved during operation of the smelter. These findings, historic air sampling data, and historic physical evidence

indicate that lead contamination throughout most of the site is not associated with the Terminal's operations, but is associated with surface contamination from an historic off-site source. Lead was not detected at elevated concentrations in soil samples from suspected former tank bottoms disposal areas. Lead was observed at very low concentrations in groundwater, except in two monitoring wells: on-site well MW-104 and off-site well SH-04. The detection of lead in groundwater from wells MW-104 and SH-04 indicates that there may be a localized source from the Terminal's operations. This finding is consistent with past observations of petroleum product in well SH-04. Although lead was observed in groundwater in a localized area, there is no impact to surface water since groundwater flow in the area is to a sink in the central portion of the island. However, in the event that groundwater in the area did migrate to surface water, the USEPA groundwater transport model indicated that there would be no adverse impacts to surface water adjacent to Harbor Island.

8.8 Summary

Following is an summary of key points relating to the fate and transport of contaminants at the Terminal.

- Constituents detected above screening levels and associated with terminal operations were identified as preliminary indicator hazardous substances at the site. They include benzene, toluene, ethylbenzene, xylenes, TPH (TPH-G, TPH-D, TPH-O), cPAHs, and lead.

- Constituents detected above screening levels, but not associated with terminal operations were identified as potential indicator hazardous substances. They include arsenic, copper, and mercury.

- Benzene was observed in subsurface soil and groundwater. Based on groundwater flow beneath the site and the results of the groundwater model, however, benzene contamination does not pose adverse environmental impacts to surface water at the perimeter of the island.

- Soil TPH contamination is found at depth in localized areas of the Terminal. Petroleum product has migrated to groundwater via soil; however, migration to surface water is limited by the direction of groundwater flow beneath the southern portion of the site. Floating product was found periodically on groundwater in four wells at or adjacent to the site during the RI. Product was only found during November 1993, December 1993, June 1994, and September 1994.

- Lead contamination is primarily limited to the surface soil, except for a localized area in the southeastern section of the Terminal. Based on the location and depth of soil samples containing elevated lead concentrations and historic

air sampling, the lead in shallow soil appears to be due to airborne discharges from the former smelter located immediately south of the Terminal.

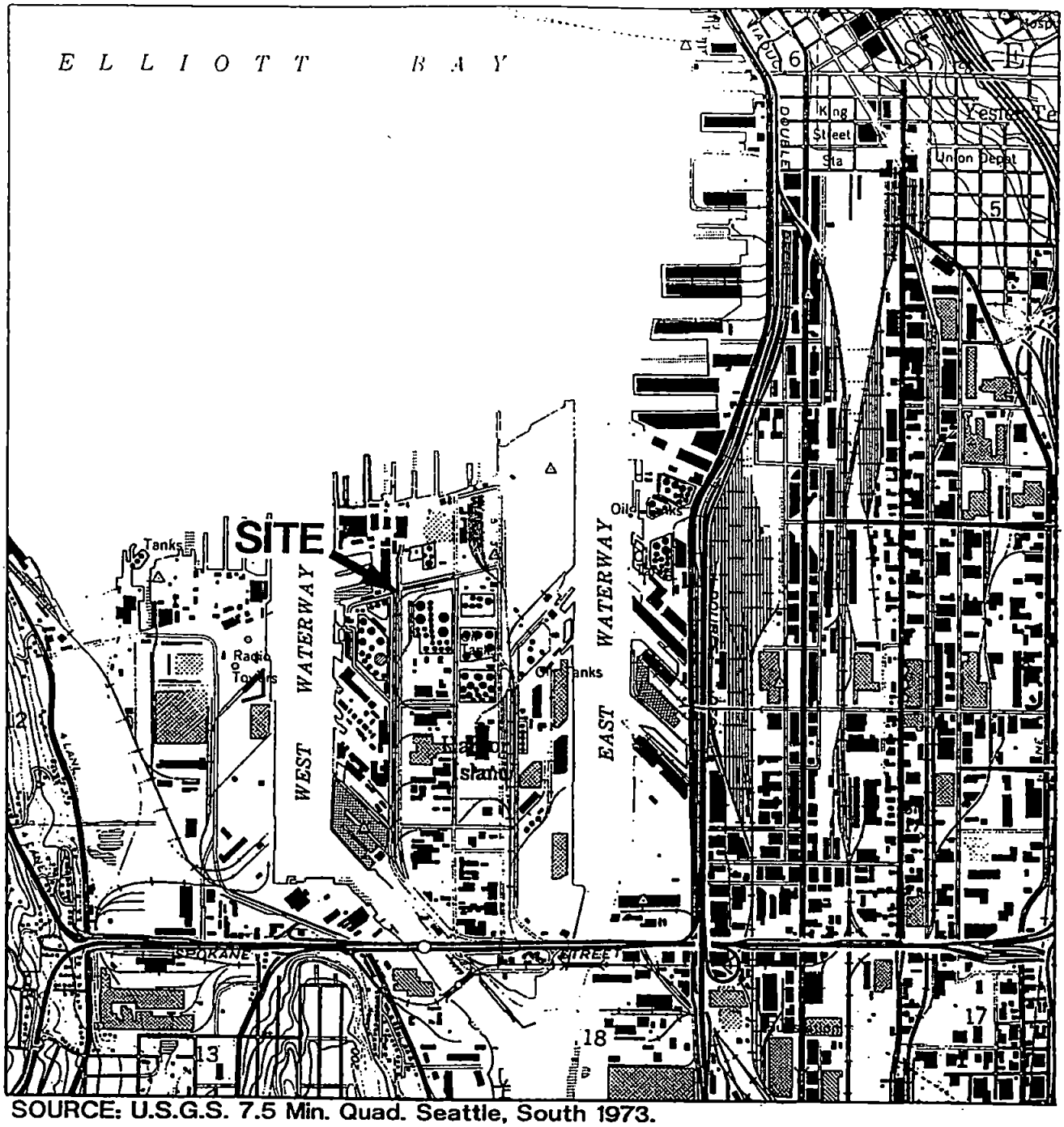
- Lead was not detected at elevated concentrations in soil samples collected from suspected tank bottoms disposal areas. Known or suspected tank bottom disposal areas were reported to be within the main and north tank farm areas.

- Select soil samples were analyzed for PCBs. PCBs were detected in only one sample at a concentration below the screening level; therefore, PCBs were not retained as potential indicator hazardous substances.

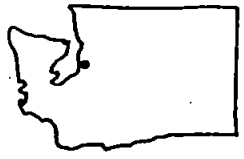
- One round of groundwater samples was analyzed for fuel additives, including EDB, EDC, and MTBE. Due to the very limited number of detections and low concentrations detected, EDB, EDC, and MTBE were not retained as potential indicator hazardous substances.

9 FIGURES

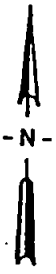
150969



SOURCE: U.S.G.S. 7.5 Min. Quad. Seattle, South 1973.



WASHINGTON



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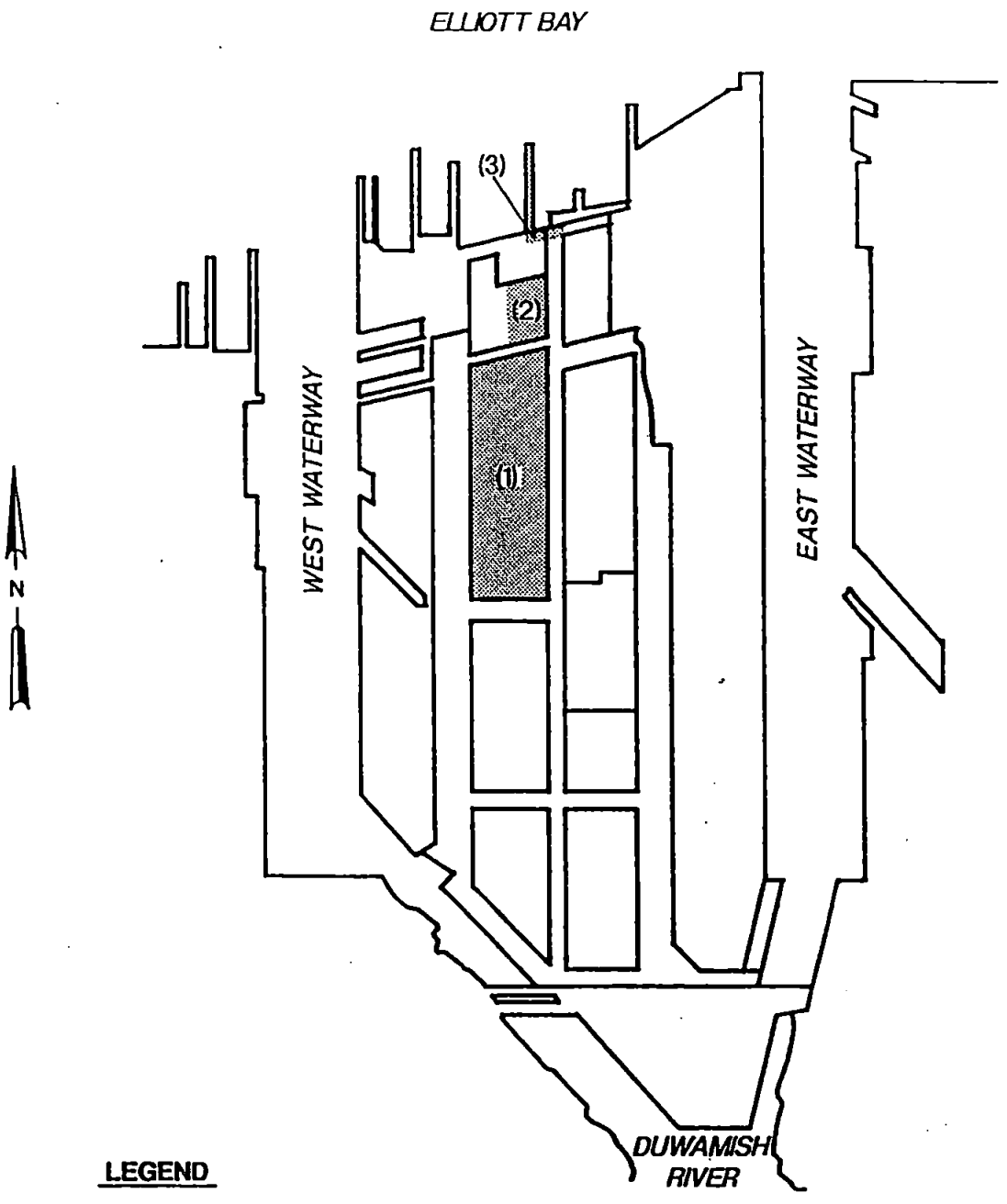
PROJECT NO. 0750-001.09

Figure 1-1
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SITE LOCATION MAP

142322



LEGEND

(1) Main Terminal

(2) North Tank Farm

(3) Shoreline Manifold and Dock Operations

NO SCALE

EMCON Northwest, Inc.

DATE 7-92
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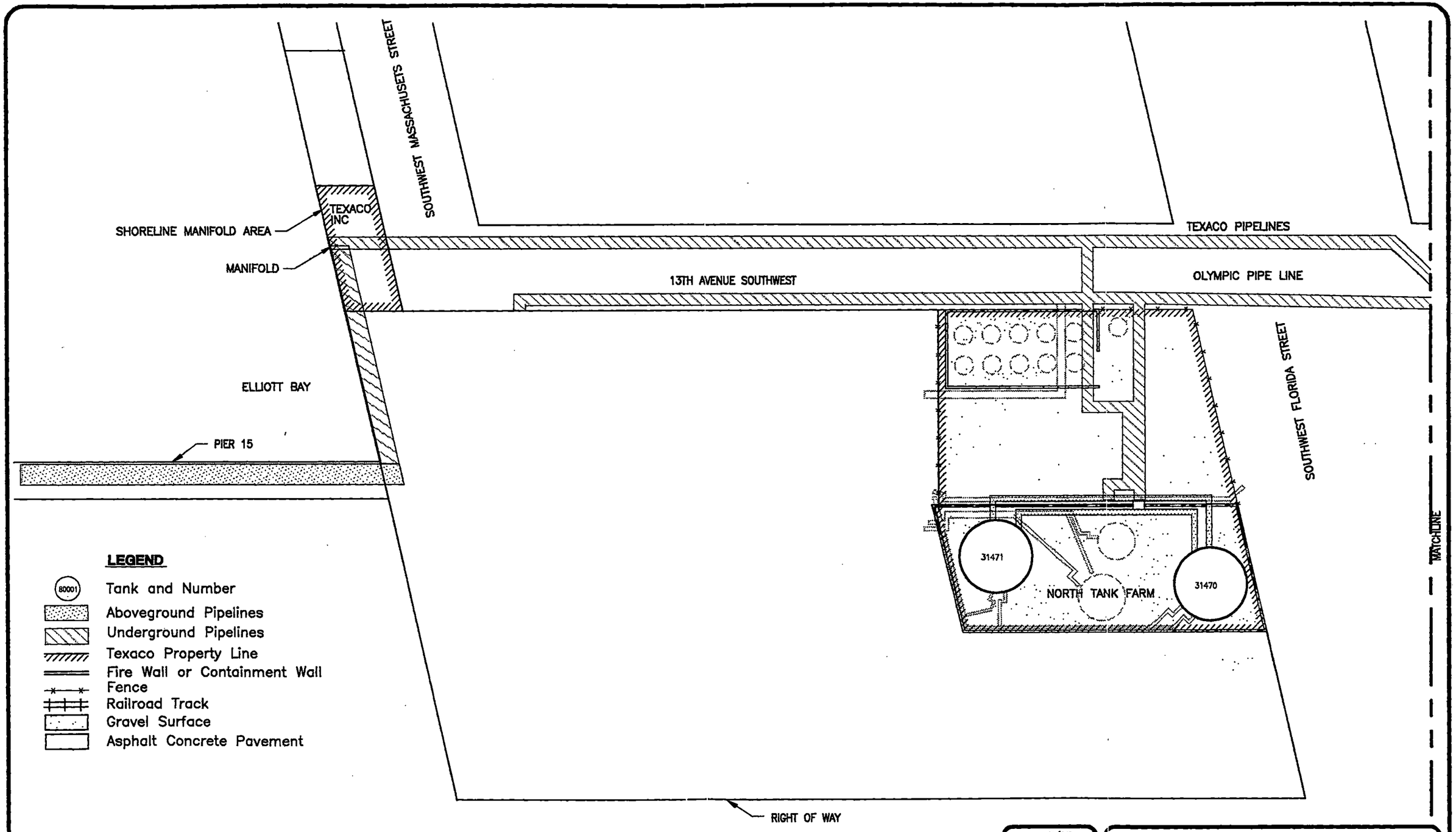
APPR.
REVIS.
PROJECT NO. 0750-001.09

Figure 2-1
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TERMINAL PROPERTIES

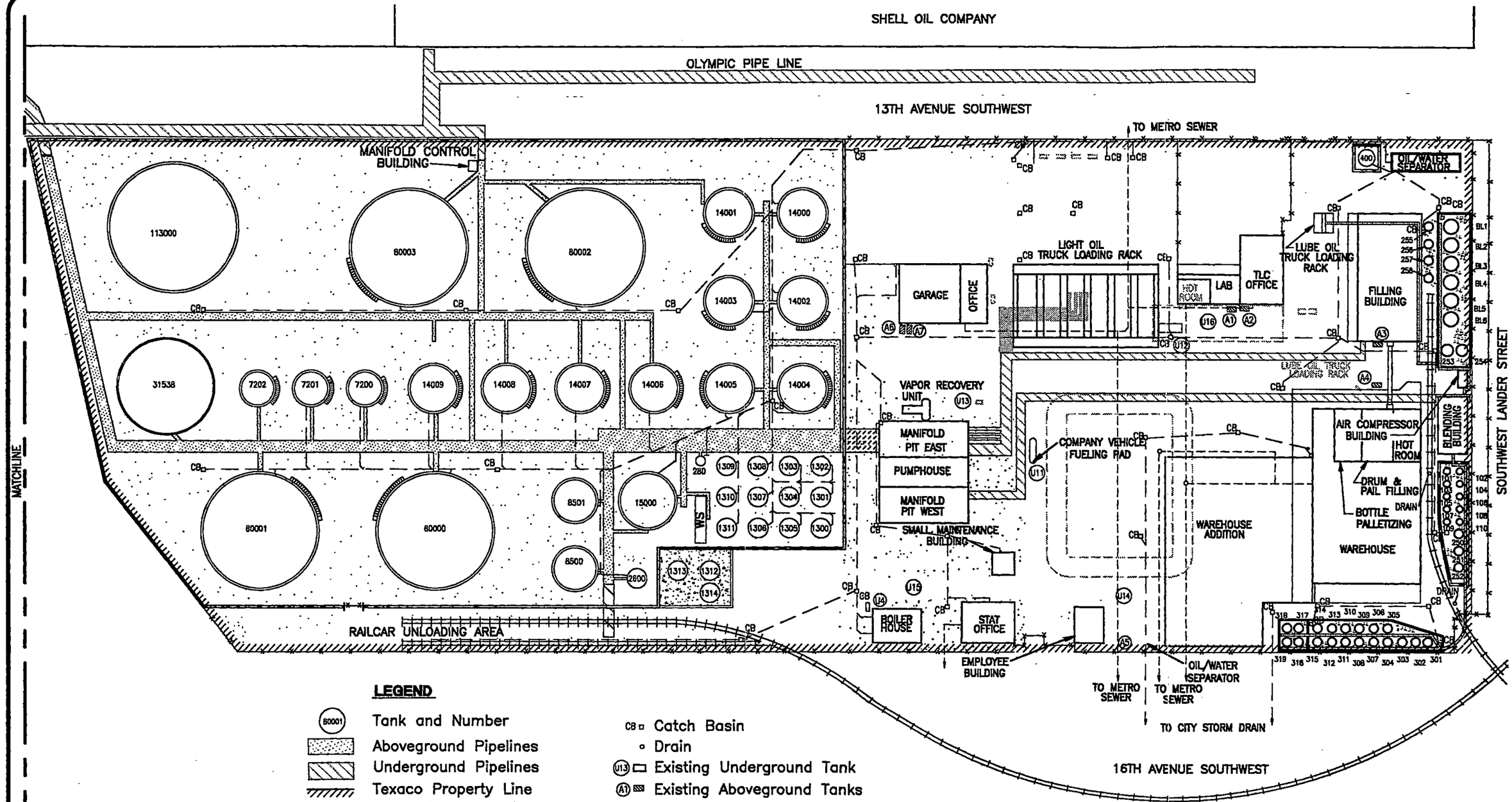


EMCON Northwest, Inc.

DATE 7/93
DWN. JG
REV.
APPR.
PROJECT NO. 0750-001.09

Figure 2-2
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON
HISTORICAL AND EXISTING STRUCTURES - NORTH TANK FARM, DOCK, & SHORELINE MANIFOLD AREAS

SCALE: 1=100 03-30-94 GISKEY STATION j:\data\dwg\0750\001\09c04 from C:\07500190\BASEMAP2



LEGEND

- Tank and Number
- Aboveground Pipelines
- Underground Pipelines
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- Concrete Pad
- CB Catch Basin
- Drain
- Existing Underground Tank
- Existing Aboveground Tanks

N

0 100 200

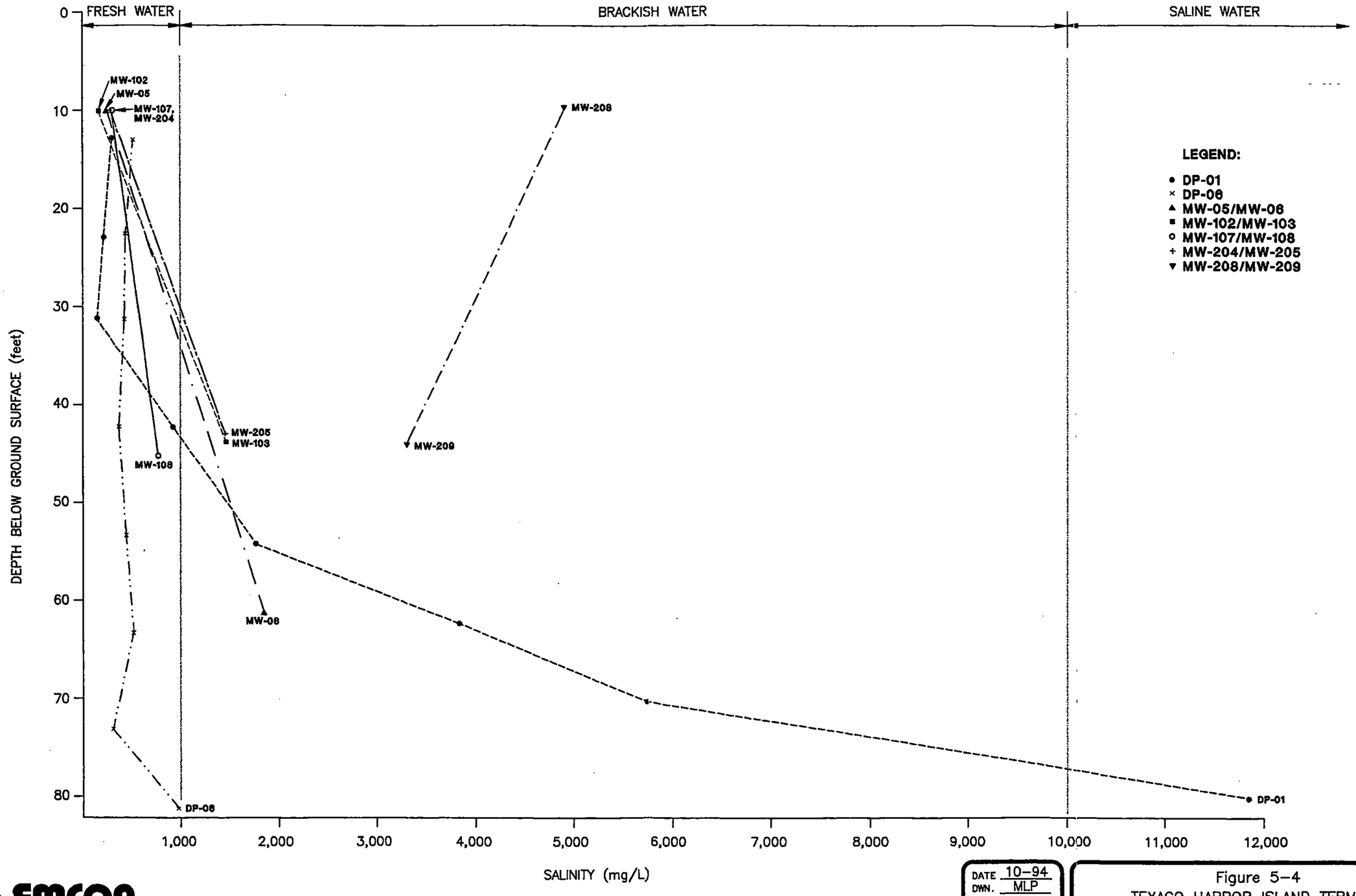
SCALE (ft)

EMCON Northwest, Inc.

DATE 7/93
DWN. JV/JG
REV.
APPR.
PROJECT NO. 0750-001.09

Figure 2-3
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON
HISTORICAL AND EXISTING STRUCTURES
MAIN TERMINAL AND TANK FARM

SCALE: 1=100 03-30-94 GISKEY STATION j:\data\dwg\0750\001\09c04 from C:\07500190\BASEMAP2



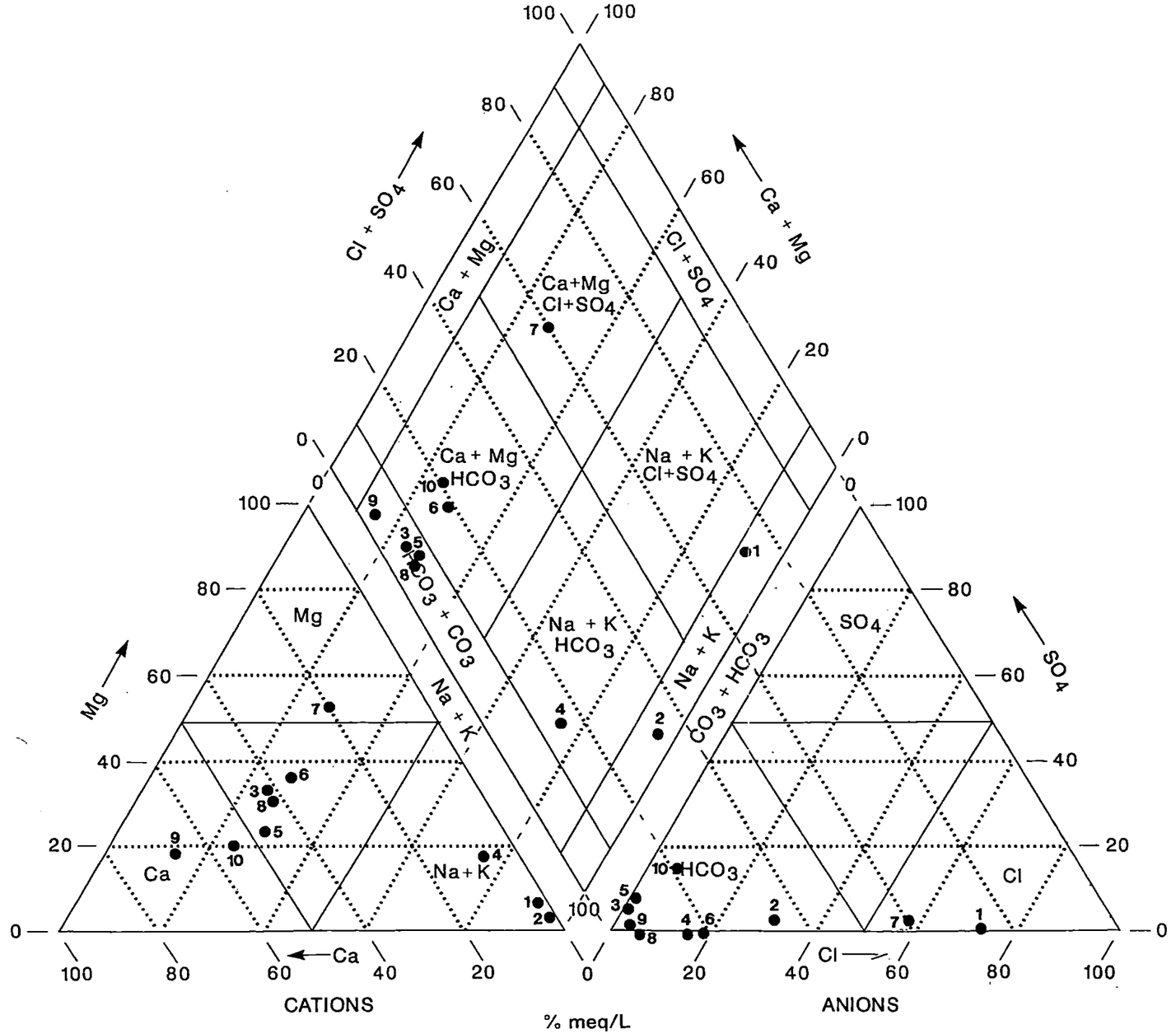
Emcon Northwest, Inc.

DATE 10-94
DWN. MLP
REV.
APPR.
PROJECT NO.
0750-001.09

Figure 5-4
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

GROUNDWATER SALINITY VERSUS DEPTH

1= 1 10-21-94 G:\DWG\0750\001\09BLC10



LEGEND:

1 = DP–01
2 = DP–06
3 = MW–05
4 = MW–06
5 = SH–04
6 = TX–01
7 = TX–02
8 = TX–03
9 = TX–04
10 = TX–06

EMCON Northwest, Inc.

DATE 10–94
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REV.
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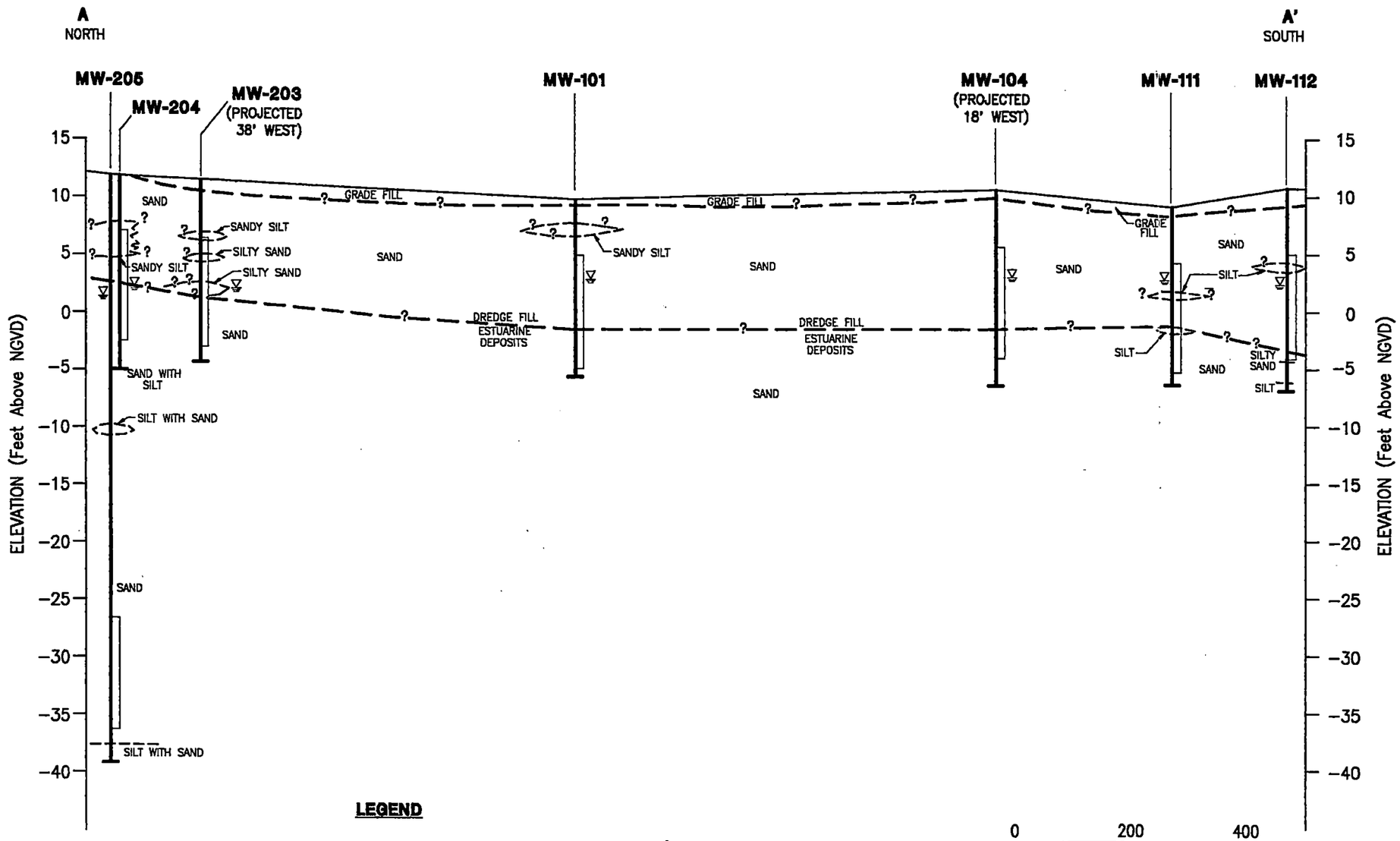
PROJECT NO. 0750–001.09

Figure 5–2
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON
MAJOR ION CHEMISTRY
NOVEMBER 1991



LEGEND

- — — —?— ESTIMATED FORMATION CONTACT
- ----?--- ESTIMATED LITHOLOGIC CONTACT
- **MW-204** MONITORING WELL NUMBER

NOTE: CROSS SECTION LOCATION SHOWN ON DRAWING 1

BOREHOLE LOCATION
WELL SCREEN LOCATION
WATER LEVEL IN WELL ON 11/05/93

0 200 400
SCALE (ft)
VERTICAL EXAG.= 20X

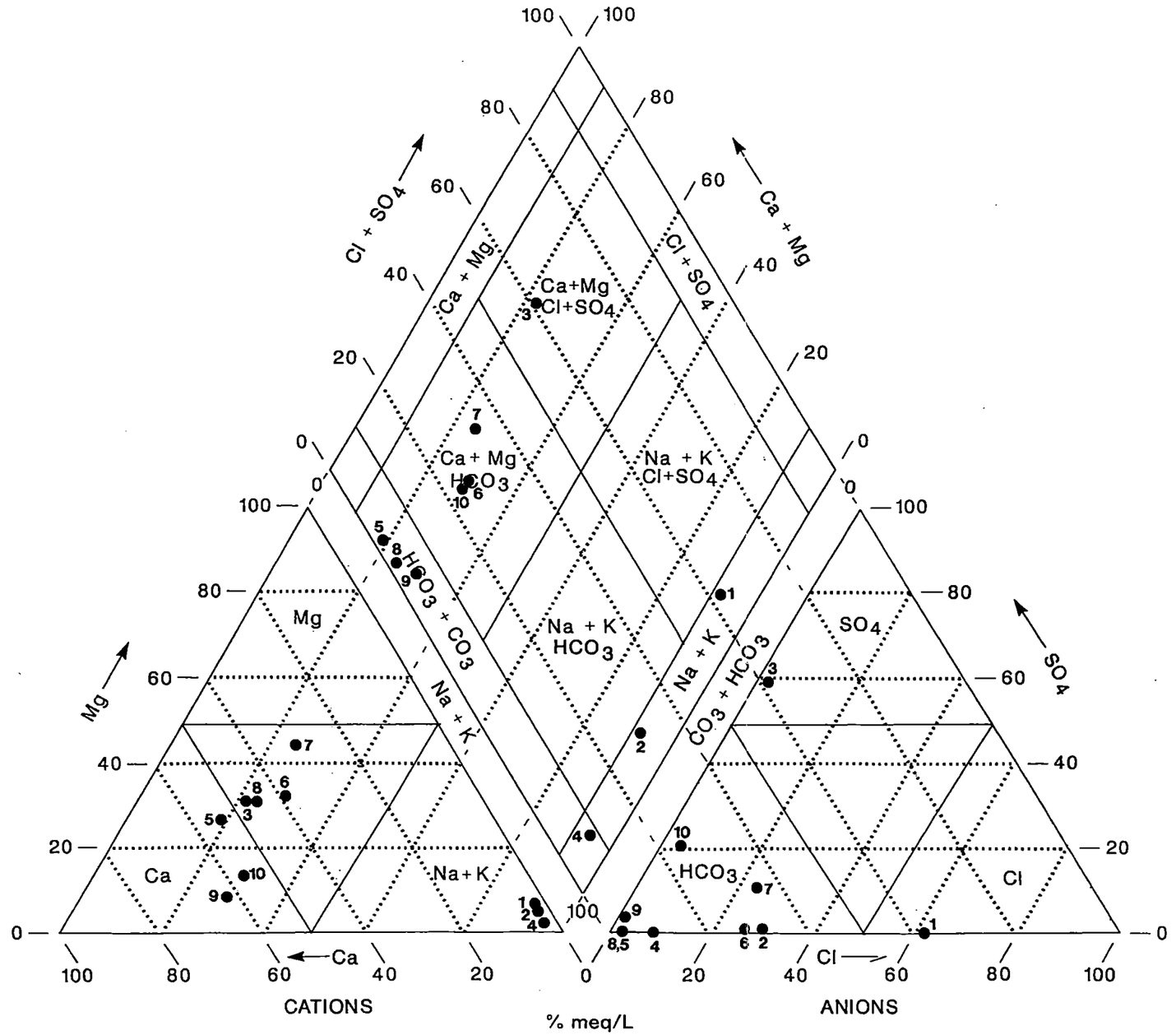
DATE 3-94
DWN. MLP
REV.
APPR.
PROJECT NO.
0750-001.09

Figure 5-1
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

HYDROGEOLOGIC CROSS SECTION

EMCON Northwest, Inc.

1= 200 06-24-94 G:\DWG\0750\001\09C07



LEGEND:

1 = DP–01

2 = DP–06

3 = MW–05

4 = MW–06

5 = SH–04

6 = TX–01

7 = TX–02

8 = TX–03

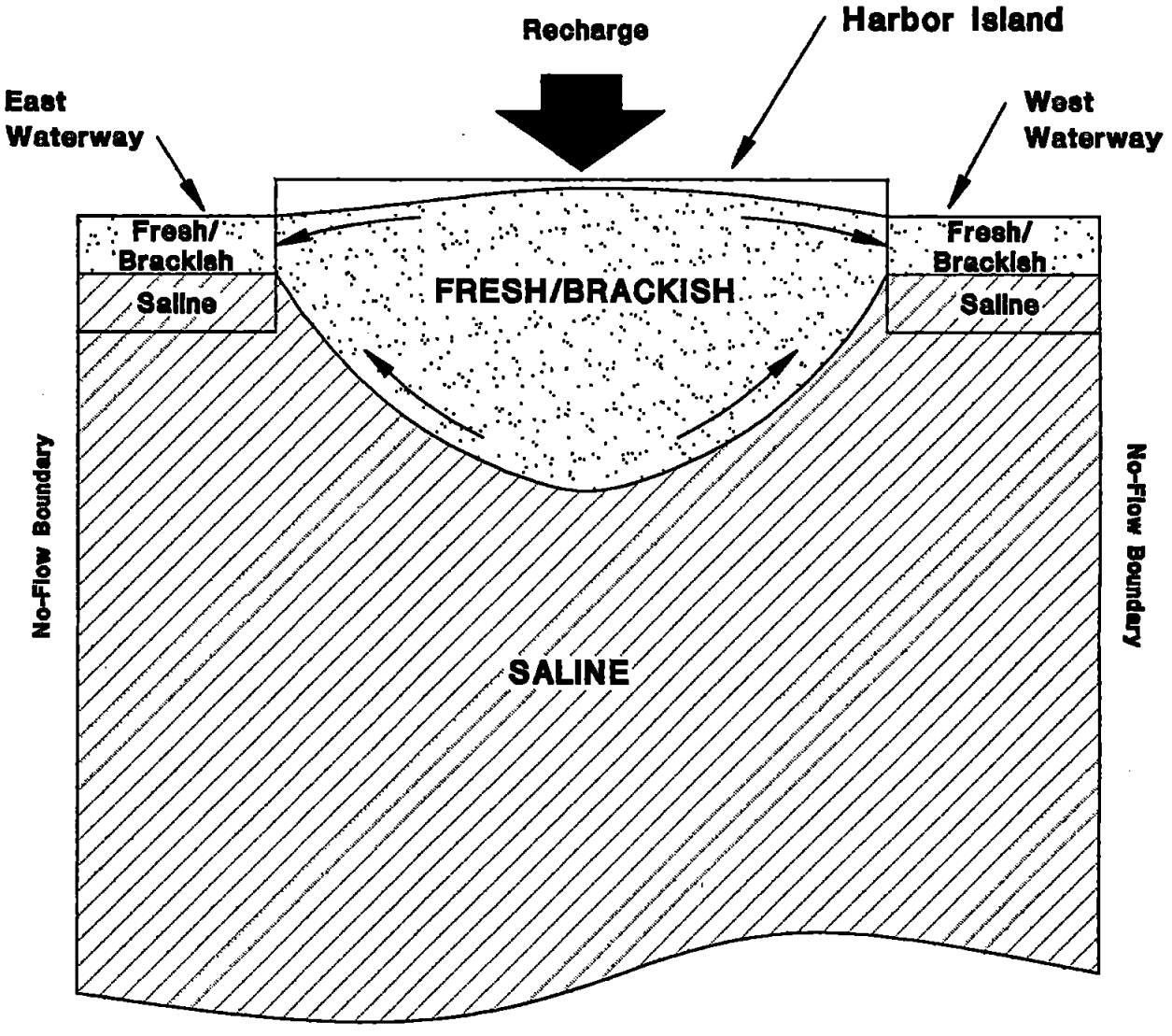
9 = TX–04

10 = TX–06

EMCON Northwest, Inc.

DATE 10-94
DWN. MLP
REV. _____
APPR. _____
PROJECT NO.
0750-001.09

Figure 5–3
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON
MAJOR ION CHEMISTRY
MARCH/APRIL 1992



SOURCE: WESTON (1993)

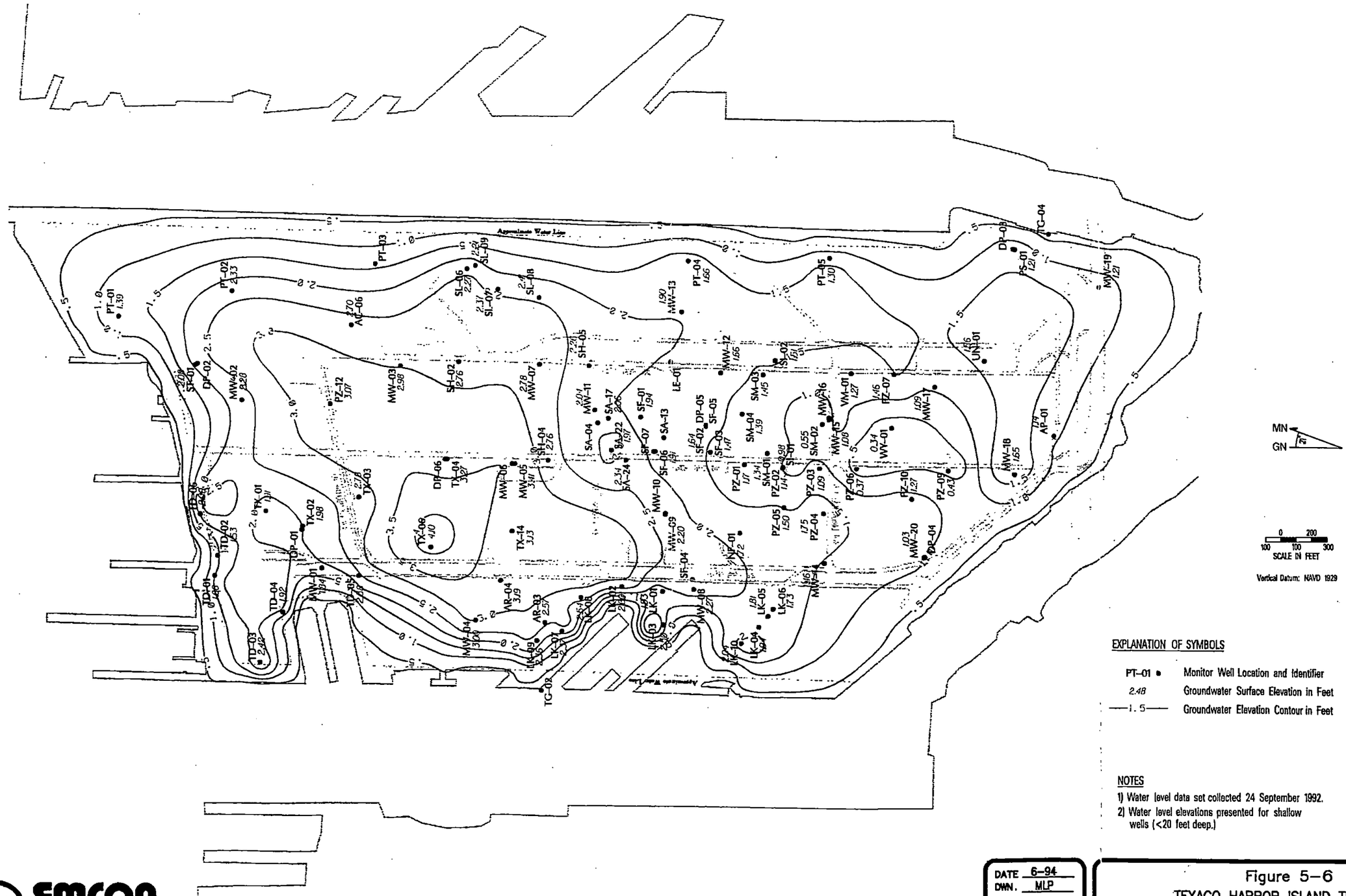
EMCON Northwest, Inc.

DATE 10/94
DWN. RB1
REV.
APPR.
PROJECT NO.
0750-001.14

Figure 5-5
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

CONCEPTUAL HYDROLOGIC MODEL

1= 1 10-26-94 G:\DWG\0750\001\14C02



EXPLANATION OF SYMBOLS

PT-01 •	Monitor Well Location and Identifier
2.48	Groundwater Surface Elevation in Feet
—1.5—	Groundwater Elevation Contour in Feet

NOTES

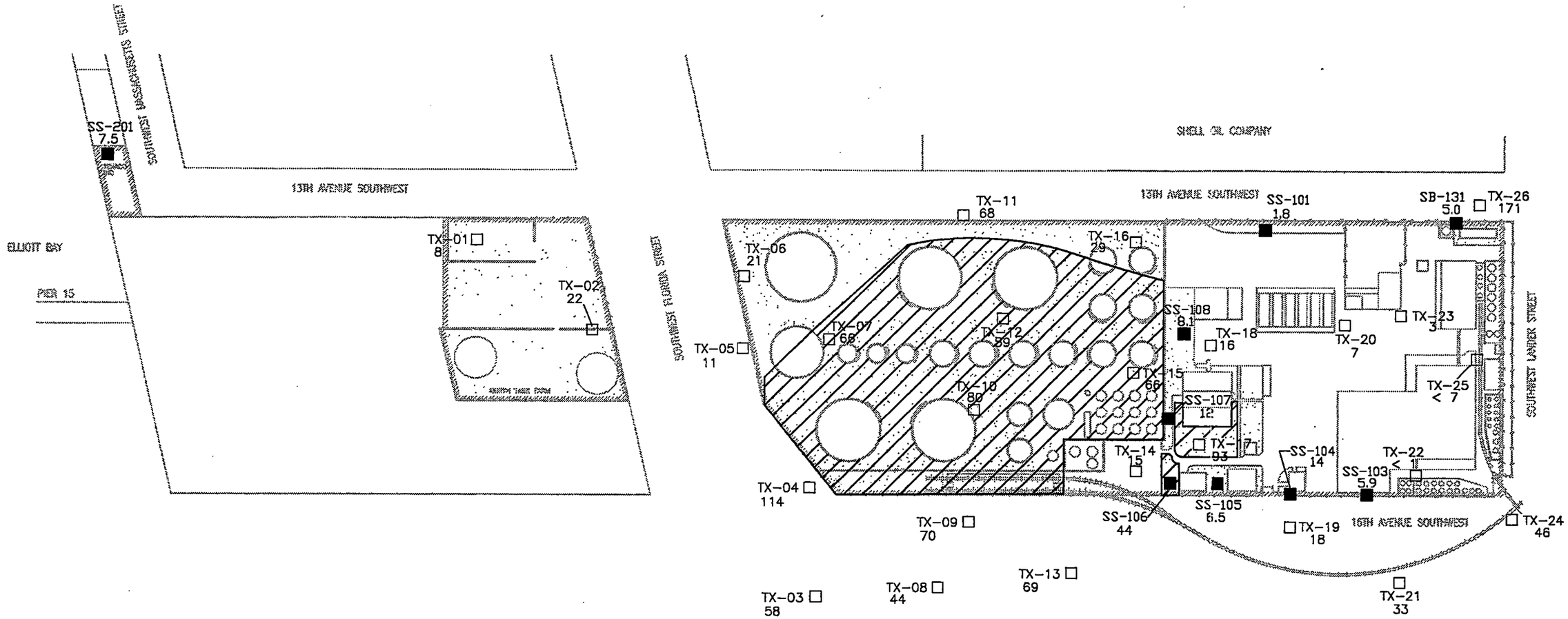
1) Water level data set collected 24 September 1992.
2) Water level elevations presented for shallow wells (<20 feet deep.)

SOURCE: WESTON (1993)

EMCON Northwest, Inc.

DATE	6-94
DWN.	MLP
REV.	
APPR.	
PROJECT NO.	0750-001.14

Figure 5-6
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON
ISLAND-WIDE GROUNDWATER CONTOUR MAP



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- TX-03 □ 58 — USEPA Surface Soil Sample arsenic concentration in mg/kg
- SS-106 ■ 44 — Surface Soil Sample arsenic concentration in mg/kg
- Area With Arsenic Concentrations Greater Than 32.6 mg/kg

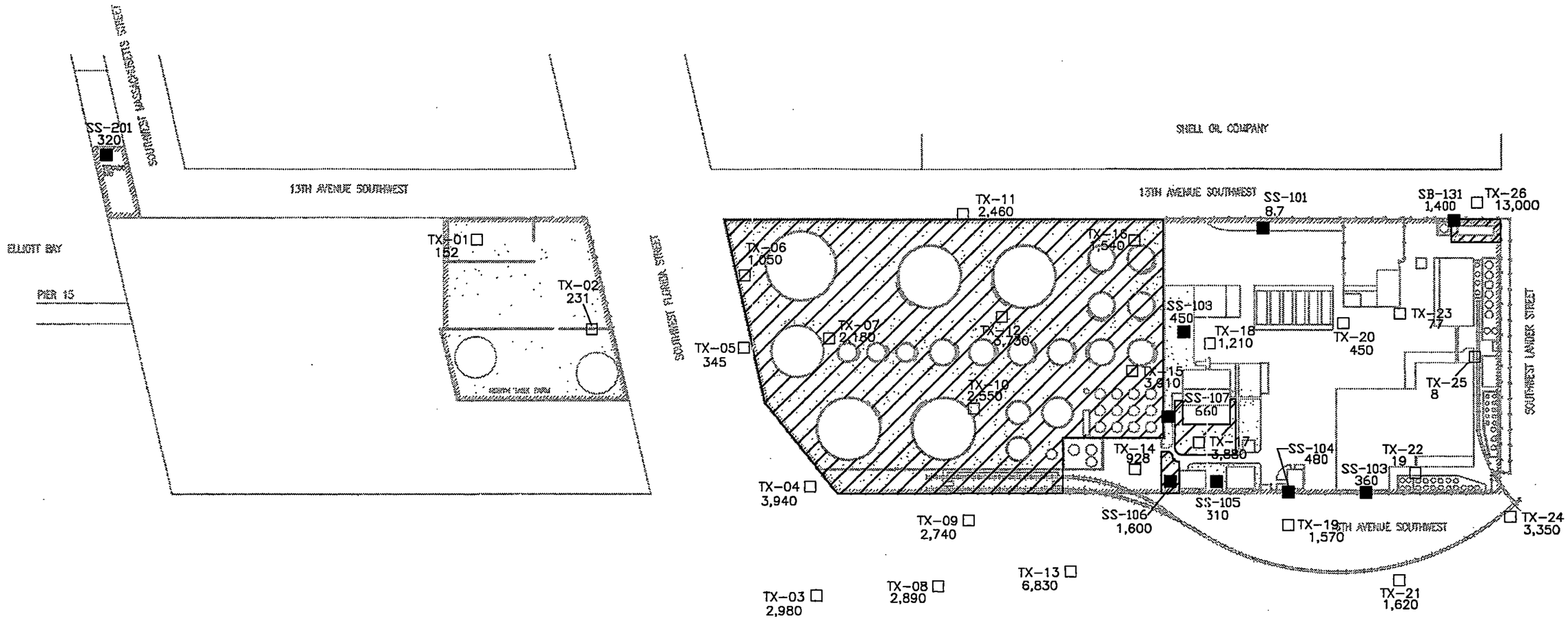
EMCON Northwest, Inc.

DATE	10-94
DWN.	EJB
REV.	
APPR.	
PROJECT NO.	0750-001.09

Figure 6-1
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SURFACE SOIL ARSENIC CONCENTRATIONS

1=200 10-25-94 G:\DWG\0750\001\FIG-6-1



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- TX-03 2,980 — USEPA Surface Soil Sample lead concentration in mg/kg
- SS-106 1,600 — Surface Soil Sample lead concentration in mg/kg
- Area With Lead Concentrations Greater Than 1,000 mg/kg

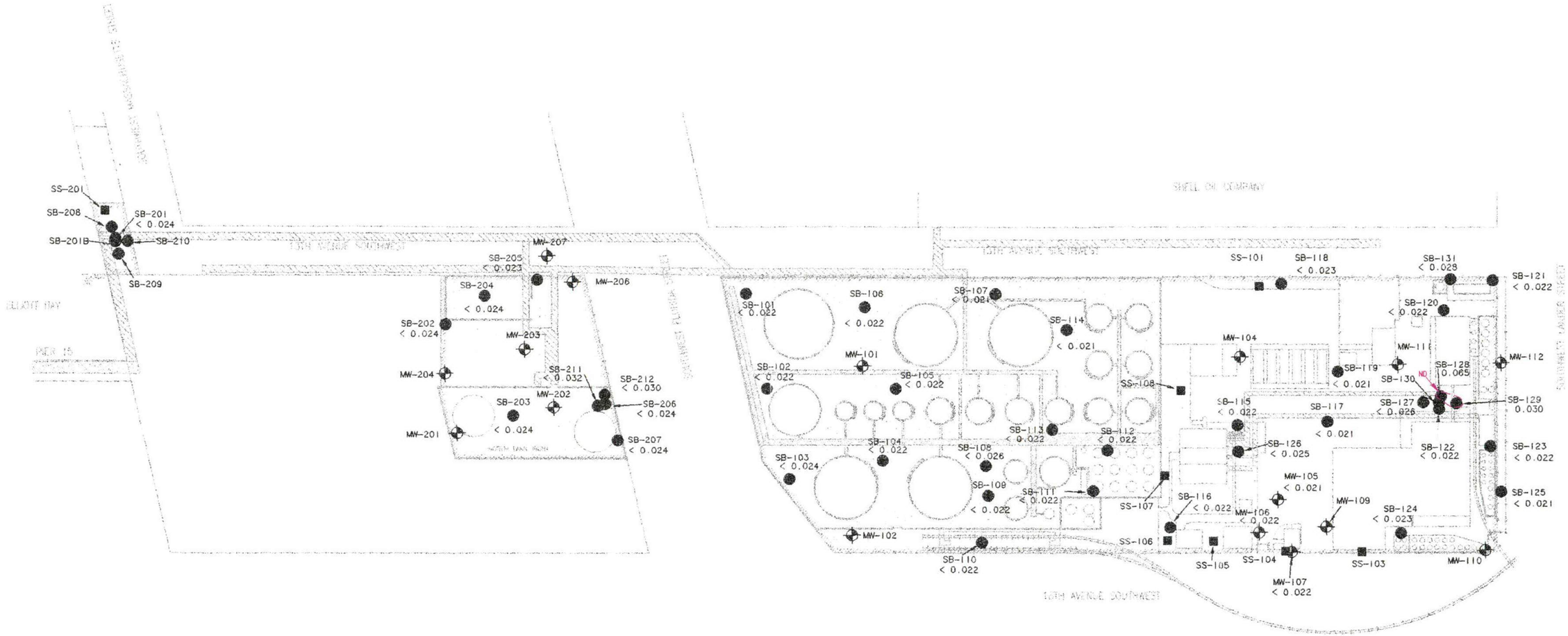
EMCON Northwest, Inc.

DATE	10-94
DWN.	EJB
REV.	
APPR.	
PROJECT NO.	0750-001.09

Figure 6-2
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SURFACE SOIL LEAD CONCENTRATIONS

1=200 10-25-94 G:\DWG\0750\001\FIG-6-2



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (mg/kg)
- SB-201 — Soil Boring
- ND — Benzene concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

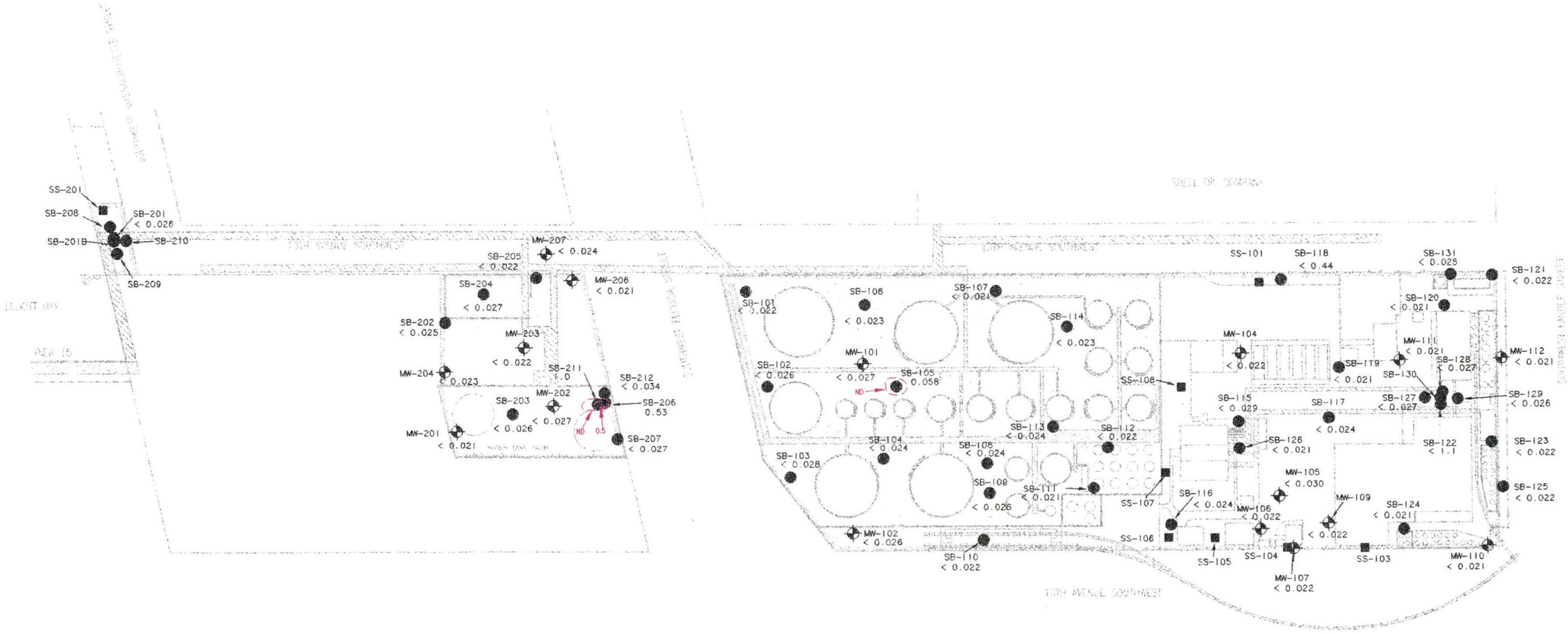
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL BENZENE CONCENTRATIONS
0.5-1.5 FEET

DRAWING NO
6-3
PROJECT NO
0750-001.14

SCALE:1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\0_1BENZ



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (mg/kg)
- SB-201 — Soil Boring
- ND — Benzene concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

EMCON Northwest, Inc.

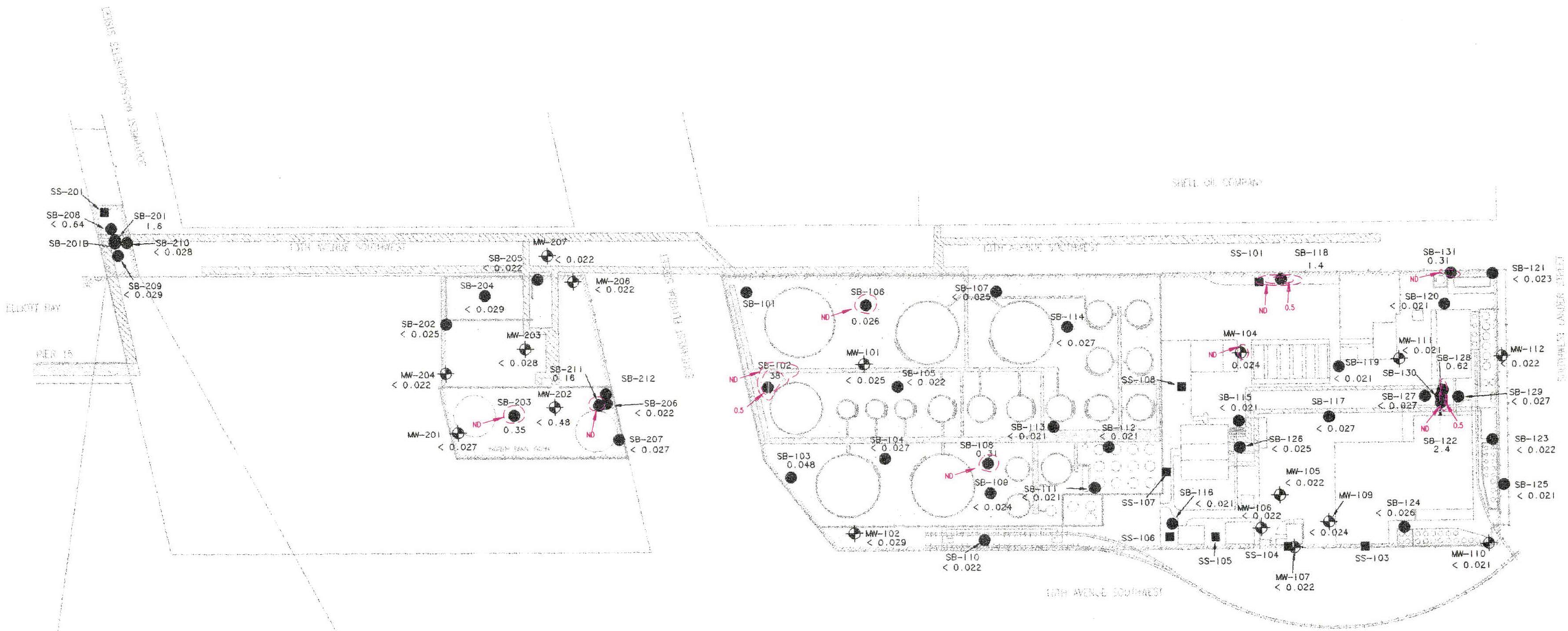
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

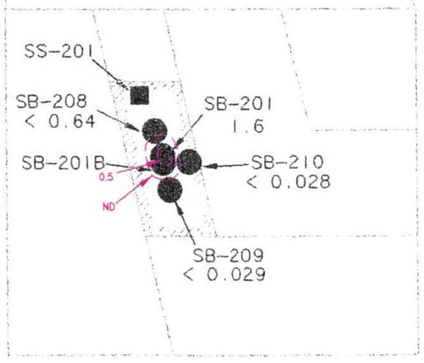
SOIL BENZENE CONCENTRATIONS

2-3 FEET

DRAWING NO
6-4
PROJECT NO
0750-001.14

SCALE:1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\1_2BENZ





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface / Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (mg/kg)
- SB-201 — Soil Boring
- 0.5 — Benzene concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE		DWN BY		CHK BY	
			DES BY		APP BY	

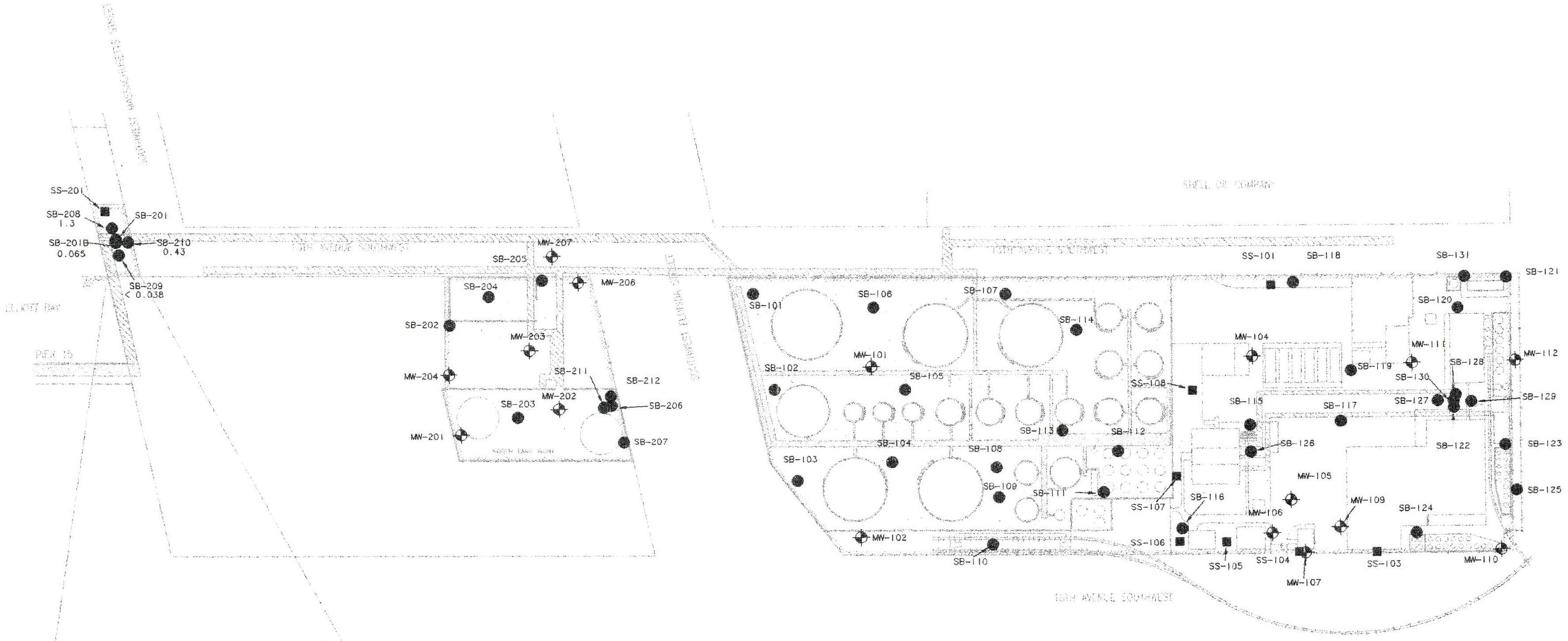
EMCON Northwest, Inc.

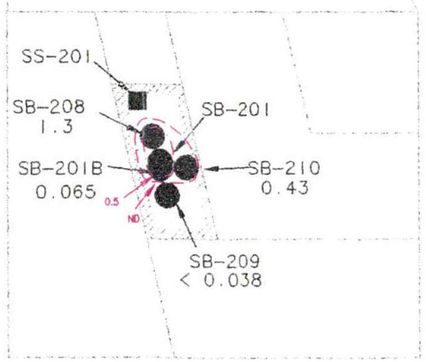
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL BENZENE CONCENTRATIONS
4-5 FEET

DRAWING NO
6-5
PROJECT NO
0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\4_5BENZ





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (mg/kg)
- SB-201 — Soil Boring
- 0.5 — Benzene concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

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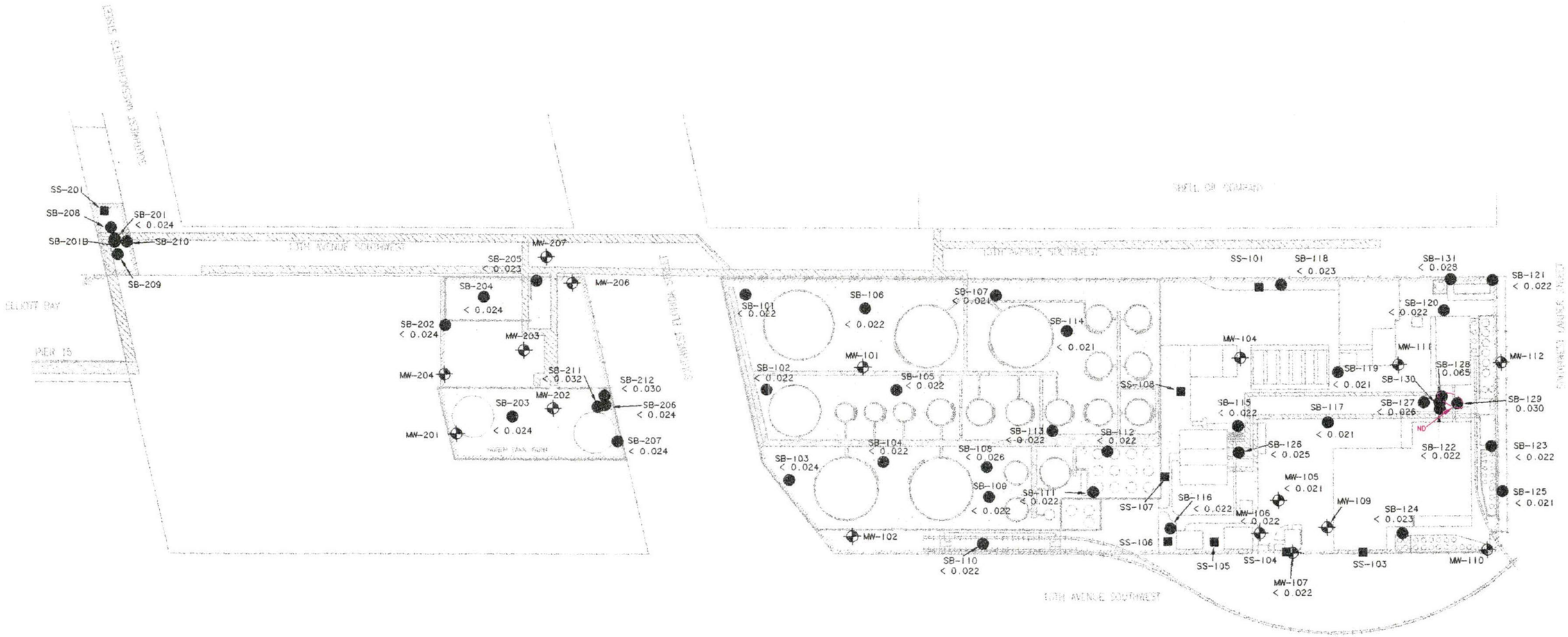
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL BENZENE CONCENTRATIONS

6.5-8 FEET

DRAWING NO
6-6
PROJECT NO
0750-001.14

SCALE:1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\6_BBENZ



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Ethylbenzene concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DWN BY / DES BY	CHK BY / APP BY			

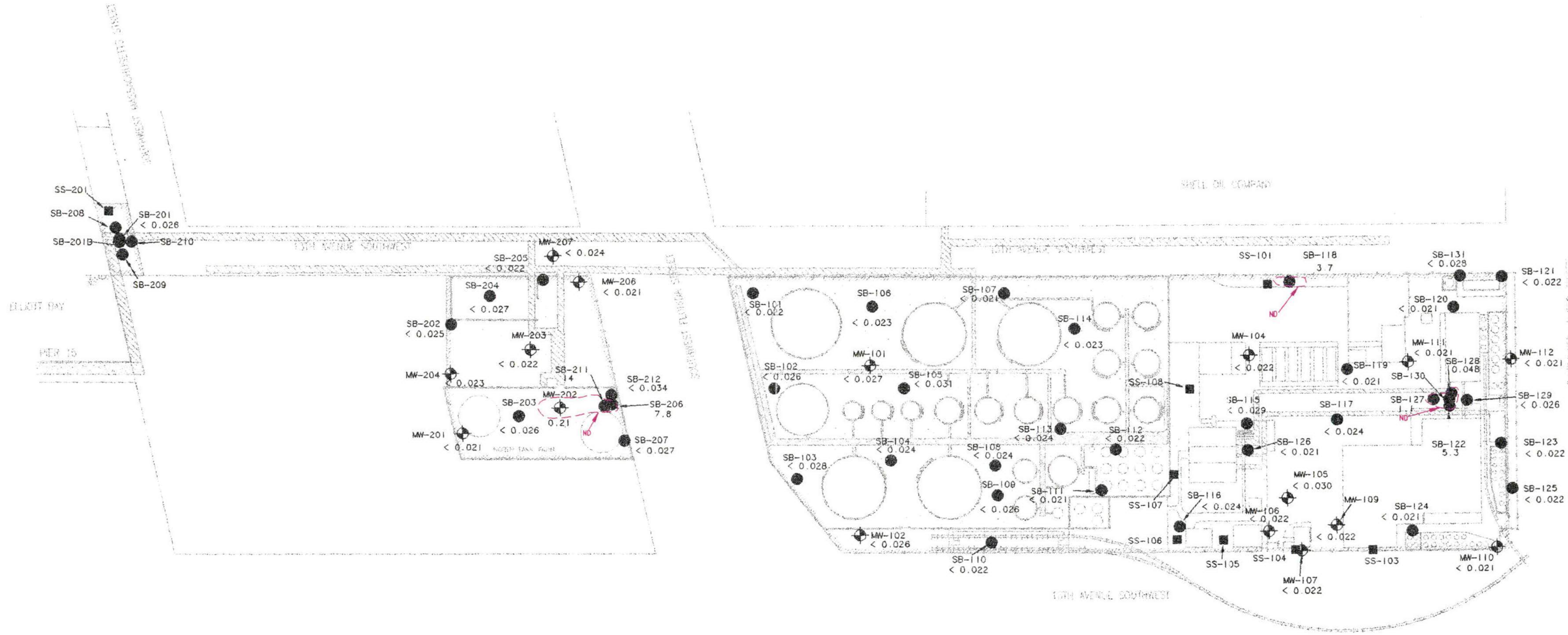
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL ETHYLBENZENE CONCENTRATIONS
0.5-1.5 FEET

DRAWING NO
6-7
PROJECT NO
0750-001.14

SCALE:1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\0_1ETH



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 Monitoring Well (Shallow)
- < 0.5 Ethylbenzene Concentration (mg/kg)
- SB-201 Soil Boring
- 20 Ethylbenzene concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE	DWN BY	DES BY	CHK BY	APP BY		

EMCON Northwest, Inc.

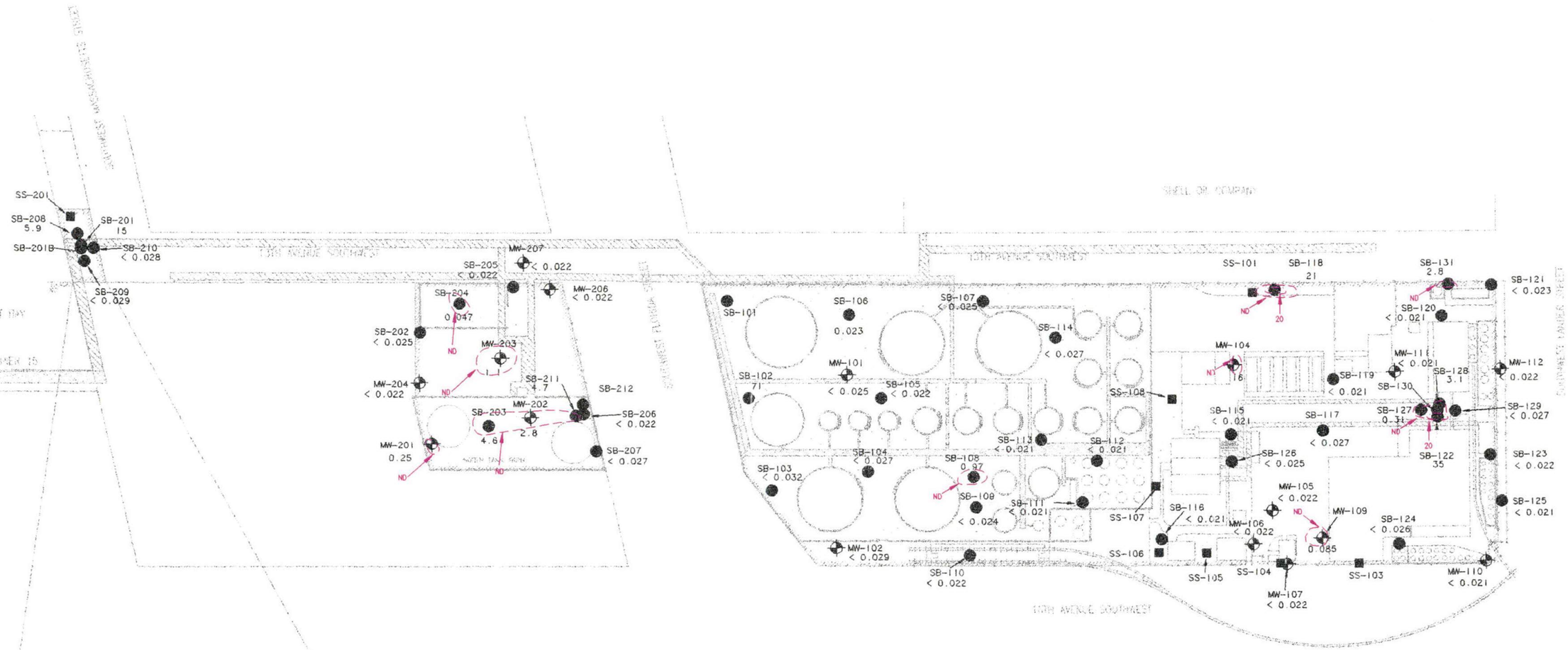
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL ETHYLBENZENE CONCENTRATIONS 2-3 FEET

DRAWING NO 6-8

PROJECT NO 0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\1_3ETH



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Ethylbenzene concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DWN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

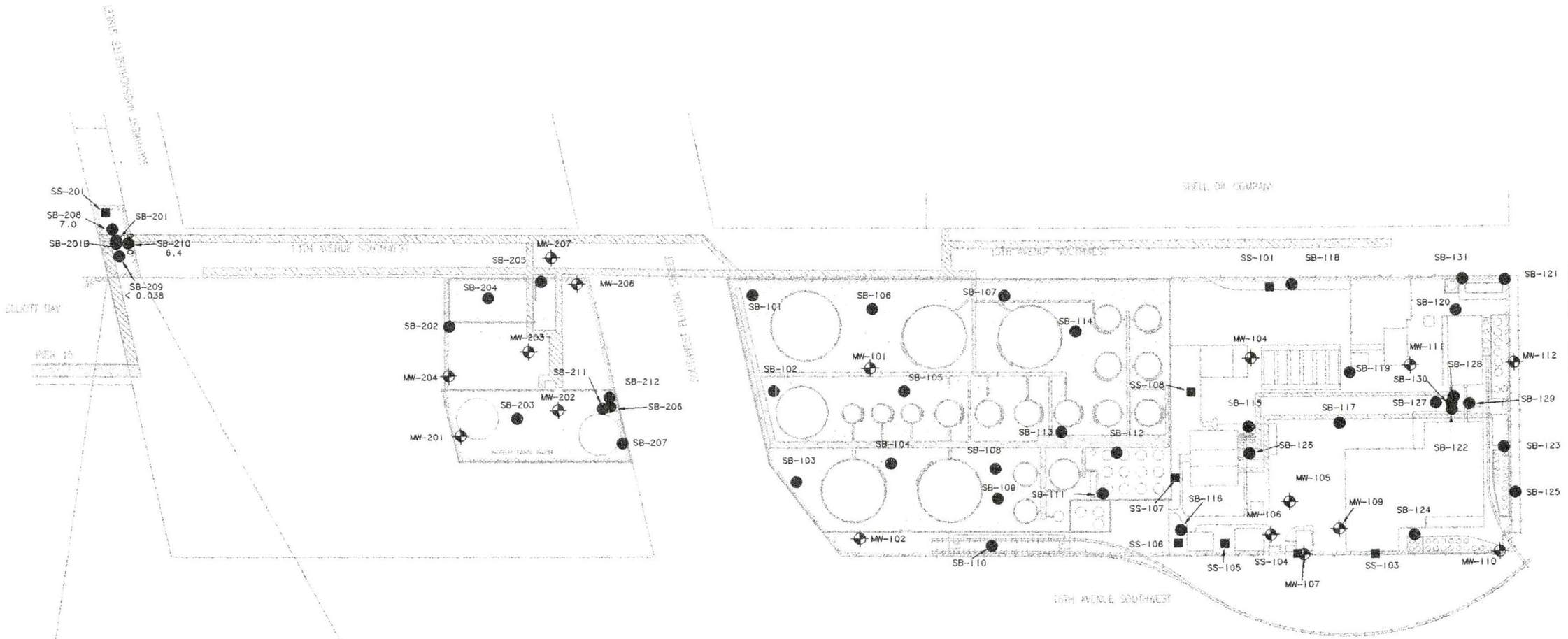
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

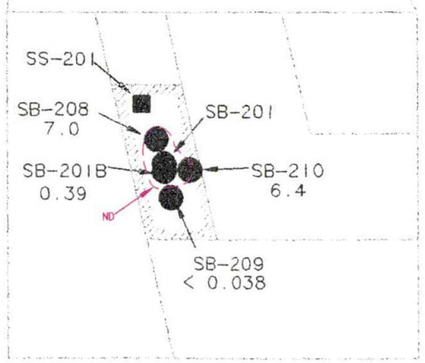
SOIL ETHYLBENZENE CONCENTRATIONS
4-5.5 FEET

DRAWING NO 6-9

PROJECT NO 0750-001.14

SCALE:1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\4_5ETH





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Ethylbenzene concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

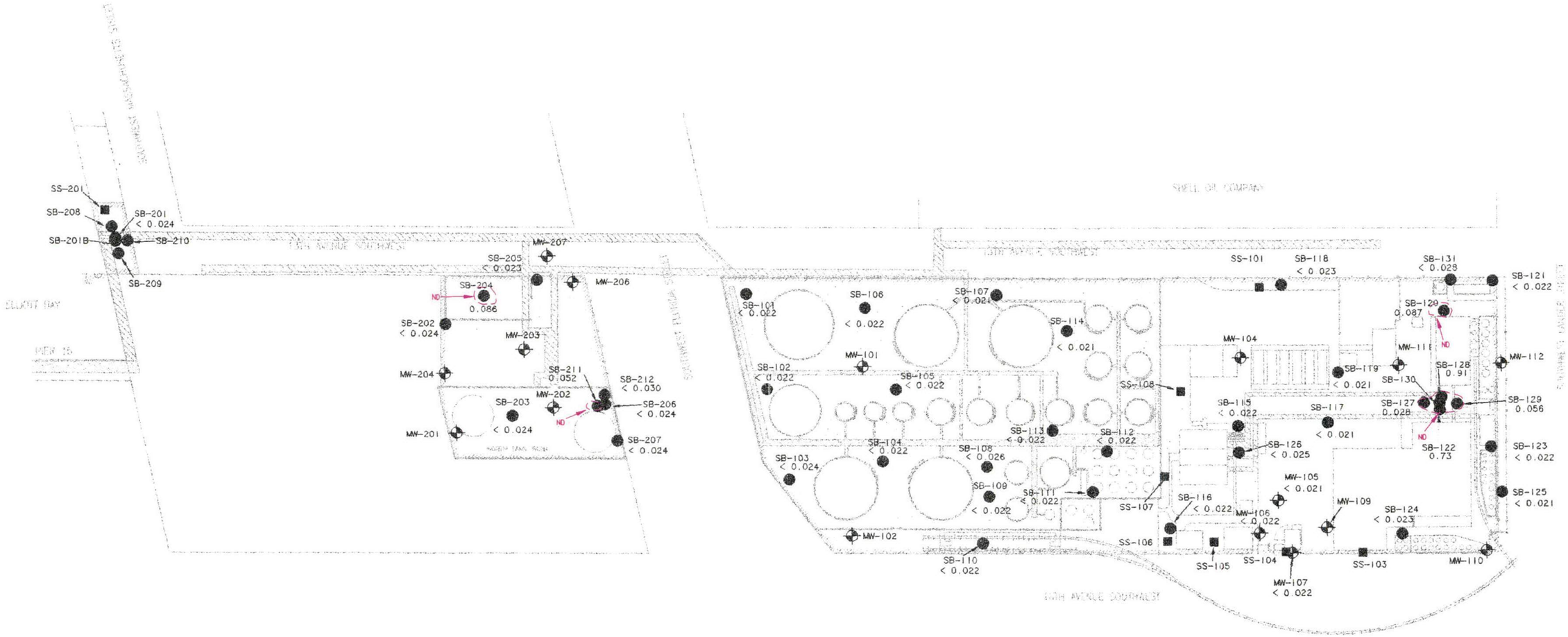
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL ETHYLBENZENE CONCENTRATIONS
6.5-8 FEET

DRAWING NO
6-10
PROJECT NO
0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\6_8ETH



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Total Xylenes concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DWN BY		CHK BY		
		DES BY		APP BY		

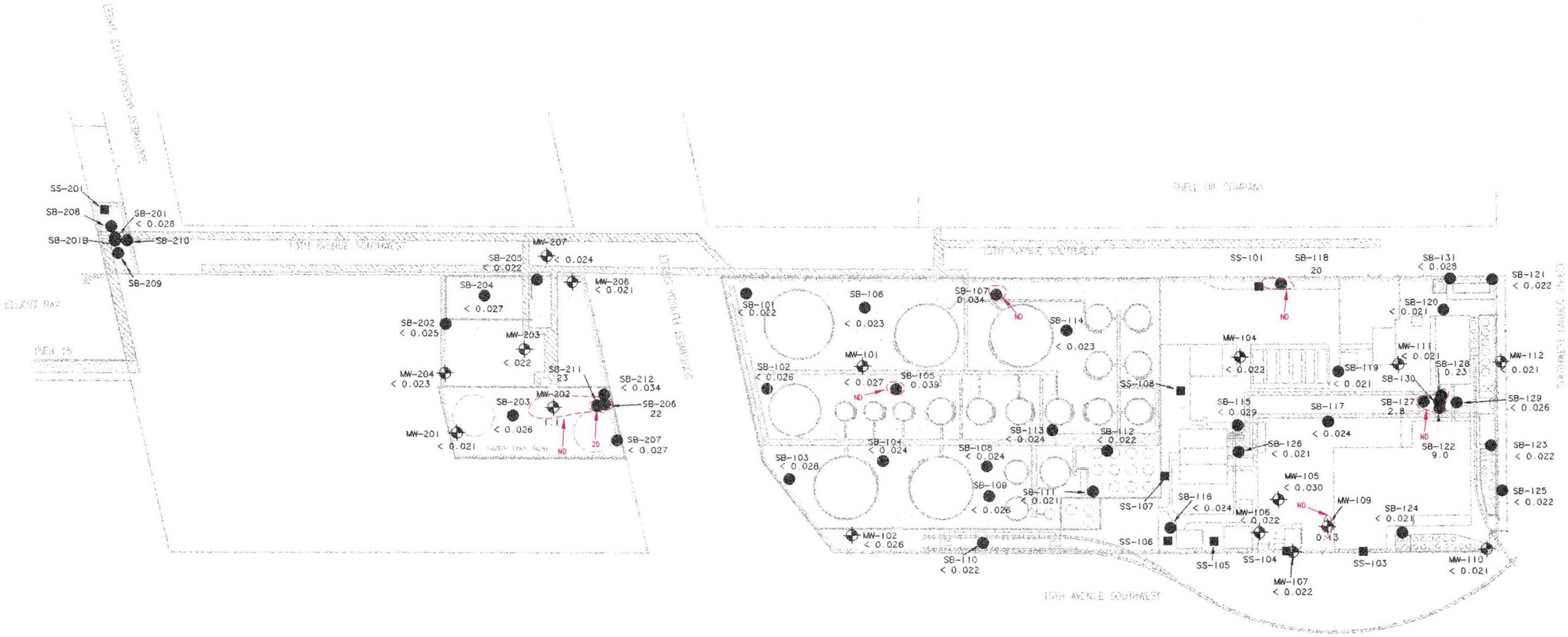
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TOTAL XYLENES CONCENTRATIONS
0.5-1.5 FEET

DRAWING NO
6-11
PROJECT NO
0750-001.14

SCALE:1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\0_1XYL



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Total Xylenes concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

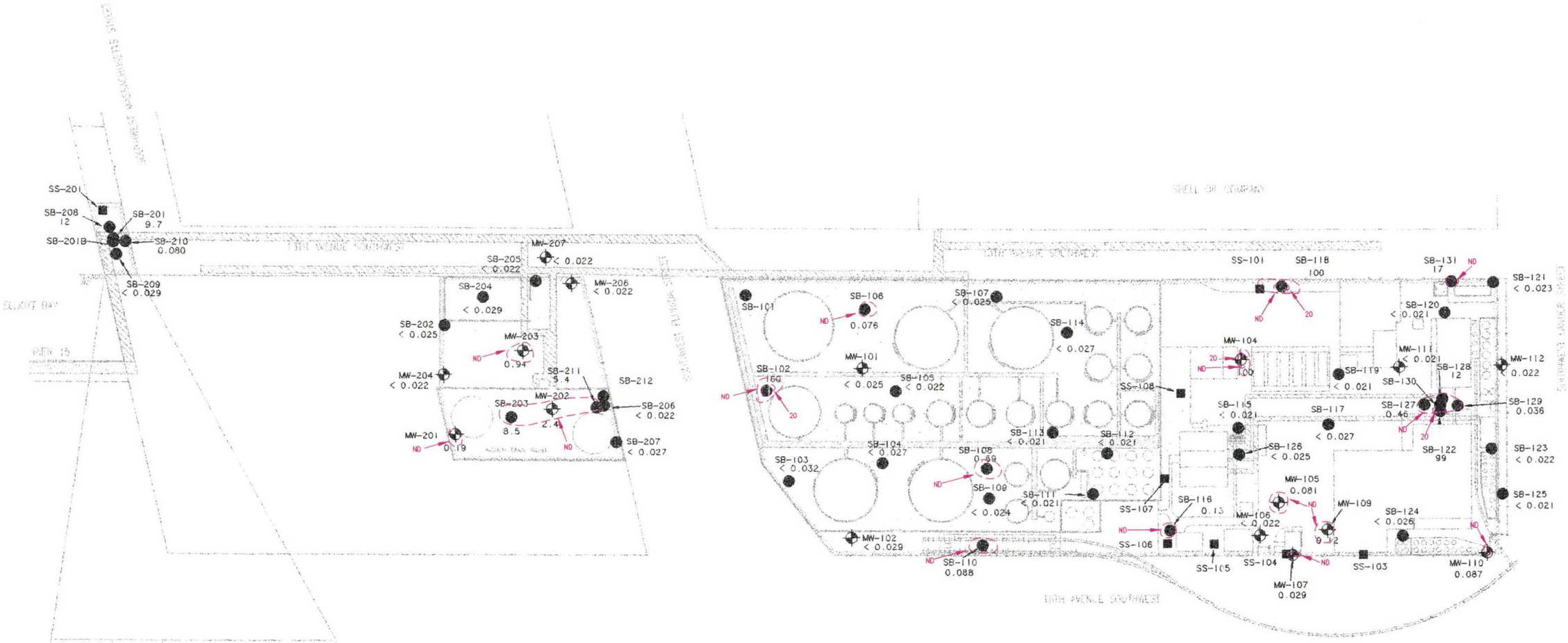
EMCON Northwest, Inc.

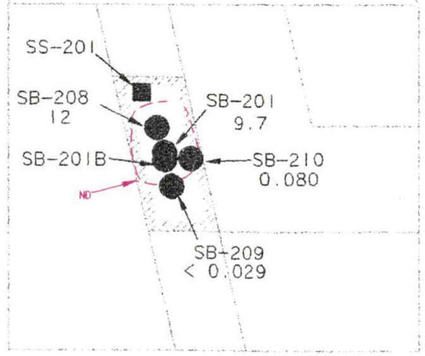
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TOTAL XYLENES CONCENTRATIONS
2-3 FEET

DRAWING NO
6-12
PROJECT NO
0750-001.14

SCALE:1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\1_3XYL





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Total Xylenes concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DWN BY		CHK BY		
		DES BY		APP BY		

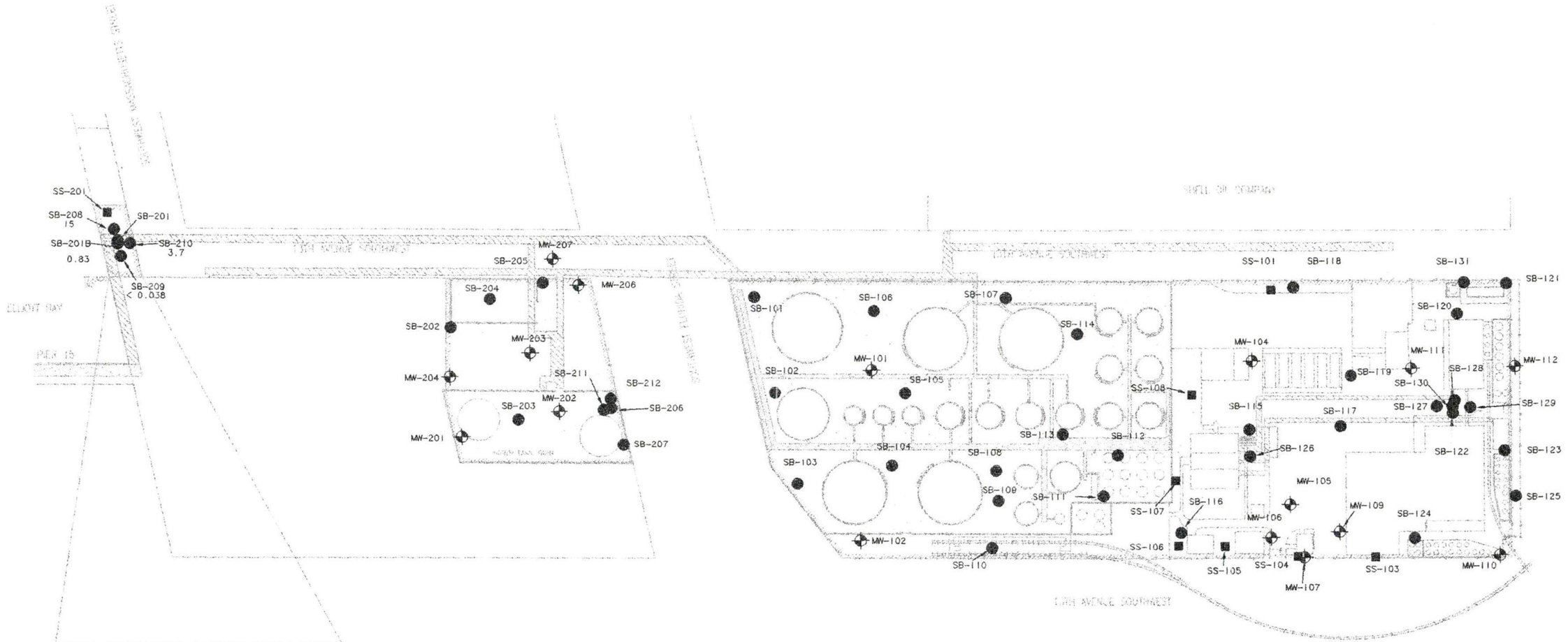
EMCON Northwest, Inc.

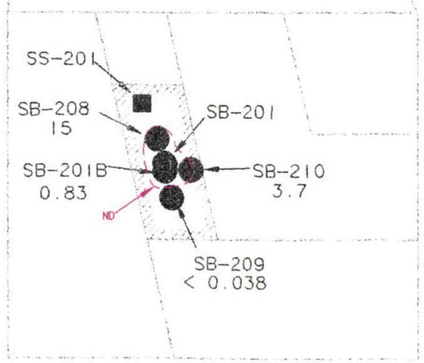
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TOTAL XYLENES CONCENTRATIONS
4-5.5 FEET

DRAWING NO
6-13
PROJECT NO
0750-001.14

SCALE: 1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\4_5XYL





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (mg/kg)
- SB-201 — Soil Boring
- 20 — Total Xylenes concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

EMCON Northwest, Inc.

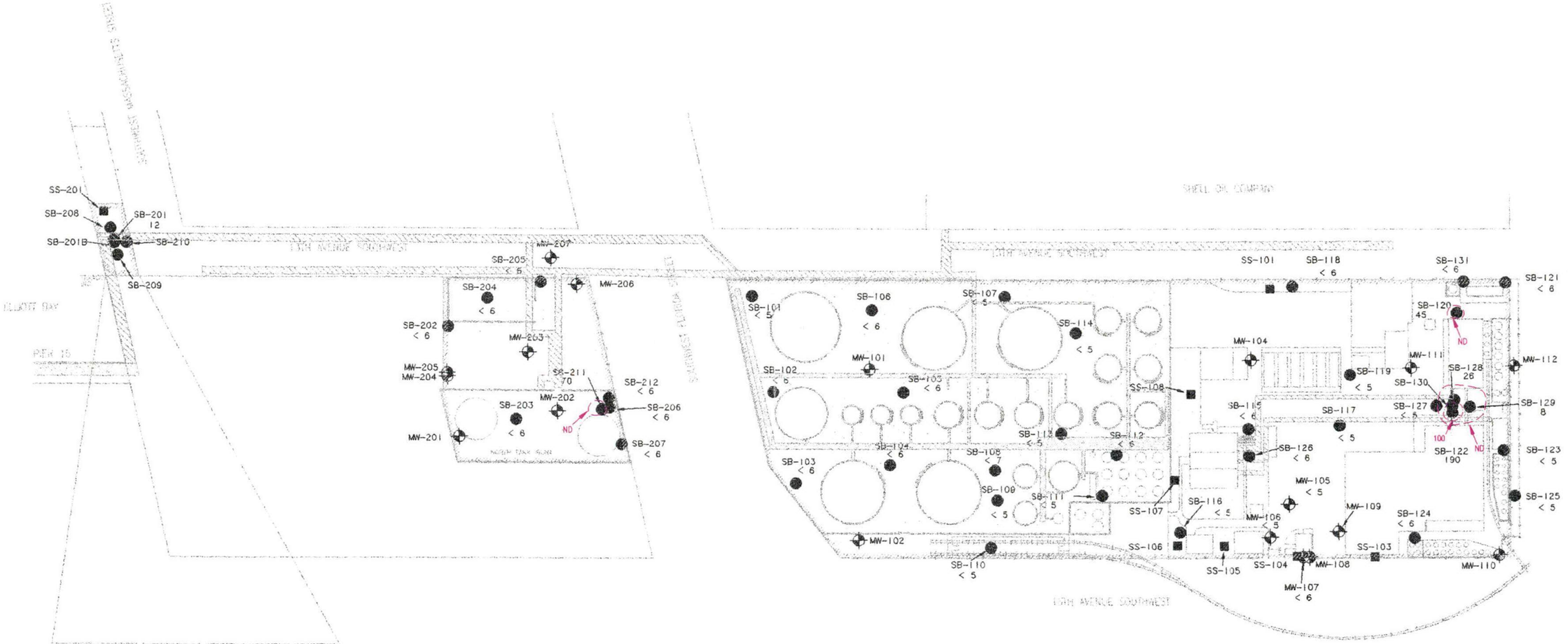
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TOTAL XYLENES CONCENTRATIONS

6.5-8 FEET

DRAWING NO
6-14
PROJECT NO
0750-001.14

SCALE:1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\6_8XYL



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	DATE OF ISSUE	DWN BY DES BY			CHK BY APP BY	

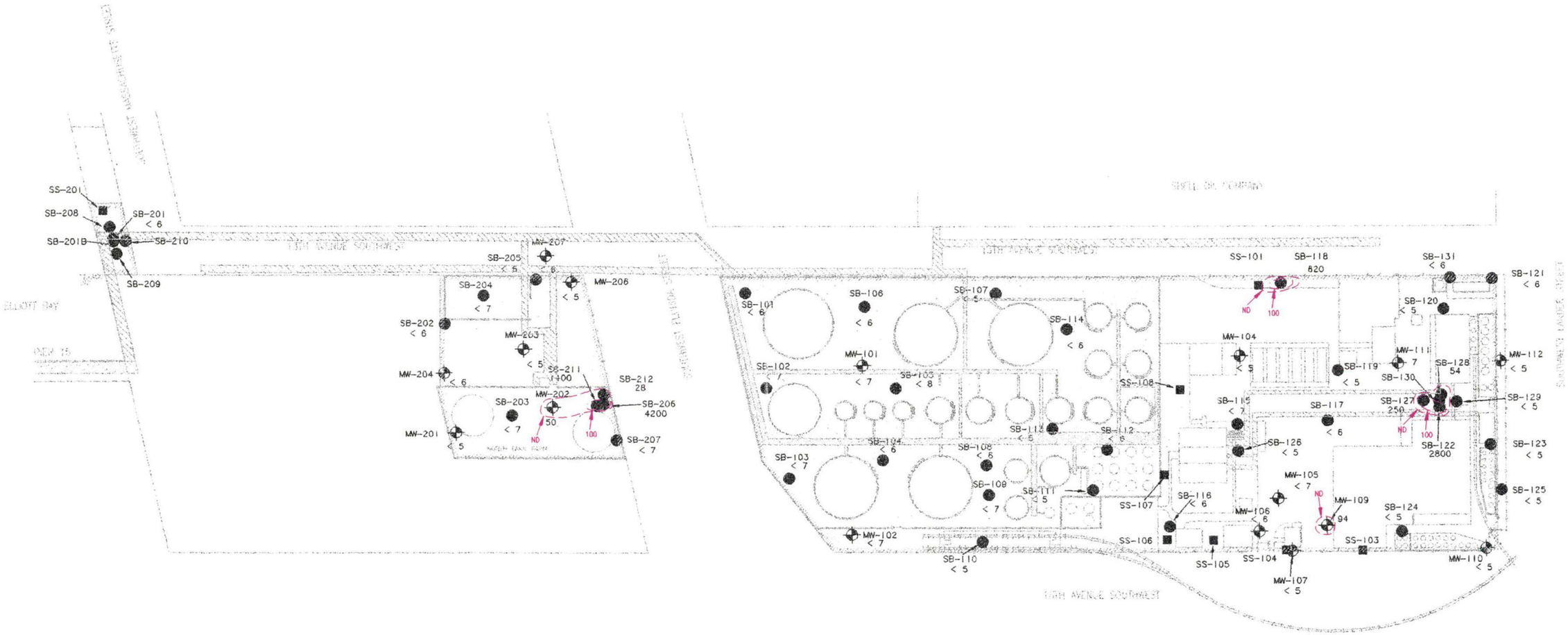
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-G CONCENTRATIONS
0.5-1.5 FEET

DRAWING NO
6-15
PROJECT NO
0750-001.14

SCALE: 1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\0_1GAS



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/kg)
- SB-201 — Soil Boring
- 100 — TPH-G concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DWN BY		CHK BY		
		DES BY		APP BY		

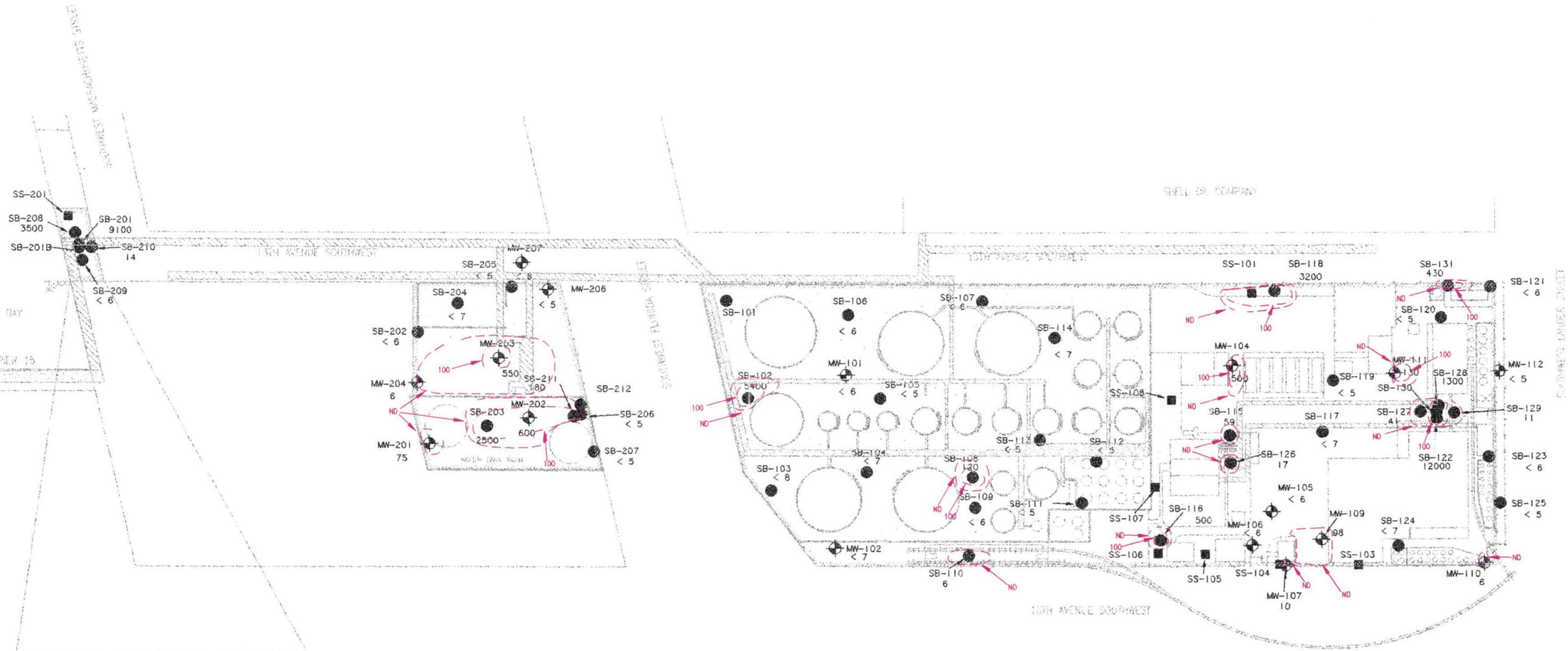
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-G CONCENTRATIONS
2-3 FEET

DRAWING NO
6-16
PROJECT NO
0750-001.14

SCALE:1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\1_3GAS



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/kg)
- SB-201 — Soil Boring
- 100 — TPH-G concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DWN BY			CHK BY	
		DES BY			APP BY	

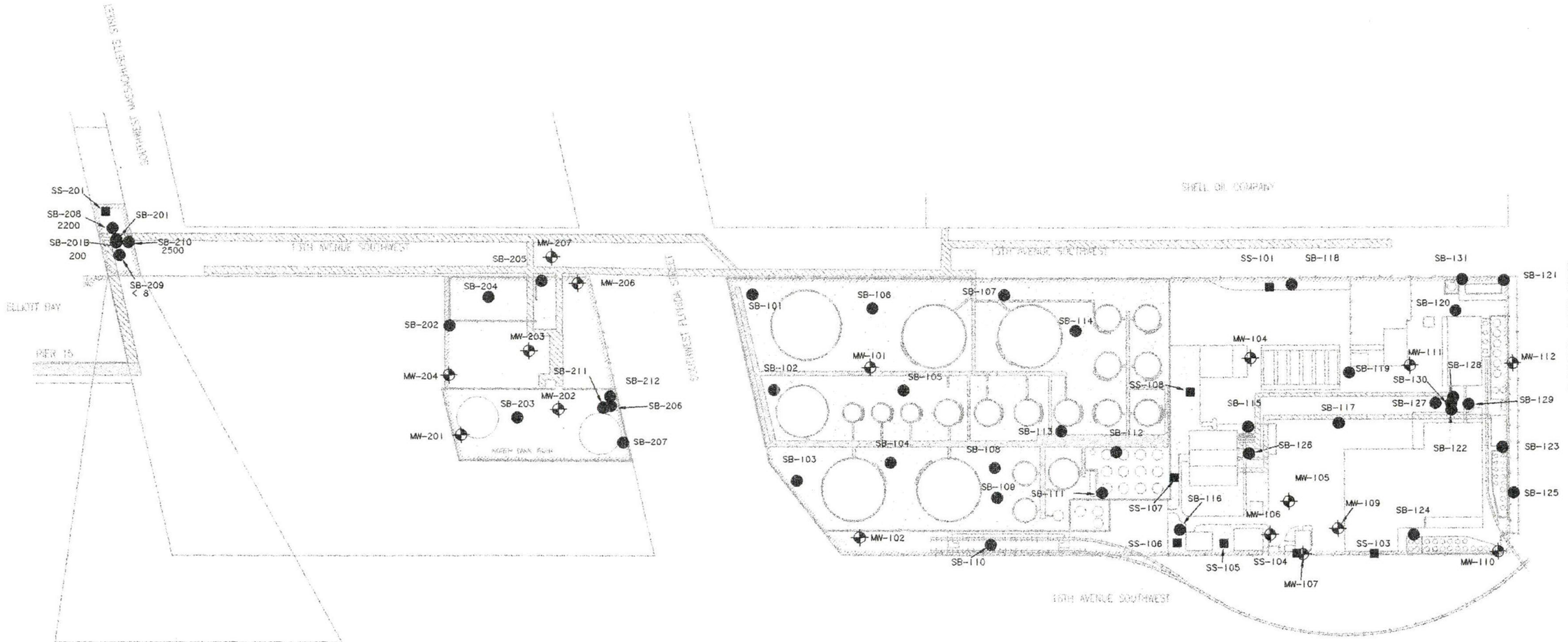
EMCON Northwest, Inc.

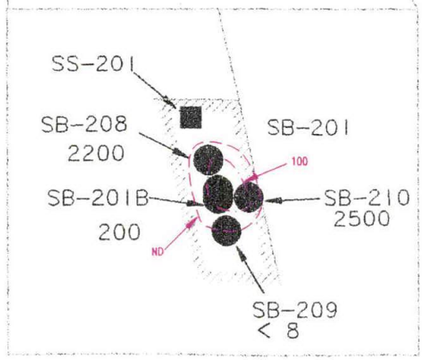
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-G CONCENTRATIONS
4-5.5 FEET

DRAWING NO
6-17
PROJECT NO
0750-001.14

SCALE:1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\4_5GAS





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/kg)
- SB-201 — Soil Boring
- 100 — TPH-G concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

EMCON Northwest, Inc.

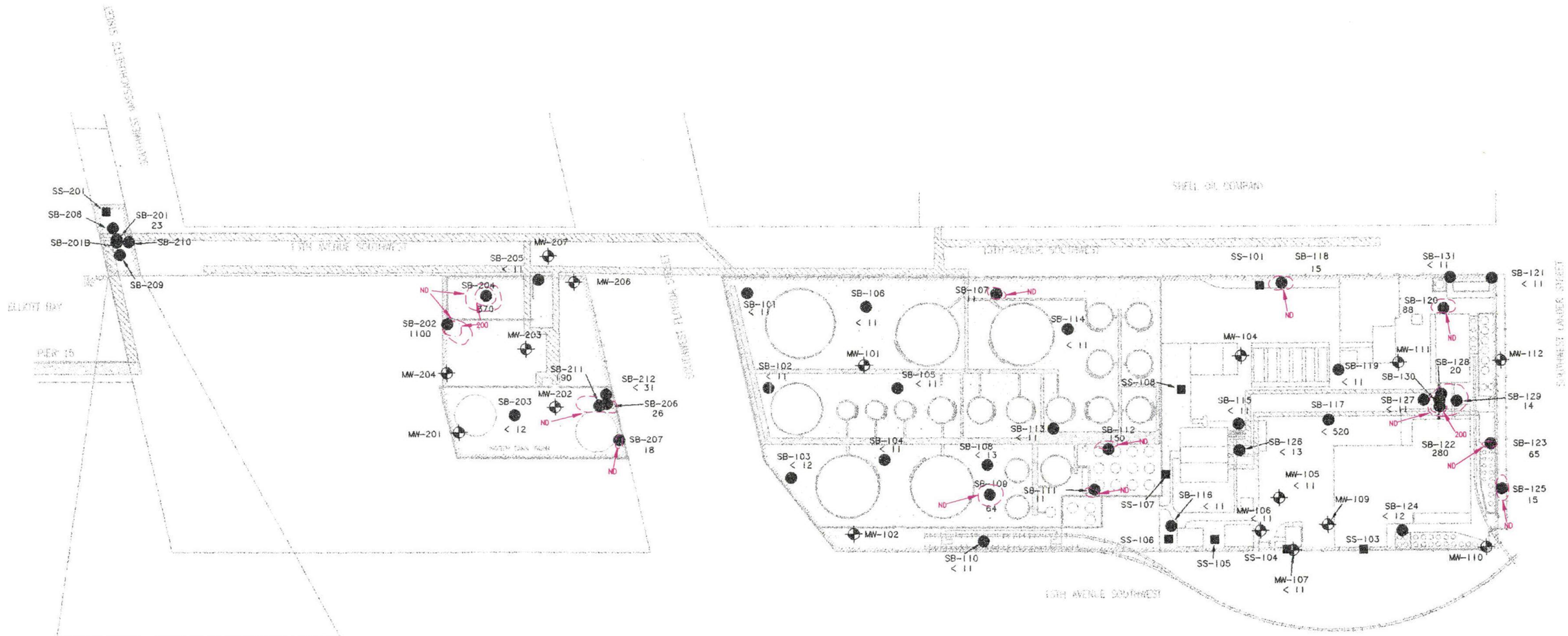
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-G CONCENTRATIONS

6.5-8 FEET

DRAWING NO
6-18
PROJECT NO
0750-001.14

SCALE: 1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\6_BGAS



REV.	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DWN BY			CHK BY	
		DES BY			APP BY	

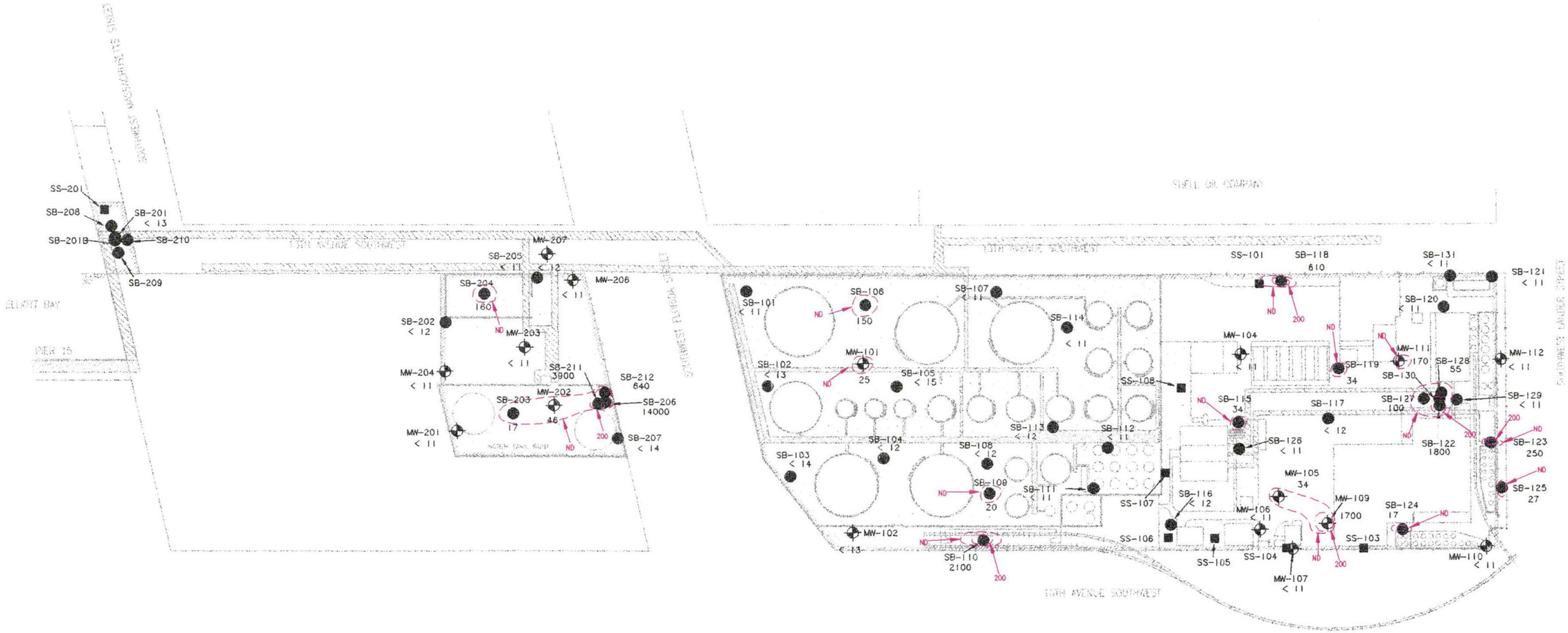
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-D CONCENTRATIONS
0.5-1.5 FEET

DRAWING NO
6-19
PROJECT NO
0750-001.14

SCALE: 1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\0_1TPHD



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-D concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

EMCON Northwest, Inc.

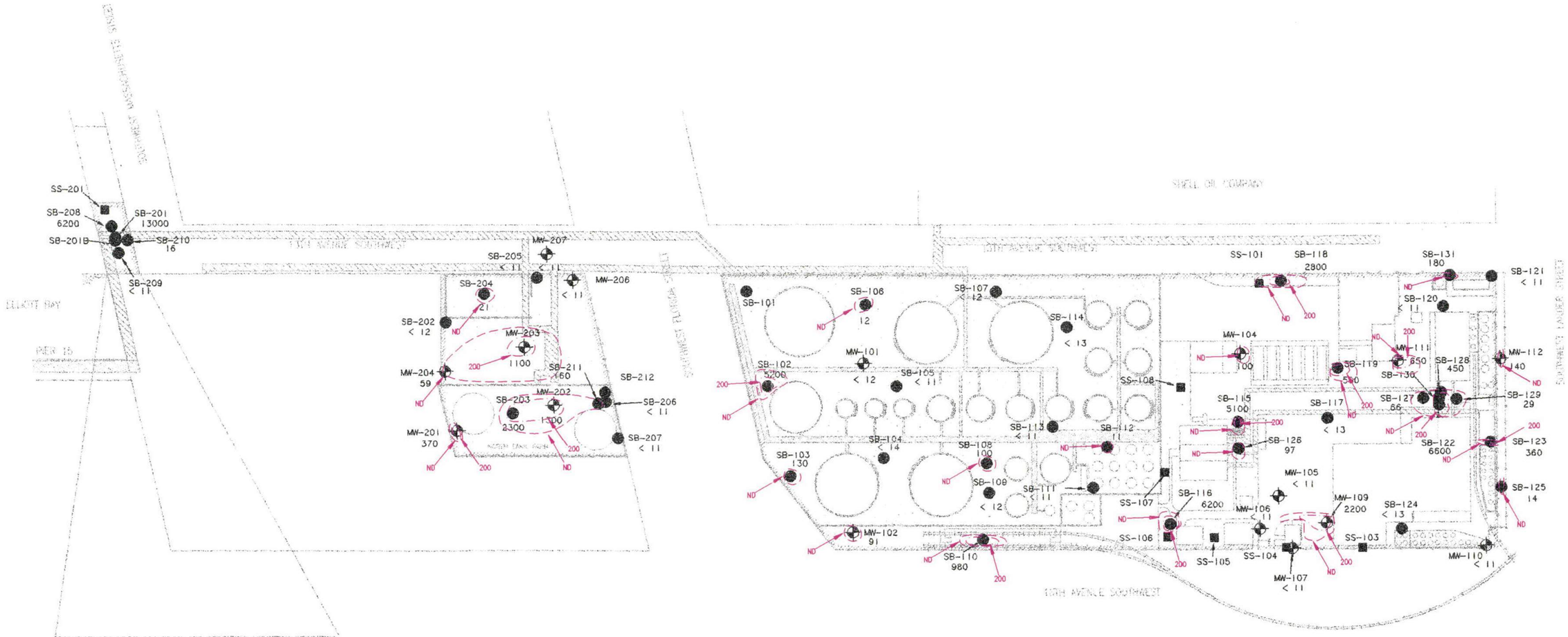
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

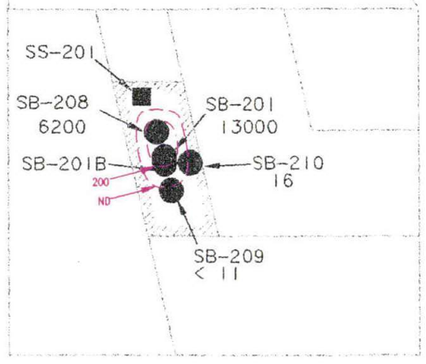
SOIL TPH-D CONCENTRATIONS

2-3 FEET

DRAWING NO
6-20
PROJECT NO
0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\1_3TPHD





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-D Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-D concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DWN BY / DES BY			CHK BY / APP BY	

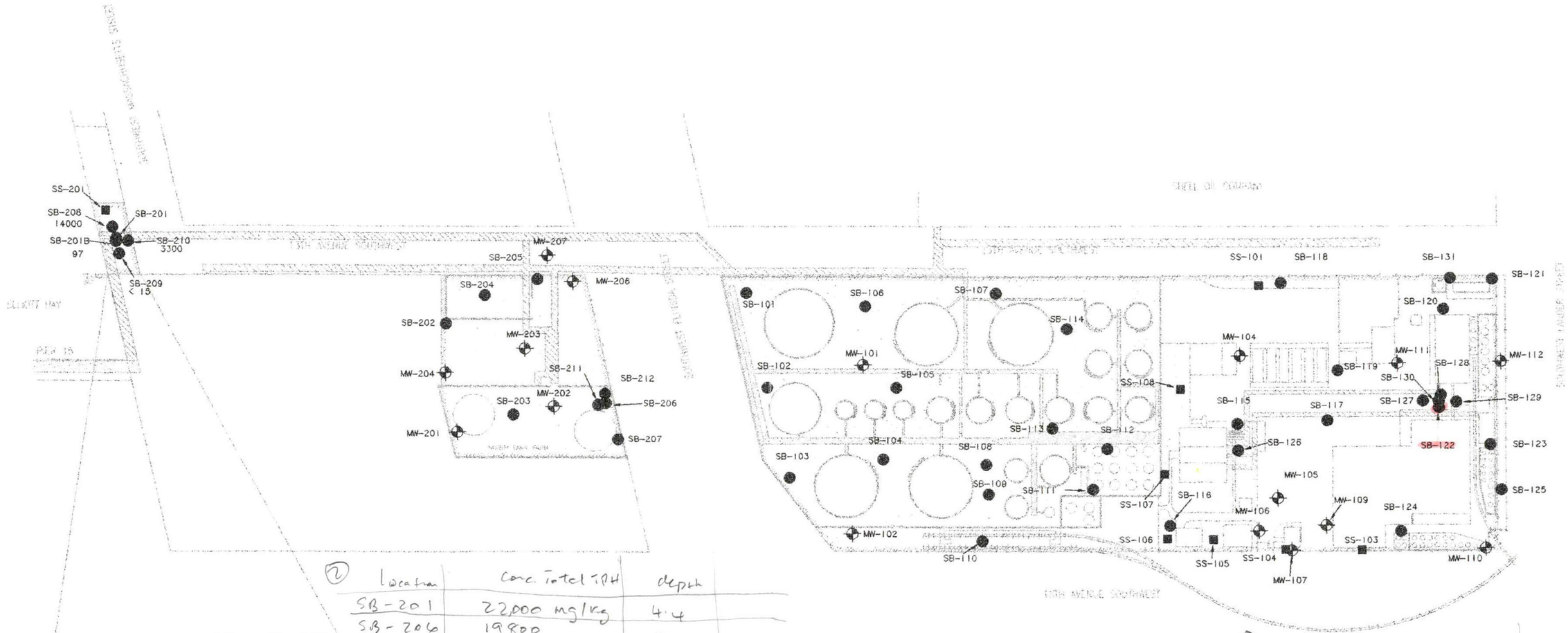
EMCON Northwest, Inc.

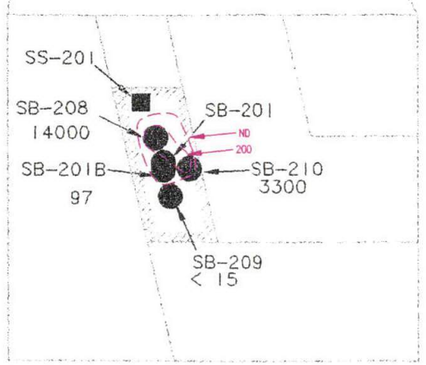
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-D CONCENTRATIONS
4-5.5 FEET

DRAWING NO
6-21
PROJECT NO
0750-001.14

SCALE: 1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\4_5TPHD





②

Location	Conc. Total TPH	depth
SB-201	22,000 mg/kg	4-4
SB-206	19800	2-0
SB-208	26640	4-6.5
SB-214	66570	0.5-8'
SB-215	34800	2-6.5
SB-216	18160	4-8
SB-217	25150	4-6
SB-218	15150	4-6

LEGEND

- Tank
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- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-D Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-D concentration contour

①

Location	Conc. Total TPH	depth
SB-122	86,640 mg/kg	1-4.5'
SB-135	49,140	2.5-8'
SB-136	47783	2.5-6'
SB-137	46560	2.5-6.5'
SB-139	26300	2-6'
SB-141	23780	2-6'
SB-142	36950	2-6'
SB-143	27183	2-8'
SB-144	20100	4-6'

③

Location	Conc. Total TPH	depth
SB-219	46090	4-8'
SB-220	12450	4-8'
SB-221	22210	4-8
SB-222	29520	4-6

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

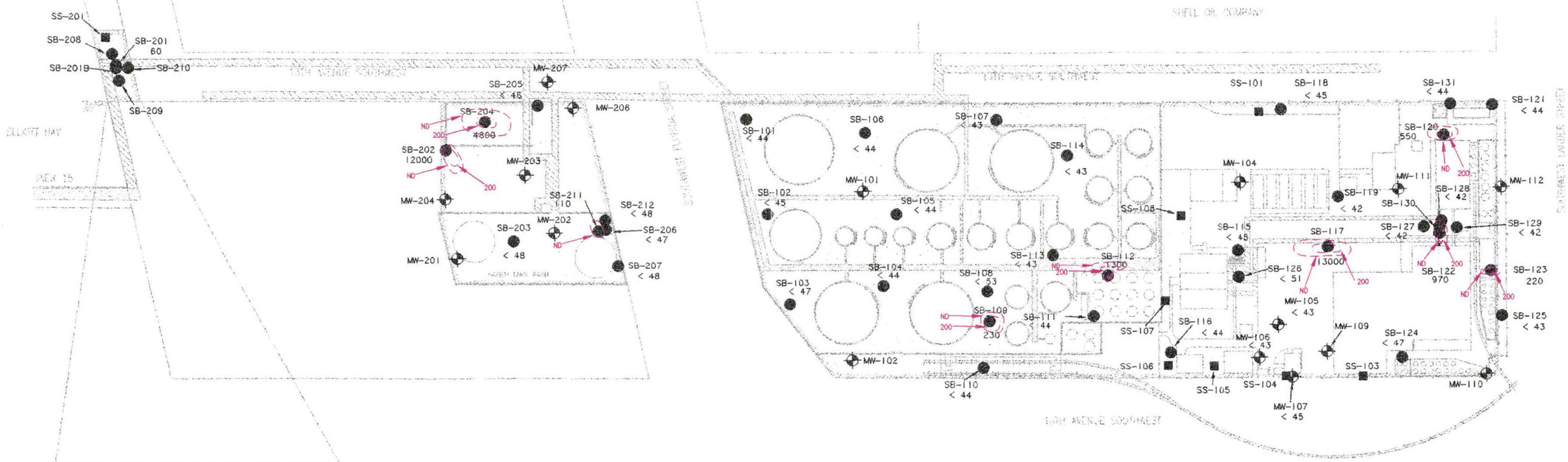
EMCON Northwest, Inc.

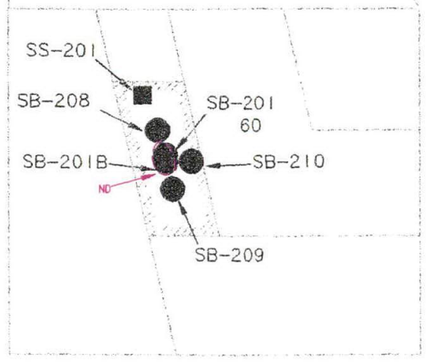
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-D CONCENTRATIONS
6.5-8 FEET

DRAWING NO
6-22
PROJECT NO
0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\6_8TPHD





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-O concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

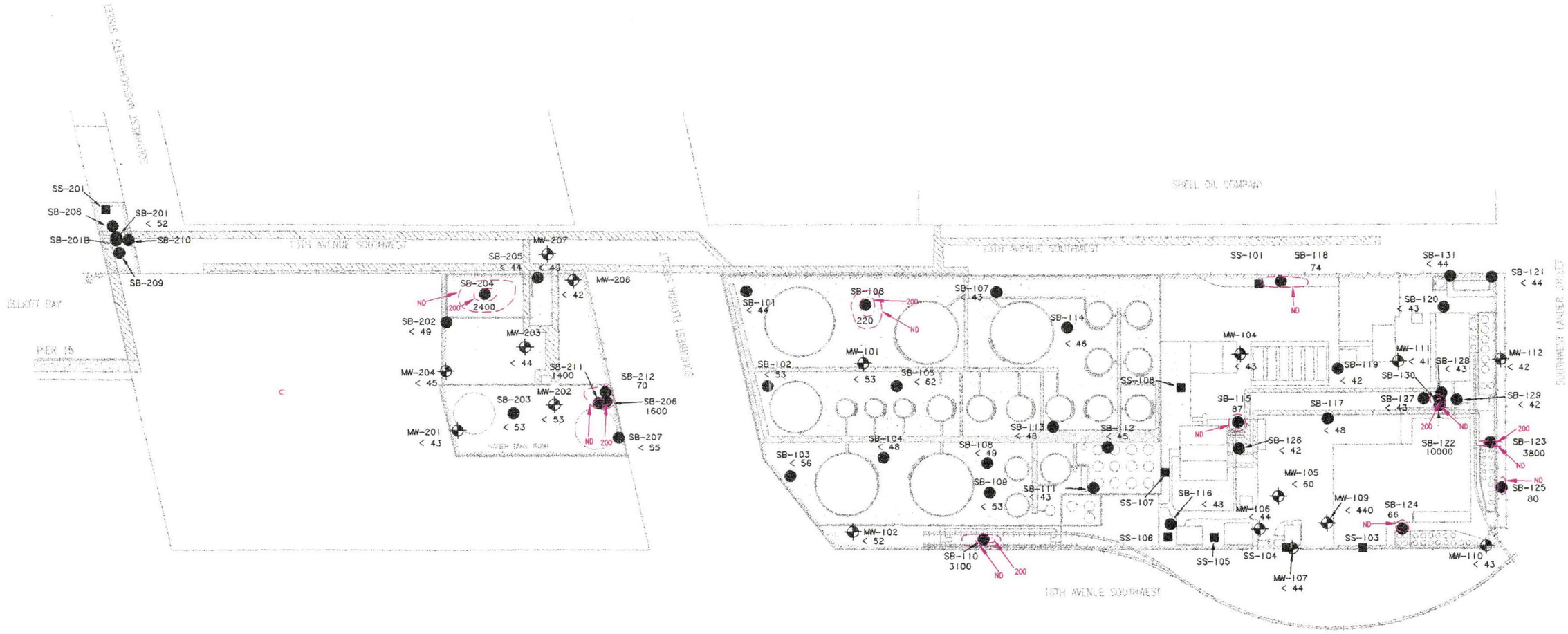
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-O CONCENTRATIONS
0.5-1.5 FEET

DRAWING NO
6-23
PROJECT NO
0750-001.14

SCALE: 1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\0_1TPHO



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-O concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DWN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

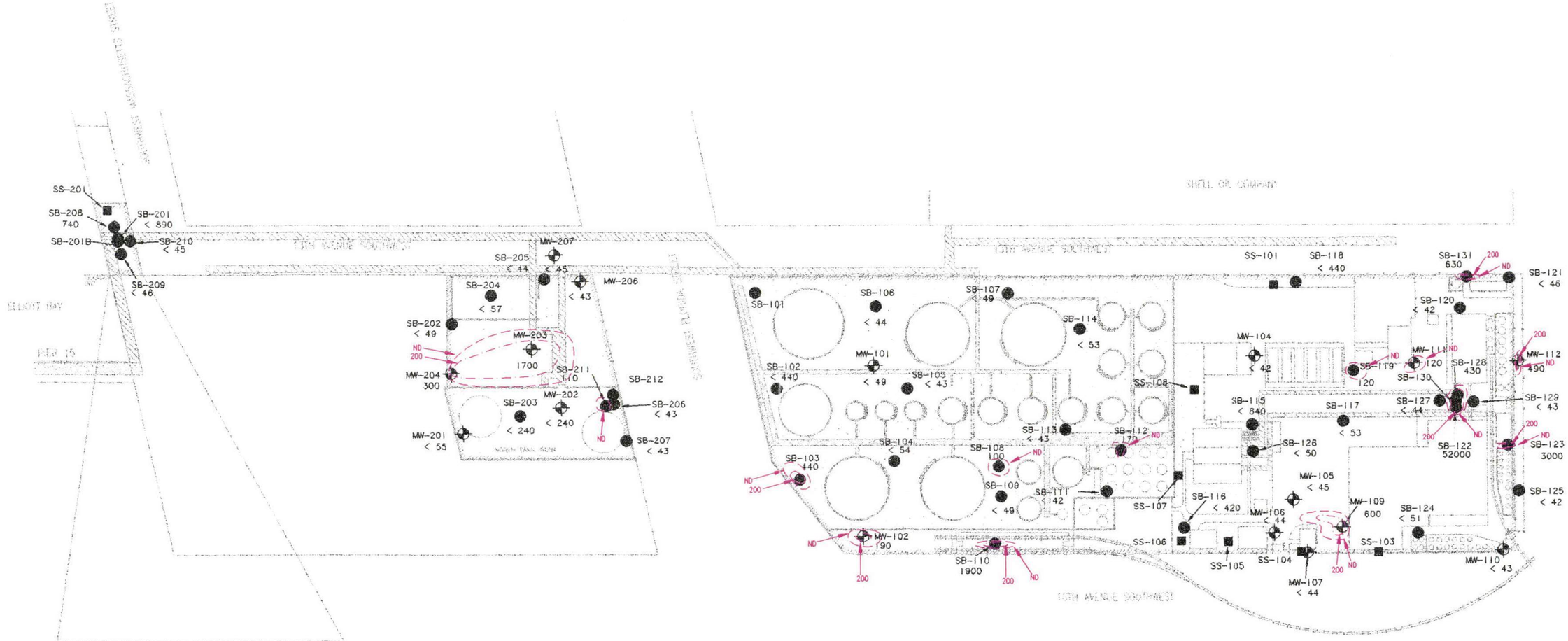
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

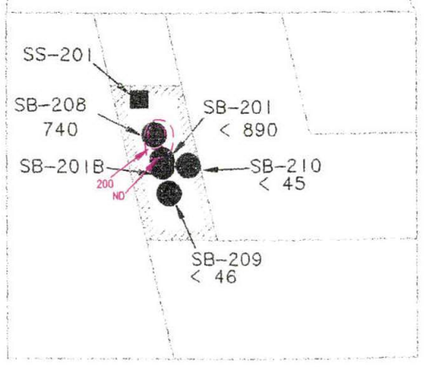
SOIL TPH-O CONCENTRATIONS
2-3 FEET

DRAWING NO **6-24**

PROJECT NO 0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\1_3TPHO





LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-O concentration contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

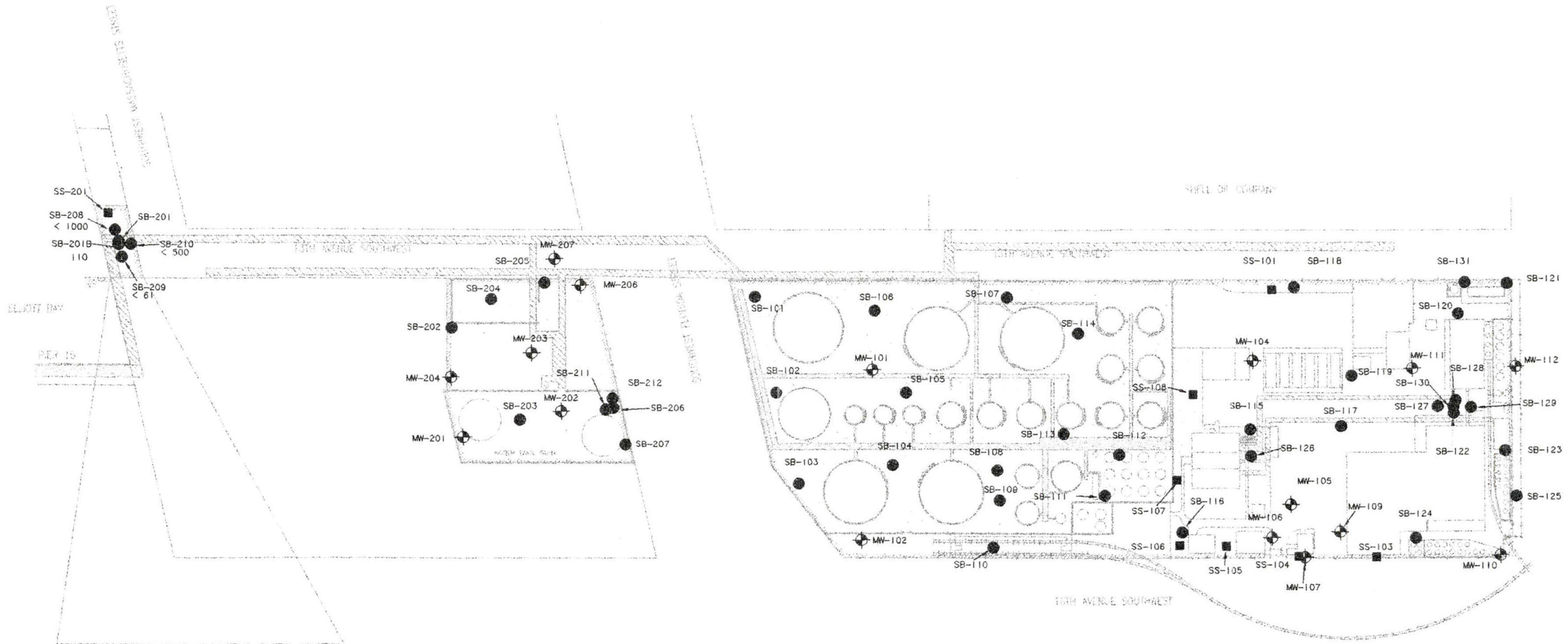
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-O CONCENTRATIONS
4-5.5 FEET

DRAWING NO
6-25
PROJECT NO
0750-001.14

SCALE:1=200 10-26-94 C:\0750109\GISKEY\GEO\MAPS\4_5TPHO



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/kg)
- SB-201 — Soil Boring
- 200 — TPH-O concentration contour

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DWN BY DES BY			CHK BY APP BY	

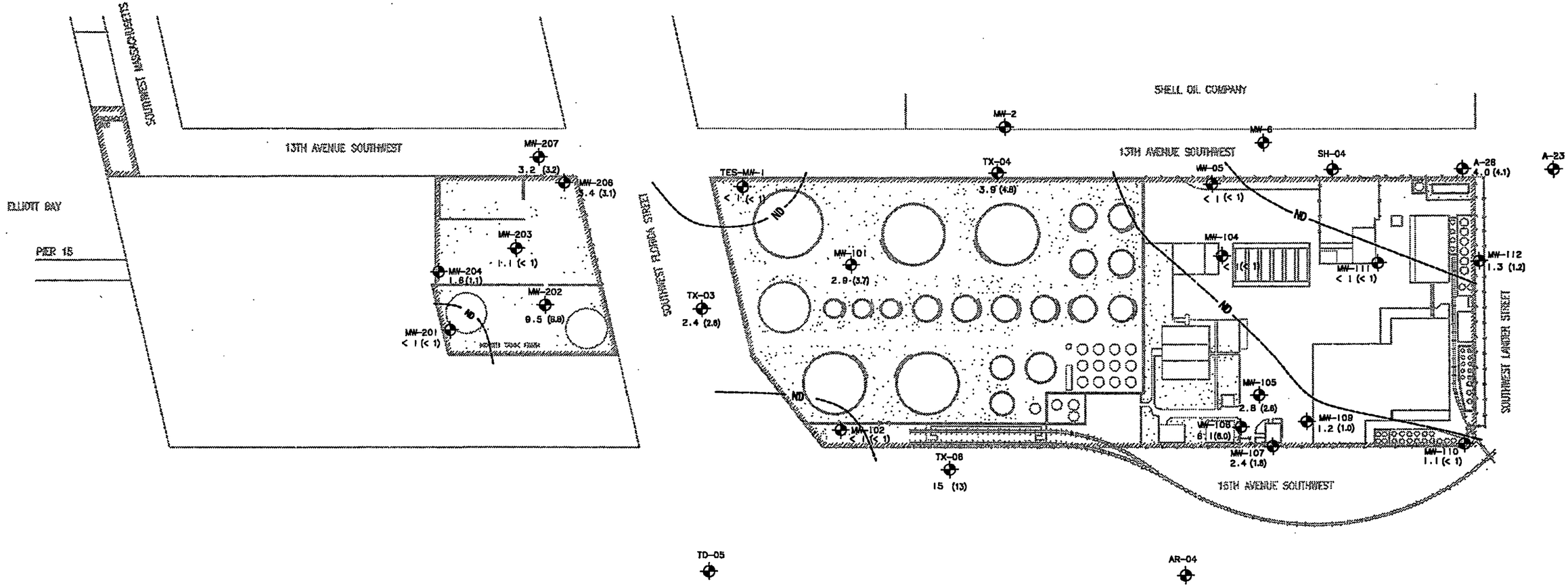
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH-O CONCENTRATIONS
6.5-8 FEET

DRAWING NO
6-26
PROJECT NO
0750-001.14

SCALE: 1=200 10-28-94 C:\0750109\GISKEY\GEO\MAPS\6_8TPHO



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Arsenic Concentration (ug/L)
- (1.1) — Dissolved Arsenic Concentration (ug/L)
- 36 — Total Arsenic Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE DRN BY DES BY CHK BY APP BY

EMCON Northwest, Inc.

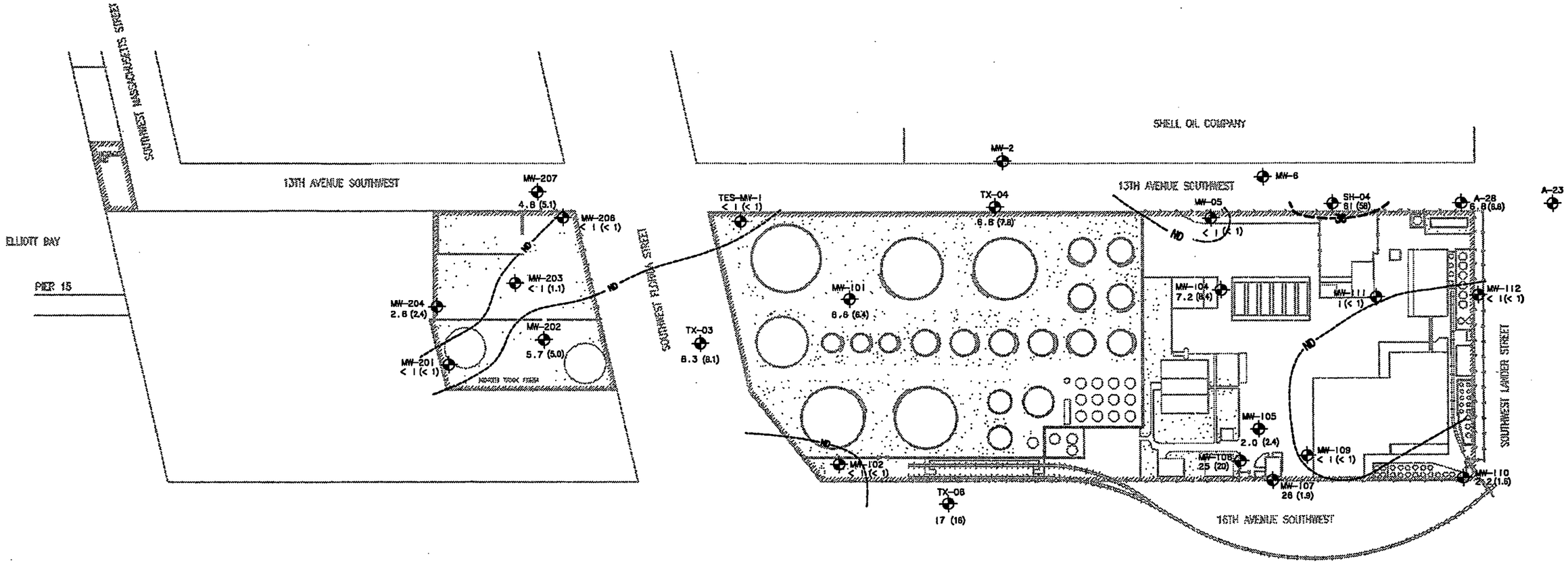
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ARSENIC CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO 7-1

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 G:\0750109\GISKEY\CHEM\MAPS\AS21



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Arsenic Concentration (ug/L)
- (1.1) — Dissolved Arsenic Concentration (ug/L)
- 38 — Total Arsenic Concentration Contour

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

BASE OF ISSUE: DRN BY: DES BY: CHK BY: APP BY:

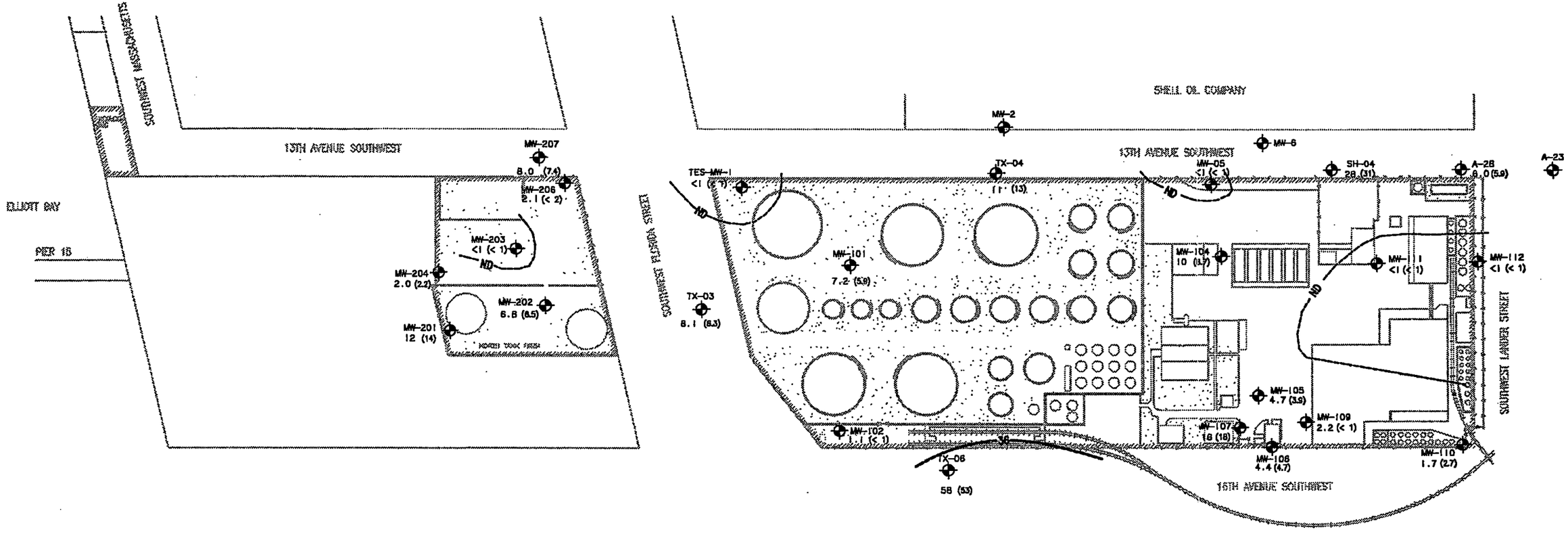
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ARSENIC CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-2
PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750100\GRSKEY\CHEM\MAPS\A502



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Arsenic Concentration (ug/L)
- (1.1) — Dissolved Arsenic Concentration (ug/L)
- 38 — Total Arsenic Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

EMCON Northwest, Inc.

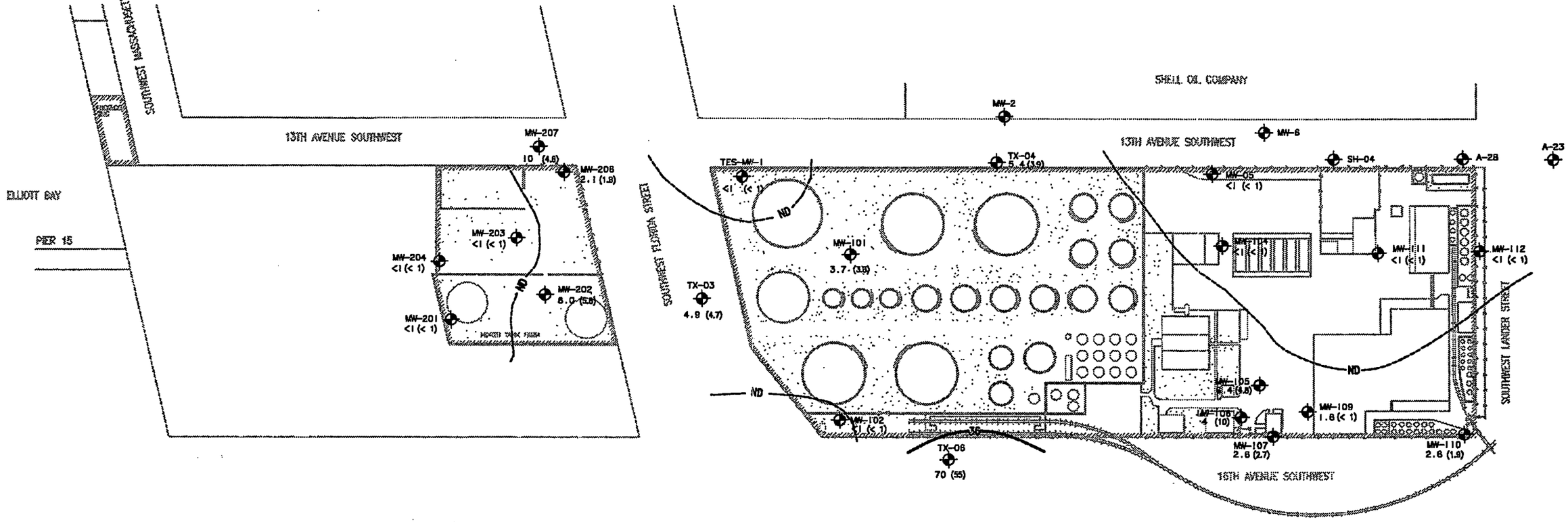
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ARSENIC CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-3

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 G:\0750109\GISKEY\CHEM\MAPS\AS93



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Arsenic Concentration (ug/L)
- (1.1) — Dissolved Arsenic Concentration (ug/L)
- 38 — Total Arsenic Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

EMCON Northwest, Inc.

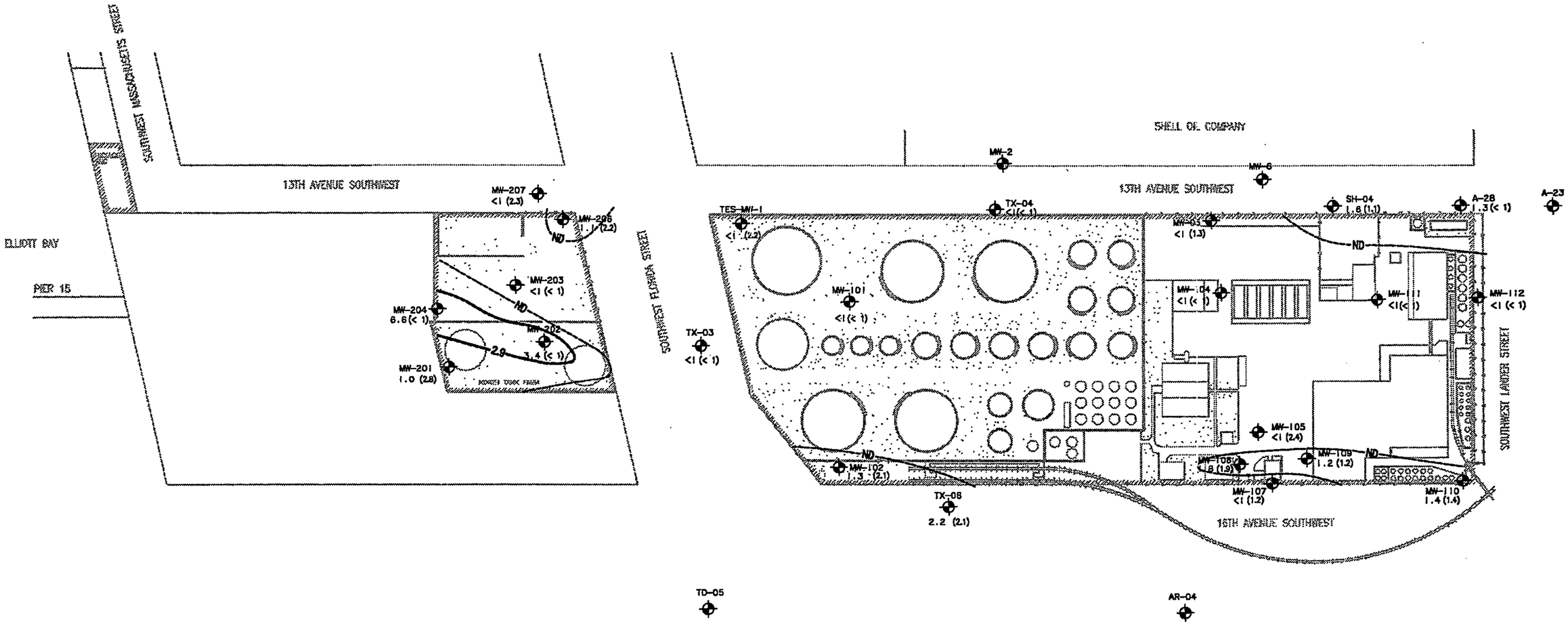
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ARSENIC CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-4

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750109\KEYKEY\CHEM\MAPS\AS04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Copper Concentration (ug/L)
- (1.1) — Dissolved Copper Concentration (ug/L)
- 2.9 — Total Copper Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

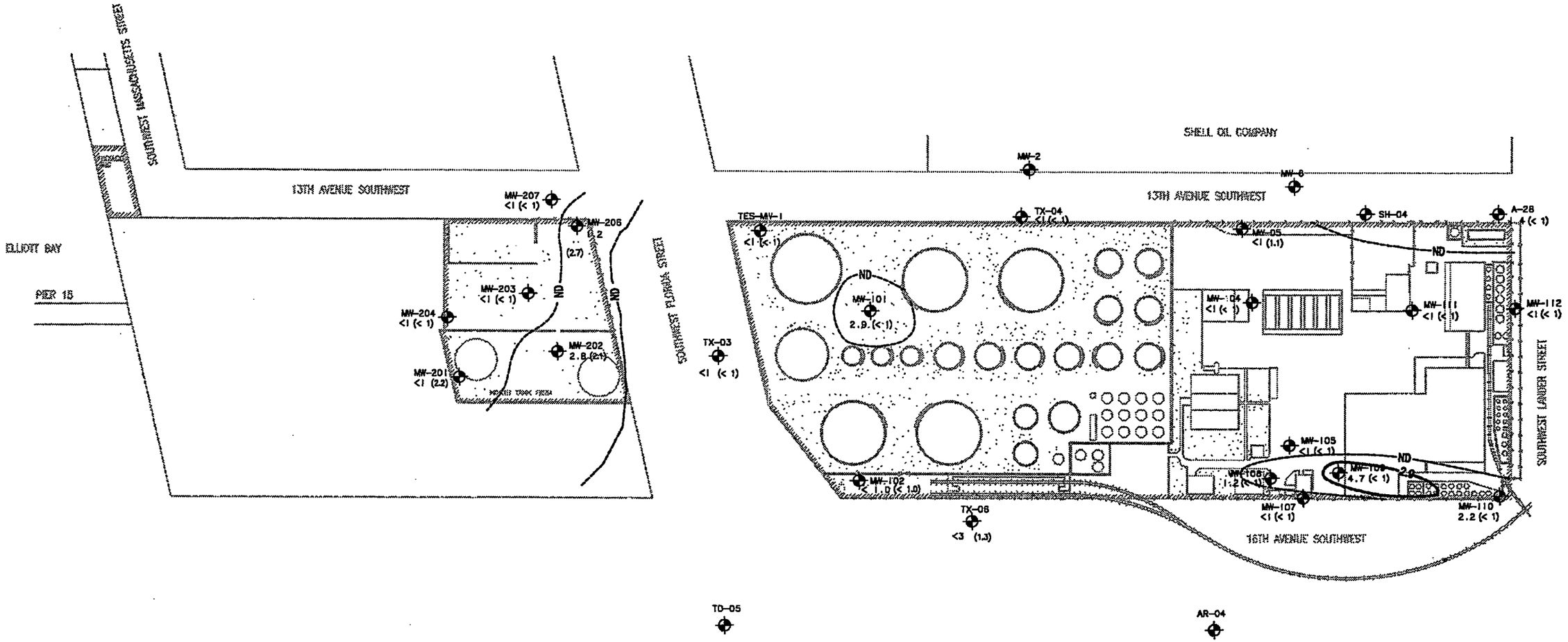
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

COPPER CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-6
PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 G:\0750109\GISKEY\CHEM\MAPS\CU22



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Copper Concentration (ug/L)
- (1.1) — Dissolved Copper Concentration (ug/L)
- 2.9 — Total Copper Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ CHK BY ____
DES BY ____ APP BY ____

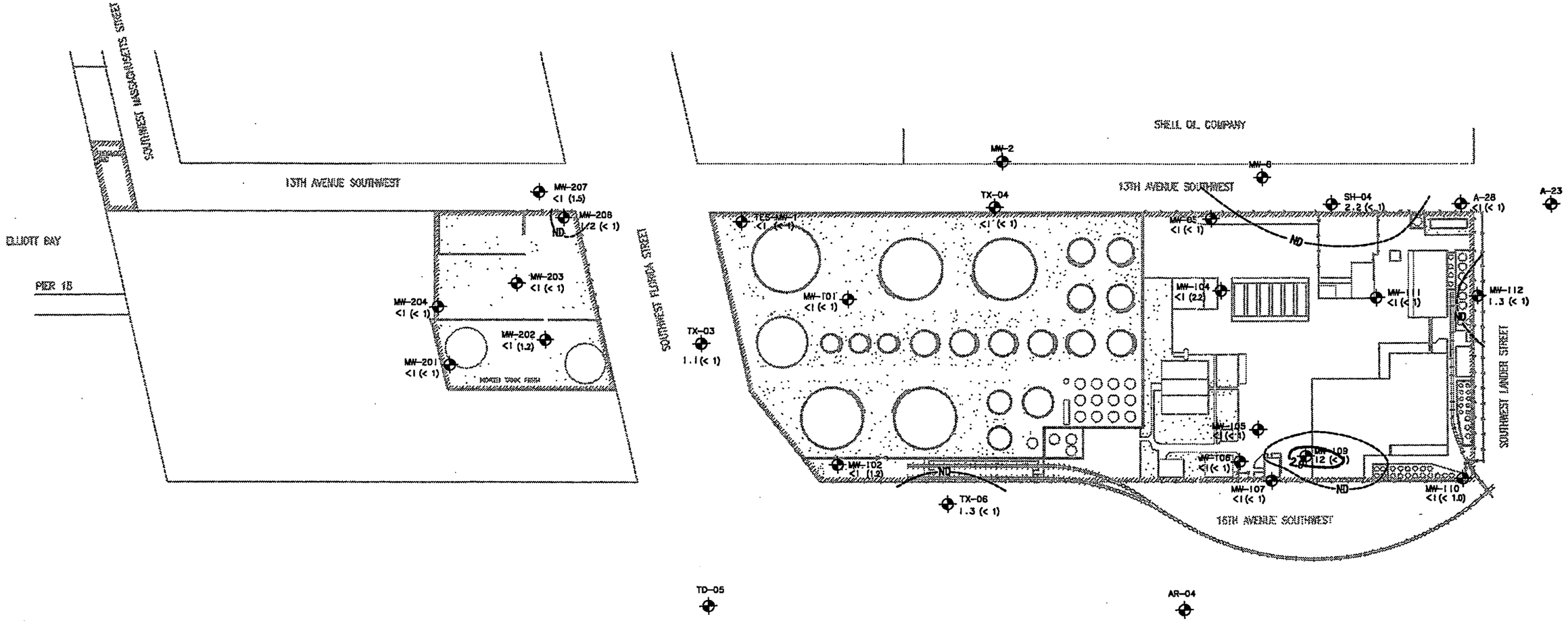
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

COPPER CONCENTRATIONS IN SHALLOW GROUNDWATER
APRIL 1993

DRAWING NO 7-5
PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750109\GISKEY\CHEM\MAPS\CU01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Copper Concentration (ug/L)
- (1.1) — Dissolved Copper Concentration (ug/L)
- 2.9 — Total Copper Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

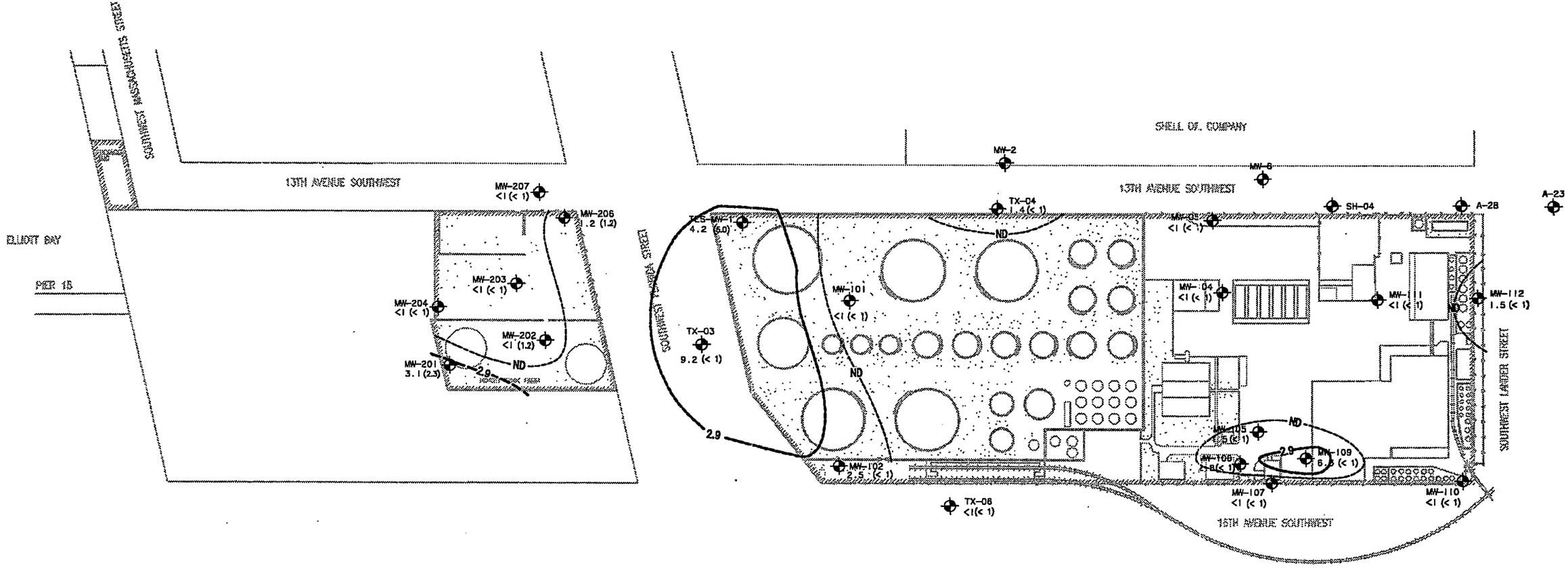
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

COPPER CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-7

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 G:\0750109\REKEY\CHEM\MAPS\CUG3



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Copper Concentration (ug/L)
- (1.1) — Dissolved Copper Concentration (ug/L)
- 2.9 — Total Copper Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DRN BY
DES BY
CHK BY
APP BY

EMCON Northwest, Inc.

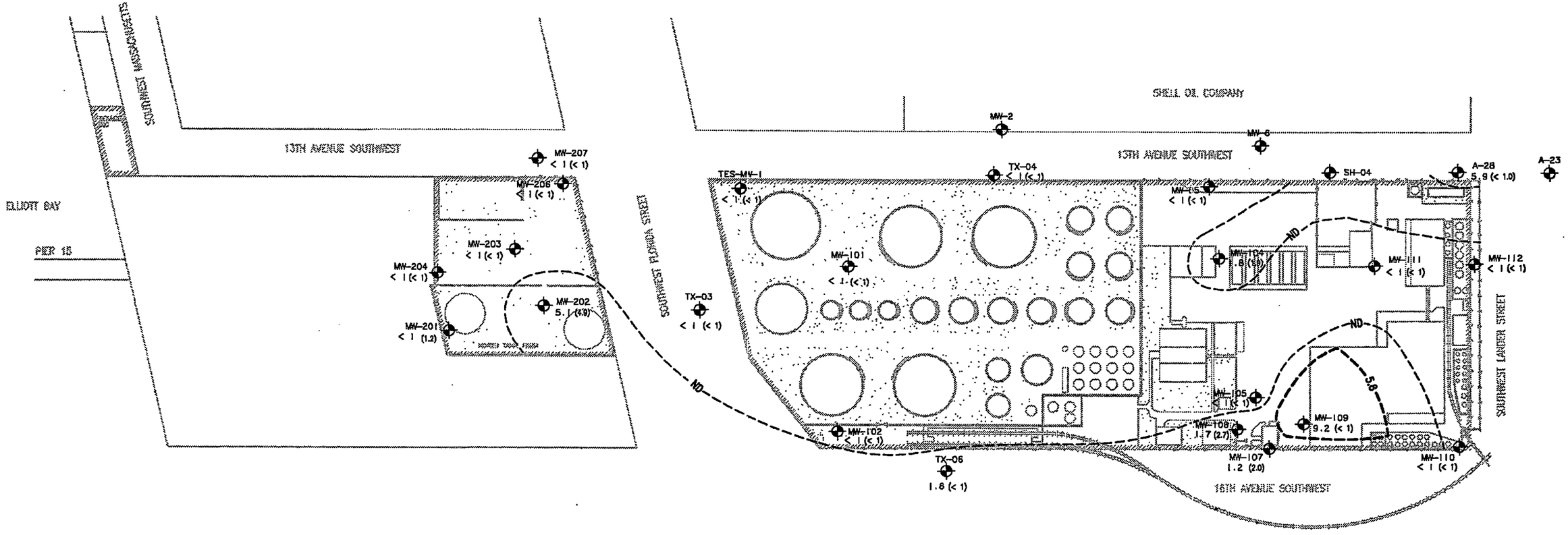
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

COPPER CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-8

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750109\DISKEY\CHEM\MAPS\CU04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- 1.6 — Total Lead Concentration (ug/L)
- (<1) — Dissolved Lead Concentration (ug/L)
- 5.8 — Total Lead Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DRN BY
DES BY
CHK BY
APP BY

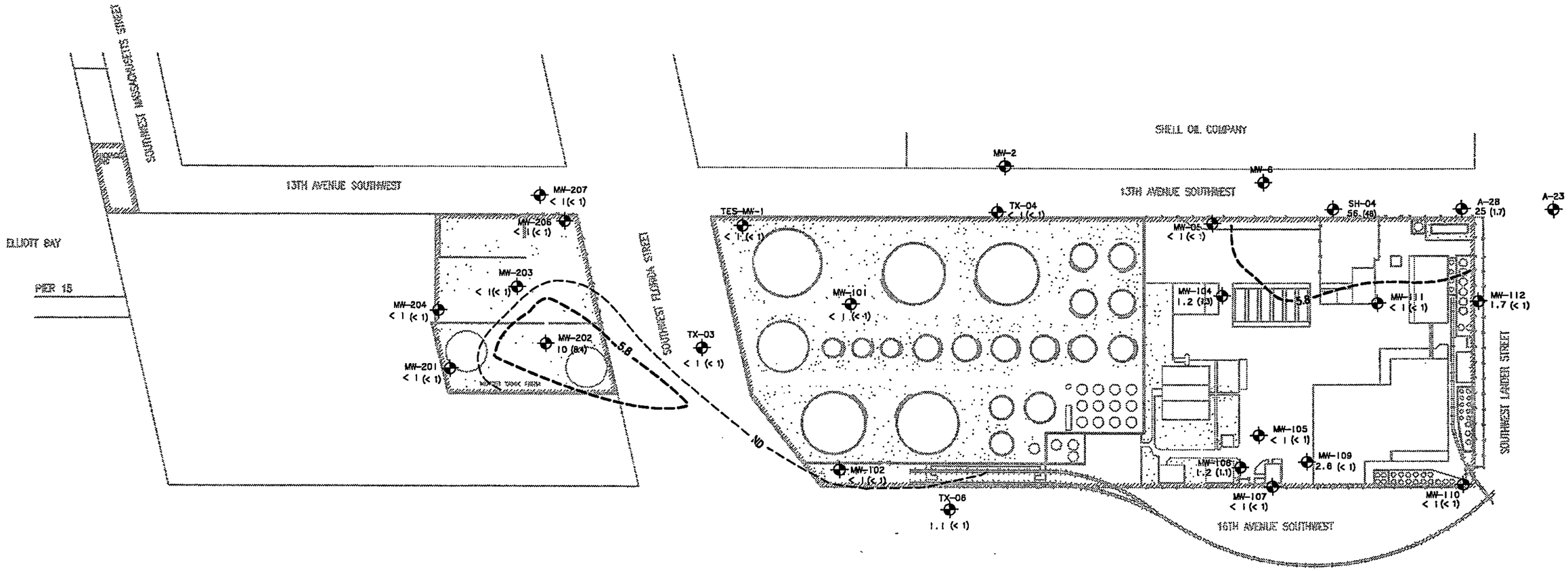
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

LEAD CONCENTRATIONS IN SHALLOW GROUNDWATER
APRIL 1993

DRAWING NO
7-9
PROJECT NO
0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\PB01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- 1.1 — Total Lead Concentration (ug/L)
- (<1) — Dissolved Lead Concentration (ug/L)
- 5.8 — Total Lead Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY / DES BY	CHK BY / APP BY			

EMCON Northwest, Inc.

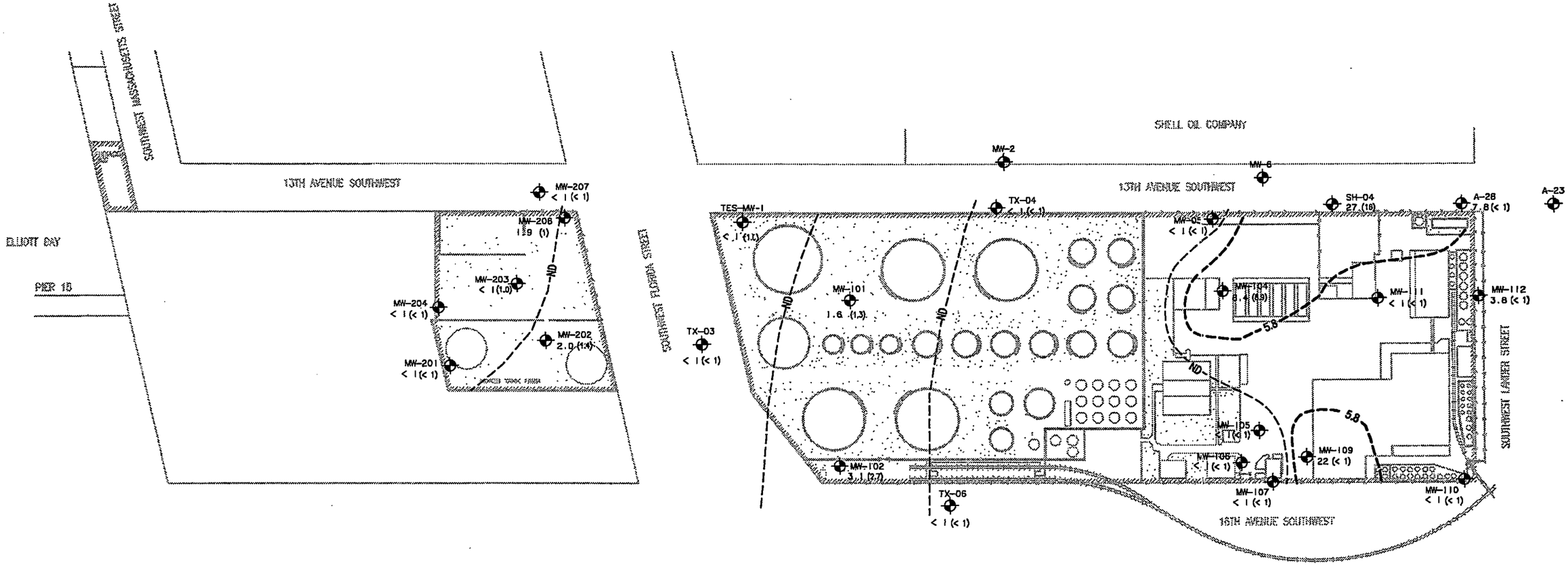
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

LEAD CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-10

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\FSG2



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- 3.8 — Total Lead Concentration (ug/L)
- (<1) — Dissolved Lead Concentration (mg/L)
- 5.8 — Total Lead Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

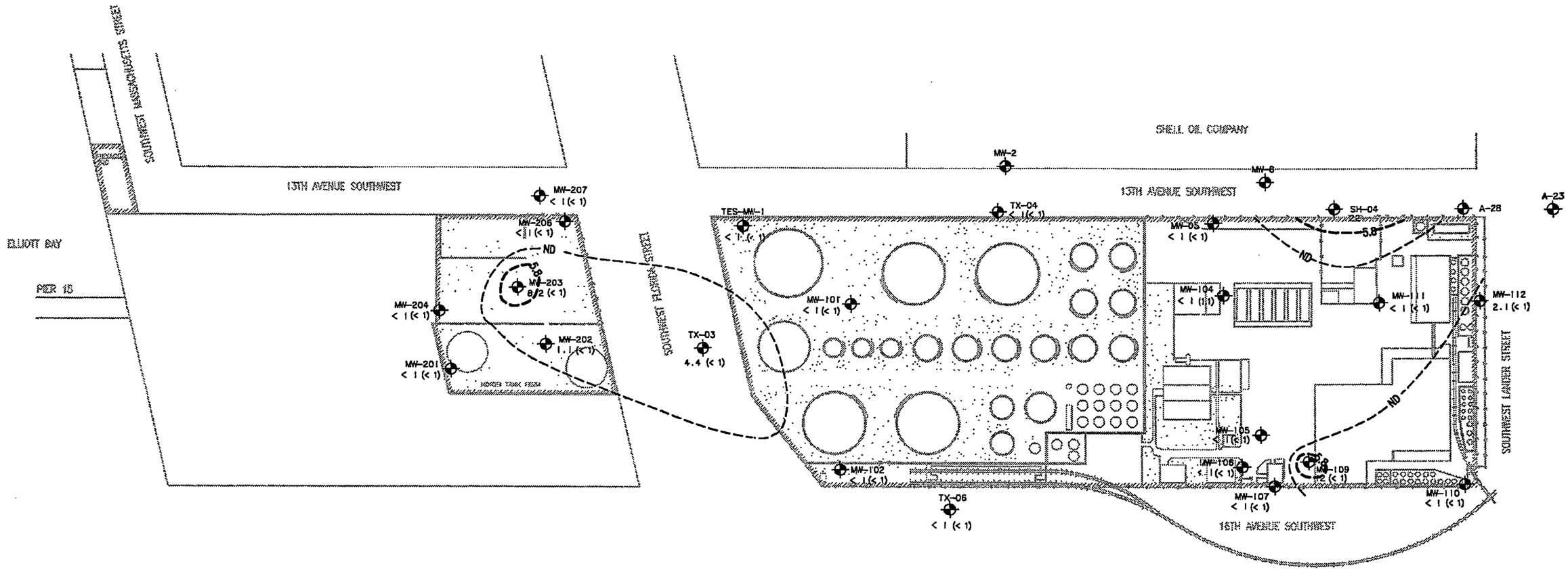
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

LEAD CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-11

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\PB93



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- 2.1 — Total Lead Concentration (ug/L)
- (<1) — Dissolved Lead Concentration (ug/L)
- 5.8 — Total Lead Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY ____ DES BY ____	CHK BY ____ APP BY ____			

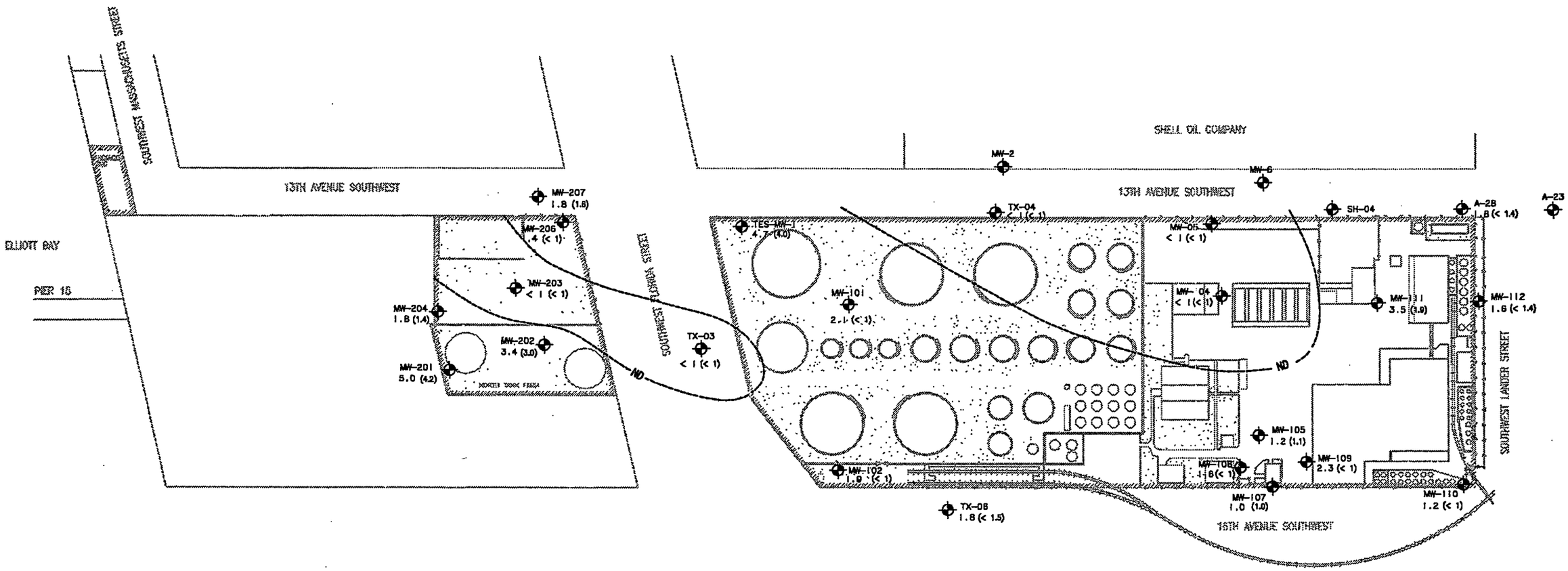
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

LEAD CONCENTRATIONS IN SHALLOW GROUNDWATER
DECEMBER 1993

DRAWING NO **7-12**
PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GSKEY\CHEM\MAPS\FB04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Nickel Concentration (ug/L)
- (1.1) — Dissolved Nickel Concentration (ug/L)
- 7.9 — Total Nickel Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
MODE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

EMCON Northwest, Inc.

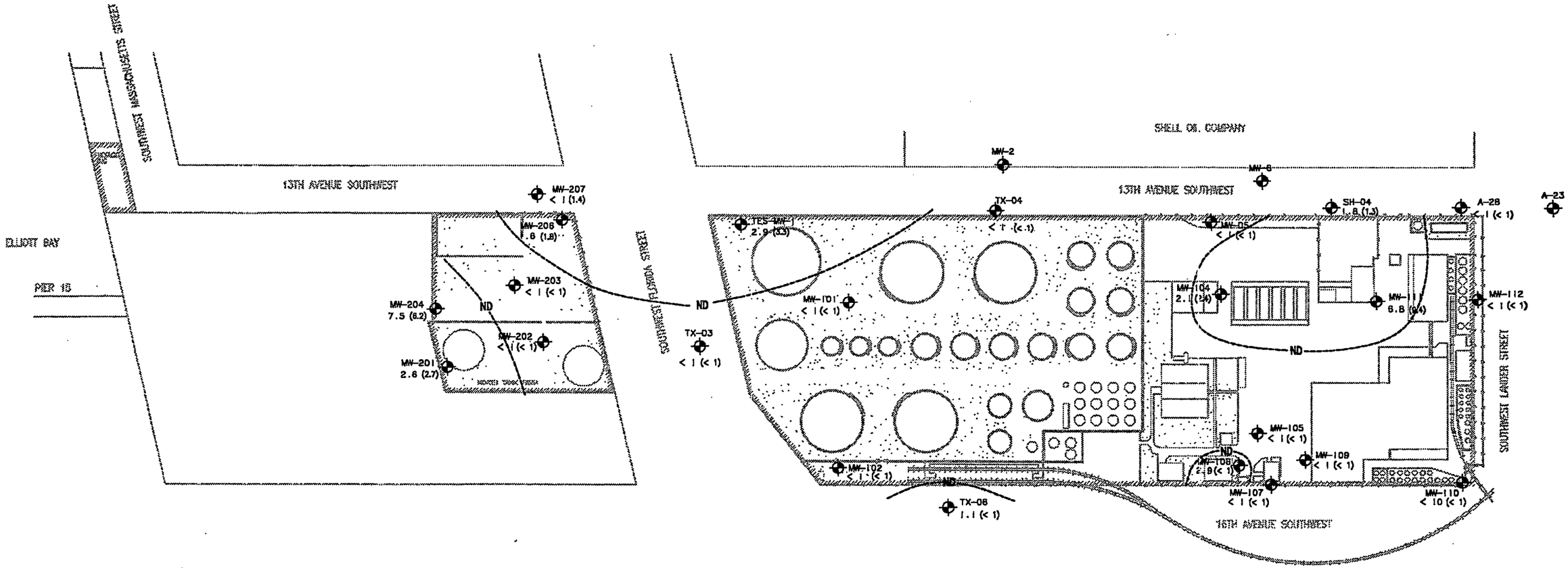
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

NICKEL CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO 7-13

PROJECT NO 0750-001.09

SCALE:1=300 10-14-94 C:\0750100\GISKEY\CHEM\MAPS\MN01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Nickel Concentration (ug/L)
- (1.1) — Dissolved Nickel Concentration (ug/L)
- 7.9 — Total Nickel Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY / DES BY	CHK BY / APP BY			

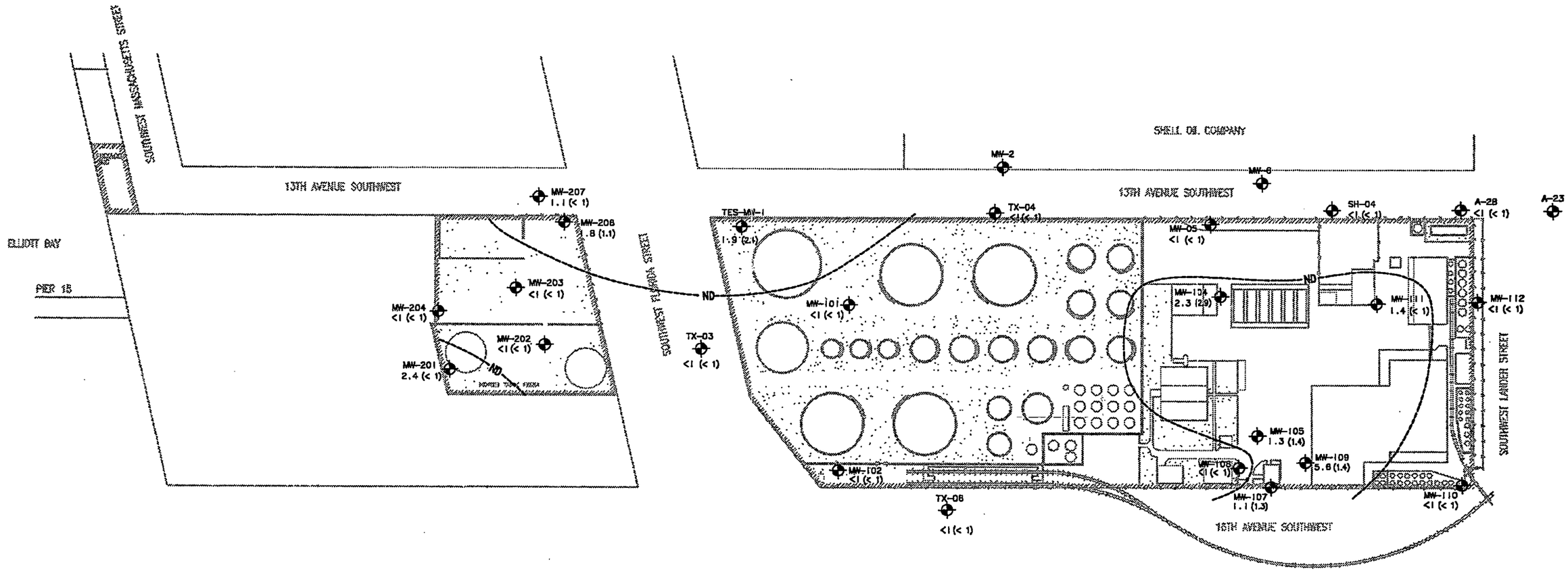
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

NICKEL CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-14
PROJECT NO 0750-001.09

SCALE:1=200 10-11-94 C:\0750100\GISKEY\CHEM\MAPS\N02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Nickel Concentration (ug/L)
- (1.1) — Dissolved Nickel Concentration (ug/L)
- 7.9 — Total Nickel Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

EMCON Northwest, Inc.

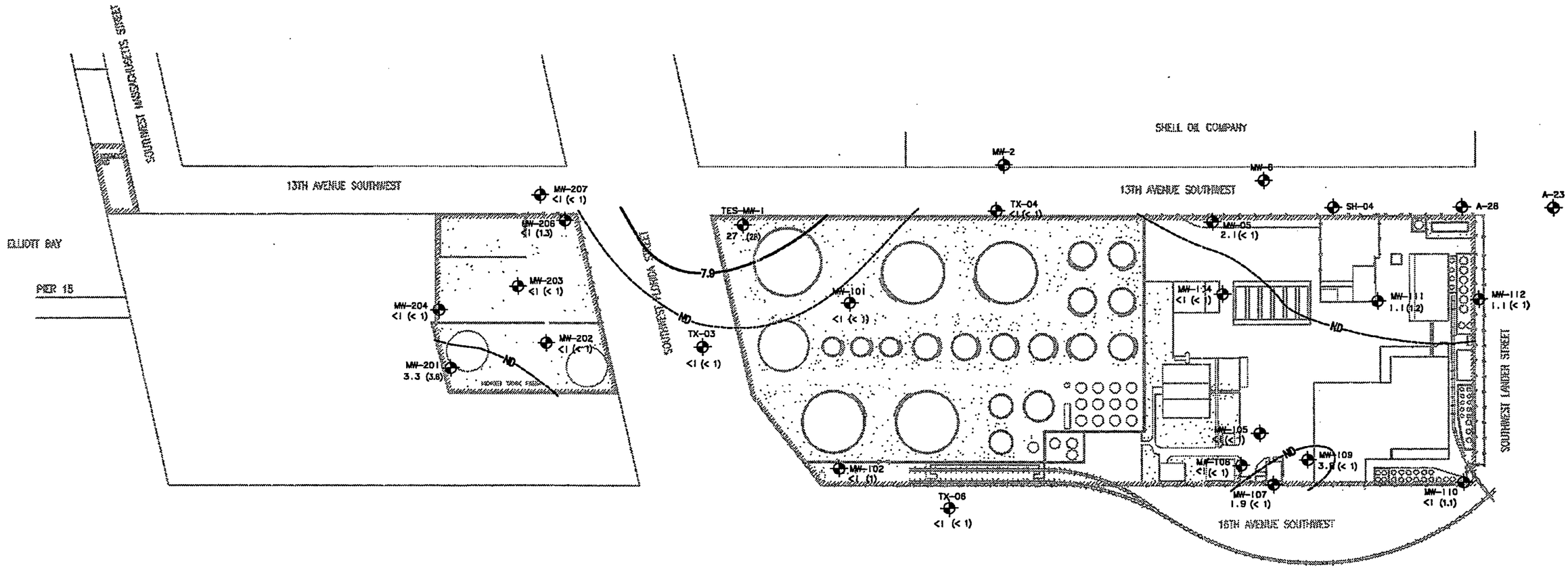
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

NICKEL CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-15

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750109\GISKEY\CHEM\MAPS\W03



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 1 — Total Nickel Concentration (ug/L)
- (1.1) — Dissolved Nickel Concentration (ug/L)
- 7.9 — Total Nickel Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY ___ DES BY ___	CHK BY ___ APP BY ___			

EMCON Northwest, Inc.

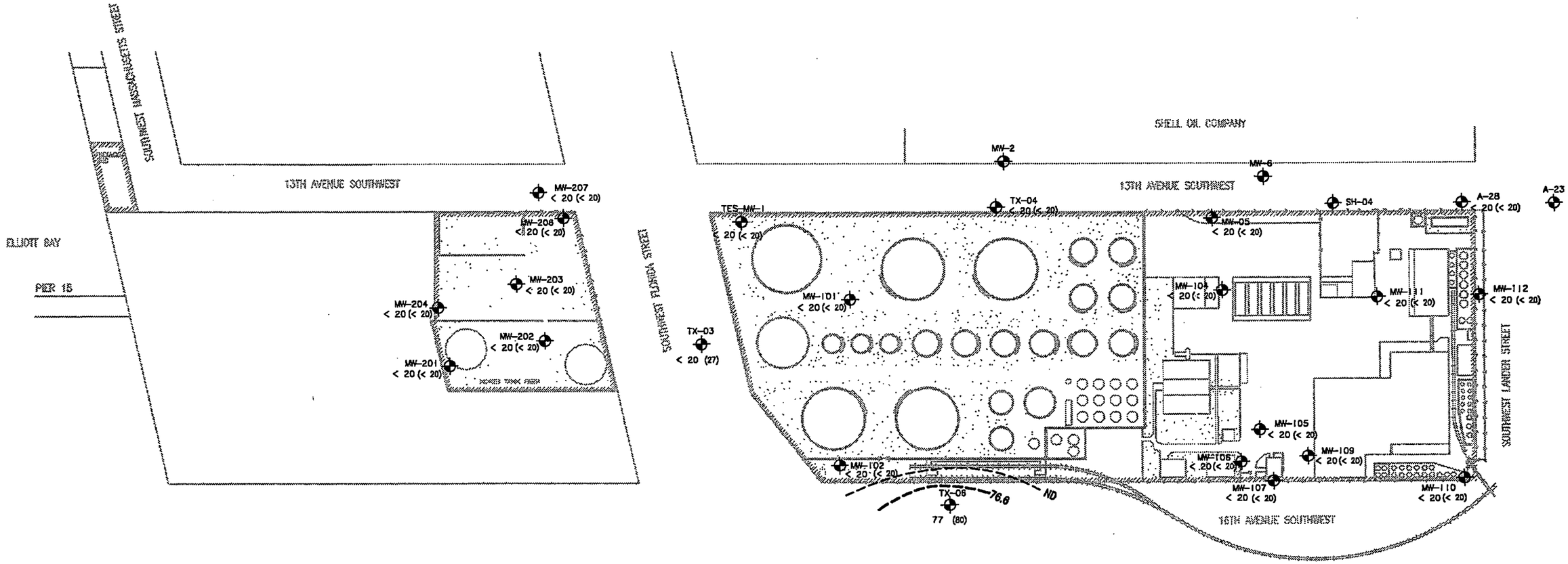
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

NICKEL CONCENTRATIONS IN SHALLOW GROUNDWATER
DECEMBER 1993

DRAWING NO 7-16

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 c:\0750109\GSKEY\CHEM\MAPS\N04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 20 — Total Zinc Concentration (ug/L)
- (< 20) — Dissolved Zinc Concentration (ug/L)
- --76.6-- — Total Zinc Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE
DRN BY
DES BY
CHK BY
APP BY

EMCON Northwest, Inc.

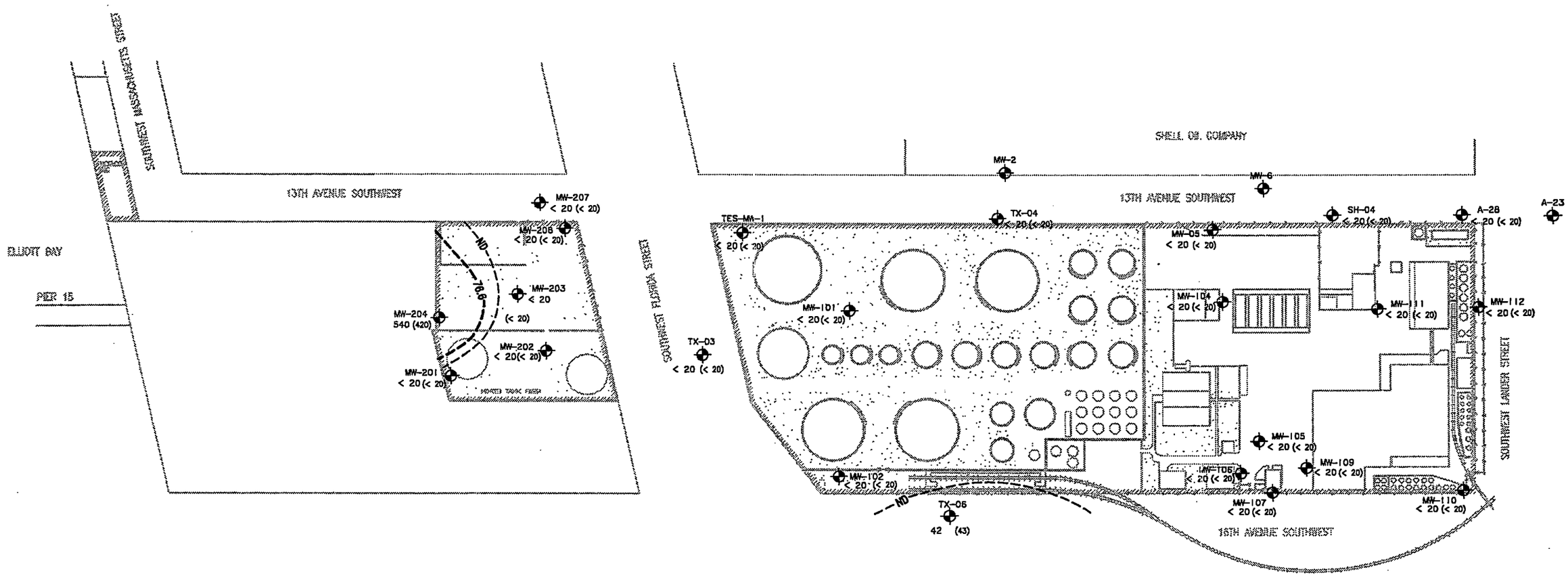
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ZINC CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO 7-17

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\QSKEY\CHEM\MAPS\ZINC1



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 20 — Total Zinc Concentration (ug/L)
- (< 20) — Dissolved Zinc Concentration (ug/L)
- --76.6-- — Total Zinc Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY ____ DES BY ____	CHK BY ____ APP BY ____			

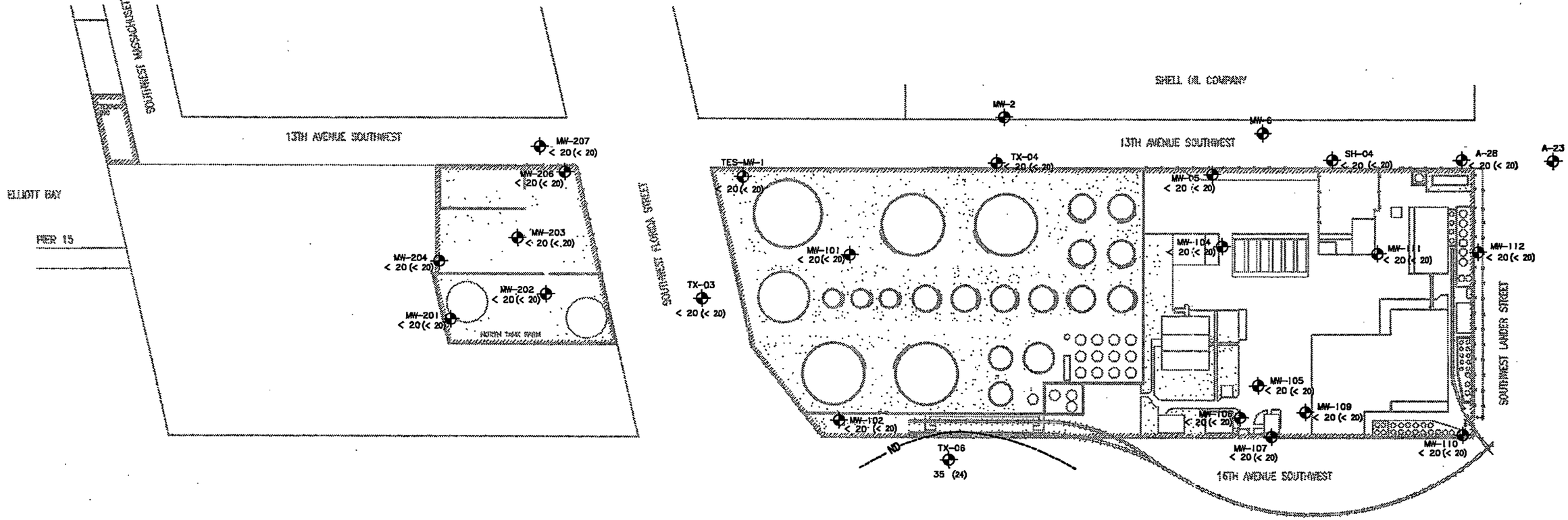
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ZINC CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO **7-18**
PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GSKEY\CHEM\MAPS\ZNQ2



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 20 — Total Zinc Concentration (ug/L)
- (< 20) — Dissolved Zinc Concentration (ug/L)
- 76.6 — Total Zinc Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY / DES BY	CHK BY / APP BY			

EMCON Northwest, Inc.

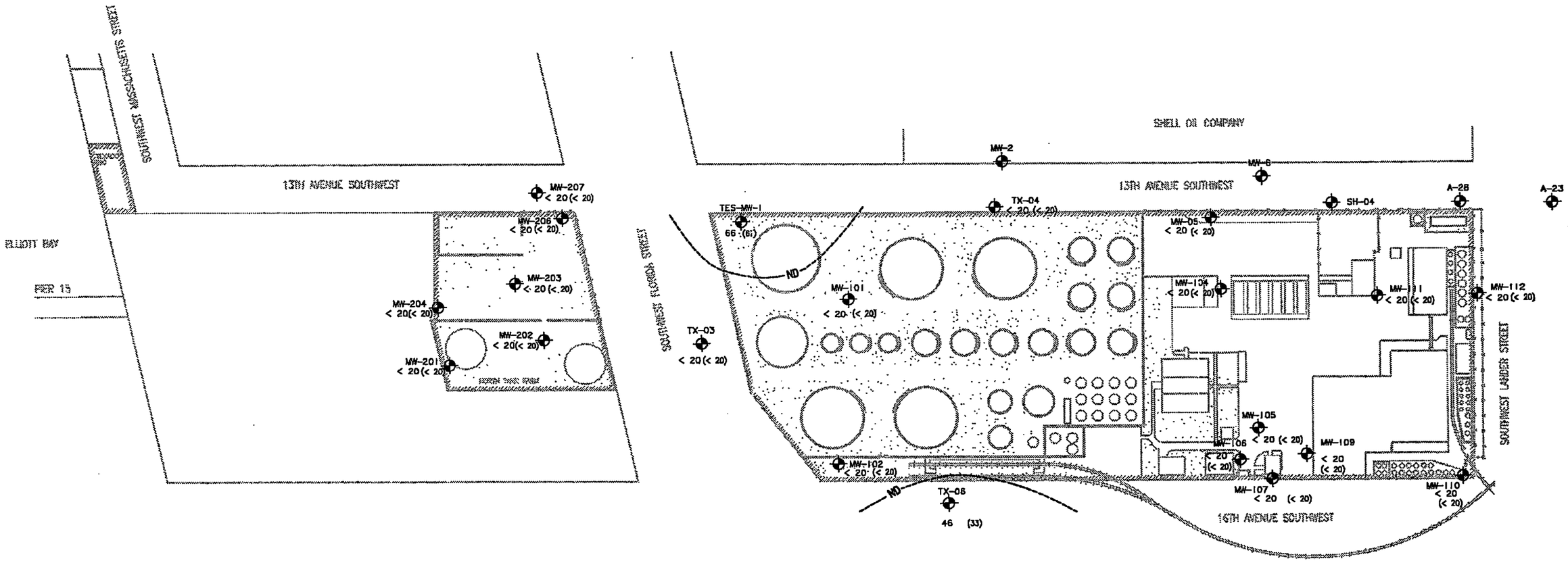
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ZINC CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-19

PROJECT NO 0750-001.09

SCALE:1=200 10-14-04 C:\0750100\GISKEY\CHEM\MAPS\ZNQ3



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 20 — Total Zinc Concentration (ug/L)
- (< 20) — Dissolved Zinc Concentration (ug/L)
- 76.6 — Total Zinc Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY DES BY	CHK BY APP BY			

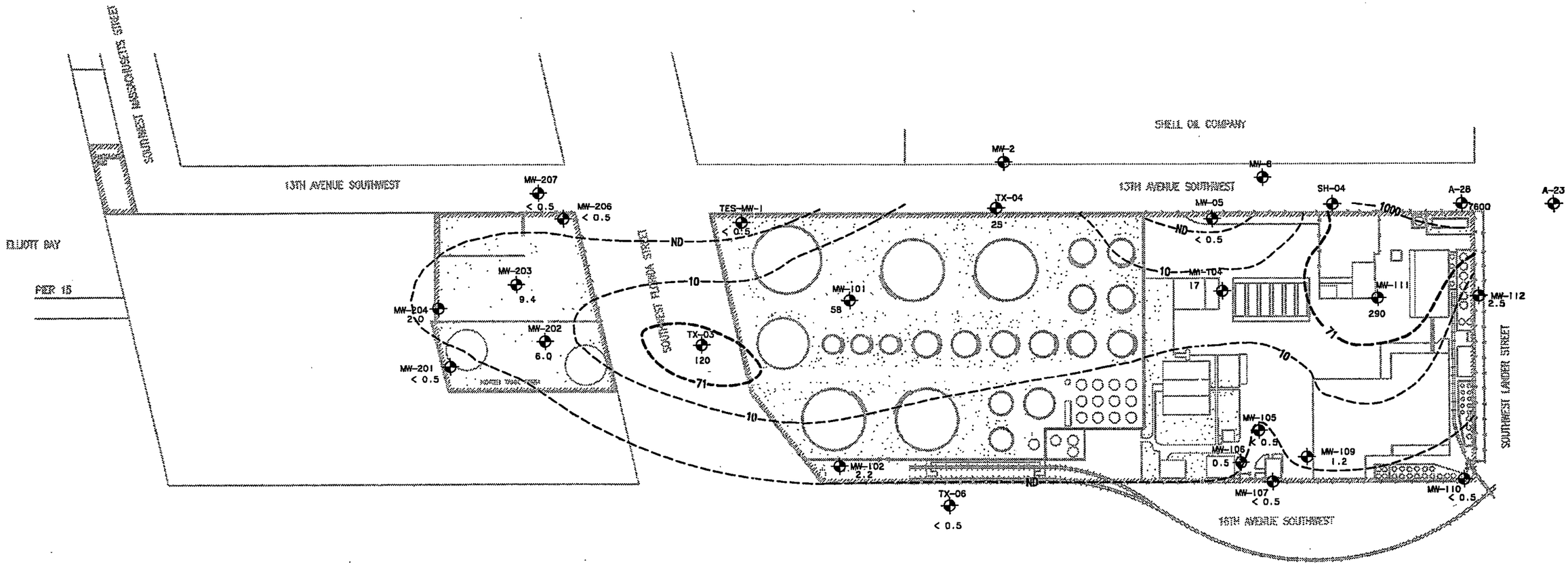
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ZINC CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO
7-20
PROJECT NO
0750-001.09

SCALE:1=200 10-14-94 C:\0750109\GISKEY\CHEM\MAPS\ZNQ4



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (ug/L)
- 71 — Benzene Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE DRN BY DES BY CHK BY APP BY

EMCON Northwest, Inc.

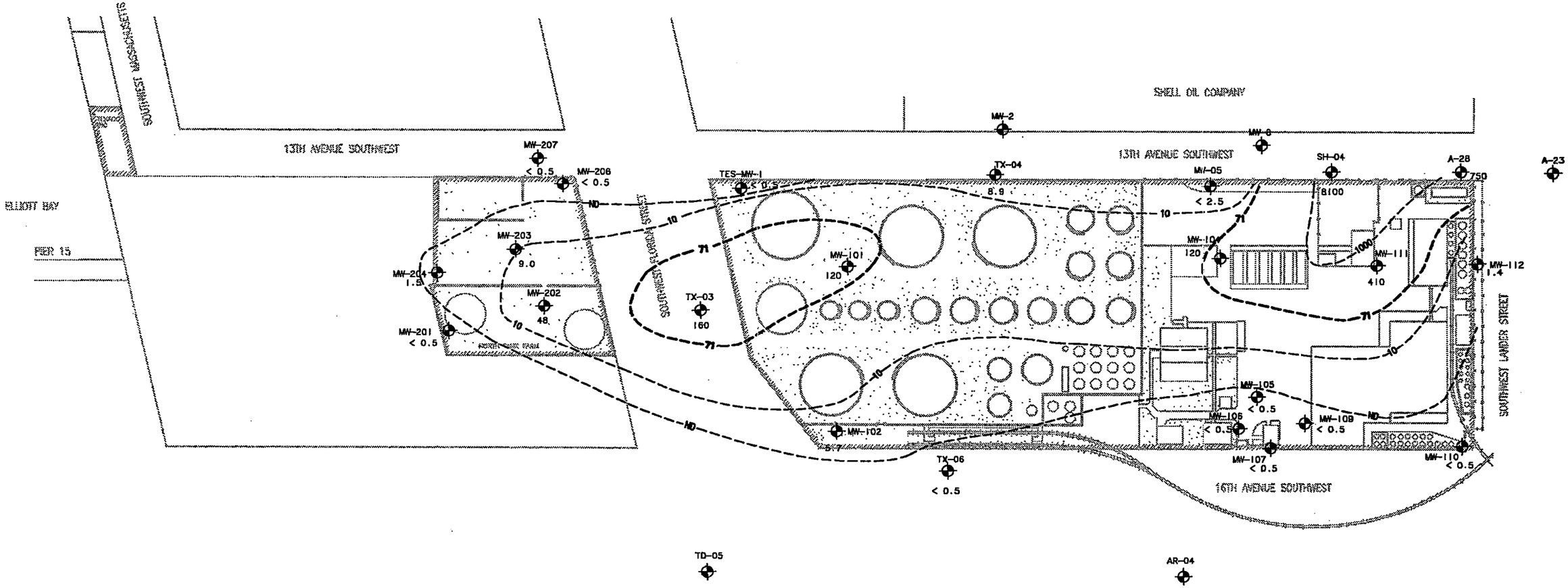
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

BENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO 7-21

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\BENZ01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (ug/L)
- 71 — Benzene Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY ___ DES BY ___	CHK BY ___ APP BY ___			

EMCON Northwest, Inc.

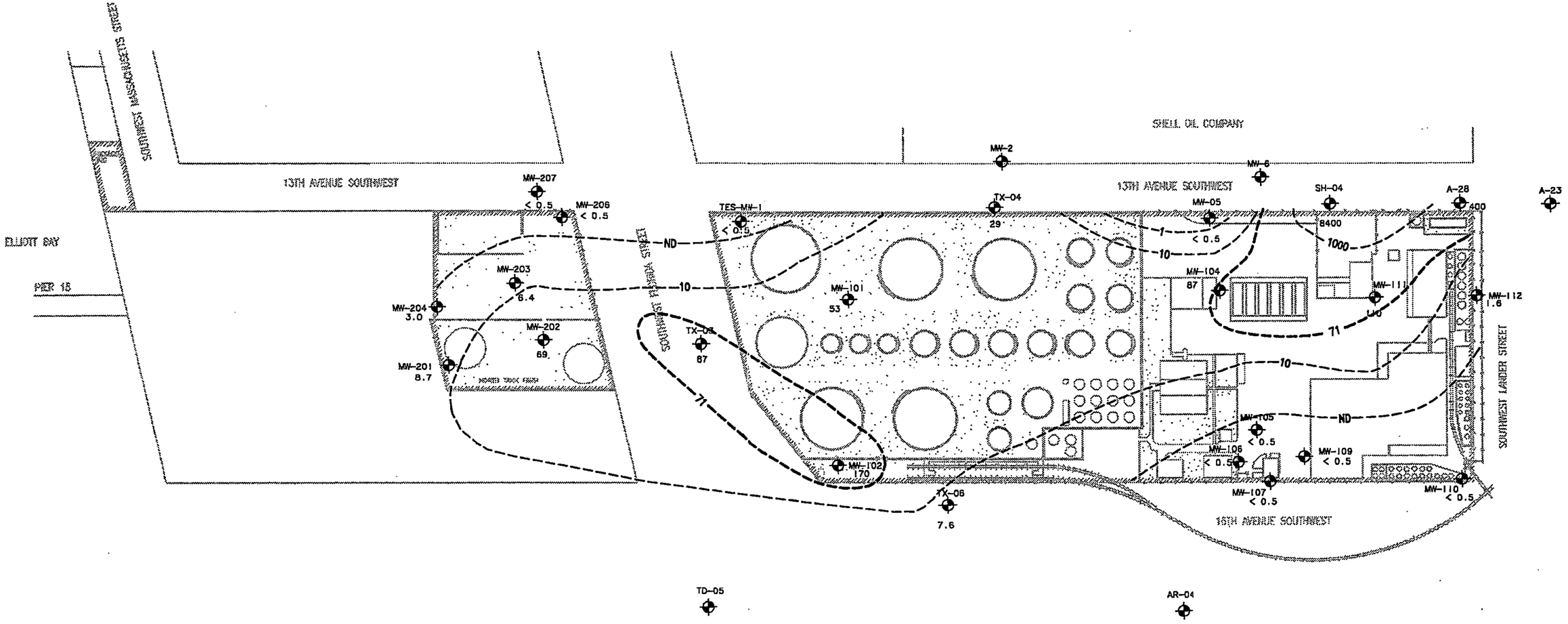
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

BENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER JUNE 1993

DRAWING NO 7-22

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 G:\0750109\GISKEY\CHEM\MAPS\BENZ02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (ug/L)
- 71 — Benzene Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY ____ DES BY ____			CHK BY ____ APP BY ____	

EMCON Northwest, Inc.

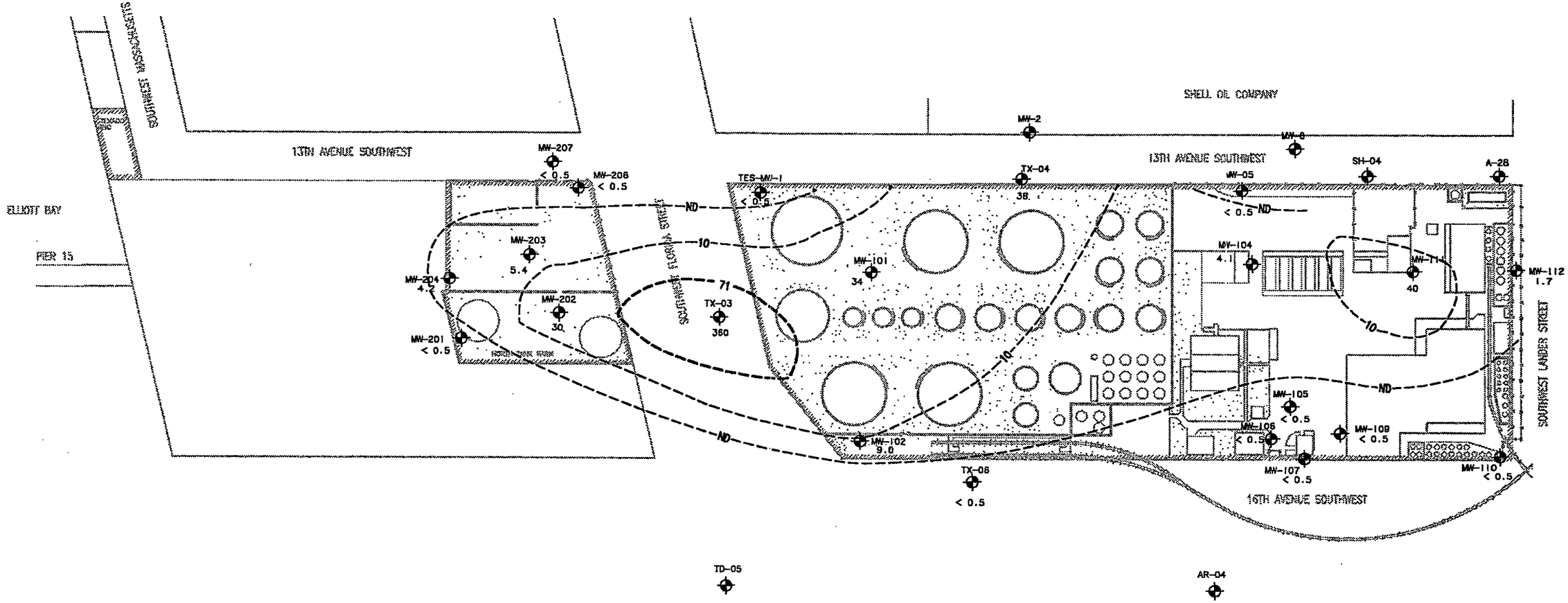
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

BENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-23

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\BENZ03



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Benzene Concentration (ug/L)
- 71 — Benzene Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE		DRN BY		CHK BY	
			DES BY		APP BY	

EMCON Northwest, Inc.

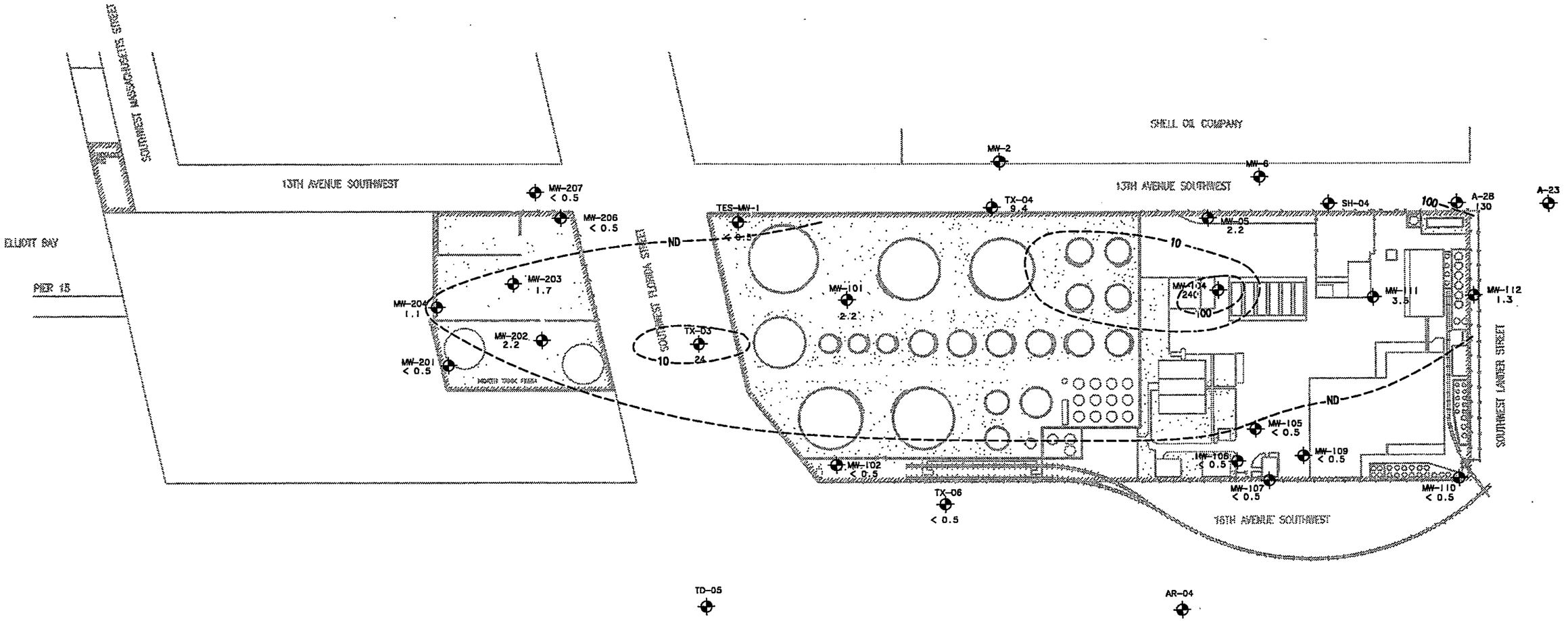
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

BENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-24

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750109\GISKEY\CHEM\MAPS\GAS01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Toluene Concentration (ug/L)
- 5000 — Toluene Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE _____ DRN BY _____ DES BY _____ CHK BY _____ APP BY _____

EMCON Northwest, Inc.

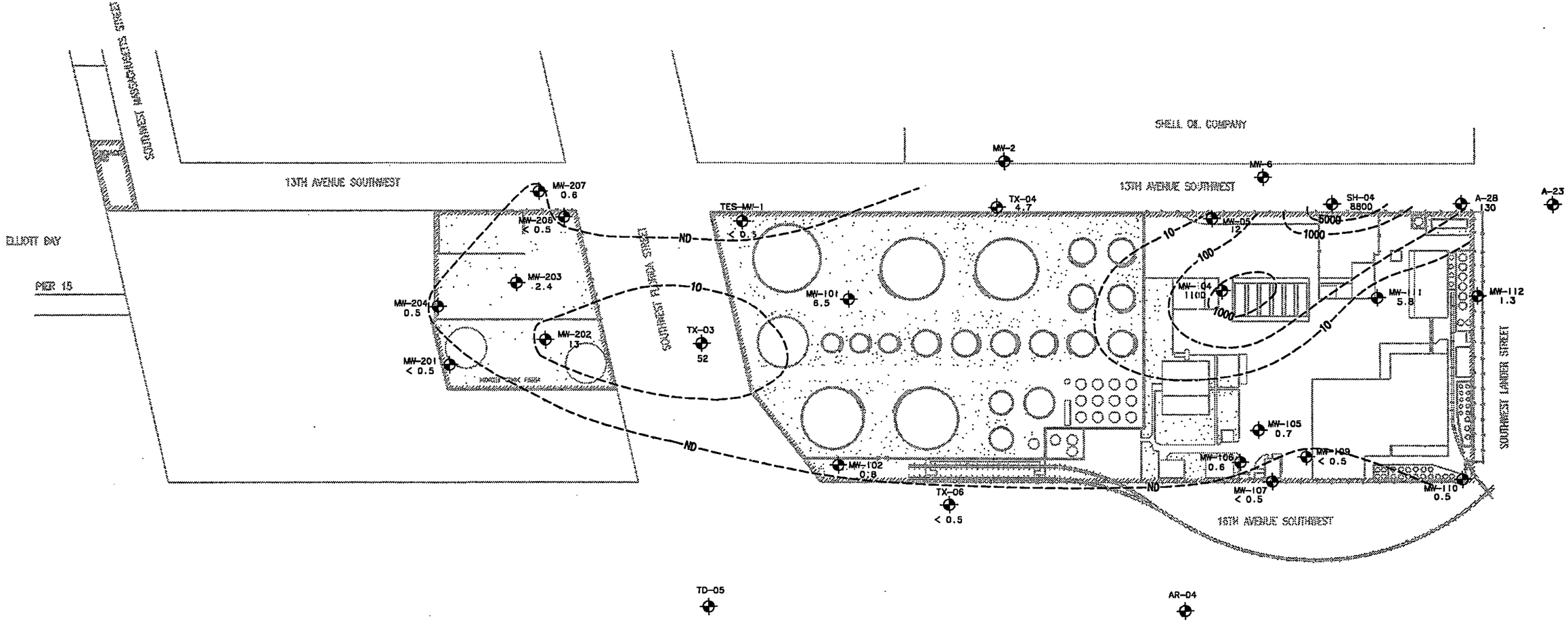
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOLUENE CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO **7-25**

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\QSKEY\CHEM\MAPS\TOLQ1



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- <0.5 — Toluene Concentration (ug/L)
- 5000 — Toluene Concentration Contour

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY DES BY			CHK BY APP BY	

EMCON Northwest, Inc.

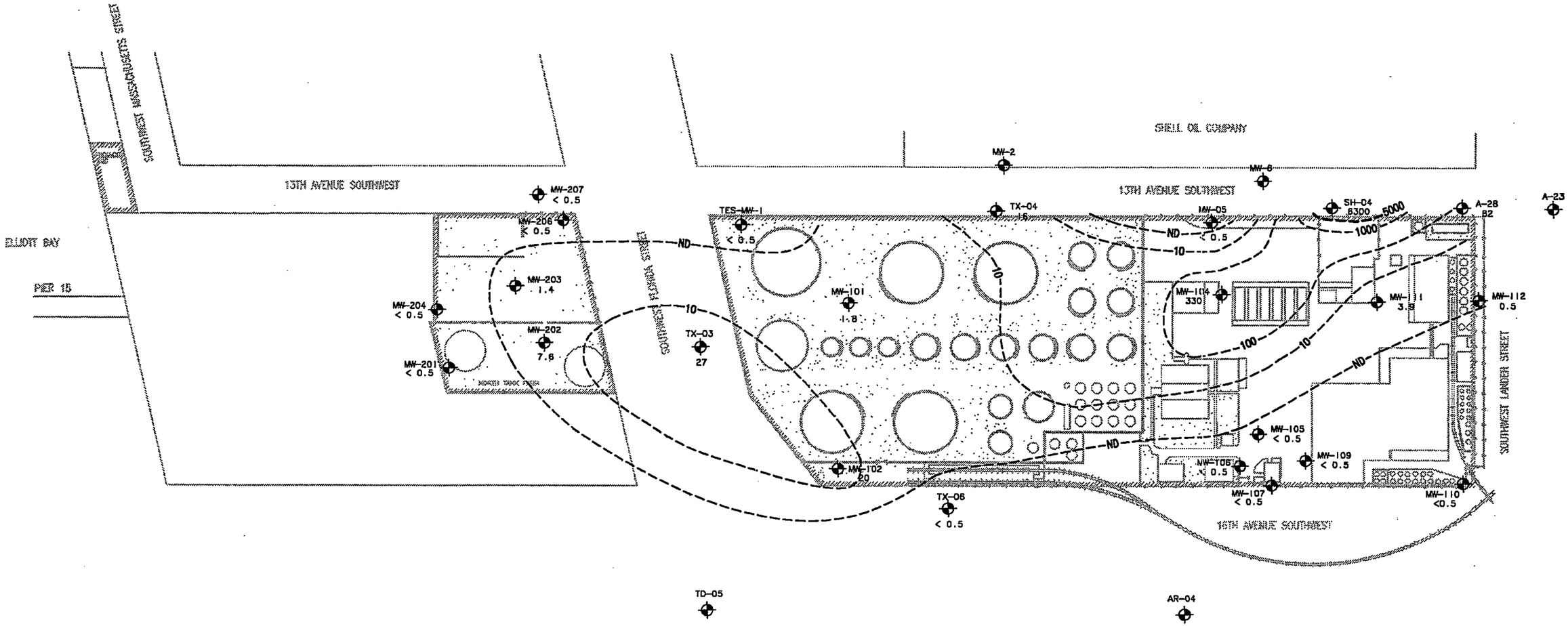
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOLUENE CONCENTRATIONS IN SHALLOW GROUNDWATER JUNE 1993

DRAWING NO 7-26

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\TOL02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- <0.5 — Toluene Concentration (ug/L)
- 5000 — Toluene Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

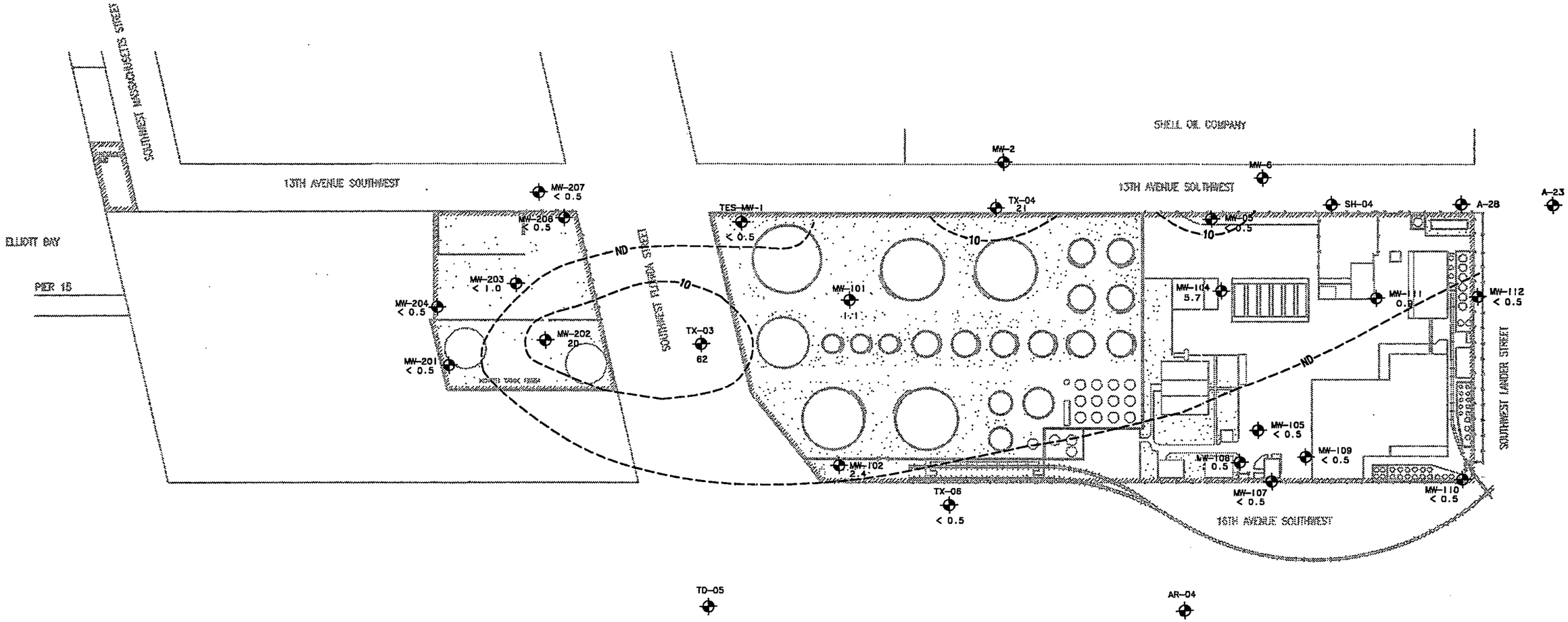
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOLUENE CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-27

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GSKEY\CHEM\MAPS\TOLQ3



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Toluene Concentration (ug/L)
- 5000 — Toluene Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

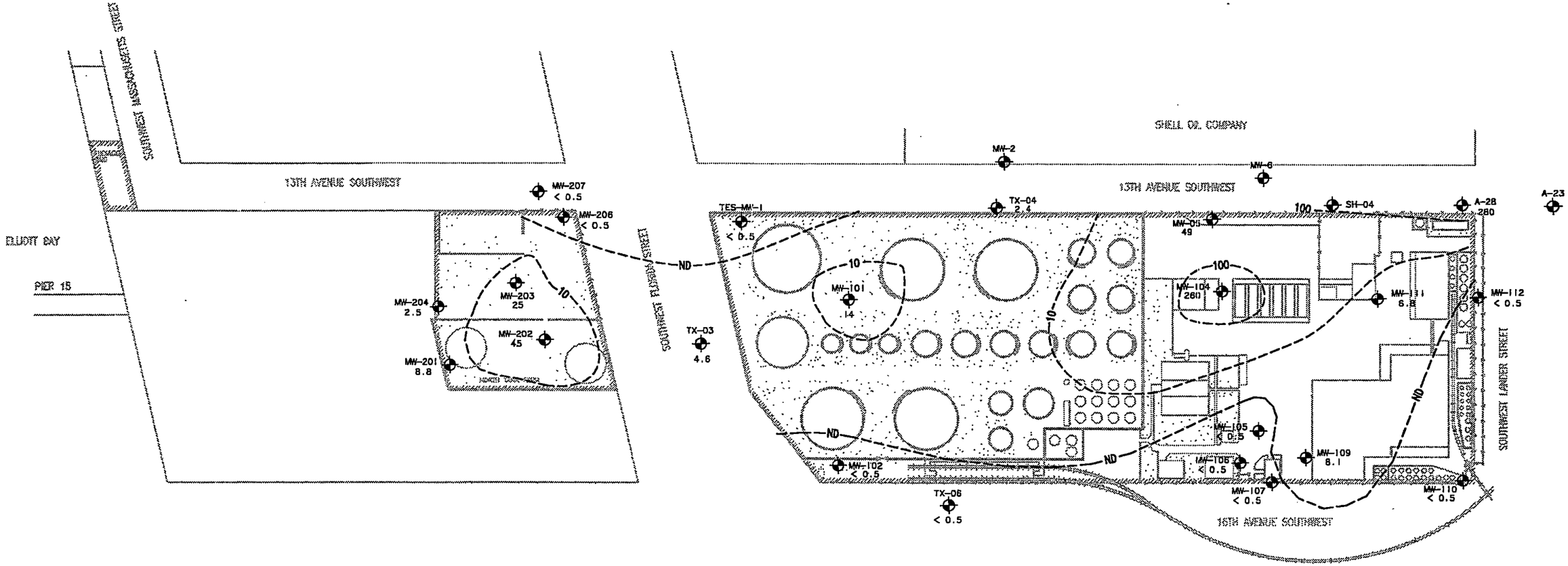
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOLUENE CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-28

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\TOL04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (ug/L)
- 430 — Ethylbenzene Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY DES BY		CHK BY APP BY		

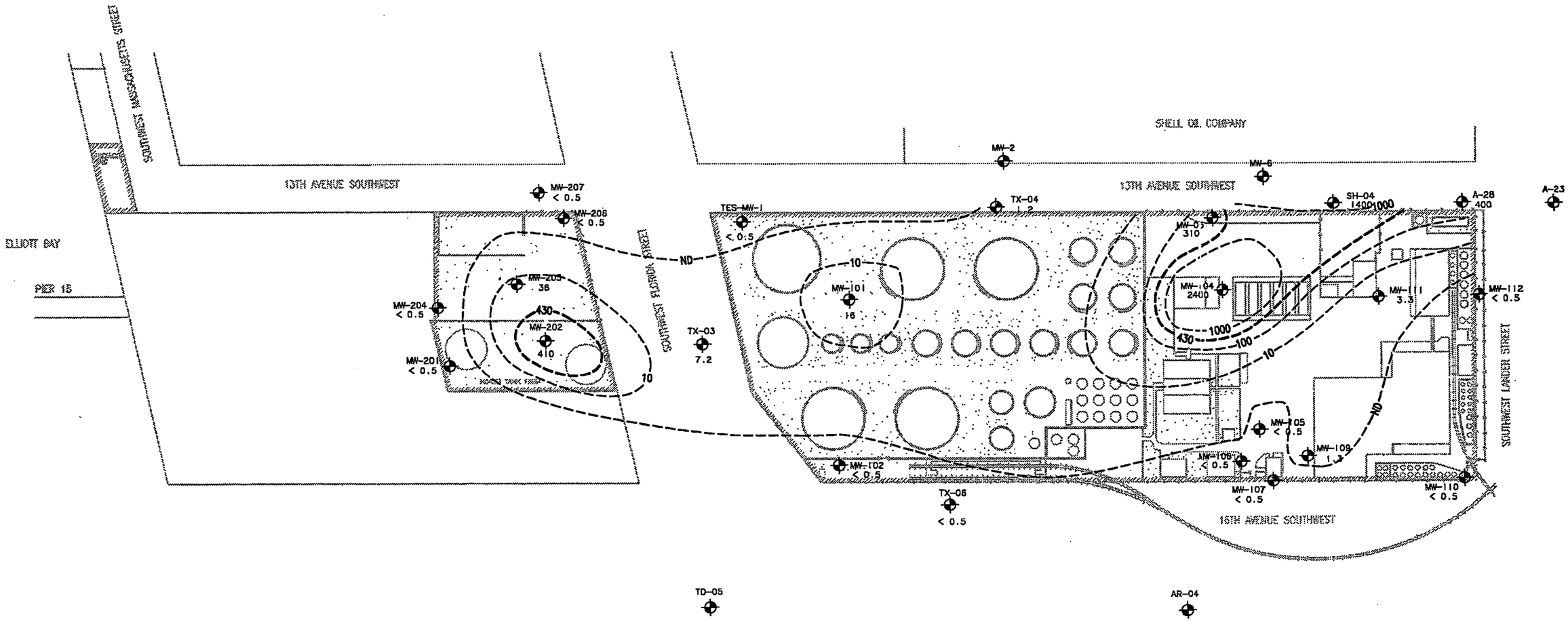
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ETHYLBENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER
APRIL 1993

DRAWING NO
7-29
PROJECT NO
0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\ETHG1



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (ug/L)
- 430 — Ethylbenzene Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

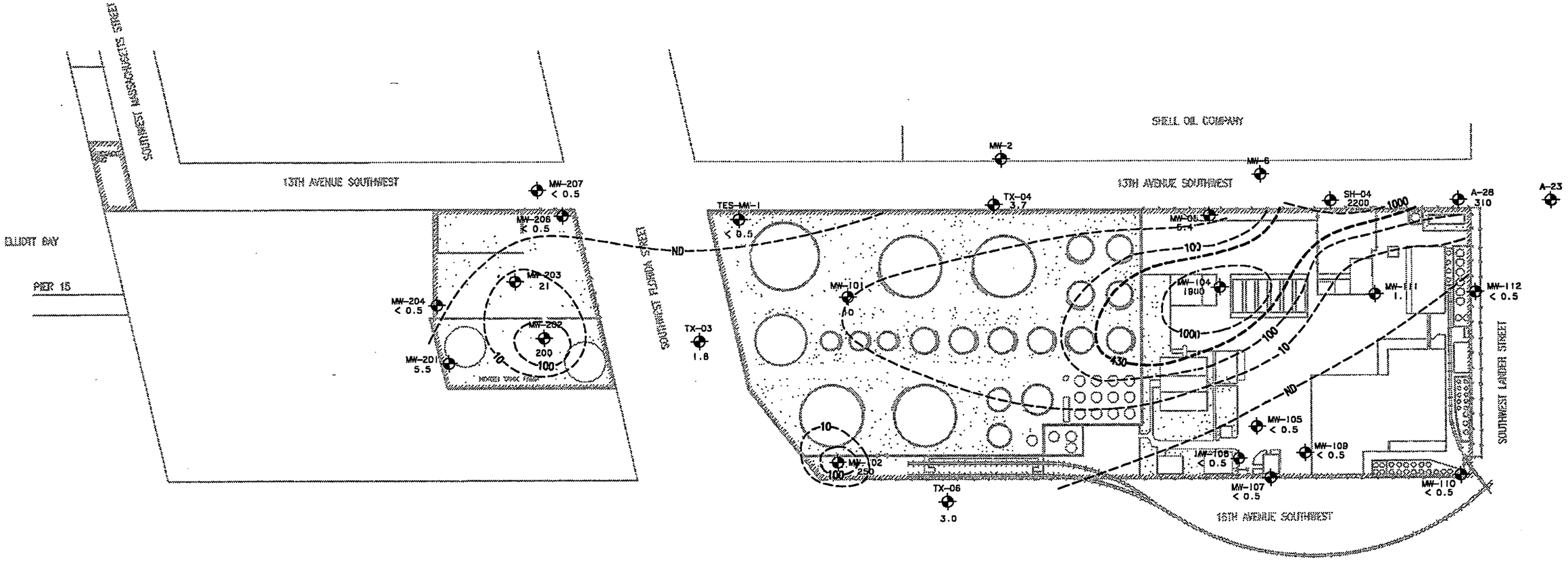
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ETHYLBENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-30

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GSKEY\CHEM\MAPS\ETH02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (ug/L)
- 430 — Ethylbenzene Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY / DES BY	CHK BY / APP BY			

EMCON Northwest, Inc.

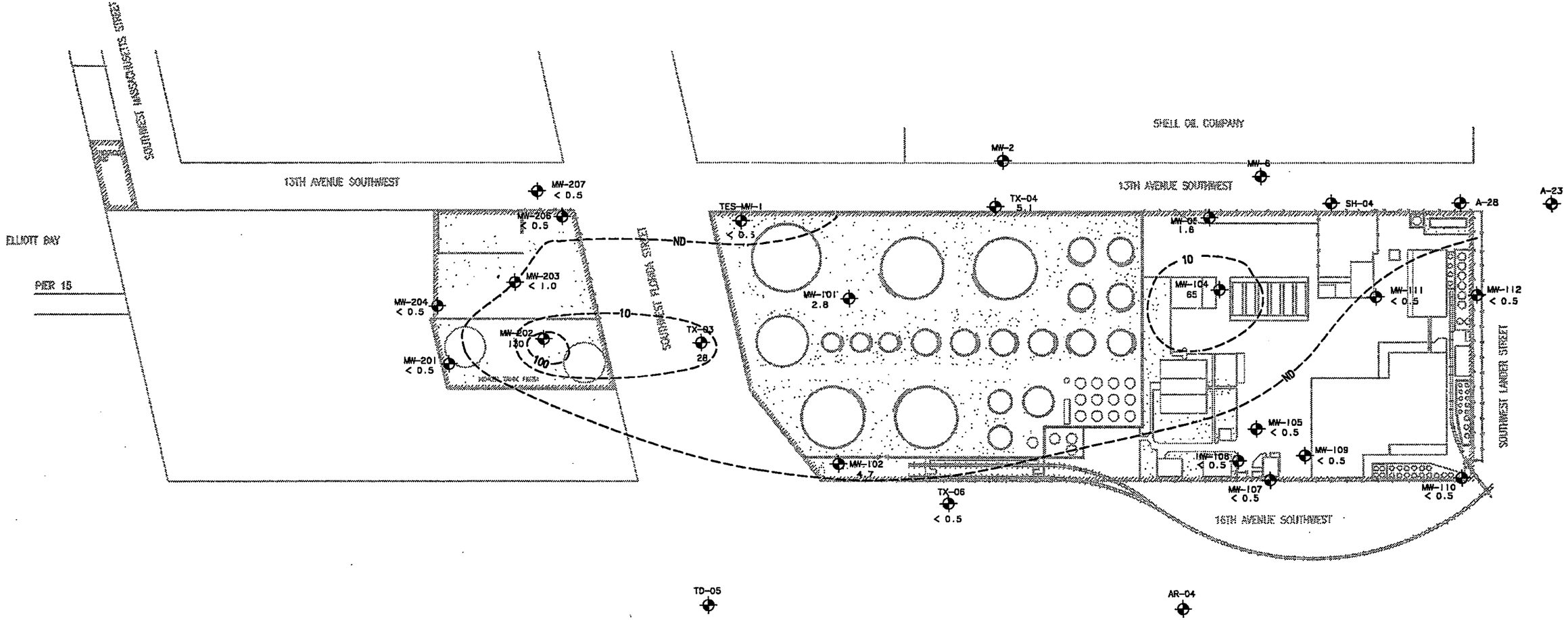
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ETHYLBENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-31

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\ETHQ3



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Ethylbenzene Concentration (ug/L)
- 430 — Ethylbenzene Concentration Contour

N

0 100 200

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY / DES BY	CHK BY / APP BY			

EMCON Northwest, Inc.

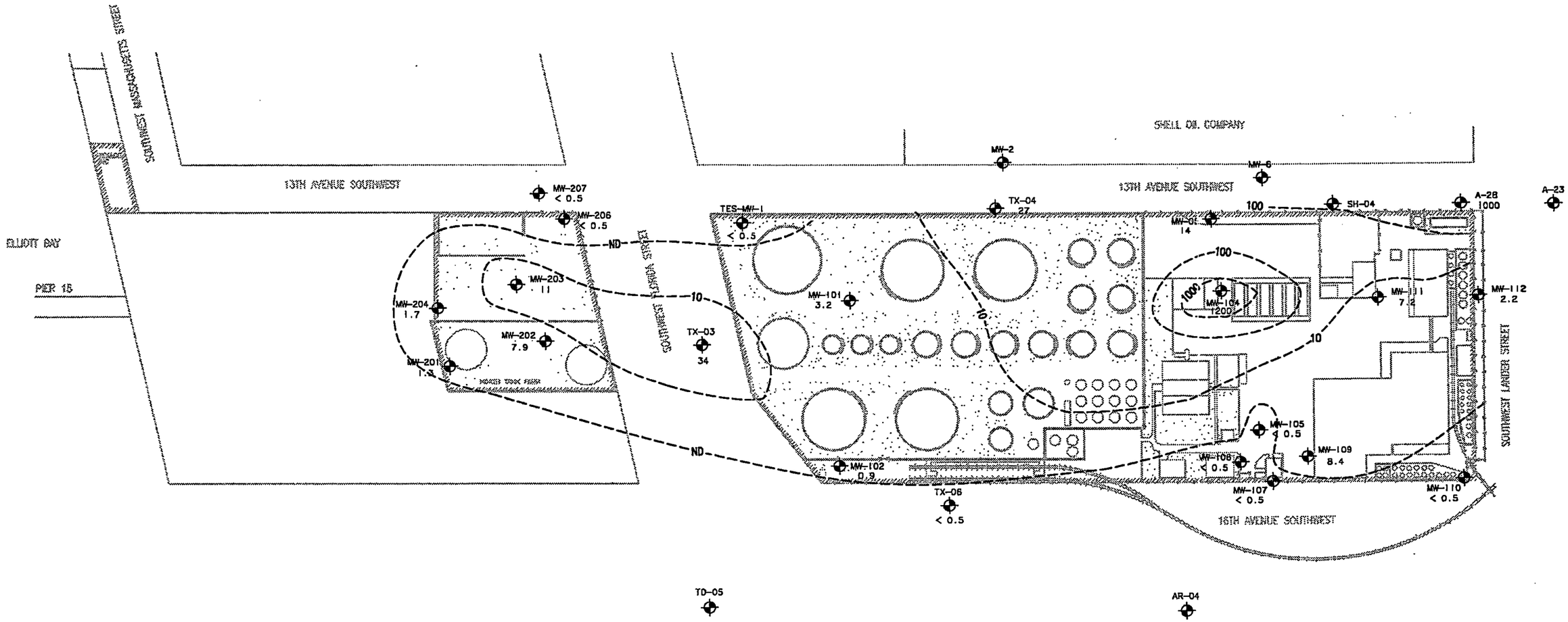
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

ETHYLBENZENE CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-32

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 G:\0750109\GISKEY\CHEM\MAPS\ETH04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (ug/L)
- 10 — Total Xylenes Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE _____ DRN BY _____ DES BY _____ CHK BY _____ APP BY _____

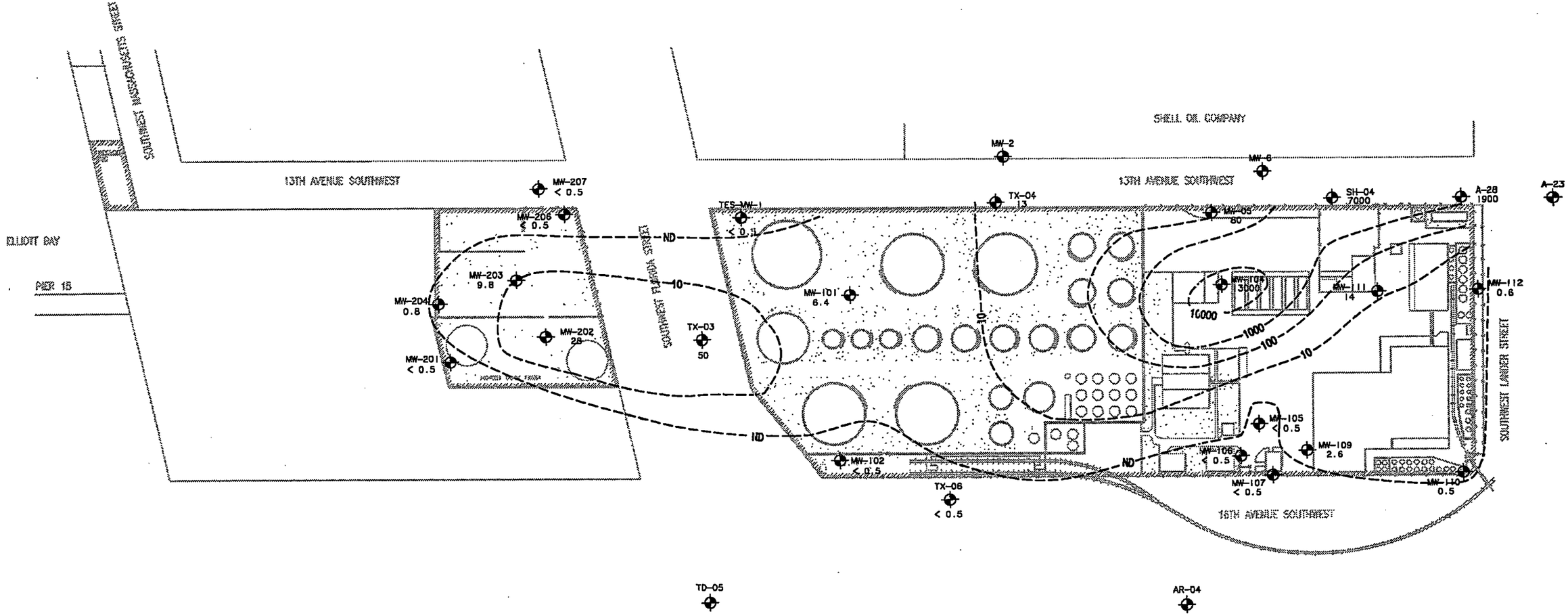
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOTAL XYLENES CONCENTRATIONS IN SHALLOW GROUNDWATER
APRIL 1993

DRAWING NO 7-33
PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\XYL01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (ug/L)
- 10 — Total Xylenes Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	CCS BY	CHK BY	APP BY
	DATE OF ISSUE		DRN BY		CHK BY	
			CCS BY		APP BY	

EMCON Northwest, Inc.

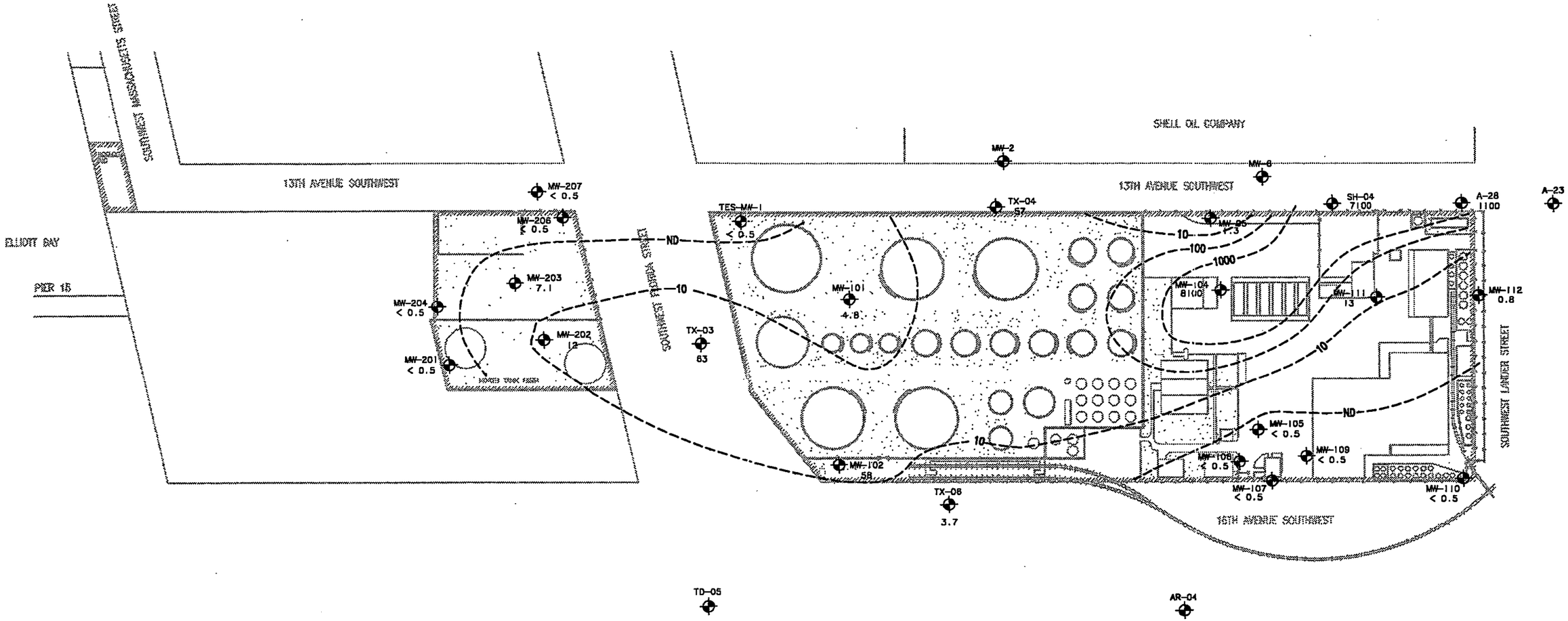
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOTAL XYLENES CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO **7-34**

PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 C:\0750109\GSKEY\CHEM\MAPS\XYL02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (ug/L)
- 10 — Total Xylenes Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY: DES BY:	CHK BY: APP BY:			

EMCON Northwest, Inc.

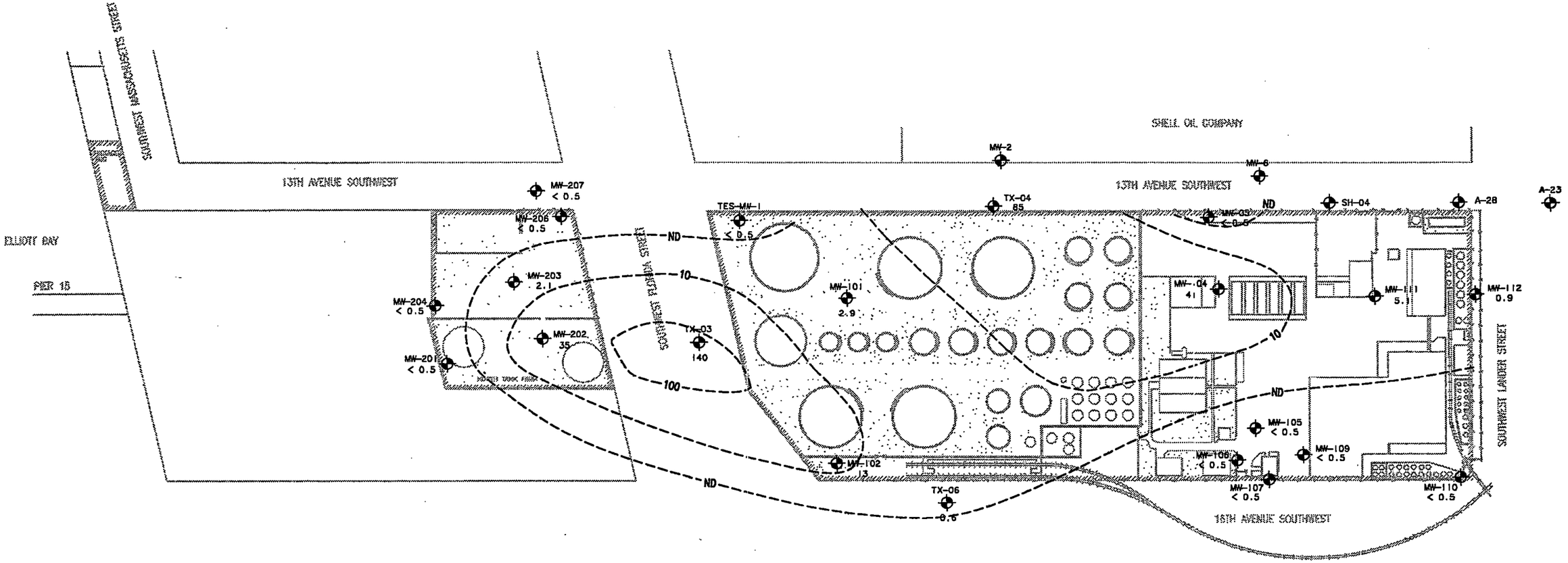
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOTAL XYLENES CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-35

PROJECT NO 0750-001.09

SCALE: 1=200 10-14-94 G:\0750109\GISKEY\CHEM\MAPS\XYL93



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — Total Xylenes Concentration (ug/L)
- 10 — Total Xylenes Concentration Contour

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
BASE OF ISSUE		DRN BY ____ DES BY ____		CHK BY ____ APP BY ____		

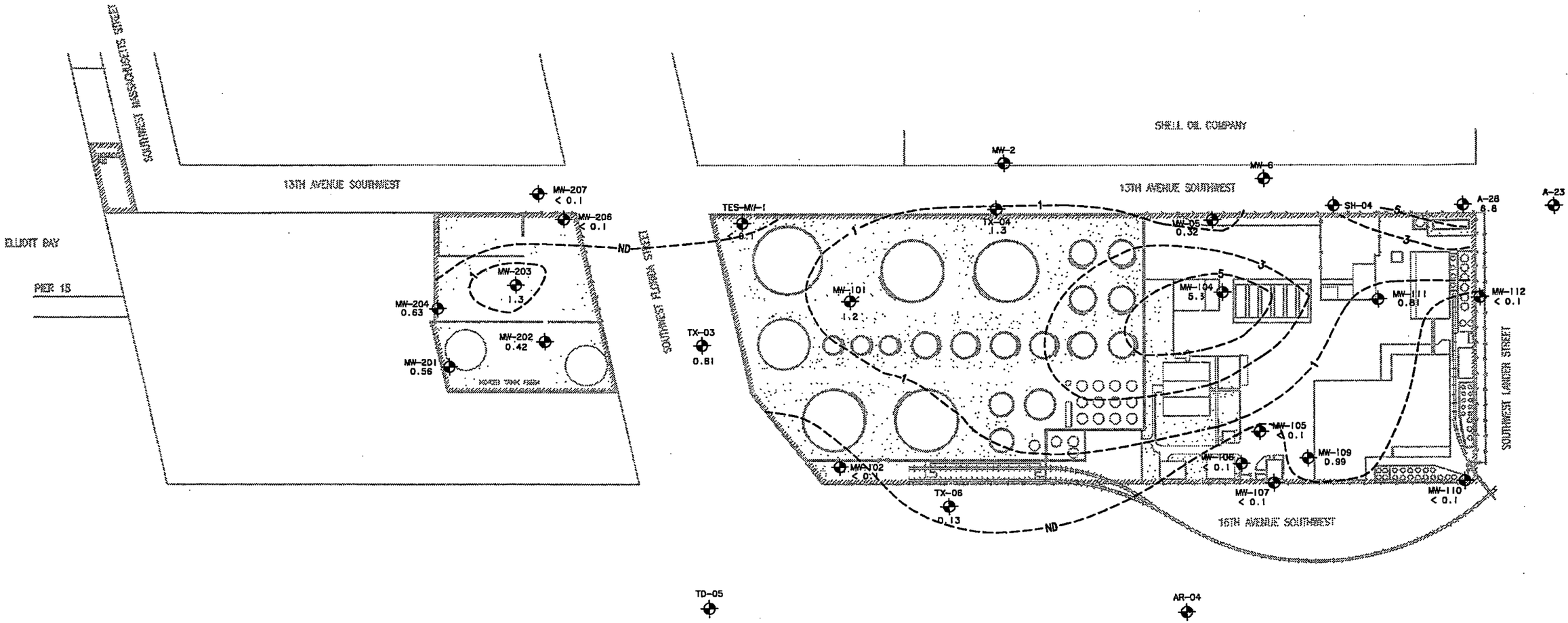
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TOTAL XYLENES CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-36
PROJECT NO 0750-001.09

SCALE:1=200 10-14-94 G:\0750109\GISKEY\CHEM\MAPS\XYL04



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/L)
- 1 — TPH-G Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE ____ DRN BY ____ DES BY ____ CHK BY ____ APP BY ____

EMCON Northwest, Inc.

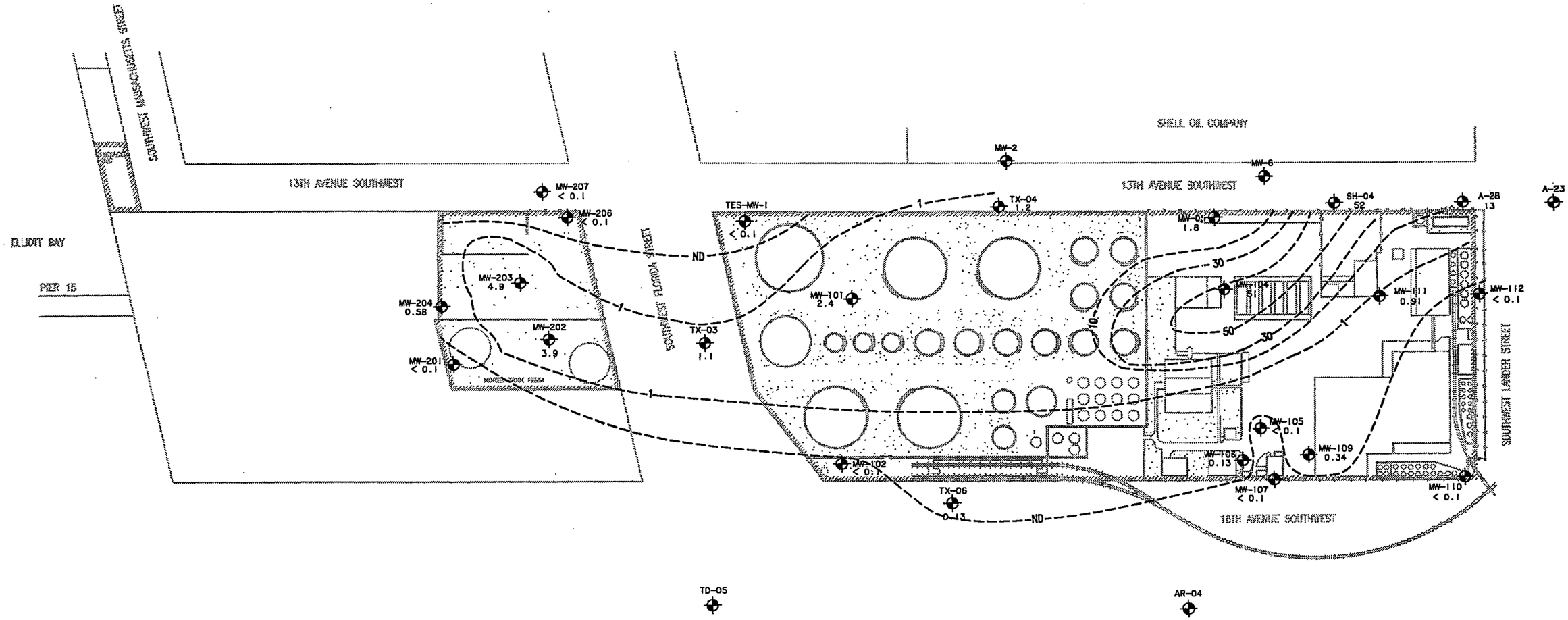
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-G CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO 7-37

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\DISKEY\CHEM\MAPS\GAS01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/L)
- 1 — TPH-G Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE _____ DRN BY _____ DES BY _____ CHK BY _____ APP BY _____

EMCON Northwest, Inc.

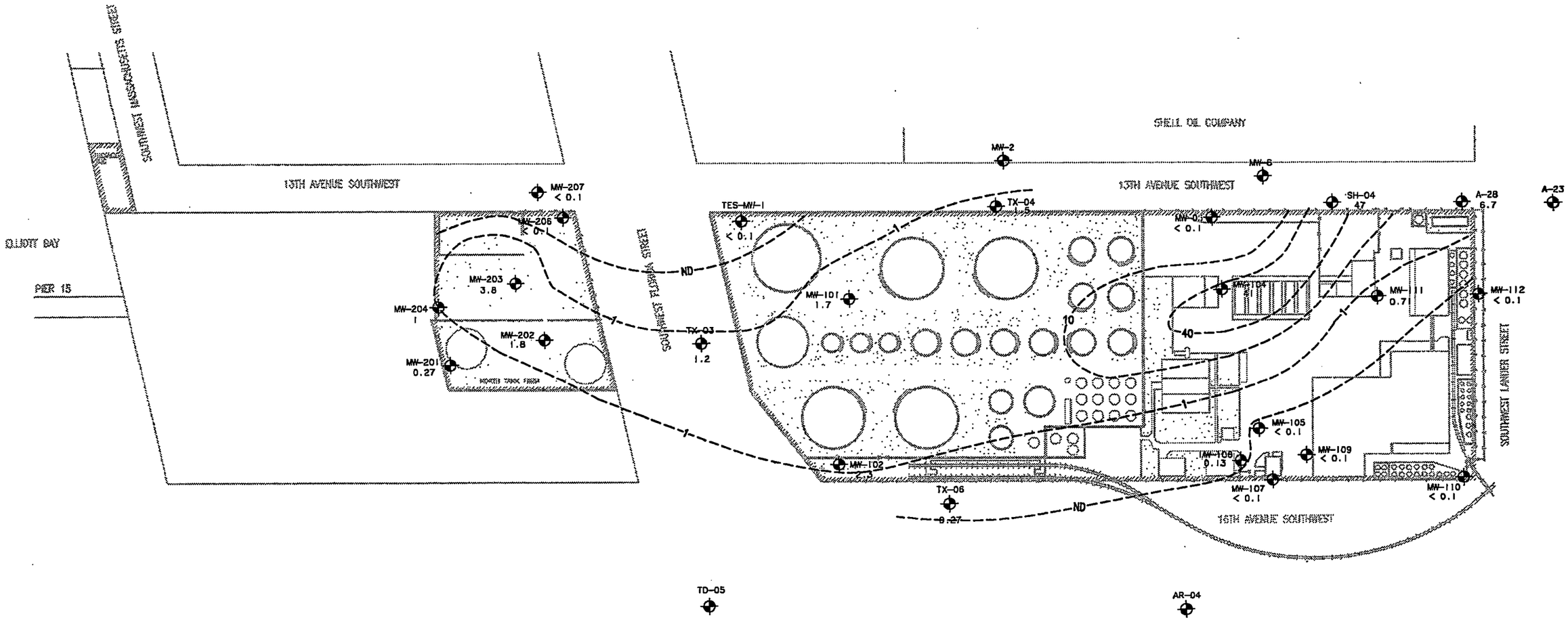
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-G CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-38

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GSKEY\CHEM\MAPS\GAS02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/L)
- 1 — TPH-G Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY / DES BY	CHK BY / APP BY			

EMCON Northwest, Inc.

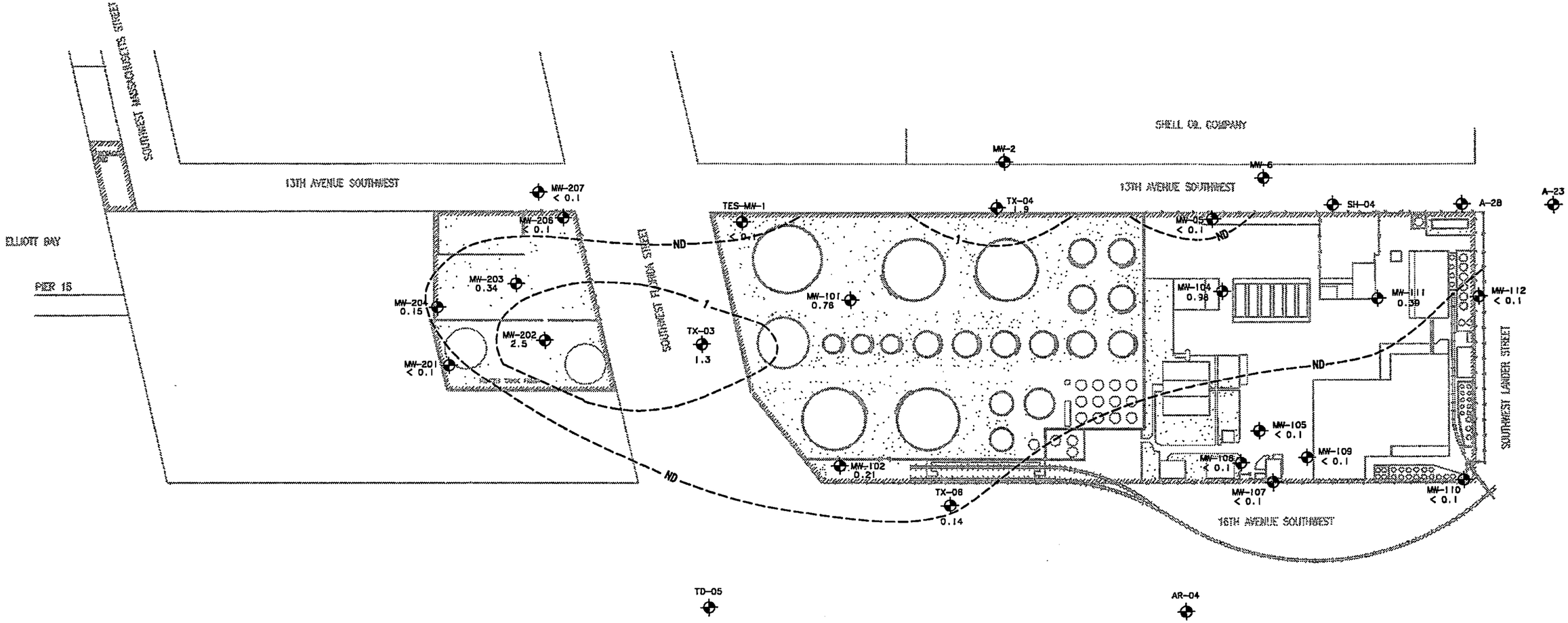
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-G CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-39

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\GAS03



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-G Concentration (mg/L)
- 1 — TPH-G Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

EMCON Northwest, Inc.

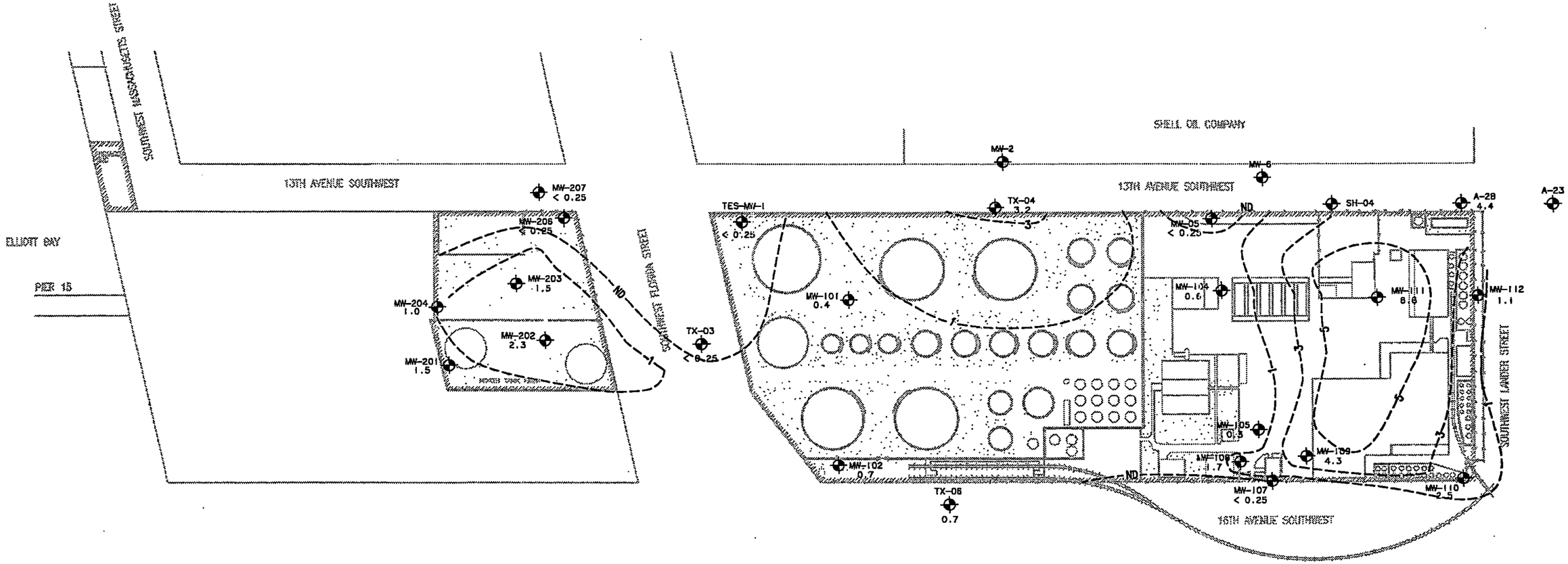
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-G CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-40

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 G:\0750109\GISKEY\CHEM\MAPS\GAS94



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-D Concentration (mg/L)
- 1 — TPH-D Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE		DRN BY	DES BY	CHK BY	APP BY

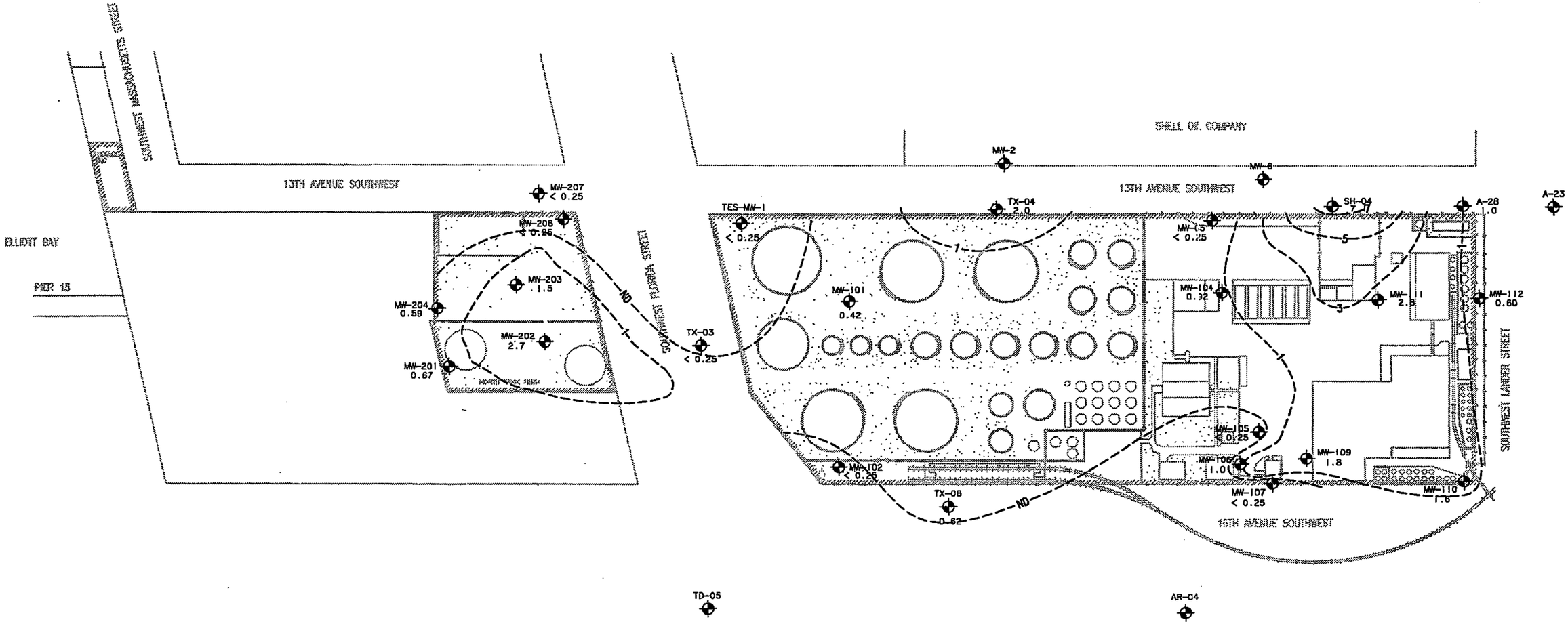
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-D CONCENTRATIONS IN SHALLOW GROUNDWATER
APRIL 1993

DRAWING NO **7-41**
PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\SISKEY\CHEM\MAPS\TPHD01



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-D Concentration (mg/L)
- 1 — TPH-D Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE _____ DRN BY _____ DES BY _____ CHK BY _____ APP BY _____

EMCON Northwest, Inc.

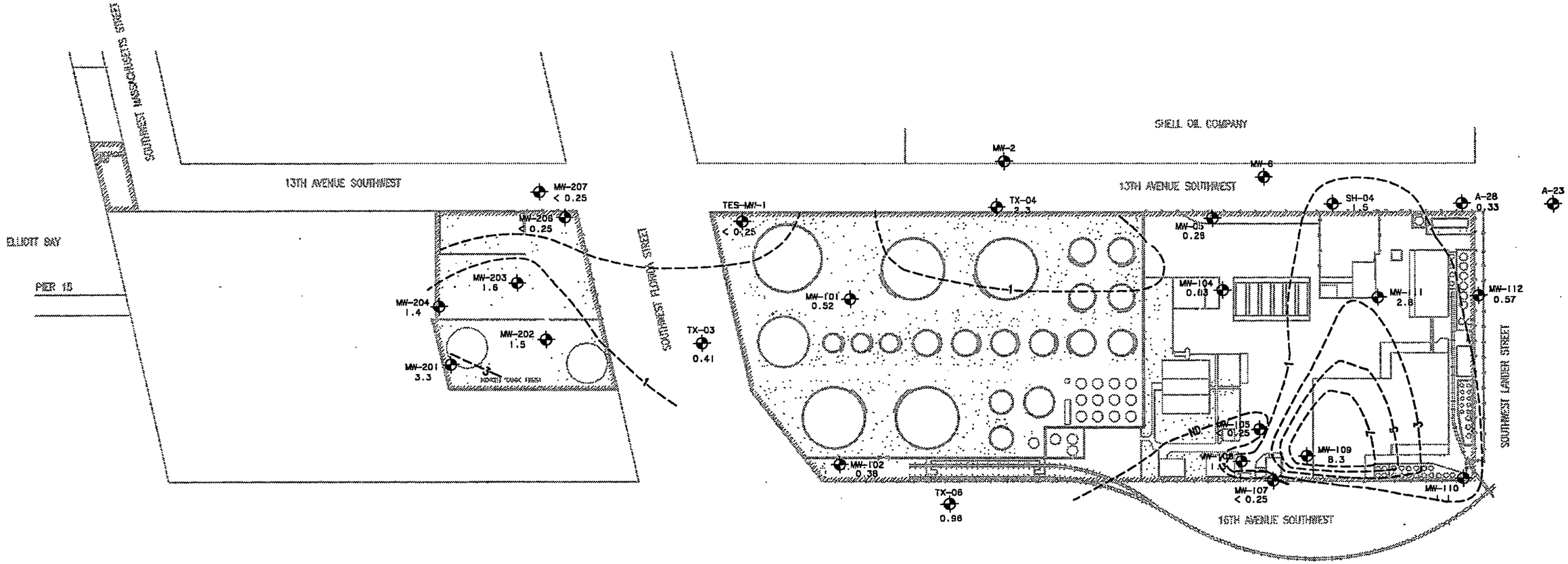
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-D CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO 7-42

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 G:\0750109\GISKEY\CHEM\MAPS\TPHD02



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-D Concentration (mg/L)
- TPH-D Concentration Contour

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
	DATE OF ISSUE	DRN BY: DES BY:	CHK BY: APP BY:			

EMCON Northwest, Inc.

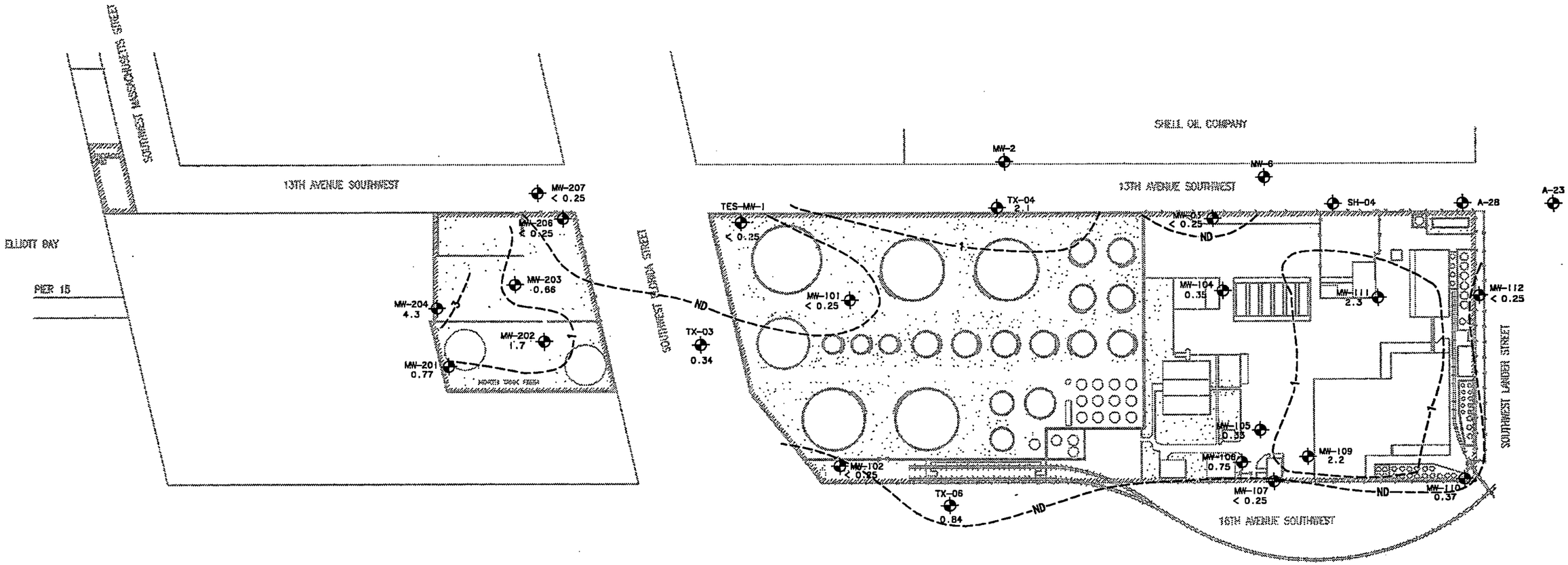
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-D CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-43

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 C:\0750109\GISKEY\CHEM\MAPS\TPHD93



REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE _____ DRN BY _____ DES BY _____ CHK BY _____ APP BY _____

EMCON Northwest, Inc.

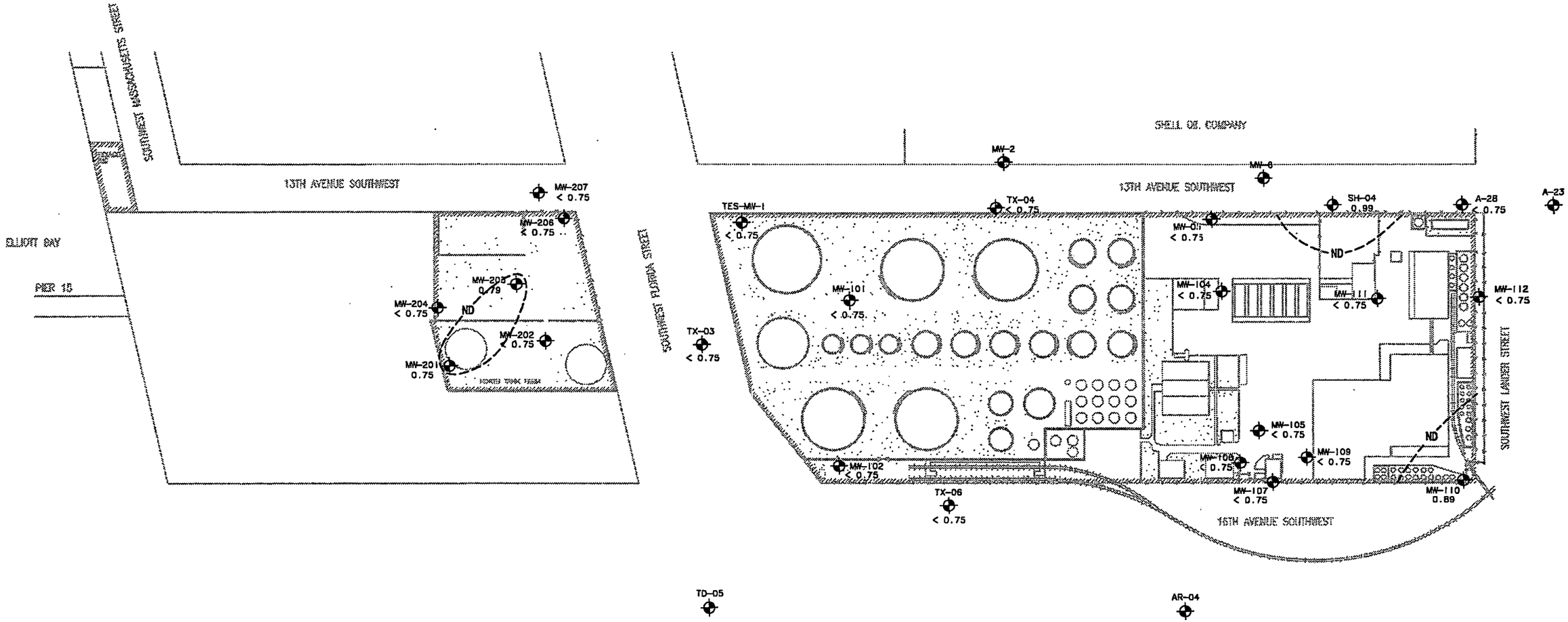
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-D CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO **7-44**

PROJECT NO 0750-001.09

SCALE:1=200 10-25-94 G:\0750109\BISKEY\CHEM\MAPS\TPHD94



LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/L)
- 1 — TPH-O Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY ____ DES BY ____	CHK BY ____ APP BY ____			

EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-O CONCENTRATIONS IN SHALLOW GROUNDWATER
JUNE 1993

DRAWING NO **7-46**
PROJECT NO 0750-001.09

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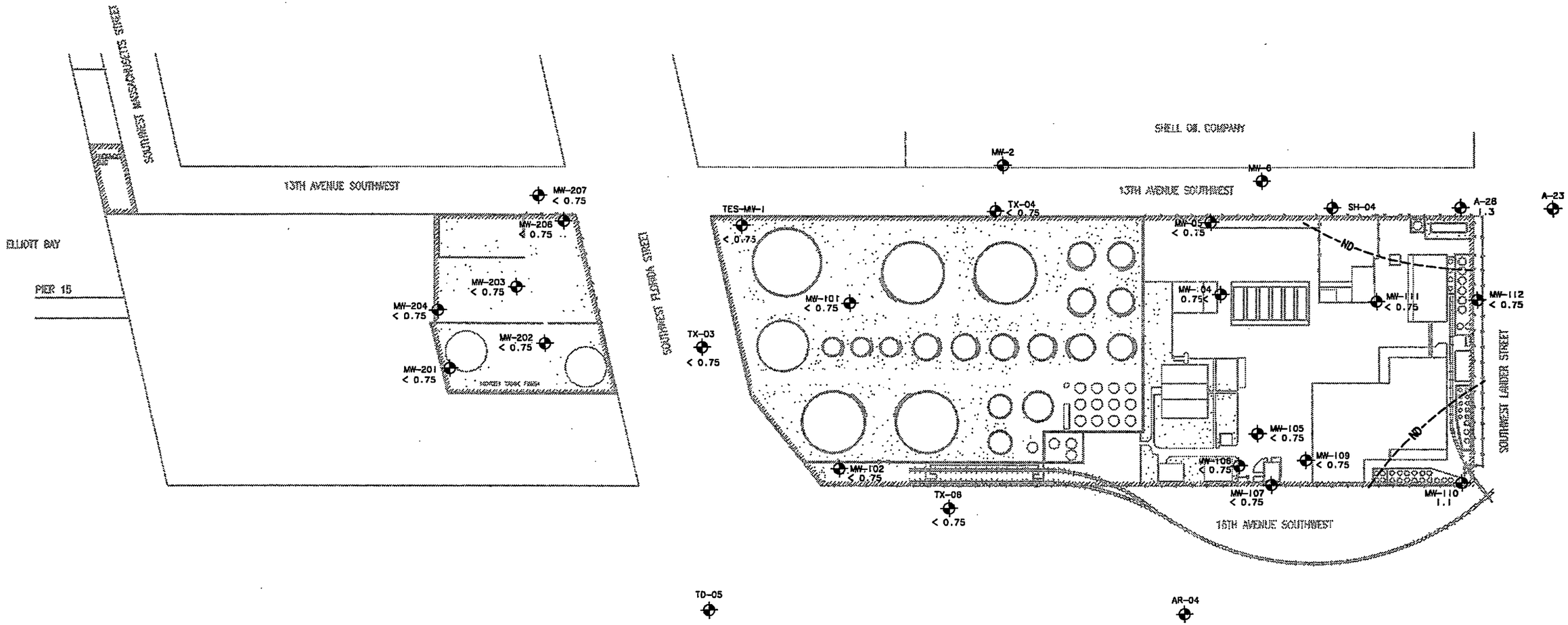

LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/L)
- 1 — TPH-O Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY		CHK BY		
		DES BY		APP BY		

EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-O CONCENTRATIONS IN SHALLOW GROUNDWATER APRIL 1993

DRAWING NO 7-45

PROJECT NO 0750-001.09

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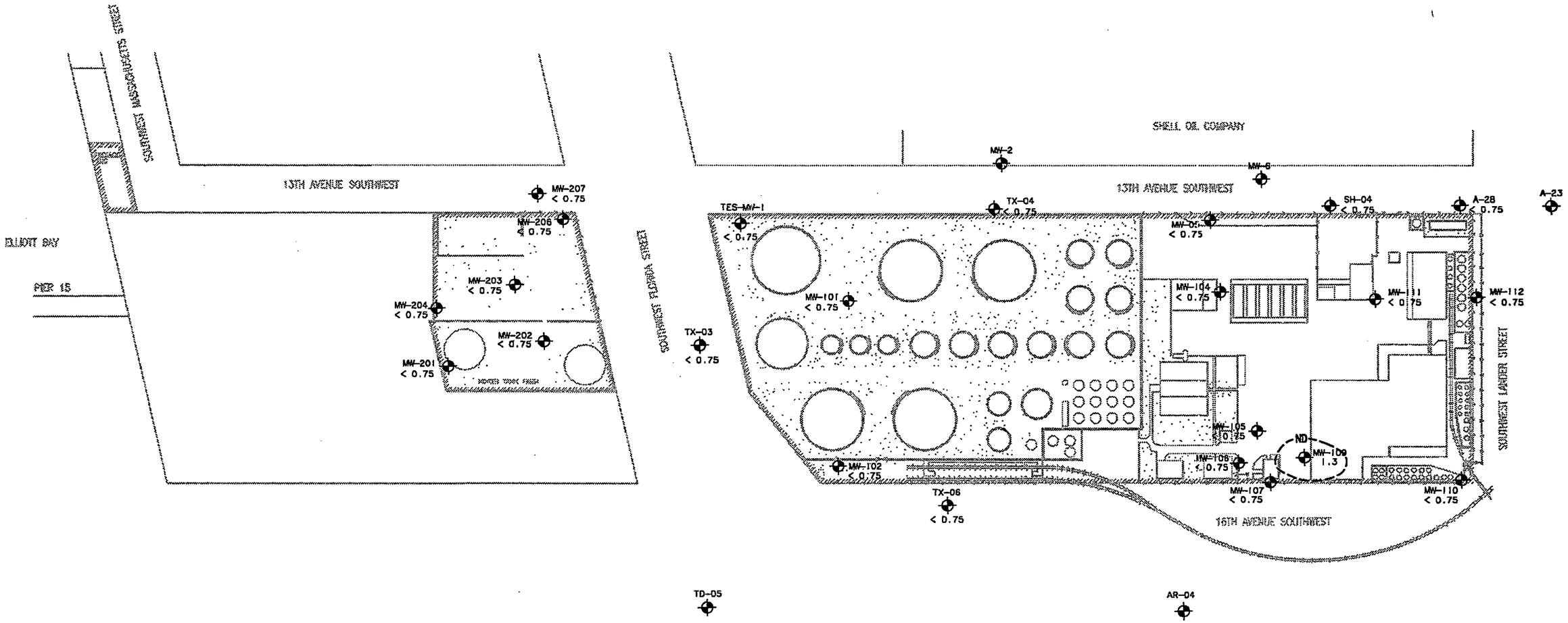

LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/L)
- TPH-O Concentration Contour

N

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE			DRN BY	DES BY	CHK BY	APP BY

Emcon Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-O CONCENTRATIONS IN SHALLOW GROUNDWATER SEPTEMBER 1993

DRAWING NO 7-47

PROJECT NO 0750-001.09

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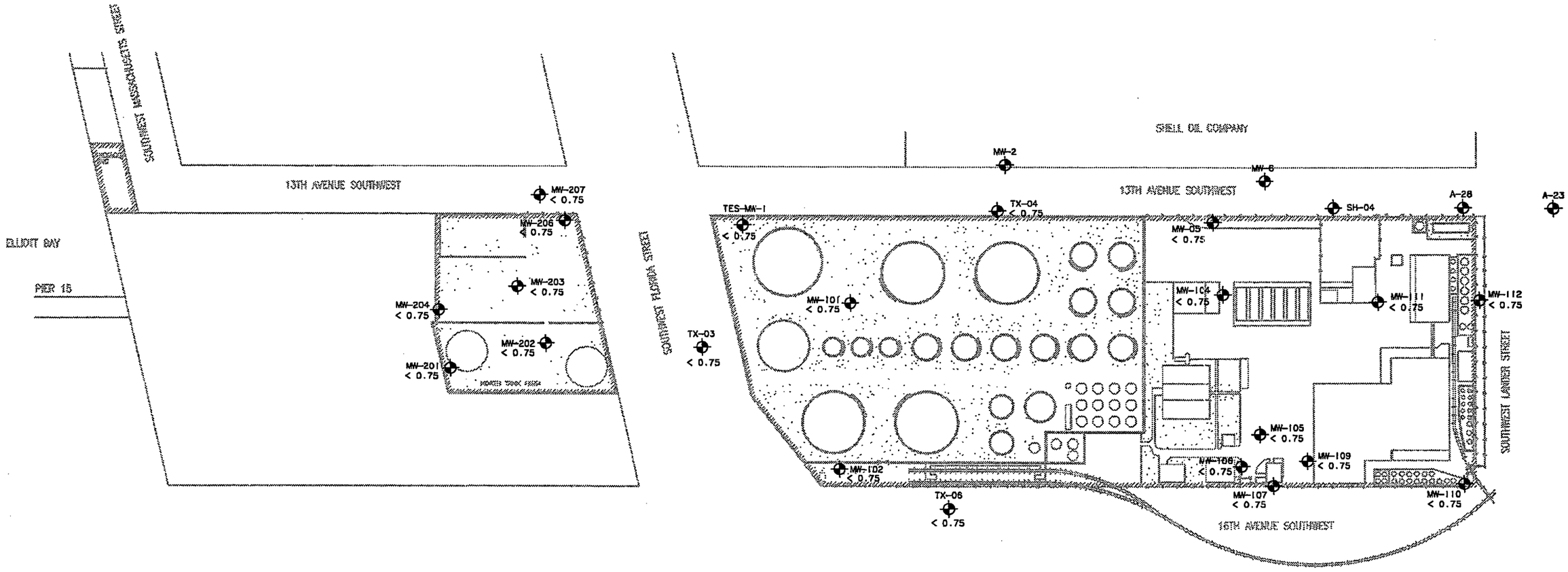

LEGEND

- Tank
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- < 0.5 — TPH-O Concentration (mg/L)
- 1 — TPH-O Concentration Contour

0 200 400

SCALE (ft)

REV	DATE	DESCRIPTION	DRN BY	DES BY	CHK BY	APP BY
DATE OF ISSUE		DRN BY			CHK BY	
		DES BY			APP BY	

EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

TPH-O CONCENTRATIONS IN SHALLOW GROUNDWATER DECEMBER 1993

DRAWING NO 7-48

PROJECT NO 0750-001.09

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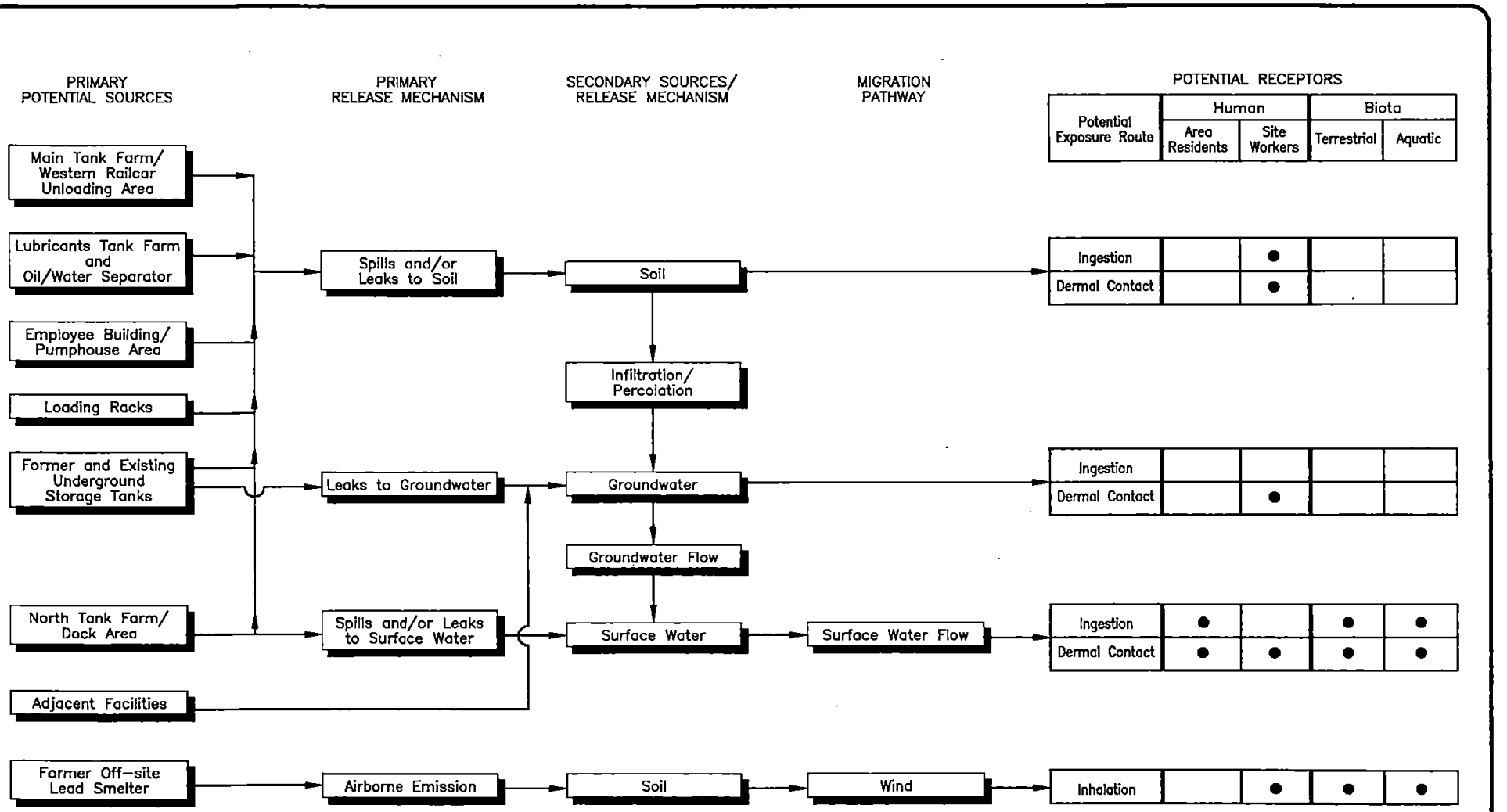

EMCON Northwest, Inc.

DATE 3/94
DWN. EJB
REV.
APPR.
PROJECT NO. 0750-001.09

Figure 8-1
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON
CONCEPTUAL SITE MODEL

1=1 03-28-94 G:\DWG\0750\001\09C09

LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, nor the use of segregated portions of this report.

The purpose of a geologic/hydrogeologic study is to reasonably characterize existing site conditions based on the geology/hydrogeology of the area. In performing such a study, it is understood that a balance must be struck between a reasonable inquiry into the site conditions and an exhaustive analysis of each conceivable environmental characteristic. The following paragraphs discuss the assumptions and parameters under which such an opinion is rendered.

No investigation is thorough enough to describe all geologic/ hydrogeologic conditions of interest at a given site. If conditions have not been identified during the study, such a finding should not therefore be construed as a guarantee of the absence of such conditions at the site, but rather as the result of the services performed within the scope, limitations, and cost of the work performed.

We are unable to report on or accurately predict events that may change the site conditions after the described services are performed, whether occurring naturally or caused by external forces. We assume no responsibility for conditions we were not authorized to evaluate, or conditions not generally recognized as predictable when services were performed.

Geologic/hydrogeologic conditions may exist at the site that cannot be identified solely by visual observation. Where subsurface exploratory work was performed, our professional opinions are based in part on interpretation of data from discrete sampling locations that may not represent actual conditions at unsampled locations.

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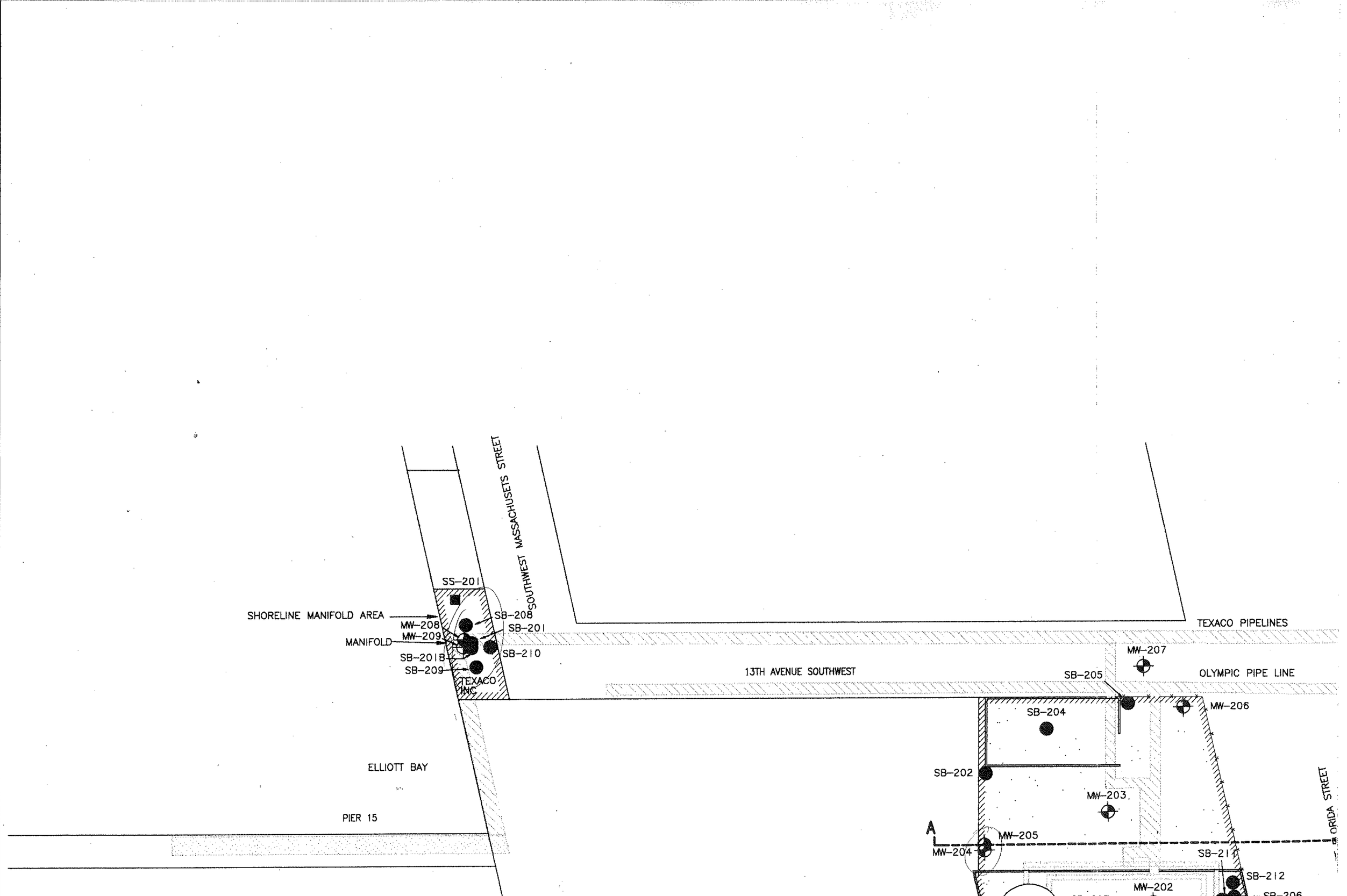
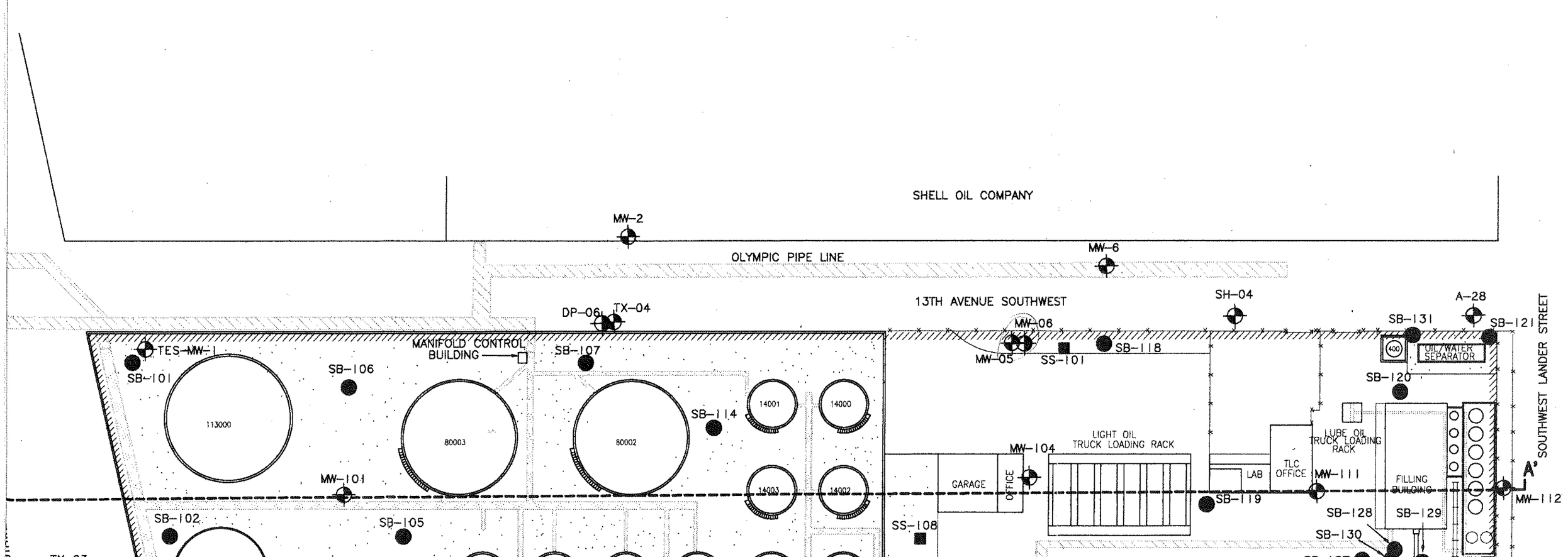
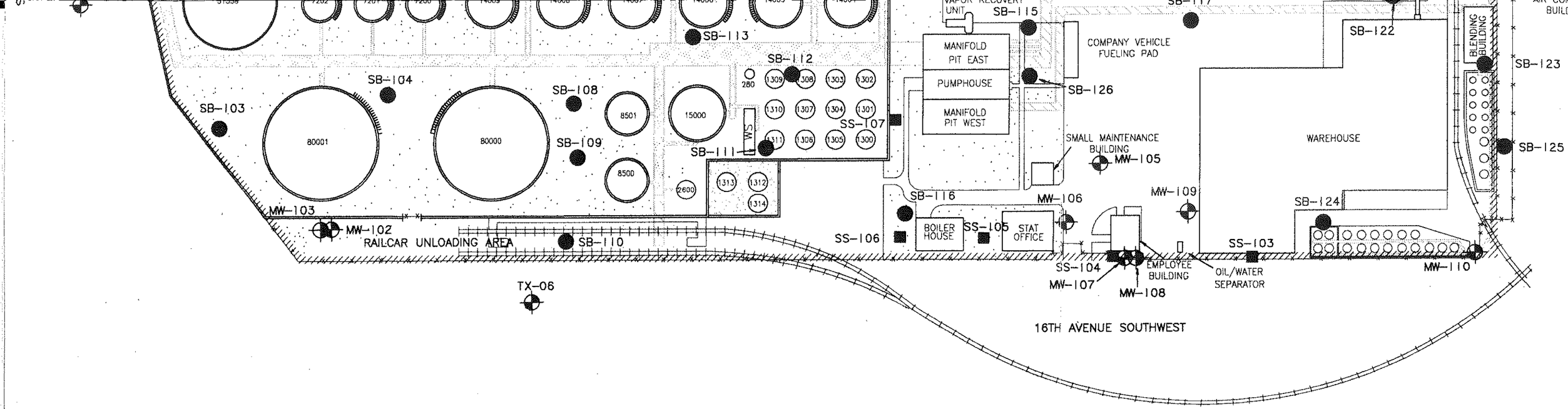

SOUTHWEST MASSACHUSETS STREET
SS-201
SHORELINE MANIFOLD AREA
MW-208
MW-209
MANIFOLD
SB-2018
SB-209
SB-208
SB-201
SB-210
TEXACO INC
TEXACO PIPELINES
13TH AVENUE SOUTHWEST
MW-207
SB-205
OLYMPIC PIPE LINE
MW-206
SB-204
ELLIOTT BAY
SB-202
MW-203
PIER 15
A
MW-205
MW-204
SB-21
SB-212
MW-202
ORIDA STREET


SHELL OIL COMPANY
MW-2
OLYMPIC PIPE LINE
MW-6
13TH AVENUE SOUTHWEST
SH-04
A-28
SB-131
SB-121
SOUTHWEST LANDER STREET
DP-06
TX-04
MW-06
SB-118
MW-05
SS-101
OIL/WATER SEPARATOR
SB-120
TES-MW-1
SB-101
MANIFOLD CONTROL BUILDING
SB-107
SB-106
113000
80003
80002
SB-114
14001
14000
14003
14002
LIGHT OIL TRUCK LOADING RACK
MW-104
GARAGE
OFFICE
LAB
TLC OFFICE
LUBE OIL TRUCK LOADING RACK
MW-111
FILLING BUILDING
A'
MW-112
MW-101
SB-119
SB-102
SB-105
SS-108
SB-128
SB-129
SB-130



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0 100 200

SCALE (ft)

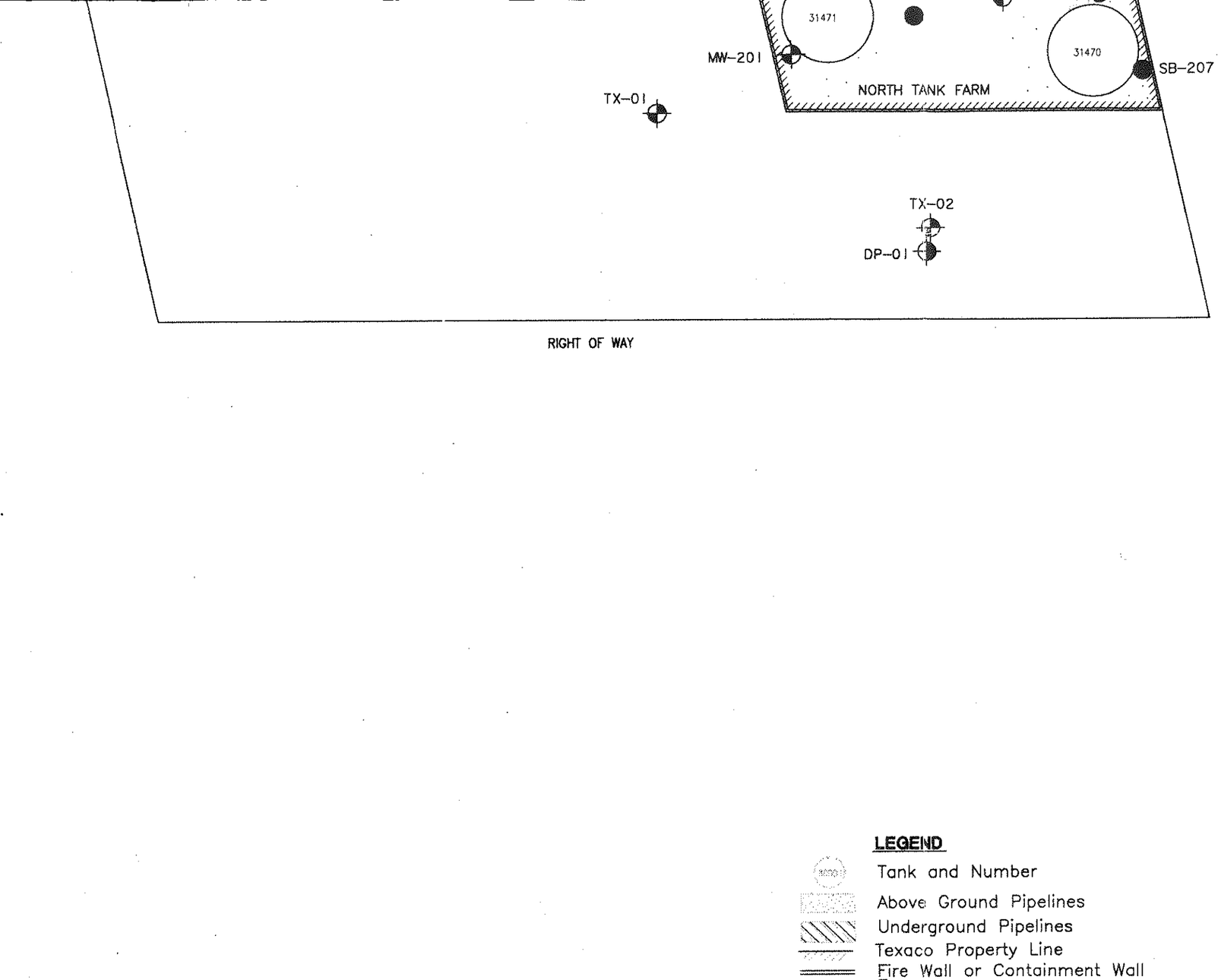
Of floating Product

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

EMCON Northwest, Inc.

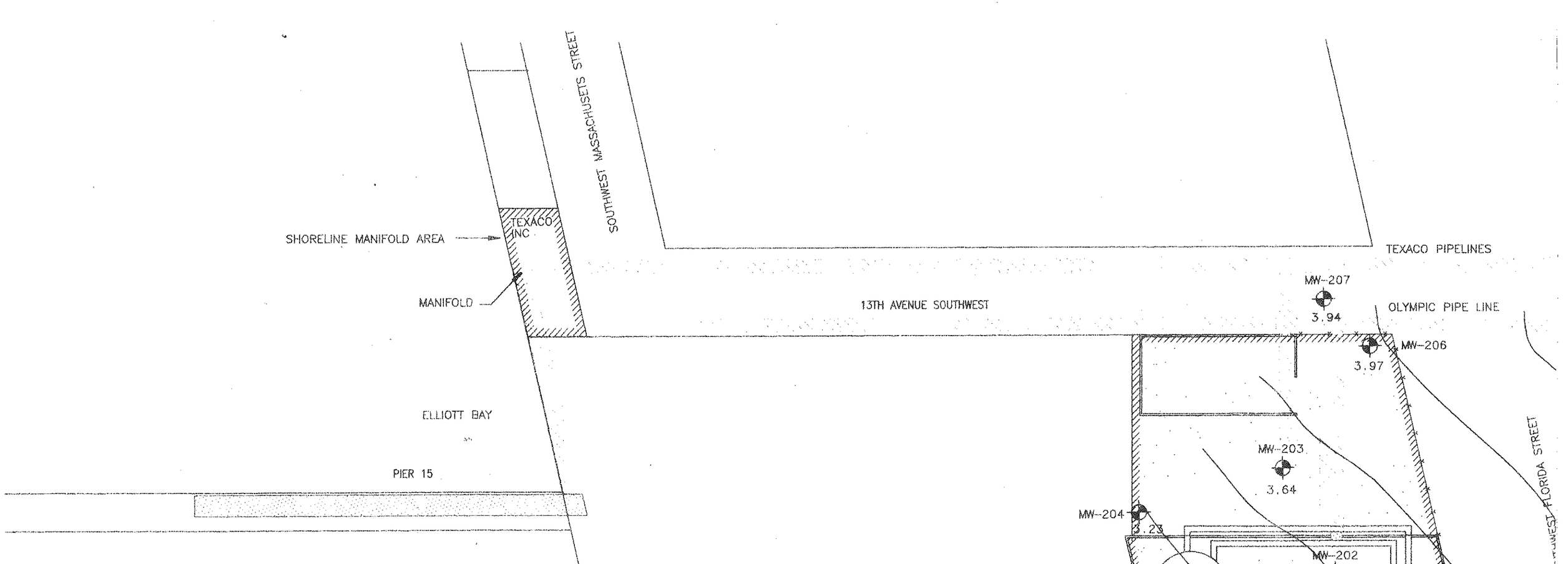
TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

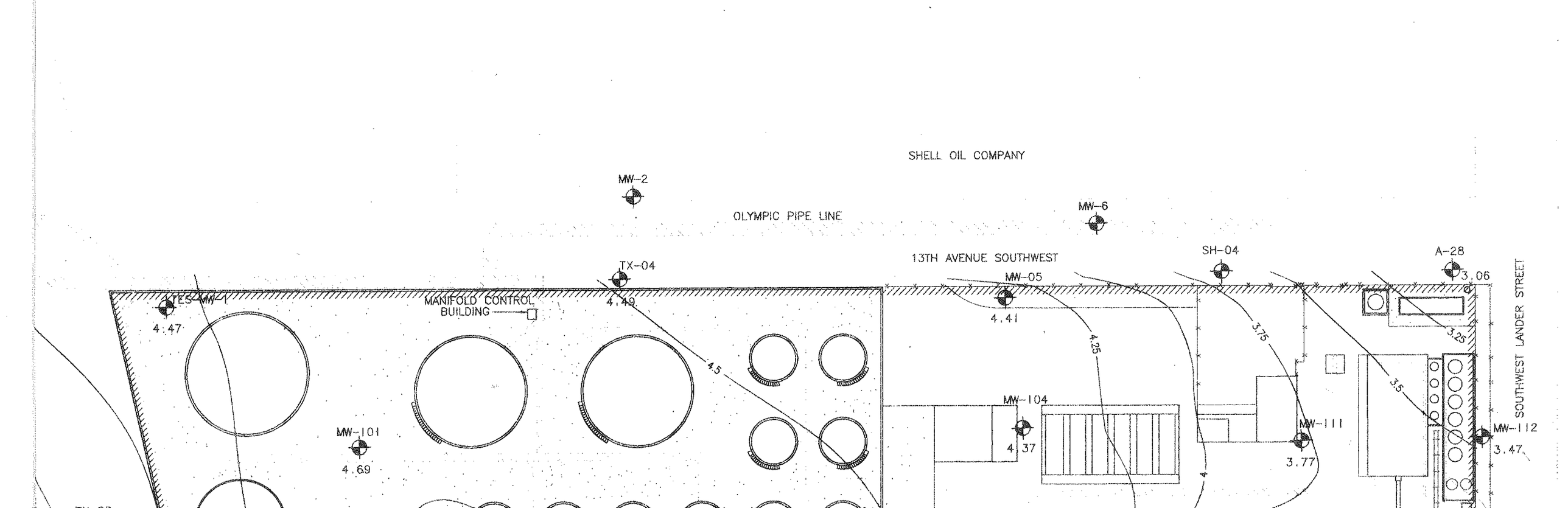
RI SAMPLING LOCATIONS

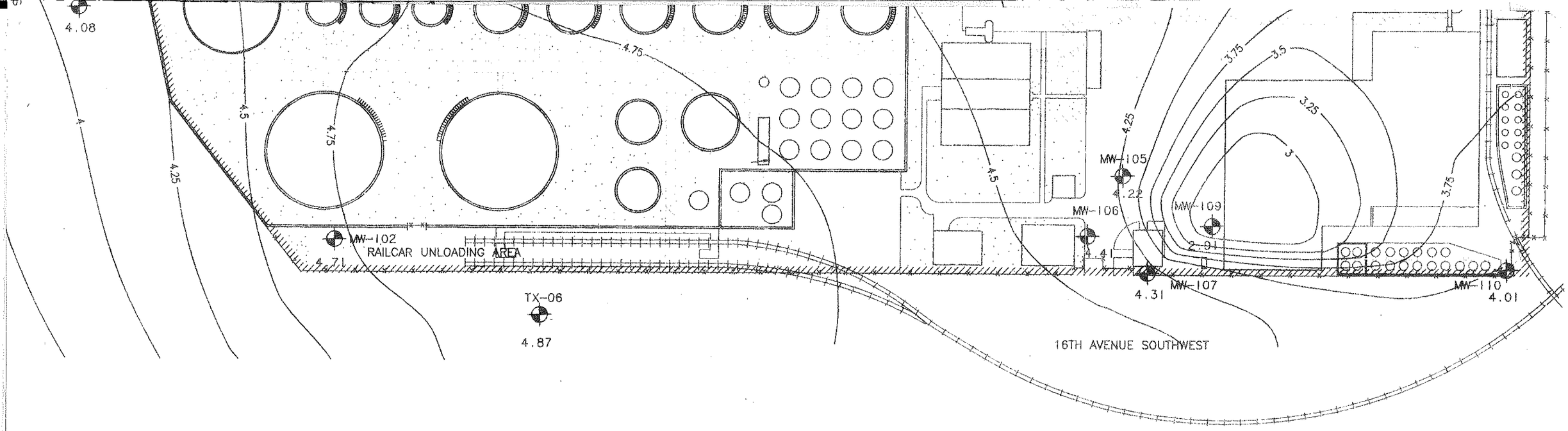


LEGEND

- Tank and Number
- Above Ground Pipelines
- Underground Pipelines
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- SS-108 Surface Soil Sampling Location
- SB-101 Soil Boring or Hand Auger
- MW-205 Monitoring Well (Deep)
- MW-204 Monitoring Well (Shallow)
- A A' Cross Section Location


SOUTHWEST MASSACHUSETS STREET
TEXACO INC
SHORELINE MANIFOLD AREA
MANIFOLD
13TH AVENUE SOUTHWEST
TEXACO PIPELINES
OLYMPIC PIPE LINE
MW-207
3.94
MW-206
3.97
MW-203
3.64
MW-204
3.23
MW-202
ELLIOTT BAY
PIER 15
SOUTHWEST FLORIDA STREET


SHELL OIL COMPANY
MW-2
OLYMPIC PIPE LINE
MW-6
13TH AVENUE SOUTHWEST
TX-04
4.49
MW-05
4.41
SH-04
A-28
3.06
SOUTHWEST LANDER STREET
TES-MW-1
4.47
MANIFOLD CONTROL BUILDING
MW-101
4.69
MW-104
4.37
MW-111
3.77
MW-112
3.47
4.5
4.25
3.75
3.5
3.25



REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

Emcon Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

GROUNDWATER CONTOUR MAP SHALLOW MONITORING WELLS

MW-201

3.10

NORTH TANK FARM

3.51

3.25

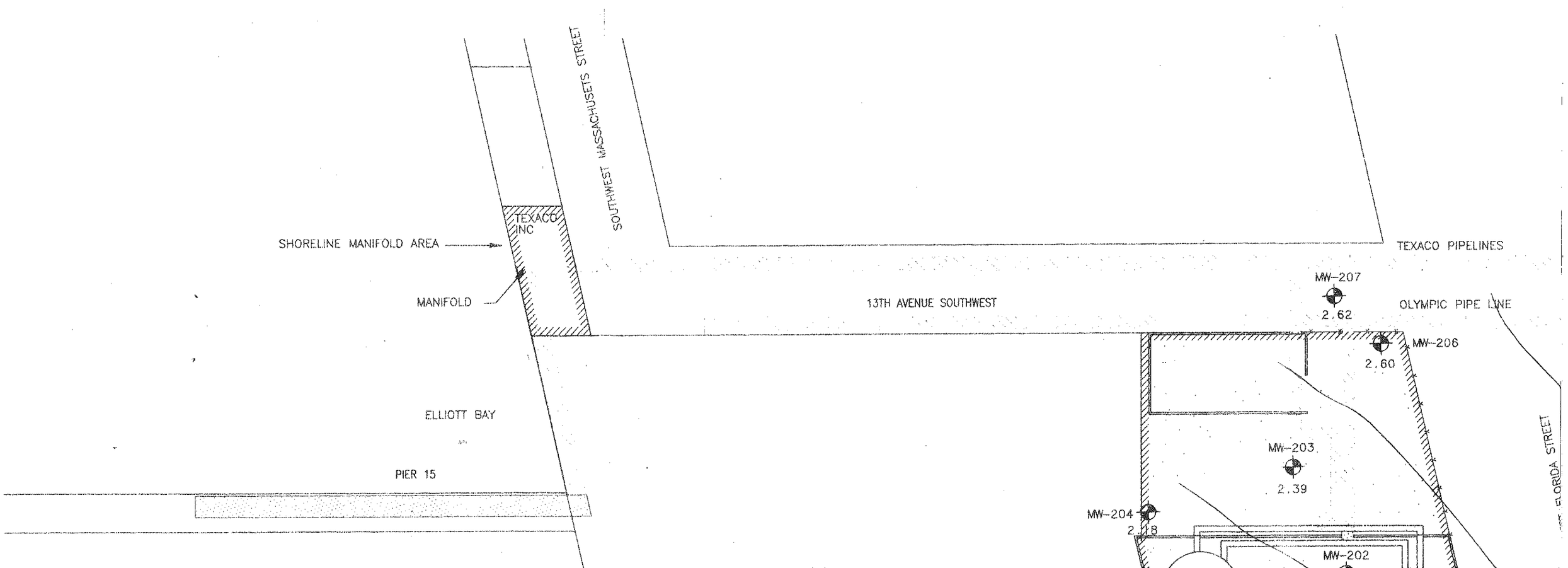
3.5

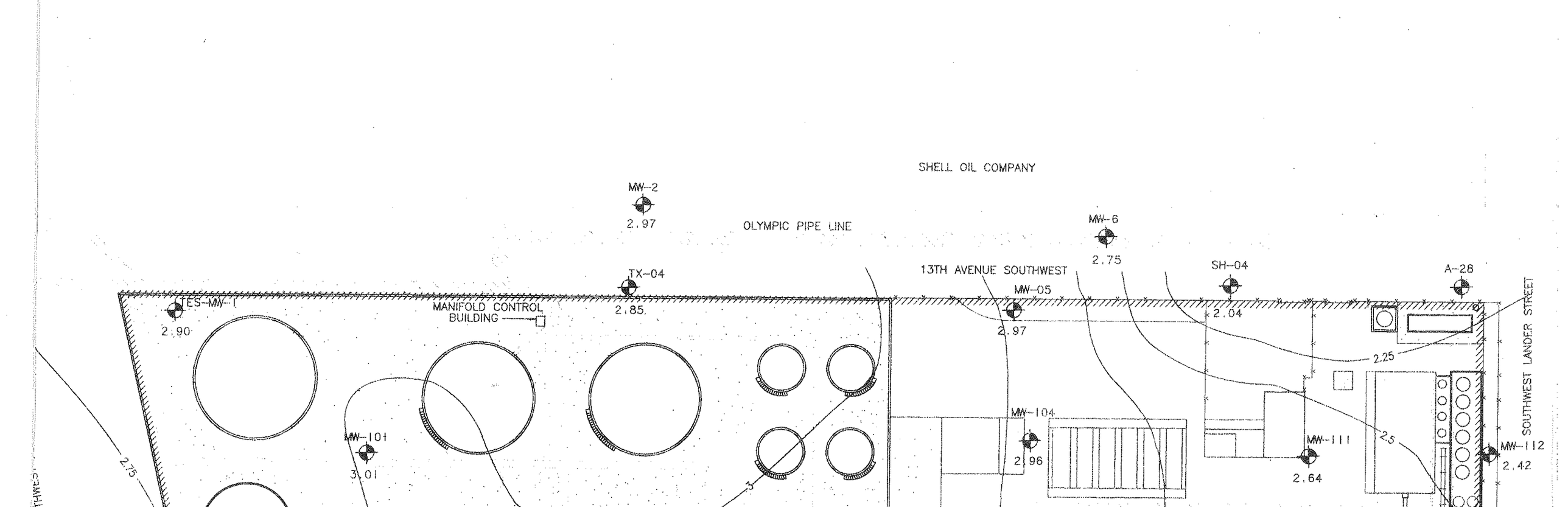
3.75

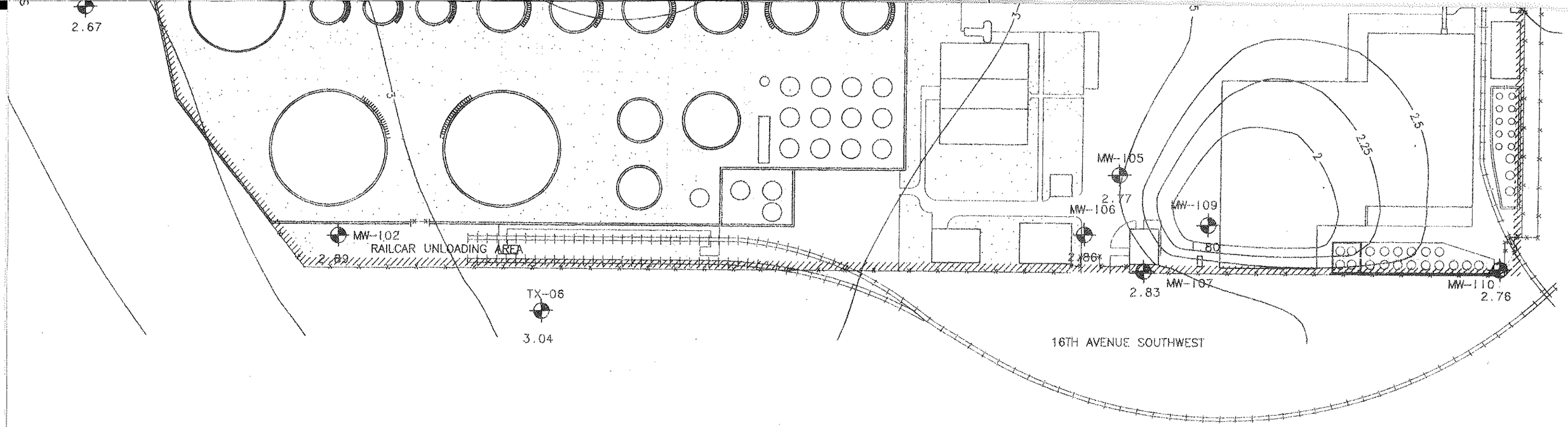
RIGHT OF WAY

LEGEND

- Tank and Number
- Above Ground Pipelines
- Underground Pipelines
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- 3.56 — Groundwater Elevation
- 3.5 — Groundwater Contour


SOUTHWEST MASSACHUSETS STREET
TEXACO INC
SHORELINE MANIFOLD AREA
MANIFOLD
ELLIOTT BAY
PIER 15
13TH AVENUE SOUTHWEST
TEXACO PIPELINES
OLYMPIC PIPE LINE
FLORIDA STREET
MW-207
2.62
MW-206
2.60
MW-203
2.39
MW-204
2.18
MW-202


SHELL OIL COMPANY
MW-2
2.97
OLYMPIC PIPE LINE
MW-6
2.75
13TH AVENUE SOUTHWEST
TX-04
2.85
SH-04
A-28
TES-MW-1
2.90
MANIFOLD CONTROL BUILDING
MW-05
2.97
2.04
2.25
SOUTHWEST LANDER STREET
MW-104
2.96
MW-101
3.01
MW-111
2.64
MW-112
2.42
2.5
2.75
3



REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

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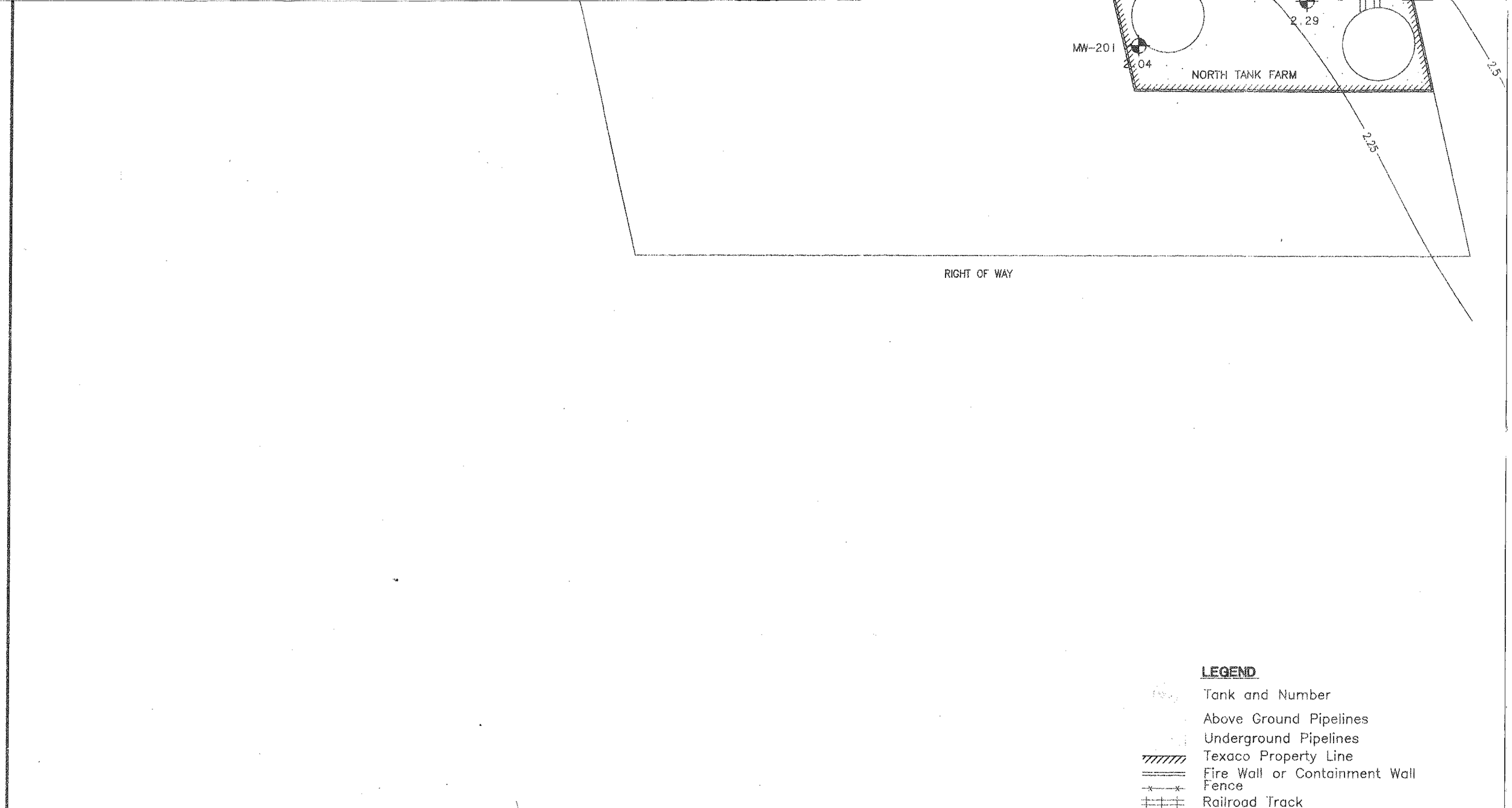
Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

GROUNDWATER CONTOUR MAP SHALLOW MONITORING WELLS



LEGEND

- Tank and Number
- Above Ground Pipelines
- Underground Pipelines
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-204 — Monitoring Well (Shallow)
- 2.25 — Groundwater Elevation
- 2.25 — Groundwater Contour

11 TH AVE. S. W.

MW-13
3.22

MW-03
3.10

GM-21S
3.46

GM-22S
3.56

SH-02
3.33

MW-4

MW-1
3.73

B-055
3.79

B-036
3.85

SHL-24
3.27

E YARD

B-054
3.92

ARCO

SHL-25
3.61

B-062
3.76

E-1
3.62

C YARD

GM-23S
3.91

B-040
4.00

SHELL

B-046
3.91

MW-3
3.93

B-060
3.74

S. W. FLORIDA ST.

SHL-27
3.96

GM-19S
3.80

GM-20S
3.55

13 TH AVE. S. W.

MW-2
3.90

MW-207
3.35

MW-206
3.32

TX-04
3.73

TES-MW-1
3.74

MW-203
3.06

MW-204
2.70

MW-101
3.91

MW-202
2.93

TX-03
3.37

MW-201
2.50

TEXACO, INC

TEXACO, INC

3.5

-12

.8

IL-23
16

HL-22
3.47

SHL-21
3.52

SHL-20
3.52

SHL-19
3.46

SHL-17
3.43

MW-6
3.53

MW-07
3.14

SH-05
2.47

SHL-08
2.40

SHL-07
2.24

SHL-09
2.79

SHL-10
2.79

MW-8
3.36

SHL-06
2.82

SHL-05
2.16

SHL-04
2.20

B YARD

D YARD

MW-5
3.67

SHL-11
3.12

SHL-16
2.78

SHL-03
1.15

MW-7
3.52

SHL-12
3.18

SHL-15
2.80

SHL-13
3.03

MW-9
2.76

SHL-14
2.48

A-25
2.64

A-29
2.59

A-27
2.76

A-26
2.62

A-6

A-17
2.63

A-8
2.56

A-4
2.63

A-5
2.61

A-7
2.59

A YARD

A-1
2.60

A-2
2.59

A-16
2.58

A-11
2.55

A-3
2.43

A-19
2.61

A-9
2.67

A-22

A-20
2.60

A-21
2.60

A-18
2.62

A-23
2.64

A-24
2.67

SF-01
2.25

A-10

A-13
2.30

A-12
2.37

A-14
2.36

SF-07

SF-06

SH-04

A-28
2.53

2.67

MW-111
3.17

MW-112
2.85

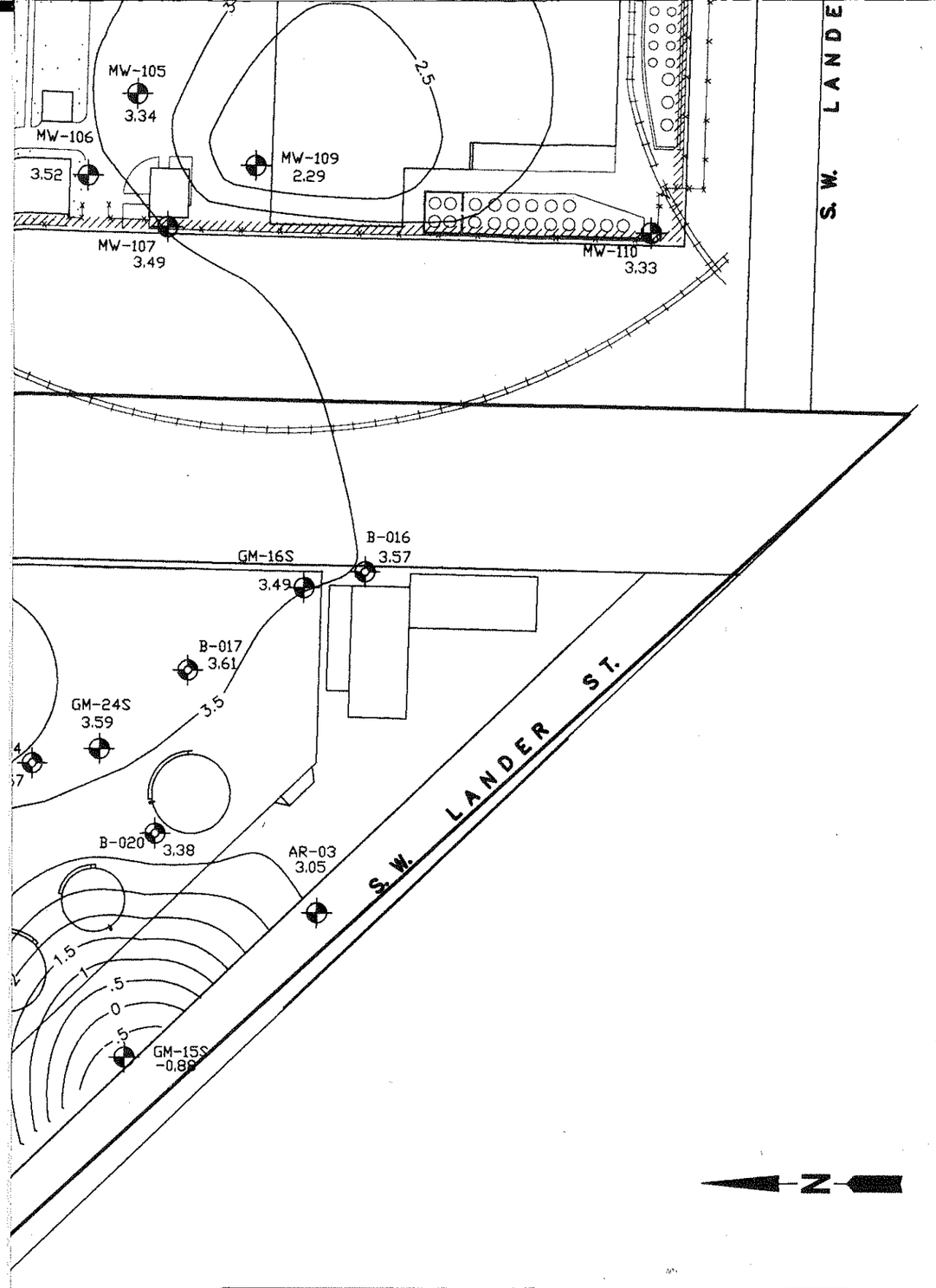
S T.

3.5

3

2.5

2.5



N

0 100 200

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

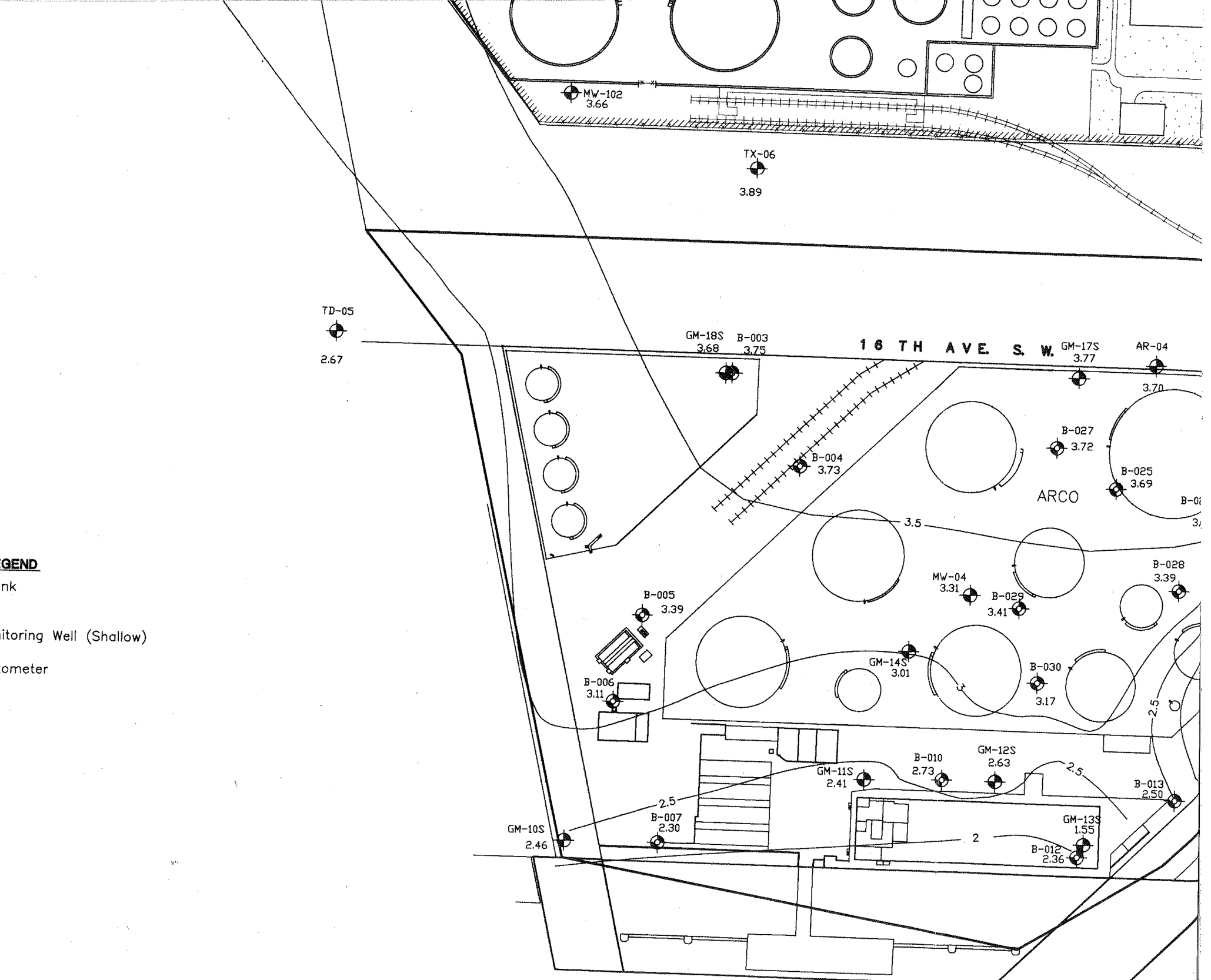
GROUNDWATER CONTOUR MAP SHALLOW MONITORING WELLS

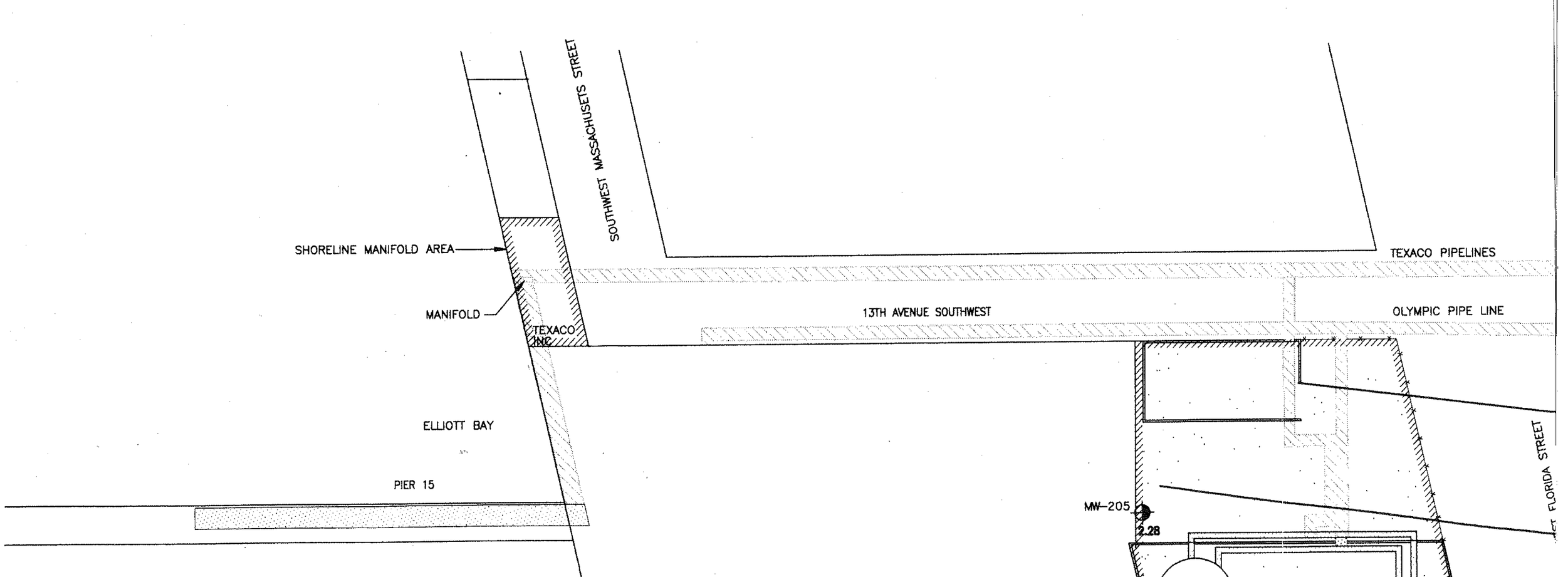
LEGEND

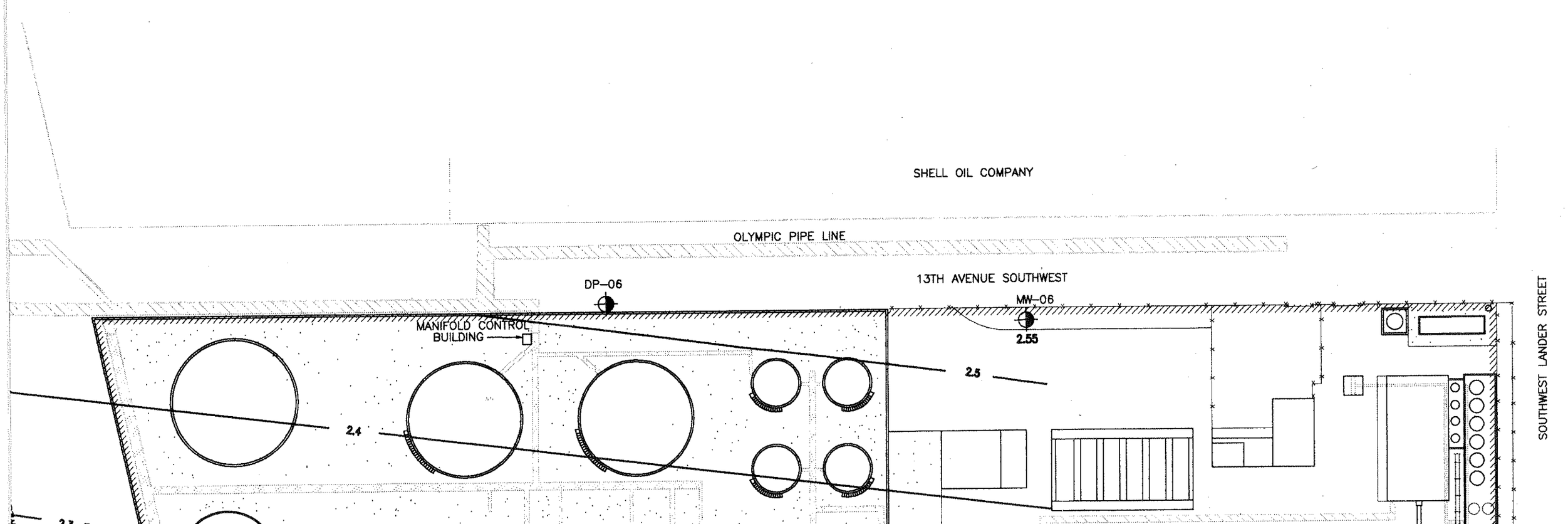
Tank

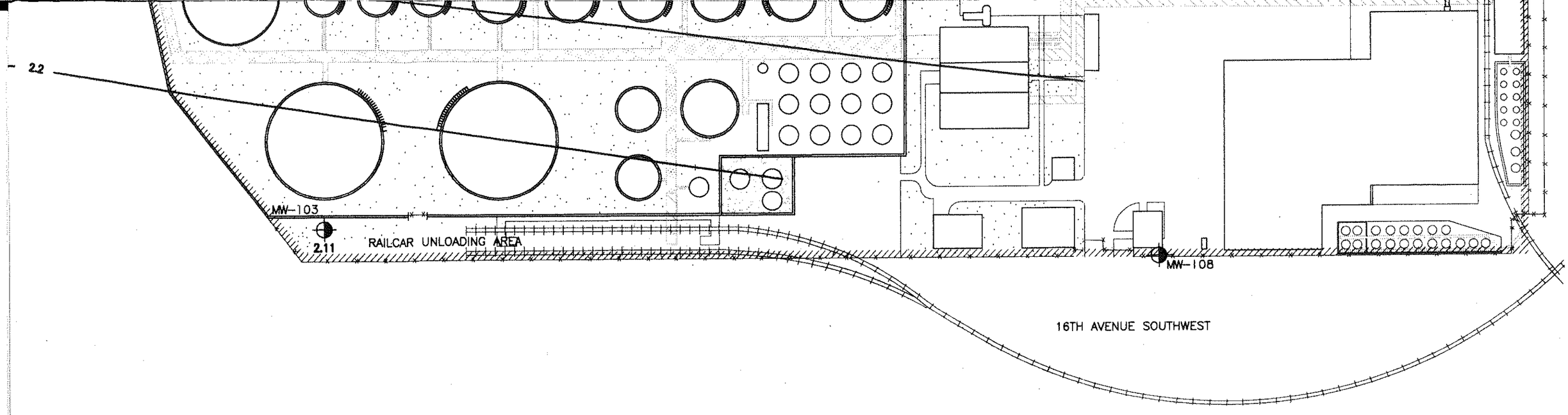
Monitoring Well (Shallow)

Piezometer




SOUTHWEST MASSACHUSETS STREET
SHORELINE MANIFOLD AREA
MANIFOLD
TEXACO INC
TEXACO PIPELINES
13TH AVENUE SOUTHWEST
OLYMPIC PIPE LINE
ELLIOTT BAY
PIER 15
MW-205
2.28
FLORIDA STREET


SHELL OIL COMPANY
OLYMPIC PIPE LINE
13TH AVENUE SOUTHWEST
SOUTHWEST LANDER STREET
DP–06
MW–06
2.55
MANIFOLD CONTROL BUILDING
2.5
2.4



N

0 100 200

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

GROUNDWATER CONTOUR MAP DEEP MONITORING WELLS APRIL 27 - APRIL 30, 1993

DRA

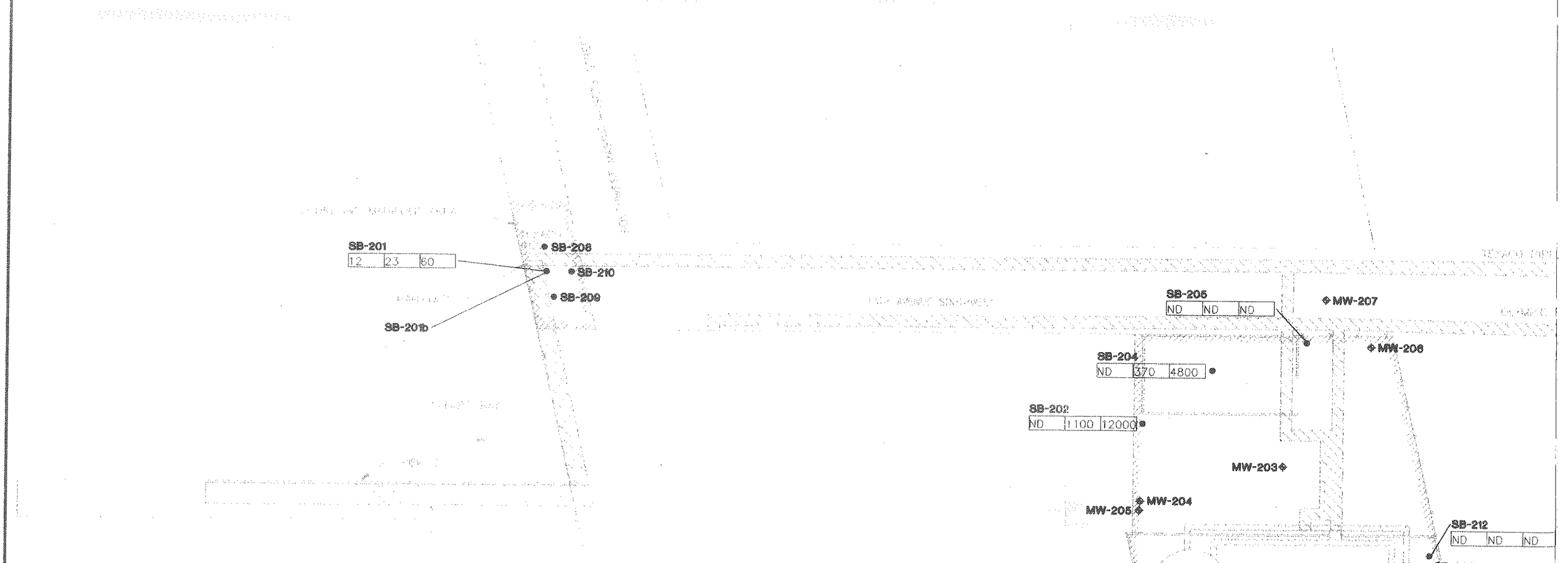
PRO
075

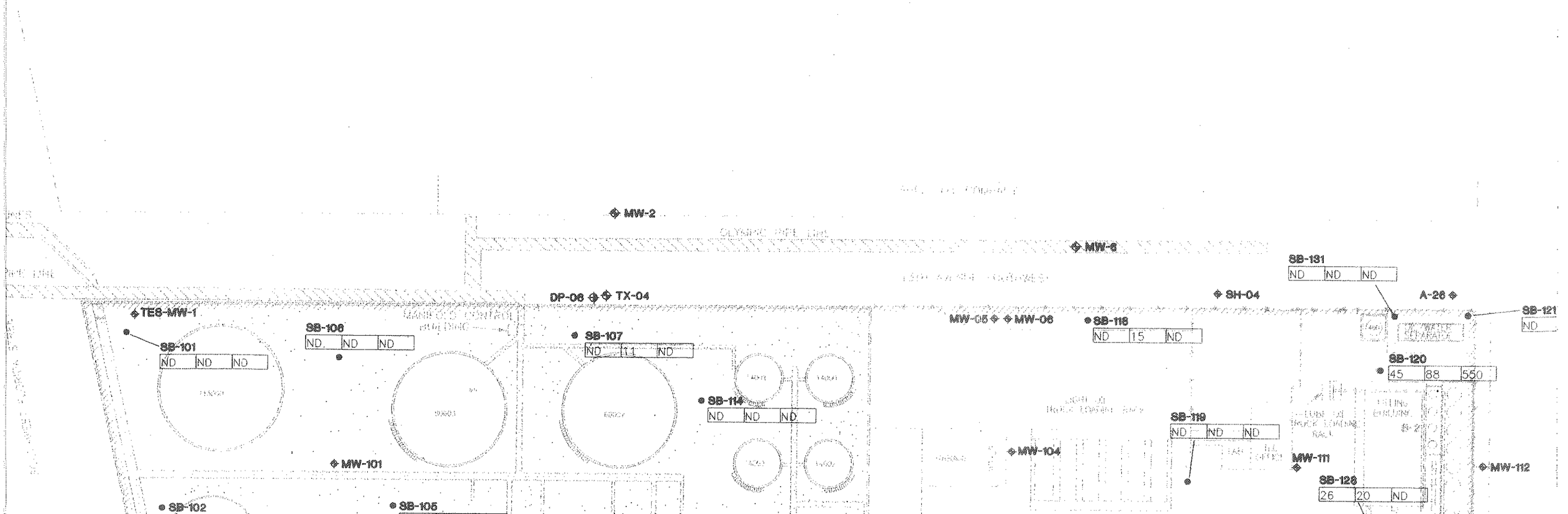
NORTH TANK FARM

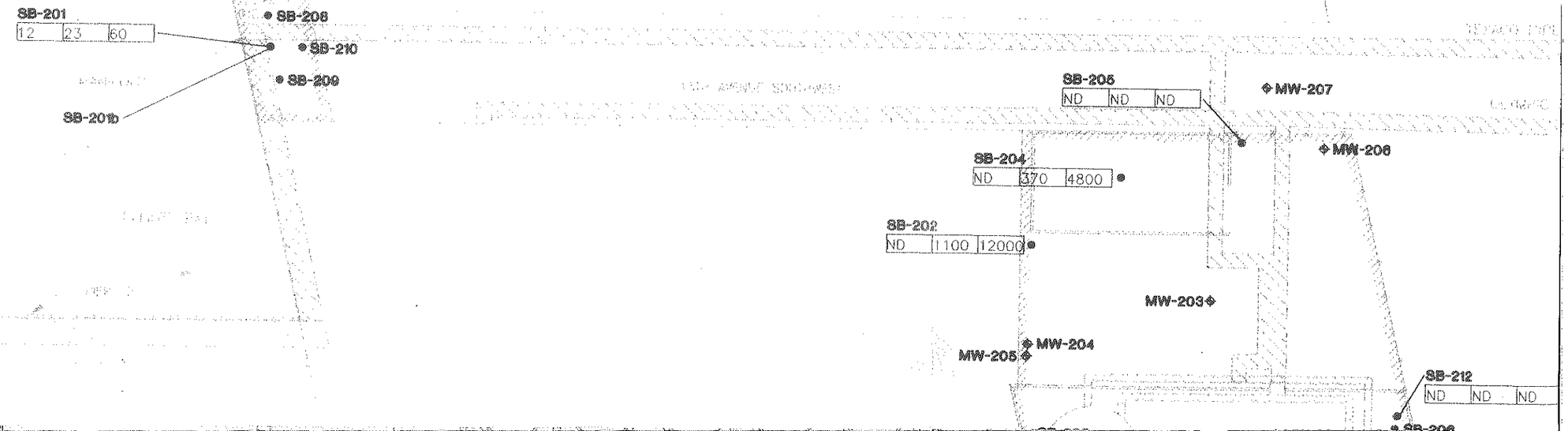
RIGHT OF WAY

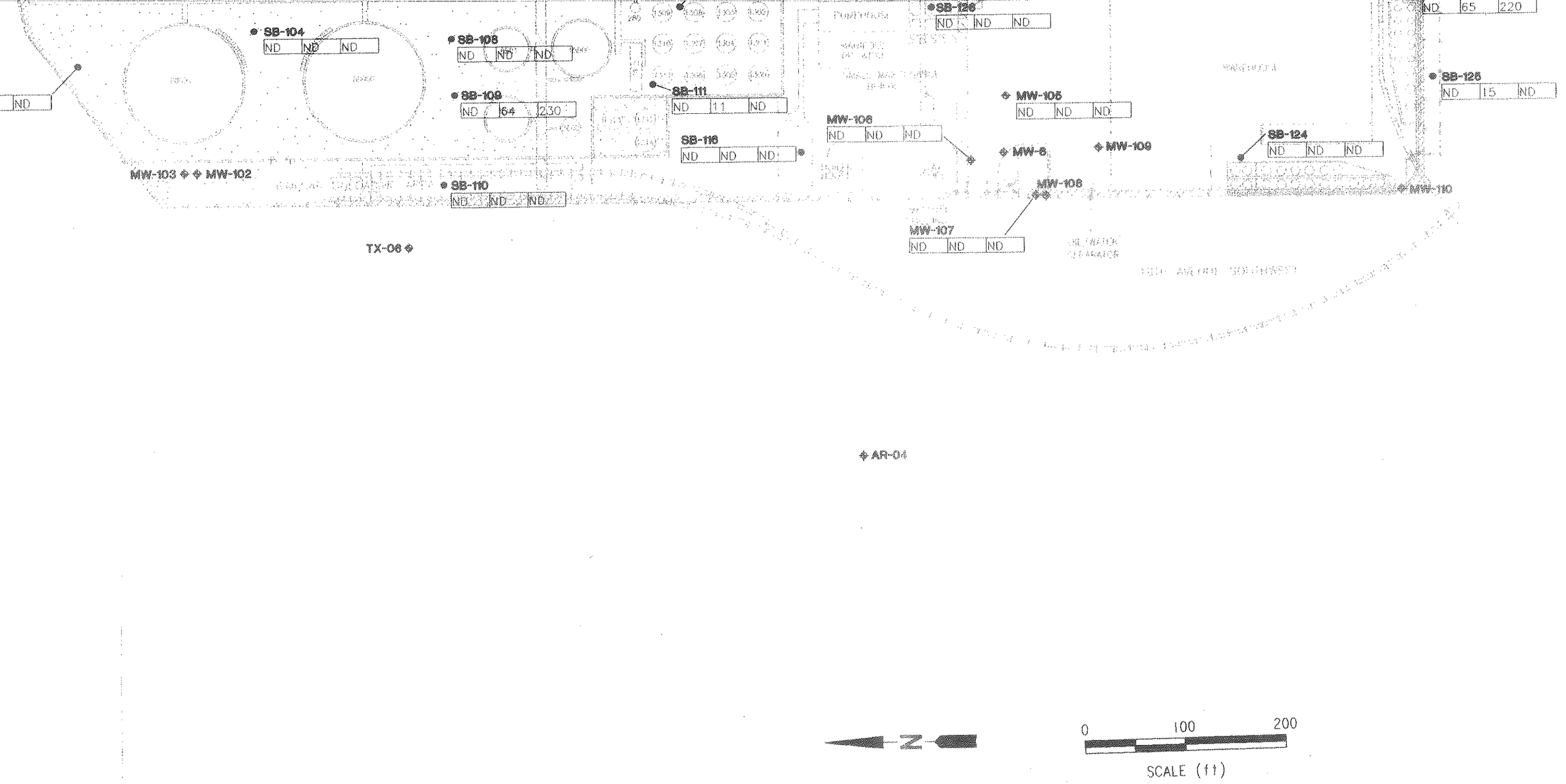
LEGEND

- Tank and Number
- Above Ground Pipelines
- Underground Pipelines
- Texaco Property Line
- Fire Wall or Containment Wall
- Fence
- Railroad Track
- Gravel Surface
- Asphalt Concrete Pavement
- MW-205 — Monitoring Well (Deep)
- 2.2 — Arithmetic Mean Groundwater Elevation, 72-hour Tidal Study, 4/27/93-4/30/93
- 2.2 — Groundwater Contour


SB-201
12
23
60
SB-208
SB-210
SB-209
SB-201b
SB-205
ND
ND
ND
MW-207
MW-206
SB-204
ND
370
4800
SB-202
ND
1100
12000
MW-203
MW-205
MW-204
SB-212
ND
ND
ND


MW-2
MW-6
DP-06
TX-04
SH-04
A-26
TES-MW-1
SB-101
ND ND ND
SB-106
ND ND ND
SB-107
ND 11 ND
SB-114
ND ND ND
MW-101
SB-102
SB-105
MW-05
MW-06
SB-118
ND 15 ND
SB-131
ND ND ND
SB-120
45 88 550
SB-121
ND
SB-119
ND ND ND
MW-104
MW-111
MW-112
SB-129
26 20 ND


SB-201
12
23
60
SB-208
SB-210
SB-209
SB-201b
SB-205
ND
ND
ND
MW-207
MW-206
SB-204
ND
370
4800
SB-202
ND
1100
12000
MW-203
MW-204
MW-205
SB-212
ND
ND
ND



REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

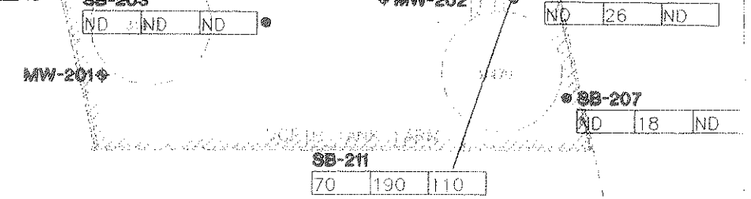
DATE OF ISSUE
DWN BY
DES BY
CHK BY
APP BY

Emcon Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH CONCENTRATIONS 0.5 - 1.5 FEET

DRAWING NO
5
PROJECT NO
0750-001.09



LEGEND

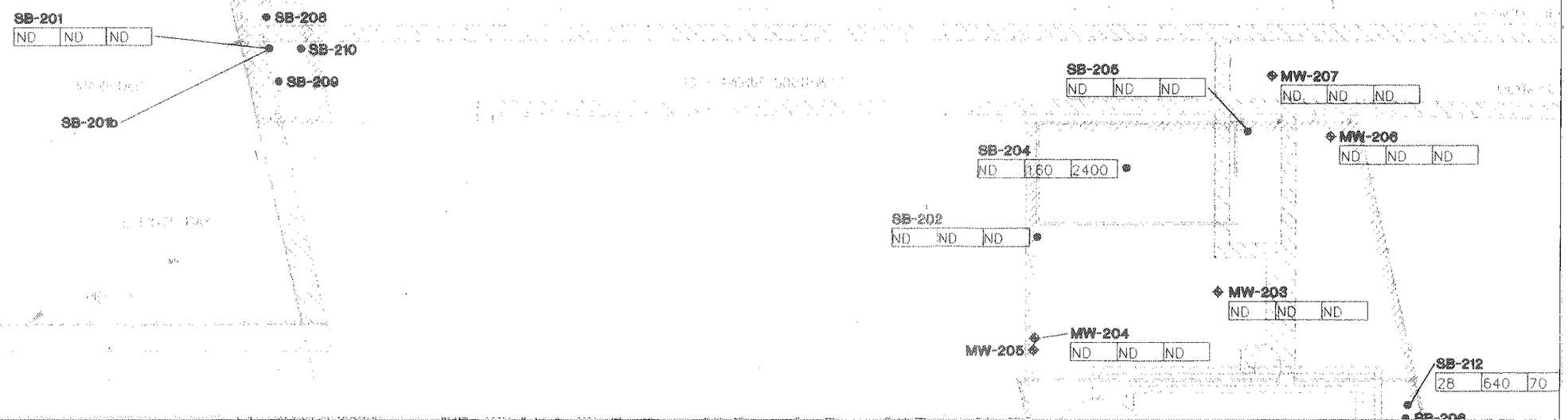
LOCATION
0.5-1.5 FT | TPH-G | TPH-D | TPH-O | Sample Results

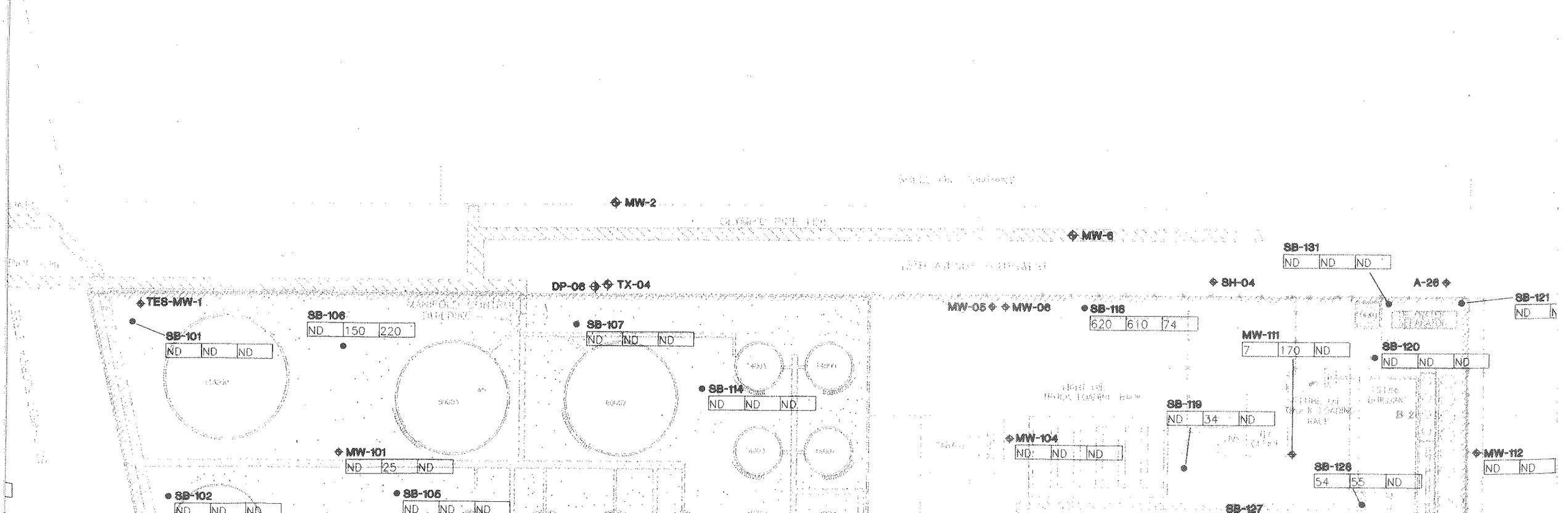
ND Not-Detected

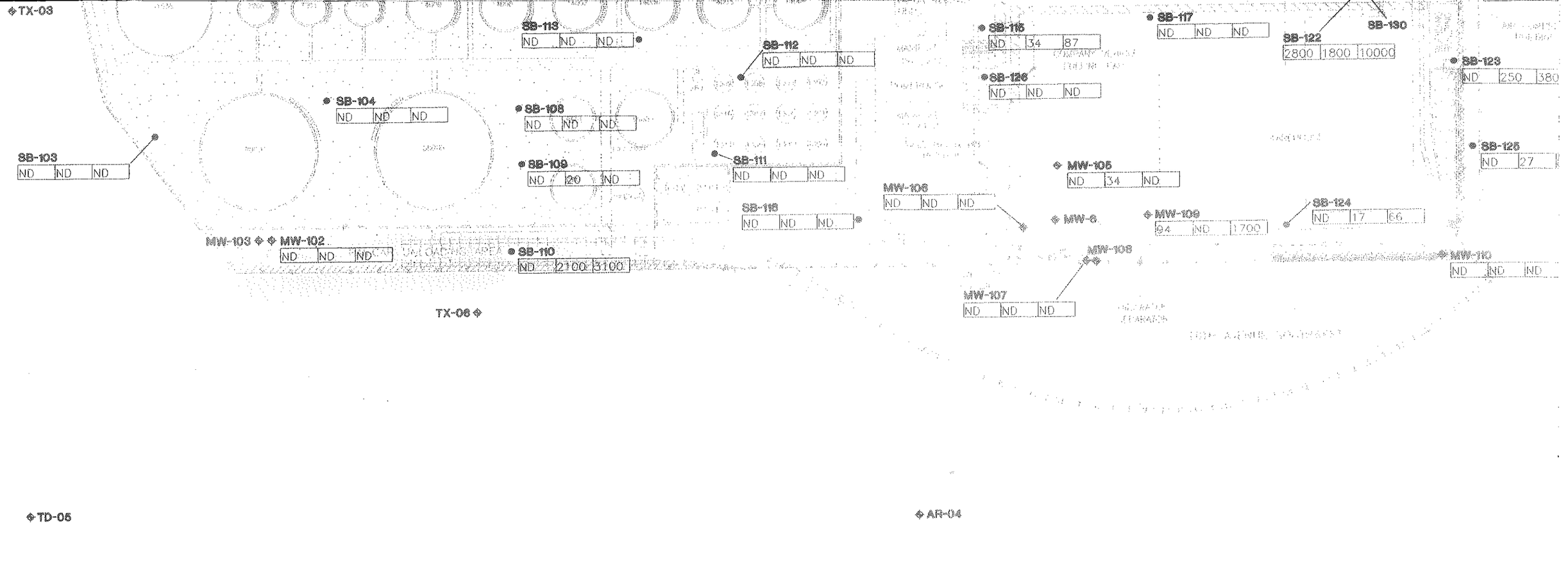
Concentrations are in mg/kg

MW-203 ● Soil Boring or Hand Auger
DP-08 ◈ Monitoring Well (Deep)
MW-203 ◈ Monitoring Well (Shallow)

Track and Storage
Above Ground Pipelines
Underground Pipelines
Tesoro Property Line
Bulk Plant or Containment Wall
Fence
Railroad Track
Gravel Surface
Asphalt Concrete Pavement


SB-201
ND ND ND
SB-208
SB-210
SB-209
SB-201b
SB-205
ND ND ND
MW-207
ND ND ND
MW-206
ND ND ND
SB-204
ND 160 2400
SB-202
ND ND ND
MW-203
ND ND ND
MW-204
ND ND ND
MW-205
SB-212
28 640 70


MW-2
MW-3
SB-131
ND ND ND
DP-06
TX-04
SH-04
A-26
SB-121
ND
TES-MW-1
SB-101
ND ND ND
SB-106
ND 150 220
SB-107
ND ND ND
MW-05
MW-06
SB-118
620 610 74
MW-111
7 170 ND
SB-120
ND ND ND
SB-114
ND ND ND
SB-119
ND 34 ND
MW-104
ND ND ND
MW-112
ND ND
MW-101
ND 25 ND
SB-126
54 55 ND
SB-102
ND ND ND
SB-106
ND ND ND
SB-127



N

0 100 200

SCALE (ft)

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

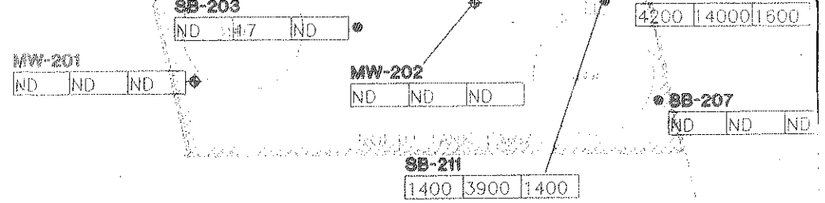
EMCON Northwest, Inc.

TEXACO HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

SOIL TPH CONCENTRATIONS

DRA

PRO



LEGEND

LOCATION
0.5–1.5 FT | TPH-G | TPH-D | TPH-O | Sample Results

ND Not–Detected

Concentrations are in mg/kg

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DP-06 ◈ Monitoring Well (Deep)
MW-203 ◈ Monitoring Well (Shallow)