MONTANA POLE AND TREATING PLANT NPL SITE

Final Remedial Investigation Report - Revision 1

Prepared for:

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November 1993

A mixture of media, including soils, were sampled on August 1, 8 and 22, 1985. Soil samples collected from the trench area were analyzed for PCP. Soil samples from the trench, the south yard, and facility yard plus oil samples from a tanker, were analyzed for priority and non-priority pollutants using USEPA Methods 625 and 8270. Soil sampling locations within the trench area and yards were not specified. Three soil samples collected from the trench area contained PCP at 610 μg/g, 450 μg/g and <0.1 μg/g concentrations. Results of priority and non-priority pollutant analyses are found in Table 1-3.

In a third sampling event, soil samples from seven unspecified sites were composited in conjunction with sludge and oil samples from the retort, petroleum tanks, drums, and the oil tanker. All samples were taken on July 31 and August 1, 1985 and analyzed for PCP, dioxins and furans. Soil sample results are summarized in Table 1-4.

From July 11 to 14, 1985, the Coast Guard Pacific Strike Team sampled soils/sludges from around and in mixing vat 413 and liquid/sludges from petroleum tank 355A. The soil composite sample from the vicinity of mixing vat 413 was analyzed for dioxin/furan homologues and data included a full data package with raw data, chromatograms and calculations. Dioxin/furan results are listed in Table 1-5 for this soil sample.

On August 1, 1985 soil composites, including a soil/ash composite from the tepee burner and a soil composite from the facility yard, were collected. Samples were analyzed for dioxin/furan homologues and PCP. Sample results are presented in Table 1-4. Split samples were sent to California Analytical Laboratories (CAL) to be analyzed for PCP and priority pollutants. These data are shown on Table 1-3.

On December 5, 1986, 20 soil samples were collected adjacent to excavated areas to determine residual values of PCP remaining on-site after soil excavation and removal. Additionally, Silver Bow Creek sediments were sampled to determine concentrations of dioxins and furans. Samples were collected by USEPA personnel. The locations of 20 soil samples were shown on maps; however, no map was found which indicated the location of the Silver Bow Creek sediment samples. PCP concentrations in soil samples obtained from the facility yard ranged from 140 mg/kg to 3,500 mg/kg. PCP concentrations in sediment samples from the sand bar near the creek trench and seepage point ranged from <0.1 mg/kg to 9 mg/kg.

PCP/Petroleum Recovery System

USEPA and its contractor began installation of two groundwater recovery systems in August 1985 as part of an emergency response action (Figure 1-5). Installation of the recovery systems coincided with the installation of 17 groundwater monitoring wells. The northern recovery system was designed to intercept contaminant flow into Silver Bow Creek. The southern system was placed south of I-15/90, downgradient of the suspected major source area (the plant process area). Each recovery system consisted of a recovery trench, two 12-inch production wells, a control house, an API separator, and an infiltration gallery. The infiltration galleries were designed to handle a flow of 4 gpm and were located upgradient of the recovery trenches.

Monthly product volumes collected from the north and south recovery systems from November 1986 to December 1988 are presented in Appendix A. The south recovery trench, downgradient of the former process area, collected a total of 5,864 gallons of oil over this time period. During this same period, 419 gallons of product were collected in the north recovery system. Both systems show a declining trend in monthly product recovery volume. Static water levels and product levels in the recovery wells have also been monitored on a monthly basis from November 1986 to the present.

Samples of skimmed underflow from the north and south separators were taken in March 1987 to identify compounds [PCP, dioxins/furans, polynuclear aromatic hydrocarbons (PAHs)] dissolved in the aqueous phase. A subsequent sampling of skimmer underflow occurred in April 1987. Samples were analyzed for PCP and metals in March and for the full set of priority pollutants, including organics and metals, in April. Sample results for both sampling events are shown in Table 1-6.

PCP was detected in the underflow of both separators but the highest concentration (235 μg/l) was noted in the south separator (CDM, 1989). Other semivolatile compounds found in the north and south separators include PAHs: fluorene, 2-methylnaphthalene, and phenanthrene; and dibenzofuran. Naphthalene and 2-methylnaphthalene were found at concentrations of 2,260 and 14,255 μg/l in the south separator underflow. The volatile organic compound common in all separator underflow samples was xylenes. Chloroform, detected in the underflow sample from the south separator, may be a laboratory contaminant (CDM, 1989). Volatiles recorded in the analyses represent compounds in the petroleum product used as the carrier oil. Semivolatile PAHs are found as impurities in carrier oils, and in association with creosote which was reportedly used for a brief period at the facility.

Groundwater Well Installation and Monitoring

Three sets of monitoring wells were installed in 1983, 1985, and 1987 at the site to determine local groundwater flow paths and the extent of groundwater contamination. These well locations are shown on Figure 1-6. A summary of drill logs for each set of wells is found in Table 1-7. Items summarized include well depth, screened interval, depth to bedrock, presence of product, and depth to product. Copies of the original drill logs are found in Appendix N. Potentiometric surfaces were estimated by CDM (1989); the potentiometric surfaces inferred from past measurements are consistent with those measured during the RI. A discussion of groundwater flow is presented in Section 3.6 of this report.

Several wells were installed by the Montana Bureau of Mines and Geology (MBMG) in July 1983. These wells are indicated as MP wells in Figure 1-6. They were located east and west of the product seep on the south side of Silver Bow Creek. Sampling of the MP wells for water levels and PCP concentrations was completed in July 1983. The results provide a set of data on the northern portion of the site prior to installation of the recovery systems. Concentrations of PCP near the saturation point of PCP in water (14 mg/l at pH of 7 and 25°C) were detected in samples from wells MP2 and MP1. PCP was also found at MP5, east of the ditch.

Two sets of wells were installed by MBMG to monitor different intervals to evaluate the vertical groundwater gradient and any stratification in groundwater quality. Wells MP1A and MP6A are screened to monitor the upper 5 feet of alluvial aquifer while wells MP1 and MP6 monitor the lower 10 feet of the aquifer. In July 1983, both pairs of nested wells showed a slight downward vertical gradient.

To further delineate the extent of groundwater contamination, 17 monitoring wells were installed by USEPA in August 1985. Geologic logs indicate that wells were drilled to depths of between 20 and 30 feet in alluvial material consisting of varying quantities of sand, clay, silt and gravel. Wells were generally screened to the bottom of the well over the full saturated column. Well 3 was drilled to bedrock, 27 feet, and refilled to a depth of 20 feet. Competent bedrock was reportedly found at a depth of 17 feet in Well 17 with weathered bedrock at 13 feet.

Drill logs for these wells also indicate product thickness plus HNu readings at discrete depths. A summary of field observations for the 1985 wells is presented in Table 1-8. Product was detected near or above the water surface in most cases and ranged to several feet below the water table. Wells W-7, W-8 and W-10 (well W-7 in particular) contained the thickest amount of floating product. Product was first detected between 2 and 8 feet below the water surface in wells W-2, W-5, W-11, and W-15. Wells W-7 and W-12 were subsequently destroyed apparently during removal activities. Continuing monitoring efforts at these wells include measurement of monthly static water levels at all wells and product thickness for select wells. The water level and product thickness data are included in Appendix A.

In April 1987, USEPA installed eight additional monitoring wells, M-1-87 through M-8-87, between I-15/90 and Silver Bow Creek. They were installed to further define the contaminant plume and to estimate the distribution of product. Wells M-1A-87 and M-9A-87 were drilled using a solid auger to determine depth to bedrock. Weathered bedrock was found at 34 feet in M-1A-87 and 36 feet in M-4A-87. Competent bedrock was reportedly found at 43 and 39 feet in these wells, respectively. These holes were subsequently sealed with clay. Well M-2-87 was placed within 5 feet of the sewerline to determine if product movement followed the permeable

1.2.4 Preinvestigation Characterization and Volume of Waste Present

The Montana Pole site was proposed for listing on the NPL as a result of PCP/petroleum contamination from the treatment of timber products. With the exception of coal tar creosote used for a short period of time in 1969, the solution used to treat timber products from 1949 to 1984 consisted of 5 percent pentachlorophenol (PCP or penta) dissolved in 95 percent petroleum product (similar in characteristics and composition to diesel fuel).

Technical grade PCP used for treating wood typically contains 85 to 90 percent penta. The remaining materials are tetrachlorophenols, 4 to 8 percent; "higher chlorophenols," 2 to 6 percent; and dioxins/furans, 0.1 percent (McGinnis, 1987). Other compounds are produced as contaminants during manufacture, including complex phenols and ethers. The principal chlorodibenzodioxin and chlorodibenzofuran contaminants found in penta are those containing six (hexa), seven (hepta), and eight (octa) chlorines (McGinnis, 1987). The most toxic isomer, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), is not typically associated with PCP.

Although over 1,000 compounds have been identified in creosote and coal tar, the major compounds associated with creosote and coal tar are PAHs. Creosote generally contains the following percentages of PAHs: 21 percent phenanthrene, 6 percent anthracene, 3 percent naphthalene plus 2 percent of the 1-methyl isomer, 10 percent fluoranthene, 8.5 percent pyrene, 3 percent chrysene, 10 percent fluorene, and 9 percent acenaphthene.

A petroleum product is used to dissolve the technical grade PCP and "cut" the creosote in preparation for operations. In addition to the straight-chain aliphatic compounds, carrier oils can contain PAHs and volatile organic compounds (VOCs) including benzene, toluene, ethylbenzene, and xylenes (BTEX). These compounds have relative high solubilities in water and volatilize at ambient conditions.

Previous data collected at the Montana Pole site and a discussion of the probable extent and nature of contamination known prior to this RI/FS study were presented in Volume 1 of the

RI/FS Work Plan (CDM, 1989) and in Section 1.2.3 of this report. This section provides a summary of contaminants by matrix.

Contaminants found in groundwater samples and in underflow of the recovery systems during previous investigations are the following:

- Pentachlorophenol
- Naphthalene
- 2-methylnaphthalene
- Fluorene
- Phenanthrene
- Pyrene
- Dibenzofuran
- Hexa and hepta dioxins
- Hexa and hepta furans
- Xylene
- Chloroform
- Toluene
- Zinc
- Selenium
- Copper
- Arsenic

Contaminated site soils removed from the site in 1985 were stored in Pole Barns constructed for this purpose. Monitoring prior to soil removal indicates that these stored soils are contaminated with PCP and dioxins/furans. On-site sludges and oils also contain PCP and dioxins/furans.

The volume of material stored on-site in pole barns was estimated from USEPA emergency response records. Preliminary estimates were made of the volume of PCP and oil product in groundwater and soils. Materials stored on-site are the following:

- Oil skimmed from groundwater in the recovery systems;
- Soils removed from the general site during soil excavation in 1985;
- Sludges representing treatment wastes from tanks and butt treatment vats and retorts;

- Treated oil/sludge;
- Equipment used previously in treatment processes; and,
- 9,000 gallons waste oil and 40 drums of sludge/liquid.

An estimated 9,000 gallons of contaminated liquid were processed to detoxify dioxins in the summer of 1986. The KPEG process detoxified the dioxin, leaving waste oil and 40 drums of PCP/reagent sludge stored on-site.

A total of 6,283 gallons of penta contaminated oil was collected from the combined north and south recovery systems from November 1986 to December 1988. The total volume of oil collected as of June 1992 was approximately 12,000 gallons.

An estimated 10,000 cubic yards of contaminated soils were excavated during site soil removal in 1985. Septic sludges unearthed during excavation were also stored with some of the soils. Soils were bagged in 3,950 3-cubic yard bags.

Gross estimates of the volume of contaminated soil and volumes of contaminated groundwater were made, before the RI was initiated, using drill log information. Soil contaminated with oil averages 5.2 feet deep. Assuming oily product has saturated the pore spaces and a contaminant area of 950,000 square feet, the total volume of contaminated soil was estimated to be 5,000,000 cubic feet. Similarly, for groundwater volume in the alluvial aquifer; an average saturated thickness of 22 feet and an aerial extent of contamination of 950,000 square feet, the total volume of contaminated alluvial groundwater was estimated to be 7,900,000 cubic feet.

Potential sources of contamination are spillage around the plant site (especially by the mixing tank and releases from the groundwater recovery system), drippings from the treated wood, leaking pipelines used to transfer products, the drainage ditch that received process wastewater from the plant, the catchment area below the retorts (concrete sumps were not used), the water discharged from clarifying tanks, the mixing vat, or areas where condensate pooled during discharge.

1.3 REPORT ORGANIZATION

This RI report is organized in accordance with Section 3.7 of the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final (USEPA, 1988c). Each section of the report and its purpose is described below. This report also includes data collected under the Supplemental Work Plan for Additional Work (Keystone, 1991a) and the Addendum to the Supplemental Work Plan for Additional Work Following the Fall Sampling (Keystone, 1991b).

The Final Baseline Risk Assessment (CDM, 1992) presents a public health evaluation and an ecological assessment. A public health evaluation is to provide a discussion of exposure, toxicity and risk assessment. *Potential risks from the site to the ecological receptors are discussed in* the environmental assessment. This document has been entered into the Administrative Record for the site.

Section 1.0 - Introduction

This section describes the purpose of the report, provides site background information including a site description and history, and provides a summary of data collected from, and the removal action at, the site before the initiation of the RI.

Section 2.0 - Site Investigation

Field procedures associated with performing the RI are presented in this section. Section 2.1 describes general field procedures, such as sample bottle and equipment preparation, sample handling, and chain-of-custody procedures. Field logs, notes and blank samples are also described in this section. Section 2.2 provides a description of field activities completed to date

Type of Sampling	Number of Samples
Surface Soil (grid samples)	53
Surface Soil (stained and/or opportunistic)	17
Surface Soils (coincident with surface water flow patterns)	5
Test Pits - Surface soil	10
Test Pits - Subsurface soil	23
Auger Borings	36

A summary of sampling and analytical procedures which support the primary objective for each sampling type are summarized in sections 2.2.4.1 and 2.2.4.2.

2.2.4.1 Surface Soils Investigation. Various surface soil sampling programs were implemented according to the RI/FS Work Plan, SAP, and QAPP, and to identify the nature and extent of potential contaminants in surface soils. Five sampling programs were performed to accomplish the previously stated objective.

1. Stained and opportunistic surface soil samples were located in several areas of the site.
2. The drainage ditch that transects the site was sampled at intervals along its length.
3. Backhoe test pits were excavated in and around the area of previous soil removal activity and around an area suspected of being used for sludge and waste disposal. Samples collected from the 0 to 3 foot interval were used for characterizing surface soils.
4. Two sampling grids were established, one each in the eastern and western pole storage areas.
5. Soil borings were placed at the site as described in Section 2.2.4.2. Samples taken from the interval 0 to 2 feet were used for characterizing surface soils.

The analytical parameters for the various programs except borings consisted of phenols (USEPA 8040) and total petroleum hydrocarbons (NYS 310.3). In addition, one visibly contaminated soil sample was required for Target Analyte List/Target Compound List (TAL/TCL) (CLP) analysis during the backhoe test pit program. Table 2-13 lists the various analytical parameters measured for the 0 to 2 foot soil boring samples.

Stained and Opportunistic Soil Sampling

Figures 2-9A and 2-9B show 17 sample locations considered for this program. These sample locations are identified by an A after the sample location number. This program accounted for additional areas of surficial contamination outside the scope of other investigations and programs. Locations were selected based on visibly stained surficial soils.

At each selected location, a sample was taken from 0-6 inches. Stainless steel trowels were used for sample collection. Sampling occurred on July 11, 1990.

During the February 1991 data review meeting, it was decided that additional surface soils sampling was required to answer concerns expressed by DHES regarding soil quality in the area of boring A-7 (Figure 2-11), located east of the railroad spur. Four surface soil samples (301, 302, 303 and 304) (Figure 2-11), from 0 to 2 feet, were collected. One sample (303) was collected approximately 15 to 30 feet north of A-7, a second was collected from the toe of the railroad grade fill west of A-7 (304), a third sample was collected from approximately 15 feet east of A-7, and the fourth sample collected from the toe of the railroad grade fill (301), approximately 15 to 30 feet south of A-7. Each of the samples was analyzed for pentachlorophenol and hydrocarbons.

Surface Water Flow Pattern Soil Sampling

Figures 2-9C and 2-9D show the five sample locations for this program. Samples are identified with a B following the sample number designation (i.e., SL-101B through SL-105B). Sampling occurred within the main drainage ditch that transects the site from south to north. Five samples were collected along the length of the ditch. The interval of this ditch between the plant process area and the interstate highway overpass was not sampled since this area was excavated during the USEPA removal action and backfilled with gravel. Samples were taken at the bottom of the ditch from 0-3 inches. Stainless steel trowels were used for sample collection. Sampling occurred on June 28, 1990. Each of the samples were analyzed for pentachlorophenol and hydrocarbons.

Backhoe Test Pit Sampling

Figures 2-9E and 2-9F illustrate the backhoe pit locations. Samples collected from test pits within the process area and the northern area of the site are identified with a C following the sample number designation. Fourteen test pits were excavated within and around the area of the previous emergency soil removal activities (SL201C through SL214C). Test pits were located to help discern the horizontal and vertical limits of visual contamination in a major source area (process area). One test pit, SL215C, was located in the northern portion of the site. Test pits were excavated to a depth where visual evidence of contamination was no longer present, or, to interception with the water table. Composite soil samples were taken from the face of the excavation at various depth intervals. Stainless steel trowels and pans were used for sample collection and compositing. Sampling occurred from July 9 through July 11, 1990. Description of the test pit excavations are provided in field notes in Appendix F4. Only 11 of the pits were sampled for pentachlorophenol and TPH. SL203C, SL204C, SL210C, and SL213C were not sampled because there was no visible sign of contamination.

According to the plant owner, some waste sludges generated at the site were disposed of on the ground surface, along with other general waste, garbage and debris, in an area west of the current removed soil storage buildings. During Round 3 an attempt was made locate the wastes/sludges within this area with test pits, soil borings, monitoring wells and organic vapor measurements. Test pits excavated in this area are identified in Figure 2-9F as TP1 through TP18. Although visible evidence of contamination was present, no samples were collected for laboratory analysis due to the presence of metal banding material, wood chips, sawdust and other debris. Results of soil borings and monitoring wells along the periphery of the potential waste disposal area are discussed in Sections 4.2 and 4.3.

Surface Soil Grid Sampling

Figure 2-10 illustrates the sampling locations for both the east and west surface soil grids. The legend on this figure indicates the symbol denoting grid sample locations. A 200-foot by 200-foot grid was established over both the east and west pole storage yards. A compass was used for aligning the grids. At each grid intersection, five aliquot samples were composited (by weight) based on a 10-foot square centered at the grid intersection. One sample from the grid intersection and four samples from the corners of the 10-foot square were taken from 0-6 inches. Stainless steel trowels were used for sampling and a balance was used for weight compositing. Sampling occurred on July 9 and 10, 1990.

During the August 1990 data review meeting between ARCO and DHES, it was agreed that additional grid samples were needed to allay data gap concerns south of Greenwood Avenue and west of the western pole storage yard (Figure 2-10 shows the additional grid locations). Sampling occurred as outlined previously. The additional grid locations were sampled on November 10, 1990. All samples were analyzed for pentachlorophenol and TPH.

A discussion of the analytical results for the surface soil sampling programs is located in Section 4.1.2. Sample handling, documentation and general sampling considerations are discussed in Section 2.1.1. Field notes for the surface soil sampling programs are located in Appendix B3.

Surface Boring Samples

Samples were collected in the 0 to 2 foot depth range from subsurface soil borings performed as part of the subsurface soils investigation. The subsurface soils investigation is discussed in Section 2.2.4.2

2.2.4.2 Subsurface Soils Investigation. Two subsurface investigation programs were performed according to the RI/FS Work Plan, Supplemental Work Plan, and Addendum to the Supplemental Work Plan. The purpose of the subsurface soil investigation program was to:

Because PCP screening results indicated PCP contamination in wells GS-18 and BMW-10, on November 13, 1990 additional PCP screening samples were taken from 5 off-site monitoring wells GS-34, GS-17, GS-22, GS-25 and BMW-9 (Figure 2-7).

A data review meeting was held in February 1991 to discuss the Round 2 and PCP screening sampling results. It was determined that the first two rounds of sampling had not adequately delineated the extent of groundwater contamination and that additional wells and a third round of groundwater sampling was needed. Round 3 groundwater sampling occurred the week of June 4, 1991. Twelve of fourteen newly installed wells, described in Section 2.3.2, and 12 off-site monitoring wells were sampled. Newly installed wells sampled during Round 3 included two weathered bedrock aquifer wells north of the I-15/90 overpass (GW-18 and GW-19), one well up-gradient and one well down-gradient of the sludge/waste disposal area in the western wood storage yard (GW-26 and GW-27 respectively) and one well (piezometer) installed to monitor sewerline bedding where the line crosses Silver Bow Creek (PZ-1). In addition, seven of the nine monitoring wells installed by ARCO in the vicinity of the southeast infiltration gallery were also sampled. These included GW-20C, GW-21, GW-22, GW-23A, GW-23B, GW-24 and GW-25. The off-site wells sampled during Round 3 consisted of 12 monitoring wells in and adjacent to the Colorado Tailings area. These wells included GS-18, GS-22, GS-25, GS-26, CT-84-6, BMW-3A, BMW-5A, BMW-9A, N-1, NE-1, NE-2, and PW-GS-4. In addition, on-site wells W-2 and W-11 were sampled for dioxins/furans using a high resolution analytical method (USEPA Method 8290). The Round 3 sampling parameters for these wells is shown in Table 2-19.

2.2.6.1 Groundwater Sampling. Prior to each sampling event, all RI designated monitoring wells were measured for total depth, static water level, and the presence of any non-aqueous phase liquid layers (NAPL). An interface probe was used for this task. Water levels were measured to a surveyed mark on the PVC stickup of each well to an accuracy of 1/100th of a foot. Where floating NAPL layers were found (no sinking layers were present), the NAPL was measured for thickness. While recording depth to water and any NAPL information, the total depth of the well was also measured. The interface probe was decontaminated between wells with hexane and deionized water to avoid cross contamination.

To purge the monitoring wells, three casing volumes of water were removed from each well. During the purging process, consecutive measurements of pH, conductivity, and temperature of the purge water were recorded. Purging was considered complete when the consecutive readings of pH conductivity, and temperature stabilized to within 10 percent, and, three casing volumes of water were removed. All purge water was collected in buckets and disposed of in the influent chambers of the oil/water separators as approved by DHES.

During Round 1, all purging occurred with dedicated stainless steel bailers. It was agreed, by ARCO and DHES during the August 1990 data review meeting, that any well exhibiting NAPL during Round 2 would be purged and sampled with a peristaltic pump, using dedicated nalgene tubing to purge and Teflon tubing to sample. In this manner, mixing of the NAPL material within the water column would be minimized and a more representative sample collected.

With the exception of those wells exhibiting NAPL, sampling was performed with dedicated bottom filling bailers. Table 2-19 highlights the analytical parameters for groundwater samples from wells for all three rounds of the groundwater investigations.

As indicated on Table 2-19, 20 percent of the Round 1 and 2 wells were sampled for the TAL/TCL list of compounds (see the QAPP for TAL/TCL lists descriptions). Wells considered for TAL/TCL during Round 1 were W-4, W-5, W-8, W-13, and W-15 and for Round 2 were those wells listed for Round 1 plus GW-6, GW-15, and GW-17.

During Round 3 sampling a limited number of wells were sampled and analyzed for dioxins/furans using high resolution method 8290. These wells were W-2 and W-11.

Additional sampling considerations for the groundwater investigation were PCP screens and NAPL samples. The 14 wells enumerated in Section 2.2.3.2 for PCP screening were purged and is apparent on Figure 3-10 (July 1990) near either the southern or the southeastern infiltration galleries. To closely investigate the possibility of mounding, ARCO installed a number of monitoring wells in the immediate vicinity of the southeastern infiltration gallery. The June 6, 1991 data used to generate Figure 3-11 include water level measurements from these additional wells. The spacing and location of these additional wells allows a close-up view of the mounding which is occurring in this area (Figure 3-12). Figure 3-12, in combination with Figure 3-11, delineates the degree and extent of mounding in the area of the southeast infiltration gallery. The groundwater mounding investigation of the southeast infiltration gallery is further discussed in Section 3.7.

Three monitoring wells were screened totally within the lower, water-bearing, weathered bedrock zone. A potentiometric surface map based on these three data points has been developed and is shown in Figure 3-13. The direction of groundwater flow in this deep water bearing zone is to the northwest, similar to the shallow zone, and the gradient is approximately 0.005 ft/ft.

The results of vertical gradient measurement data collected as part of the November 1990 groundwater sampling event are given in Table 3-4. These measurements included three off-site (Lower Area One) well nests near Silver Bow Creek. The difference in water elevations for wells screened within the top of the alluvial aquifer and at the base of the alluvial aquifer was fairly consistent across the site. Measured groundwater elevations of the well nests indicated a downward vertical gradient, with the exception of well nests M-7/M-8, BMW-1A/1B and GS-17S/17D. The downward vertical gradients ranged from 0.0070 ft/ft to 0.03 ft/ft. The upward vertical gradients ranged from 0.002 ft/ft to 0.017 ft/ft. Water level measurements at the well nest formed by wells GW-2 and GW-3, which monitor the base of the alluvial aquifer and the weathered bedrock, respectively, showed a small downward vertical hydraulic gradient. Although there is generally a downward vertical gradient across the site, groundwater contamination is concentrated in the shallow portions of the alluvial aquifer as discussed in Section 4.3. Also, based on the information presented in Figures 4-12 and 4-13, some limited migration of dissolved contamination is occurring to the north side of Silver Bow Creek.

Preliminary results of samples collected under the Lower Area One investigations indicate PCP in some monitoring wells on the north side of Silver Bow Creek (ARCO, 1993). The extent of groundwater contamination in this area will need to be considered in the MPTP Feasibility Study and during implementation of remedial action at the site.

An evaluation of vertical groundwater flow of the MPTP site in relation to the LAO Operable Unit was conducted using groundwater elevations for well nests BMW-1A/B, GS-17S/D and GS-25/GS-25C. Groundwater elevation measurements were obtained from past reports. Each of these locations showed that wells within LAO were found to have a slight upward hydraulic gradient. Although these data were not collected at the same time as water levels at the MPTP site and were not collected from a single measurement episode, they do indicate that this is a regional groundwater discharge area. This evidence is supported by data gathered in the LAO investigation (Chen-Northern and CH2M Hill, 1990) which determined that Silver Bow Creek is a gaining stream, overall, within LAO.

In-situ rising and falling hydraulic conductivity tests (slug tests) were performed at 28 well locations across the site. Slug test data results provide information for the specific locations in which the tests are conducted. Slug test results do not provide information on the overall aquifer characteristics. The results of hydraulic conductivity testing are given in Table 3-5 and mapped on Figure 3-14.

Rising and falling head slug tests data analysis followed the method of Bower and Rice (1976) for an unconfined aquifer condition. Under ideal conditions, these two processes are entirely reciprocal. Deviations from the ideal include the screened/filter pack interval spanning the water table, allowing previously unsaturated material to accept some of an input slug. This situation occurred in wells GW-1, GW-5, GW-9, and GW-17; all others in which both types of slug tests were performed are screened entirely below water level. For the wells receiving both tests, the average permeability calculated for the slug in tests is 0.0034 cm/sec, and for slug out tests is 0.0037 cm/sec. There was no consistency to the difference in values; in some cases the input predominant chemical process involved the use of pentachlorophenol. Due to the chemical composition and physical properties of these chemicals, their release into the groundwater system had the potential to go into solution as well as form a separate, nonaqueous phase liquid (NAPL). A NAPL is described as "the physical and chemical differences between a hydrocarbon liquid and water which results in a physical interface between a mixture of the two liquids" (Huling and Weaver, 1991). NAPLs can generally be divided into two fractions, light (LNAPL) and dense (DNAPL), which describes the specific gravity of the liquid relative to water.

As discussed in Sections 2.2.3.3 and 2.2.6, water levels were measured at several monitoring well locations with an oil/water interface probe, during the groundwater sampling program, to determine the presence of distinct phases of hydrocarbon fluid. A floating product (LNAPL) was evident in 8 of the 39 site monitoring wells measured (Table 3-8). In all of the wells where NAPLs were detected, only a light oil (floating) phase was observed. A dense NAPL has not been measured historically, and evidence gathered during the RI did not indicate the existence of a DNAPL phase. Historically, LNAPL has been observed in several monitoring wells as well as at creek seeps. The LNAPL was found to contain wood treating chemicals as well as petroleum hydrocarbons.

A review of LNAPL thickness collected by the MBMG (Table 3-8) indicates that hydrocarbon thicknesses have generally decreased between the period between 1986 and 1991. This decrease may be associated with the removal of approximately 12,000 gallons of NAPLs, to date, by the on-site groundwater recovery systems. LNAPL thickness ranged from less than 0.01 feet (wells W-2, GW-11, and GW-16) to 2.19 feet (well W-8). Based on the locations of wells which contain product, boring logs, seep locations and professional judgement, the LNAPL plume is configured as represented in Figure 3-15. Some seeps of this NAPL into Silver Bow Creek are also present (Figure 2-3). Product thickness measurements for wells containing product are provided in Appendix A.

Several monitoring wells within this inferred NAPL plume area (Figure 3-15) have never been observed to contain a floating hydrocarbon layer (wells W-3, W-6, M-6-87, M-7-87, M-8-87), while other wells (W-2 and W-10) have intermittently been shown to contain a floating hydrocarbon layer. This indicates that preferential pathways of NAPL flow may exist. These preferential pathways cannot be delineated from the existing data. Therefore, for the purposes representation of the NAPL plume, Figure 3-15 indicates continuity of the plume.

It should be noted that the measurements presented in Table 3-3 are apparent thicknesses. An apparent thickness is not considered as a true or actual hydrocarbon thickness within the soil formation. This apparent thickness is caused by inflow into the well over time and the subsequent accumulation of hydrocarbon fluids around the well screen. According to Depastrovich (1979) and Kueper and McWhorter (1987), the difference between the apparent and true (formation) thickness is the result of the differences in capillary pressures and density of the fluids. These effects will be considered for calculation of LNAPL volumes in the forthcoming feasibility study report for the site.

3.7 GROUNDWATER INVESTIGATION OF THE SOUTHEAST INFILTRATION GALLERY

To determine the effects of the southeast infiltration gallery on local groundwater elevations, water levels were monitored over a period of 6 days at 5 minute intervals. During this period of time the southeast infiltration gallery, and the north groundwater recovery system which feeds it, operated normally and continuously. Automatic data-loggers were used to monitor water levels in the south wet well, which feeds the southeast infiltration gallery, and at monitoring wells GW-20A, GW-20B and GW-20C, which are located immediately adjacent to this infiltration gallery. Hourly groundwater level measurements were obtained manually at monitoring wells GW-1, GW-2, GW-4, GW-8, GW-21 and GW-22.

The groundwater elevations calculated from the data-logger and manual measurements are summarized in Tables 3-9 and 3-10. Figures 3-16, 3-17, and 3-18 show the groundwater elevations at the southern wet well and at the monitoring wells listed above. As shown in Figure

4.1 STORED PLANT PROCESS AND MISCELLANEOUS MATERIALS

This section discusses the analytical data generated from the liquids/sludges, removed soils and dismantled/stored equipment investigations.

4.1.1 Liquids/Sludges Investigation

The intent of sampling on-site liquids and sludges was to characterize the degree and type of contamination in these materials. Sampling was conducted as described in Section 2.2.5. Table 2-17 summarizes the information gathered during the liquids/sludges inventory. Table 4-1 lists the estimated volumes of oils and sluges stored on site. A summary of the range of concentrations of constituents of concern are presented in Table 4-2.

4.1.1.1 Aromatic Volatile Organic Compounds. Benzene, toluene, ethylbenzene, and xylenes (BTEX) are used to represent volatile organic compounds (VOCs) discussed in the following text.

The three samples of separator recovered oil showed BTEX concentrations of 146,100 μg/l for SO-T01, 304,000 μg/l for SO-T08, and 57,000 μg/l for SO-D10-19. Of the four samples of KPEG treated oils, only KO-D39 and KO-TO4 had BTEX concentrations above the method detection limits of 2.0 μg/l. Sample KO-D39 had a 34,300 μg/l BTEX concentration, and sample KO-TO4 had a 43,500 μg/l BTEX concentration. The two KPEG reagent sludge samples had BTEX concentrations of 60,000 mg/kg for KS-Comp 1 and 253,000 mg/kg for KS-Comp 2. The only sample taken of miscellaneous sludges, MS-D65, had BTEX concentrations of 27,000 mg/kg. The two miscellaneous liquid samples, MO-EMULS1 and MO-EMULS3, had BTEX concentrations of 321,800 μg/l and 42,100 μg/l, respectively.

Both phases of the mixed sludges and liquids were sampled. A total of five drums were considered. The oil phase BTEX concentrations ranged from 105,200 μg/l in drum MM-D64, to 390,000 μg/l in drum MM-D11. The sludge phase BTEX concentrations ranged from 86,000 μg/kg in drum MM-D34, to below the method detection limit of 2.0 μg/l in drums MM-D58 and MM-D64.

Volatile organic compounds are present in significant concentrations in all stored liquids and sludges, with the exception of some sludges, MM-D58 and MM-D64, and KPEG treated oils, KO-D36 and KO-D43.

4.1.1.2 TCL Semivolatile Organic Compounds. Pentachlorophenol (PCP) and polynuclear aromatic hydrocarbons (PAH) were the predominant constituents of the TCL semivolatiles. For the separator recovered oils, the PCP concentrations for SO-TO1, SO-TO8, and SO-D10-19 were 2,700 μg/l, 1,900 μg/l, and 2,300 μg/l, respectively. For the KPEG treated oils and KPEG reagent sludges PCP concentrations were below the method detection limits (5 to 10 mg/kg) for all samples. For the one miscellaneous sludge sample (MS-D65) the PCP concentration was 7,500 mg/kg. For the miscellaneous liquids, the PCP concentrations ranged from below the method detection limit to 160,000 μg/l. PCP concentrations were only found above the method detection limits in two drums of the five sampled for miscellaneous liquids mixed with sludges. Sample MM-D58 PCP concentrations were 11,000 μg/l and 6,500 mg/kg for the oil and sludge phases, respectively. Sample MM-D64 had PCP concentrations of 8,800 μg/l and 17,000 mg/kg for the oil and sludge phases, respectively.

The detected PAH concentrations reported under the TCL Semivolatile organic compound analysis (greater than the method detection limits which ranged from 250 mg/kg to 3,100 mg/kg) are generally attributed to the non-carcinogenic PAH compounds acenaphthylene, acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene and naphthalene. Carcinogenic PAH concentrations above method detection limits were limited. Samples MM-D58, KS-COMP1 and MM-D64 had chrysene concentrations of 520 mg/kg, 170 mg/kg and 650 mg/kg respectively. Sample MM-D58 had benzo(a)pyrene concentration of 150 mg/kg.

The separator recovered oils ranged in PAH concentration from 5,924 μg/l for SO-D10-19, to 5,710 μg/l for SO-TO8. KPEG treated oils had PAH concentrations ranging from 6,730 μg/l to 1,152 μg/l in KO-D43 and KO-D36, respectively. The KPEG reagent sludge PAH concentrations were 14,180 mg/kg for KS-Comp1 and 2,046 mg/kg for KS-Comp2. The one miscellaneous sludge sample, MS-D65, had a PAH concentration of 2,350 mg/kg. The miscellaneous liquids, MO-EMULS1 and MO-EMULS3, had PAH concentrations of 246,800 μg/l and 748,000 μg/l, respectively. The miscellaneous liquids mixed with sludges had PAH concentrations ranging from 6,220 μg/l for MM-D34 to 2,800 μg/l for MM-D64 for the liquid phase and from 13,380 mg/kg for MM-D34 to 3,520 mg/kg for MM-D58 in the sludge phase.

4.1.1.3 Metals and Corrosivity. The following locations were sampled for TCLP metals: MM-D11; MS-D65; KO-TO4; SO-D10-19; SO-TO1; and SO-TO8.

Sludge/oil samples analyzed for TCLP metals were less than detection limits for the TCLP metals concentrations, arsenic (100 μg/l), cadmium (10 μg/l), mercury (0.2 μg/l), lead (100 μg/l), and silver (10 μg/l). Barium ranged from 310 μg/l at MS-D65, to below 200 μg/l at SO-D10-19. Chromium concentrations were 1,630 μg/l and 11.5 μg/l in samples MM-D11 and MS-D65, respectively. Chromium concentrations in the remaining samples were below the method detection limits (10 μg/l). The metals barium and chromium in the TCLP extract were detected at concentrations less than the regulatory limits for hazardous waste designation, established by the USEPA (40 CFR Part 261). The regulatory limits are listed in Table 4-3.

Samples were analyzed for non CLP metals. All arsenic concentrations were below the method detection limit of 2 mg/kg. Cadmium concentrations ranged from 14 mg/kg at KS-Comp5 to below the method detection limit (4 to 5 mg/kg) for MM-D11 sludge phase, MM-D34 oil phase, MM-D18 sludge phase, MM-D58 sludge phase, SO-TO1, and SO-TO8. Chromium concentrations ranged from 720 mg/kg to below the method detection limits (6 to 10 mg/kg). Copper concentrations ranged from 290 mg/kg to below the method detection limit (5.3 to 50 mg/kg) at sample locations MS-D65, SO-D10-19, SO-TO1, and KO-TO4. Lead concentrations ranged from 1,200 mg/kg at locations SO-D10-19 and KO-TO4, to below method detection limits (10 mg/kg) at MM-D11 oil phase and MM-D34 oil phase. Zinc concentrations ranged from 250 mg/kg at MO-EMULS3, to below method detection limits (7 to 33 mg/kg).

Results of samples analyzed for corrosivity show that samples collected from KO-D43, KS-Comp2 and KS-Comp5 were found to be corrosive. The remaining samples were non-corrosive.

4.1.1.4 TCLP 8240/8270 Analyses. TCLP 8240/8270 analyses were conducted on selected samples that included: MM-D11, MS-D65, KO-T04, SO-D10-19, SS-D99, SO-T01 and SO-T08.

Results from the TCLP 8240 analyses indicate that all parameters were less than the detection limits of 200 μg/l and 400 μg/l. One sludge sample (MM-D11) had higher detection limits of 200,000 μg/l and 400,000 μg/l. The TCLP extract regulatory limits are listed in Table 4-3.

Results from the TCLP 8270 analyses indicated that samples MS-D65, SO-D10-19 and SO-D99 had concentrations of 2,4,6-trichlorophenol of 964 μg/l, 128,000 μg/l, and 497 μg/l, respectively. These same samples had concentrations of pentachlorophenol of 14,300 μg/l, below method detection limit (510,000 μg/l), and 4,920 μg/l respectively. The high detection limit of 510,000 μg/l may be due to dilution of the sample required because of matrix interferences.

4.1.1.5 TCL Pesticides/PCB. Pesticide/PCB data were, for the most part, below the method detection limits. For the pesticides analysis, only aldrin and 4,4-DDT were detected above method detection limits (7.5 mg/kg to 75.0 mg/kg). For sample MM-D18, aldrin concentrations were found at 24.00 mg/kg and 29.00 mg/kg in the oil and sludge phases, respectively. The aldrin concentration for samples KO-D39 and KO-D43 were 9.39 mg/kg and 3.40 mg/kg, respectively. For separator oil recovered samples SO-TO1 and SO-TO8, the aldrin concentrations were 1.30 mg/kg and 1.00 mg/kg, respectively. For the oil phase of MM-D34, the aldrin concentration was 2.00 mg/kg. The compound 4,4-DDT was found in the separator recovered oil samples SO-TO1, SO-TO8, and SO-D 10-19 at concentrations of 3.00 mg/kg, 3.10 mg/kg, and 2.40 mg/kg, respectively.

4.1.1.6 TCLP Pesticides/Herbicides. Samples were analyzed for TCLP pesticides/ herbicides. Pesticides were less than the detection limit for Lindane (4.06 to 25.8 μg/l), endrin, (1 to 532 μg/l), chlorodane (5 to 2,660 μg/l) and toxaphene (51.5 to 5,320 μg/l) for all samples analyzed. Heptachlor was quantified in samples K0-T04 and S0-T08 at 27.4 μg/l and <99 μg/l, respectively. Heptachlor epox was quantified in samples KO-T04 and SO-T08 at 2.43 and 299 μg/l, respectively. Methoxychlor was quantified on one sample (KO-T04) at 6.62 μg/l.

Herbicide 2,4-D was not quantified in any of the samples at detection limits 1.01 to 100 μg/l. Herbicide 2,4,-TP (silvex) was quantified in samples collected from MM-D11 (0.149 μg/l), SO-D99 (6.5 mg/l) and SO-T01 (9.78 μg/l).

4.1.1.7 Dioxins. The concentrations of dioxins varied with the sample and congener type (Table 4-4). Concentrations of 2,3,7,8-TCDD were below the method detection limits (0.08 to 0.3 ppb) for the five samples that were analyzed. Octachloro-dibenzo dioxin ranged from 92,870 ppb for MO-EMULS3, to 37.5 ppb for MM-D11 oil phase. Total pentachloro-dibenzo dioxins (PeCDD) ranged from 26.8 ppb for MS-D65, to below the method detection limit of 0.1 ppb for sample MM-D11 oil phase and of 0.4 ppb for sludge phase. Total hexachloro-dibenzo dioxins (HxCDD) ranged from 1,100 ppb for sample MS-D65 to 0.55 ppb for sample MM-D11 oil phase. Total heptachloro-dibenzo (HpCDD) dioxin concentrations ranged from 16,290 ppb for sample MO-EMULS1, to 17.1 ppb for sample MM-D11 oil phase.

Concentrations of 2,3,7,8-TCDF ranged from 13.0 ppb for sample MS-D65, to below the method detection limit of 0.05 ppb for samples MM-D11 for oil phase and 0.2 ppb for sludge phase. Octachloro-dibenzo furan ranged from 5,790 ppb for MO-EMULS3, to 0.45 for MM-D11 oil phase. Total pentachloro-dibenzo furan (PeCDF) concentrations ranged from 591 ppb for sample MS-D65 to 3.6 ppb for sample MM-D11 sludge phase. Total hexachloro-dibenzo furan

(HxCDF) concentrations ranged from 2,580 ppb for sample MO-EMULS3 to 1.0 ppb for sample MM-D11 oil phase. Total heptachloro-dibenzo furan (HpCDF) concentrations ranged from 5,442 ppb for sample MO-EMULS3 to 0.61 ppb for sample MM-D11 oil phase.

Nine samples were extracted according to TCLP procedures, and the resultant extracts were analyzed for dioxins/furans. Of the extracts analyzed for 2,3,7,8-TCDD, all sample locations were below the method detection limits ranging from 0.3 ppt to 2.0 ppt. Octachloro-dibenzo dioxin ranged from 347,780 ppt for sample MO-EMULS1, to below the method detection limits ranging from 3.1 ppb to 7.0 ppt for MM-D11 oil phase KO-T04 and SO-T08. The concentrations of octachloro-dibenzo dioxin for the SO-D10-19 and SO-T01 samples are considered unusable data. Total PeCDD concentrations ranged from 31.2 ppt for sample SO-D10-19, to below the method detection limits of 0.4 ppb, 0.1 ppb, and 2.2 ppt for MM-D11 sludge phase, MM-D11 oil phase, and KO-TO4. The concentration of total PeCDD for the MO-EMUL5 sample was 15.9 ppb. Total HxCDD concentrations ranged from 8,710 ppt for sample SO-TO1 to below the method detection limits of 0.02 ppb and 2.2 ppt for MM-D11 oil phase and KO-TO4. The concentration of total HxCDD for the MM-D11 sludge phase sample was 8.8 ppb. Total HpCDD concentrations ranged from 126,970 ppt for sample MO-EMULS1, to below the method detection limits of 0.54 ppb and 7.8 ppt for samples MM-D11 oil phase and KO-TO4. Concentrations of TCLP extracted 2,3,7,8-TCDF ranged from 54.9 ppt for sample SO-TO8, to below the method detection limits of 0.4 ppt and 0.5 ppt, respectively, for samples MM-D11 and KO-TO4. Octachloro-dibenzo furan ranged from 26,320 ppt for sample MO-EMULS1, to below the method detection limits of 0.08 ppb and 5.2 ppt for MM-D11 oil phase and KO-TO4. The concentrations of octachloro-dibenzo furan for the SO-D10-19, SO-TO1, and SO-TO8 samples are considered unuseable data. Total PeCDF concentrations ranged from 1,070 ppt for sample MO-EMULS1, to below the method detection limits of 3.6 ppb, 0.02 ppb and 1.3 ppt for samples MM-D11 sludge phase, MM-D11 oil phase, and KO-TO4, respectively. Total HxCDF concentrations ranged from 36,276 ppt for sample SO-TO8 to below the method detection limits of 0.02 ppb and 1.9 ppt for samples MM-D11 oil phase and KO-TO4, respectively. Total HpCDF concentrations ranged from 38,870 ppt for sample SO-TO8 to below the method detection limit of 3.0 ppt for sample KO-TO4.

hydrocarbons towards the tops of the soil bags. However, the other organics (i.e., phenols, PAHs, and VOCs) did not exhibit this tendency.

TPH concentrations in the top sample in each of the four stratified soil bags ranged from a high of 23,600 mg/kg in building three, to a low of 2,200 mg/kg in building two. The low TPH concentrations in the bottoms of the four stratified bags ranged from 4,450 mg/kg in building three, to below method detection limits in building four.

The soil sample from building one showed a high TPH concentration of 9,960 mg/kg (middle), to 9,540 mg/kg (bottom), and the lowest concentration of 8,570 mg/kg (top). These levels are similar, indicating that there is no vertical chemical stratification within the bags.

4.1.2.5 CLP Metals and Non CLP Metals. Samples for metals analyses were collected at the same locations as the dioxin/furans (i.e., bottom of building three soil bag and a composite of all sample locations). The metals were sampled for TCLP as well as total metals concentrations. The TCLP extracted metals were below method detection limits for all metals except arsenic, barium, and cadmium. Arsenic TCLP concentration were 118 μg/l and 112 μg/l for the composite and building three bottom sample, respectively. Barium TCLP concentrations were 1,080 μg/l and 1,560 μg/l for the composite and building three bottom sample, respectively. Cadmium TCLP concentrations were 12.5 μg/l and 11.7 μg/l for the composite and building three bottom sample, respectively. These TCLP metals concentrations are less than the USEPA established (40 CFR Part 261) TCLP regulatory limits of 5,000 μg/l for arsenic, 100,000 μg/l for barium, and 1,000 μg/l for cadmium.

Maximum total metals concentrations measured were 183,000 μg/kg for copper, and 644 μg/kg for cadmium, in the building three bottom sample. In the composite sample, maximum total metals concentrations measured were 194,000 μg/kg for zinc and 742 μg/kg for cadmium.

4.1.2.6 Dioxins. Dioxins and furans were sampled in building three at the bottom of the bag (visibly worst case) and as a composite of all sample locations. Analytical results are summarized in Table 4-7. Concentrations for 2,3,7,8-TCDD were below the method detection limits of 0.04 ppb and 0.06 ppb for both samples. Total PeCDD concentrations were 0.21 ppb for the composite and below the method detection limits of 0.09 ppb for building three bottom sample. Total HxCDD concentrations were 39.6 ppb for the composite and 34.8 ppb for building three bottom. Total HpCDD concentrations were 629 ppb for the composite and 482 ppb for building three bottom.

For the furans, total TCDF concentrations were 0.5 ppb for the composite and 0.11 ppb for building three bottom. Total PeCDF concentrations were 13.3 ppb for the composite sample and 12.1 ppb for building three bottom. Total HxCDF concentrations were 102 ppb for the composite and 99.9 ppb for building three bottom. Total HpCDF concentrations were 202 ppb for the composite and 170 ppb for building three bottom. Total TCDD equivalent concentrations ranged from 2.12 to 9.45 ppb.

4.1.3 Dismantled/Stored Equipment Investigation

Wipe samples of dismantled/stored equipment were taken as described in Section 2.2.7. Phenols, PAHs, and dioxin/furans were the analytical parameters of interest for this investigation. HNu readings were also performed to assess the presence of any volatile organic compounds. All readings were at or very near background. Field notes for this investigation are found in Appendix B3.

4.1.3.1 Phenolics. Analytical results for the phenolics indicate that PCP was the predominant compound quantified. The second round sampling event indicated PCP concentrations for the wipe samples collected before cleaning were 3.09 μg/wipe for the large pipe, 317 μg/wipe for the steel tank, and 179.82 μg/wipe for the nickel tank. The large pipe wipe sample after steam cleaning had a 6.05 μg/wipe PCP concentration. Wipe sample results from the steam cleaned and pre-steam cleaned large pipe are very similar (i.e., 3.90 μg/wipe pre-steam cleaned and 6.05 μg/wipe steam cleaned).

4.2.1.2 Backhoe Test Pit Soils. A series of 15 backhoe test pits were excavated from within and around the former process area. Only 11 of the pits were sampled. SL203C, SL204C, SL210C, and SL213C were not sampled because there was no visible sign of contamination. One test pit was excavated and sampled in the northern portion of the site. Test pits were excavated to variable depths based on the position of the water table and field observations. Analytical results are presented in Figures 4-3.

PCP concentrations measured from surficial test pit samples were found to range from 3,100 μg/kg (SL-207-C) to 743,000 μg/kg (SL-212-C). Generally, the lowest PCP concentrations were found at perimeter locations. Test pit data, both within and along the perimeter of the excavated portion of the former process area show concentrations at depths similar to the range of PCP concentrations for the bagged (removed) soils. Bagged soils had PCP concentrations ranging from 171,000 μg/kg (building two top), to 1,450,000 μg/kg (building five top). At 0 to 3 feet, test pits SL-212-C and SL-201-C had PCP concentrations of 743,000 μg/kg and 500,000 μg/kg, respectively.

As indicated for PCP, the TPH data for the test pits and removed soils correlate. Removed soils TPH data ranged from below the method detection limits, to 23,600 mg/kg (building three top) for fuel oil #4 (Table 4-6). Test pit analytical data indicates the presence of fuel oils #4 and #6. At 0 to 0.5 feet, test pits SL-206-C and SL-215-C had TPH concentrations of 3,470 mg/kg and 4,300 mg/kg, respectively (Figure 4-3).

During the round 3 investigation, test pits were dug in a potential debris and waste disposal area in the western portion of the site (Figure 4-1). Although no samples were collected for laboratory analysis, historical information indicates that process sludge and other wastes may have been disposed of in this location. Odorous and visible contamination and elevated HNu readings were documented in this area during the round 3 investigation. This area will need to be further evaluated and appropriately addressed during remedial action, and will be further discussed in the FS.

4.2.1.3 Stained and Opportunistic Soil Samples. A series of 17 samples were collected from a depth interval of 0 to 6 inches from surface soils which displayed visual evidence of contamination. As discussed previously in Section 2.2.4, each of these samples was analyzed for PCP and TPH. Results of these analyses are presented on Figure 4-3.

PCP was detected in each of the 17 sample locations, with concentrations ranging from 141 μg/kg (sample SL-001-A) to 1,510,000 μg/kg (sample SL-011-A). The majority of hydrocarbons were not detected in the stained soil samples. However, fuel oil #4 was detected in 9 of the 17 samples.

Supplemental surface soil samples 301, 302, 303 and 304 contain PCP concentrations ranging from below detection limits (110 μg/kg to 430 μg/kg) to 139 μg/kg. TPH concentrations were below detection limits of 34.9 mg/kg to 717 mg/kg for all samples. PAH concentrations range from 59.38 μg/kg to 469.3 μg/kg and are shown on Figure 4-6. BTEX concentrations range from below detection limits (3.1 μg/kg to 6.8 μg/kg) to 1.4 μg/kg and are shown on Figure 4-7.

4.2.1.4 Surface Grids. As discussed in Section 2.2.4, two surface soil grids were oriented over the eastern and western treated wood storage yards. Samples were collected from a 0 to 6-inch interval and analyzed for pentachlorophenol and TPH. Results of this sampling are shown on Figure 4-3.

With the exception of sample locations SL-W15, SL-W16, SL-W3, and SL-W4, pentachlorophenol concentrations measured within the western treated wood storage yard were generally below 1,000 μg/kg. The highest PCP concentrations were measured in surface soil sample SL-W15 (144,000 μg/kg). Sample SL-W16, located 200 feet further west, showed a concentration of 7,740 μg/kg. Due to the PCP concentration measured in sample SL-W16, an additional three surface soil samples were collected in November 1990. The purpose of these samples was to define the western limit of PCP. These three samples (SL-W21, SL-W22 and SL-W23) had PCP concentrations of 56 μg/kg, 150 μg/kg and less than 11 μg/kg respectively. Samples SL-W3 and SL-W4, located along Greenwood Avenue, were found to have PCP concentrations of 1,190 μg/kg and 22,400 μg/kg, respectively. To find the southern boundary of PCP contaminated soil, three surface samples were collected from the southern side of Greenwood Avenue. PCP was detected in only one of these samples (SL-W28), at a concentration of 36.3 μg/kg. Samples SL-W24 and SL-W25 were both below detection limits (less than 11.1 μg/kg).

Pentachlorophenol was detected in each of the 27 surface soil grid samples collected over the east treated wood storage yard (Figure 4-1). Throughout this area, the majority of samples had PCP concentrations less than 1,000 μg/kg. Three areas were identified within the eastern storage yard as having PCP concentrations greater than 1,000 μg/kg. With the exception of several samples near the former wood treating process area, the two areas were limited to one individual sample having a concentration greater than 1,000 μg/kg rather than a group of samples. These samples are SL-E1 and SL-E7. Near the former wood treating operations, PCP concentrations ranged from 163 μg/kg (SL-E20) to 30,700 μg/kg (sample SL-E26).

Through the use of the hydrocarbon scan method, hydrocarbons were detected at one surface soil grid location only, which was located within the western treated wood storage yard. The hydrocarbon scan showed that surface sample SL-W4 showed a concentration of 1,370 mg/kg, and was composed only of fuel oil #6 (Figure 4-2).

These above results, in combination with the subsurface sample results discussed in Section 4.2.2, indicate that treated wood drippage contributed significantly less contamination to the site than did the process area and waste discharge drainage ditch discussed in subsequent sections.

4.2.1.5 Near Surface Soil Borings. Surface soil samples (0 to 2 foot interval) were collected from the soil borings. Boring locations are shown on Figure 4-1. These surface soil samples were analyzed for phenols, PAHs, TPH, VOCs, and metals. Dioxins/furan analysis was performed for only a limited number of samples. Dioxins, furans and metals results are discussed separately (Sections 4.2.3 and 4.2.4). PCP concentrations in the near surface soil borings were found to exceed 10,000 μg/kg in the former process area and along the historic drainage ditch (Figure 4.3). The maximum PCP concentration measured

1,160,000 μg/kg (A14) and was sampled in the northern portion of the site along the historic drainage ditch. The maximum PAH concentration measured was 2,304,320 μg/kg (A13) and was found in the northern portion of the site along the historic drainage ditch (Figure 4-4). Elevated TPH concentrations (greater than 10 mg/kg) in near surface soil borings were found in the former process area and north of Interstates 15/90 (Figure 4-3). The maximum TPH concentration was 55,600 mg/kg (A13) and was sampled within the former process area. The maximum BTEX concentration measured was 2,400 μg/kg (GW3/A,B) and was sampled from the former process area (Figure 4-7). Near surface soil boring results indicate elevated concentrations of the contaminants of concern in the former process area and along the historic drainage ditch.

4.2.1.6 Summary of Surface Soils Sampling Results. As presented in Sections 4.2.1.1 through 4.2.1.5, surface soil samples were collected from various areas of the site using several different sampling methods. Figure 4-3 shows areas of the site which contain surface soils contaminated with greater than 15,000 μg/kg of PCP and 100 mg/kg of TPH. The values 15,000 μg/kg and 100 mg/kg were chosen for illustrative purposes only. Actual cleanup criteria will be based on risk calculations for PCP and other contaminants of concern, and regulatory considerations. PAH analyses were conducted only on boring samples (see Section 4.2.1.5). Dioxins/furans and metals are discussed in Sections 4.2.3 and 4.2.4.

4.2.2 Subsurface Soils

Analytical data for the subsurface soil samples collected from the four areas of the site are shown in Figures 4-4 through 4-7. The concentration ranges for the constituents of concern are summarized on Table 4-10. Subsurface soils in this study are defined as those collected from below the surface 0-2' boring interval and from below the surface (0-3') backhoe/test pit sample interval. This includes areas above and below the water table. As discussed in Section 2.2.4, subsurface soil samples were collected from 36 locations throughout the site identified as A-1 through A-27 and B-1 through B-8 and B-11. The B-1 through B-8 and B-11 locations were selected where elevated concentrations of PCP were known or previously detected in surface soil samples to collect information on stratification of the contamination at these locations.

The following sections discuss the concentrations of PCP, PAHs, TPH and BTEX detected in subsurface soil samples at the site. A discussion of dioxin/furan sampling results is found in Section 4.2.3. A discussion of metals sampling results is found in Section 4.2.4.

4.2.2.1 Wood Treatment Process Area. A total of 6 subsurface borings, A-8, A-16, A-19, A-20, A-21 and A-22, and 7 subsurface backhoe test pits (below the 0-3 foot interval) were completed within the former process area of the site (Figures 4-4 and 4-7). PCP results generally indicate elevated PCP concentrations (up to 593,000 μg/kg) in process area subsurface soils, extending to about 18 feet below surface (Figure 4-4). The water table is at approximately 10 feet. PCP concentrations below 18 feet decrease rapidly with depth. At A-8 a concentration of 1,850 μg/kg was detected at the interval of 41-43 feet, which is at the weathered bedrock surface. PCP concentrations for weathered bedrock samples at A-16 and A-21 were less than 116 μg/kg. LNAPLs were observed during the subsurface investigation in this area of the site (see boring logs and test pit field notes in Appendix F3 and Appendix B1). There was no evidence of oily product or DNAPLs (dense non-aqueous phase liquids) in the borings at the weathered bedrock surface.

Similar trends were noted for hydrocarbon (Figure 4-5) and total PAH distributions (Figure 4-6). BTEX concentrations were less stratified, and ranged from 2,422 μg/kg (41 to 43 feet) (GW3/A,B) to 4,390 μg/kg (6 to 8 feet) (GW3/A,B) (Figure 4-7).

The above results support indications that contamination is generally associated with the oily wood treating product, which was released at the surface, spread through and contaminated subsurface vadose zone soils and is floating and moving as a layer on the water table. In support of this information, groundwater contamination is also concentrated in the upper reaches of the shallow aquifer on the site (see Section 4.3).

4.2.2.2 Eastern Treated Wood Storage Yard. A total of 10 subsurface borings were completed in the eastern treated wood storage yard at locations A-7, A-9, A-10, A-11, A-17, A-18, B-1, B-2, B-3, and B-4. Pentachlorophenol concentrations measured in the subsurface soils located within this area were all below detection limits. Hydrocarbons concentrations measured in the subsurface soils located within this area were all below detection limits.

Total PAH concentrations were quantified at A-17 and A-18 below the water table. Total PAH concentrations were 62.5 μg/kg at A-18 (40 to 44 feet). PAH concentrations are shown on Figure 4-6.

The BTEX constituents were generally detected in only two boring locations (A-8 and A-16), both of which are located in close proximity to the former process area. However, BTEX was detected in each sample at depth rather than being limited to surficial samples as is the case for the other organic contaminants. BTEX concentrations are mapped on Figure 4-7.

Soil contamination in the eastern treated wood storage yard is essentially limited to surface soils (see Section 4.2.1).

4.2.2.3 Western Treated Wood Storage Yard. A total of 11 subsurface borings were completed in the western treated wood storage yard. These include boring numbers A-1, A-6, A-23, A-24, A-25, A-26, A-27, B-5, B-6, B-7 and B-8 (Figure 4-1).

Detectable levels of pentachlorophenol in the western treated wood storage yard subsurface soils were limited to locations B-6 and A-25. Subsurface soil sample B-6, which was located within an area of the site where a light oil component has been consistently measured in the nearby W-8 monitoring well, was found to have a PCP concentration of 2,290 μg/kg at the 12-14 foot interval. This elevated concentration is considered to be the result of a free oil layer which has migrated along the groundwater surface to this location from the process area, rather than a result from direct contamination from surface soils at this location. 179 μg/kg of PCP, a low concentration in comparison to process area soil levels, was measured in A-25 at the interval 3-5 feet. PCP concentrations measured in other subsurface samples collected were all below detection limits.

Hydrocarbons concentrations measured in the subsurface soils located within this area were all below detection limits.

The distribution of total PAHs is similar to that observed for PCP. The 12-14 foot interval of B-6 had a concentration of 4,904 μg/kg. PAH concentrations in the 3-5 foot interval of A-23, A-25, A-26 and A-27 ranged from 12.5 μg/kg to 116 μg/kg. All other subsurface samples in this area were below detection limits (Figure 4-6).

Low level BTEX constituents were detected in four of the subsurface boring locations in this area as shown on Figure 4-7.

4.2.2.4 Northern Area. A total of 9 subsurface borings were completed in the northern area. These are soil sample locations A-2, A-3, A-4, A-5, A-12, A-13, A-14, A-15 and B-11 (Figure 4-1). Samples A-2, A-4, and A-14 were each located within the historic drainage ditch which runs through the site.

Pentachlorophenol was detected in subsurface samples from borings A-2, A-3, A-4, A-12, A-13, A-14 and A-15 and appears to be associated with the historic drainage ditch and with LNAPL floating on the groundwater. Data from these borings indicate high concentrations of PCP (up to 300,000 μg/kg) to a depth of about eight feet which is approximately two feet below the groundwater table. Data from A-13, A-14 and A-15 indicate that below approximately eight feet, concentrations of PCP are much lower (Figure 4-4).

Data from boring A-13 showed a relatively low level of PCP at the surface (108 μg/kg) and a relatively high level of 88,200 μg/kg near groundwater (2 to 6 foot interval). Other borings in the northern area indicate relatively high concentrations of PCP at the surface in addition to near the groundwater table. The data are not extensive enough to clearly define contamination stratification patterns in the northern area. It will be important to collect additional samples during remedial action to ensure that all soils requiring remediation are addressed, and that clean soils can be segregated.

PCP concentrations at the top of the weathered bedrock, from 28 to 36 feet, ranged from below detection limits of 36.8 μg/kg (boring A-2) to 192 μg/kg (boring A-14). As with the former process area of the site, there was no evidence of oily product or DNAPLs in samples at the weathered bedrock surface. PCP was not detected in subsurface samples of boring A-5, which is located along the eastern boundary of the site, nor in subsurface samples of A-12, which is located along the western boundary of the site.

Total hydrocarbons were detected in six borings at depths less than 8 feet and followed a pattern similar to PCP. Concentrations were found to decrease with depth below the water table, with no hydrocarbons being detected at the interval above the weathered bedrock surface. Concentrations ranged from less than 36.1 mg/kg to 55,600 mg/kg. The concentration 55,600 mg/kg was detected in a surface soil sample. No hydrocarbons were detected in any of the samples collected from borings A-5 or A-12 (Figure 4-5).

PAHs were detected in each of the 8 subsurface borings within the northern area and concentrations ranged from 3.5 to 364,500 μg/kg (Figure 4-6). These concentrations decrease with depth in a pattern similar to that found for PCP.

BTEX constituents were detected in all of the subsurface boring locations in this area except for A-5. Concentrations, ranging from below detection limits (approximately 2 μg/kg) to 1,390 μg/kg, followed a stratigraphic pattern similar to PCP (Figure 4-7).

4.2.2.5 Subsurface Soils Analysis Summary. As presented in Sections 4.2.2.1 through 4.2.2.4, subsurface soil samples were collected from various areas of the site using two different sampling methods, borings and backhoe pits. Figure 4-8 shows a plan view of the site with cross-section A-A', B-B', and C-C' locations. These cross-sections, shown in Figures 4-9, 4-10 and 4-11, delineate subsurface PCP contamination. The most heavily contaminated subsurface soils (PCP) are located near and above the groundwater surface. Stratifications of PAH, TPH, and VOC concentrations generally correlate with PCP stratification, and are discussed individually in the above sections. Dioxins/furans and metals are discussed in Sections 4.2.3 and 4.2.4.

4.2.3 Dioxin/Furan Analysis

A total of 12 surface and subsurface soil samples were collected from selected boring intervals and analyzed for dioxins/furans (Table 4-9). Two samples from the northern site area contained detectable concentrations of 2,3,7,8-TCDD. Interval 0 to 2 feet in boring A-14 had a concentration of 10.6 ng/kg (ppt). Interval 8 to 12 feet in boring A-16 measured 3.8 ng/kg (ppt). Total 2,3,7,8-TCDD equivalent concentrations provided in Table 4-9 ranged from 0 to 16 ppb. All data summary tables are located in Appendix L.

4.2.4 Metals Analysis

A total of 86 soil samples consisting of 24 surface and 62 subsurface soil samples were collected from selected boring intervals and analyzed for arsenic, cadmium, chromium, copper, lead, and zinc. Elevated levels of these metals were found in samples near Silver Bow Creek and near the eastern railroad right-of-way. Elevated concentrations of metals at the site, above naturally occurring background levels, are considered to be related to historic mining operations in the vicinity of the site, rather than MPTP related activities.

The arsenic concentrations detected in the soil samples collected from the 0 to 2 foot depth interval ranged from 3,620 μg/kg in A25 to 356,000 μg/kg in A12. The cadmium concentrations ranged from 214 μg/kg in A23 to 3,310 μg/kg in A4. The chromium concentrations ranged from 4,640 μg/kg in A15 to 15,000 μg/kg in A24. The copper concentrations ranged from 23,800 μg/kg in A23 to 1,140,000 μg/kg in A12. The lead concentrations ranged from 6,620 μg/kg in A23 to 264,000 μg/kg in A12. The zinc concentrations ranged from 42,200 μg/kg in A23 to 1,720,000 μg/kg in A4.

Subsurface samples were collected to a depth of 41 feet. The concentrations of Ar, Cd, Cr, Cu, Pb, and Zn detected in the subsurface soil samples have no discernible stratification. The maximum concentration of arsenic (220,000 μg/kg) was found in the soil sample collected at the 29 to 32 foot interval in the A12 soil boring. The maximum concentration of cadmium (3,270

μg/kg) was detected in the soil samples collected from the A4 boring at the 6 to 8 foot interval. The maximum concentration of chromium (22,700 μg/kg) was found in the soil sample collected at the 3 to 5 foot interval in soil boring A24. The maximum concentration of lead (1,280,000 μg/kg) was found in the 29 to 32 foot interval sample collected from soil boring A12. The maximum concentration of zinc (1,720,000 μg/kg) detected was found in the soil sample collected at the 6 to 8 foot interval in soil boring A6.

4.3 GROUNDWATER QUALITY

As described in Section 2.2.6 and Section 2.2.10, a total of 52 on-site monitoring wells, 16 off-site monitoring wells, and 2 off-site private wells (Figure 4-2) were used to generate groundwater quality information for the site and general vicinity. The 16 off-site wells were located within the LAO Operable Unit. Each of the off-site wells is screened within some interval of the alluvial aquifer. Well logs are provided in Appendix F3.

Groundwater concentrations of various organic and inorganic parameters are discussed in the following sections and summarized in Table 4-12. The objective of the sampling program was to provide a chemical characterization of the groundwater at the former wood treating site, determine the interaction between surface water quality and groundwater quality, and determine the extent of groundwater contamination. To facilitate the description of the nature and extent of the groundwater constituents within the area investigated, the site is divided into two areas (northern and southern areas). These areas were chosen due to the physical separation of the site via Interstate 15/90 as well as the distinctive processes or lack of processes which took place in these respective areas. Although the boundaries of the site extend to Silver Bow Creek, the 16 off-site monitoring wells (located within Lower Area One) are discussed within the overall context of the northern area.

The group of wells which are located within the Mount Moriah Cemetery (Figure 2-13) are considered to be upgradient of the site and representative of background conditions.

μg/l and less than 1.0 μg/l. Wells M-8, M-7, and M-6 which are screened at 4 to 9 feet, 18.5 to 21 feet and 32.5 to 35 feet, respectively, were found to have concentrations of 5,050 μg/l, 667 μg/l, and less than 20.8 μg/l during round 1 sampling. Similar decreases in PCP concentrations with depth are also noted in well nests downgradient from elevated wells. A concentration of 13,900 μg/l was observed in shallow well W-2 while the adjacent deeper well (GW-18) PCP concentration was below the detection limit (less than 1.0 μg/l); PCP concentrations in shallow wells M-4-87 and M-5-87 were 177 μg/l and 294 μg/l while the concentration observed in deeper well GW-19 was below the detection limit. A summary of monitor well construction data is presented in Table 2-11. The above information indicates that the most contaminated groundwater is within the shallow depths of the alluvial aquifer.

During the second round sampling program (fall 1990), a total of 9 off-site monitoring wells were sampled for PCP using a screening method (Keystone 589). Concentrations of PCP were generally very low in these wells and ranged from less than 1.0 μg/l (wells BMW-1A, BMW-9A, GS-17 and GS-34) to 21.1 μg/l (well GS-25) (Figures 4-12, 4-13, and 4-14). As a follow-up to the screening, the majority of wells which showed a detectable concentration of PCP were resampled in the spring of 1991 (round 3) using USEPA Method 8040. With the exception of wells NE-1 and N-1, PCP was below detection limits in each of the off-site wells. Concentrations of 15.9 μg/l and 1.5 μg/l were noted in monitoring wells NE-1 and N-1, respectively (Figure 4-14 and Table 4-13).

The LAO monitoring well data indicate PCP contamination dissolved in the goundwater is migrating past Silver Bow Creek and that the contamination that reaches the Silver Bow Creek system is significantly diluted contamination as it migrates downstream.

Pentachlorophenol was not detected in either the Mount Moriah Cemetery irrigation well composite (upgradient), or the Bontempo residential well north of Silver Bow Creek (Figures 4-12 and 4-13). These data are presented in Appendix L.

The PCP isopleths contoured for the site are shown in Figure 4-12. The isopleths were developed using data from rounds 1 through 3. As shown on this figure, the overall PCP plume is delineated by the 1 μg/l concentration isopleth. The plume boundary is delineated by Silver Bow Creek on the north, wells GW-4, GW-10 and GW-17 on the east, W-16 and GW-8 on the south, and GW-26, GW-27, GW-9, GW-12, and GW-6 on the west. Interior plumes delineating areas with greater concentrations are also shown. LNAPLs floating on the groundwater surface are discussed in Section 3.6.2.3, and Figure 3-15s a graphical representation of the inferred LNAPL plume.

Figure 4-15 displays the PCP concentration with respect to depth and site stratigraphy in a south to north orientation. As previously discussed, concentrations of PCP were highest in the shallow wells which intersect the water table surface. From this cross-sectional view, it can been seen that the PCP plume is limited in depth. Although the high concentration of PCP detected at well W-4 is shown to extend over the long well screen length, it is believed that this value is representative of the screened section which intersects the water table.

4.3.3.1 Dioxin/Furans. During round 3, groundwater samples were collected for dioxin/furan analysis from wells W-2 and W-11. Total 2,3,7,8-TCDD equivalent concentration for W-2 was 13.07 ppt and 53.70 ppt for well W-11. Dioxin/furan analytical results are provided in Table 4-11.

4.3.4 Hydrocarbon Scan

The hydrocarbon scan was used to determine if one or more hydrocarbon fractions were present within the groundwater system. With few exceptions, the predominant hydrocarbon detected within groundwater samples was fuel oil #4. However, for the purposes of mapping the individual concentrations of the various hydrocarbons at a well location, as well as graphically displaying the hydrocarbon plume, a value for total hydrocarbons is presented. This value was obtained by summing each of the six hydrocarbons detected using the testing method. An estimated plume map for TPH is shown in Figure 4-16. Figures 4-17 and 4-18 provide the hydrocarbon scan results of sampling rounds 1, 2 and 3.

Within the former process area of the site (southern area), the concentration of total hydrocarbons was the most elevated in wells W-15 (6,500 mg/l) W-13 (911 mg/l), and W-8 (192 mg/l) which also have floating product in them. Well W-15 is located within or adjacent to the retorts and associated work tanks, and thus most likely provides groundwater quality data directly representative of the former process area. Wells GW-1, GW-2 and GW-3, which are downgradient of well W-15, showed reduced hydrocarbon concentrations with depth of 37.1 mg/l, 2.58 mg/l and less than 0.1 mg/l, respectively. This suggests that hydrocarbons tend to migrate more within the horizontal plane than vertically, as discussed in Section 4.3.2 for pentachlorophenol.

Within the northern area, the highest concentrations of TPH were also measured in wells which have or continue to show the occurrence of an LNAPL (wells W-4 and W-5). The highest concentrations measured in these two wells was 639 and 4,250 mg/l, respectively. Total hydrocarbon concentrations in surrounding northern area wells ranged from less than 0.2 mg/l detection limits (wells M-7, W-3, GW-6, GW-12, GW-13, GW-14, GW-15, and GW-17, GW-18 and GW-19) to 16.7 mg/l (well W-10 - round 1).

Approximate boundary of the total hydrocarbon concentrations greater than 1.0 mg/l quantified during round 1, 2, and 3 are shown on Figure 4-16. TPH concentrations with respect to depth and site stratigraphy in a south to north orientation are shown in Figure 4-19. Hydrocarbons were not readily detected in deeper monitoring wells.

No hydrocarbons were detected in either the Mount Moriah Cemetery irrigation well composite (upgradient), or the Bontempo residential well north of Silver Bow Creek (Figure 4-18). These data are presented in Appendix L.

4.3.5 Polynuclear Aromatic Hydrocarbons

PAH constituents were detected in several of the monitoring wells at the site. Total PAH concentrations are shown on Figures 4-20 and 4-21.

In the southern area of the site the concentration of PAHs ranged from below detection limits (wells GW-3, GW-4, GW-7, GW-9, GW-10, GW-27 and W-16) to 3,668,691 μg/l (well W-8, round 1) (Figure 4-20).

In the northern area of the site concentrations of PAHs ranged from below detection limits (GW-18, GW-19, GW-17, GW-15, GS-18, BMW-9A, GS-25) to 559,208 μg/l (well W-4, round 1) (Figure 4-20).

PAH concentrations in wells W-4, W-5, W-8 and W-15 were considerably lower in round 2 samples than in round 1 samples (Figure 4-20). This decrease is considered to be due to an adjusted sampling procedure for round 2 to minimize the collection of NAPLs with the water sample.

No PAHs were detected in either the Mount Moriah Cemetery irrigation well composite (upgradient), or the Bontempo residential well north of Silver Bow Creek (Figure 4-21). These data are presented in Appendix L.

Approximate boundary of the total PAH concentrations greater than 1 μg/l quantified during rounds 1, 2, and 3 are shown on Figure 4-22.

Figure 4-23 displays the concentration of PAHs with respect to the overall site stratigraphy. The distribution of PAHs is similar to the patterns previously observed and discussed for PCP and hydrocarbons (see Sections 4.3.2 and 4.3.3). One exception noted in the data is found at well nest M-6, M-7 and M-8. The round 2 data from M-6, which is the deepest of the three wells (screened interval 32.5 to 35 feet), indicates that PAHs are present in relatively high

4.3.8.1 **Arsenic.** The distribution of arsenic concentrations for site and off-site monitoring wells measured during rounds 1, 2 and 3 are shown on Figures 4-27 and 4-28. Arsenic concentrations in the site shallow groundwater ranged from 10 μg/l (majority of site wells) to 125 μg/l (well PZ-1). The majority of wells in which arsenic was detected are located along the periphery of Silver Bow Creek.

4.3.8.2 **Cadmium.** Cadmium was detected during both sampling rounds 1 and 2 in only two of the site monitoring wells (wells M-1 and W-3) (Figures 4-29 and 4-30). Both of these wells are located within the northern area, and are in close proximity to Silver Bow Creek. Concentrations ranged from 8.4 μg/l (well W-3) to 29 μg/l (well M-1). Cadmium was quantified in off-site wells, GS-18, BMW-9A, GS-25, GS-26, CT-84-6, N-1 and PW-4 at concentrations ranging from 5.99 to 232 μg/l.

4.3.8.3 **Chromium.** Chromium was not detected in any of the shallow or deep site monitoring wells using a detection limit of 10.0 μg/l. Under the lower detection limit of 3 μg/l obtained using the TAL testing method, only one of the 7 samples was found to have a chromium concentration at the detection limit (well W-13).

4.3.8.4 **Copper.** The distribution of copper concentrations for site monitoring wells measured during the three sampling rounds are shown on Figures 4-31 and 4-32. Copper concentrations in the shallow groundwater ranged from less than 25 μg/l to 34,600 μg/l in well M-1. This well is located along the northeastern boundary of the site, adjacent to Silver Bow Creek. Generally, copper was detected in only the monitoring wells located within the northern area, near Silver Bow Creek.

4.3.8.5 **Lead.** Lead was not detected within the groundwater system at any site monitoring wells using the detection criteria of 3.0 and 5.0 μg/l. Subsequent samples tested under a lower detection limit of 2.0 μg/l showed that lead was at or slightly above detection limits in wells GW-15, W-13, and W-5.

4.3.8.6 **Zinc.** The distribution of zinc concentrations for site monitoring wells measured during the three sampling rounds are presented on Figure 4-33 and 4-34 and ranged from below detection limits of 20 μg/l in the majority of site wells to 11,600 μg/l in M-1. Although zinc occurs throughout the groundwater system, the higher concentrations are encountered in wells closest to Silver Bow Creek. Zinc was detected at depth in only two of the four monitoring well nest locations at concentrations of 75 μg/l at M-7 and 75.7 μg/l at M-8.

4.3.9 LNAPL Samples

During the July and November 1990 sampling events, a sample of the nonaqueous phased liquid which was found to be present in several wells was collected and analyzed. As discussed previously in Section 3.6.2.3, this separate phase fluid consisted of a lighter than water fraction, or Light Non-Aqueous Phase Liquid (LNAPL). The intent of collecting these samples was to characterize this major source material for dissolved groundwater contaminants.

A total of three samples were collected during the first sampling round. These included wells W-5, W-8, and W-15. Each of these wells consistently contained measurable amounts of LNAPL. During the November (round 2) sampling event, a second, confirmatory LNAPL sample was collected from well W-8. Although several other site monitoring wells were found to contain LNAPL, a sufficient volume of sample could not be collected from those wells for analytical purposes.

An additional LNAPL sample was collected from within Silver Bow Creek, at the location of a seep, SD-005 (Figure 4-2). The intent of this sample was to characterize the oil entering the Creek.

As expected, the concentrations of PCP and total PAH were similar for LNAPL obtained from the surface water seep and for the LNAPL obtained from the monitoring wells. Pentachlorophenol concentrations ranged from 127,000 mg/l to 429,000 mg/l, while total PAH concentrations ranged from 12,124 mg/l to 897,251 mg/l. BTEX was measured in only the

4.4.2 Total Polynuclear Aromatic Hydrocarbons

Surface water concentrations for total PAH for both rounds of sampling are shown on Figure 4-35. As illustrated, other than the one source area, SW-005, PAH concentrations were below the method detection limits for all PAH compounds during the surface water sampling events. The concentration of PAH located within the containment boom at SW-005, showed concentrations of 49.53 μg/l and 47.5 μg/l for the first and second sampling rounds, respectively.

Sediment concentrations for PAH derived from the one round of sampling (round 2) are shown on Figure 4-36. PAH concentrations were highest at the immediately downstream location, SD-002, at a concentration of 4,958 μg/kg. The one source area sample near an active seep, SD-005, displayed a concentration of 1,761 μg/kg PAH. The upstream (background) sample location, SD-001 had a concentration of 245 μg/kg and the far downstream sample location, SD-004, had a concentration of 95.4 μg/kg PAH.

The sediment data indicate an increased PAH concentration in the Silver Bow Creek sediments adjacent to and downstream of the site; although some non-site related PAH contamination in Silver Bow Creek may also be present. Sample location SD-002, downstream of the site, is located adjacent to an asphalt production/storage area which could input some PAHs and other hydrocarbon constituents to Silver Bow Creek. The upstream (background) sample SD-001 concentration of 245 μg/kg also indicates the possibility of additional sources of PAHs upstream of the Montana Pole site.

4.4.3 Total Petroleum Hydrocarbons

Figures 4-35 and 4-36 show TPH concentrations for the surface water and stream bed sediment investigations, respectively. For both media, gasoline and lubricating oil were not present, and kerosene and fuel oil #2 were below detection limits. Fuel oil #6 was less than the detection limits for the sediments and showed a concentration of 0.593 mg/l for round 1 surface water sampling at the seep area, SW-005. Fuel oil #4 was present in the sediments at the farthest downstream location, SD-004, at a concentration of 161 mg/kg and was found in round 2 of the surface water sampling at seep location SW-005 at a concentration of 2.17 μg/l.

4.4.4 Metals

Elevated metals concentrations in Silver Bow Creek surface water, sediment and bank material are considered to be the result of historic mining activities in Butte rather than related to the Montana Pole site. The RI field investigations included sampling and analysis for inorganics to determine the degree of metals contamination on and adjacent to the site for consideration during risk assessment and for remedial action evaluation and selection.

Figure 4-37 illustrates the metals concentrations for both rounds of surface water sampling. Total cadmium and chromium both exhibited below detection limit concentrations (<5 μg/l and <10 μg/l respectively) for both rounds. Total arsenic concentrations ranged from 12.9 μg/l (SW-006) to 15,000 μg/l (SW-001). Total copper concentrations ranged from 93.6 to 220 μg/l. Total lead concentrations ranged from <5 to 30.3 μg/l (SW-005). Total zinc concentrations ranged from 262 to 1120 μg/l.

Dissolved metals concentrations in Silver Bow Creek are also presented in Figure 4-37.

Figure 4-38 illustrates the metals concentrations found in Silver Bow Creek sediments for the one round (round 2) of sampling. Arsenic concentrations ranged from 70,400 to 842,000 μg/kg. Cadmium concentrations ranged from 4,440 to 21,900 μg/kg. Chromium concentrations ranged from 5,550 to 18,700 μg/kg. Copper concentrations ranged from 656,000 to 5,210,000 μg/kg. Lead concentrations ranged from 362,000 to 714,000 μg/kg. Zinc concentrations ranged from 1,360,000 to 6,220,000 μg/kg.

4.4.5 Other Surface Water Investigation Parameters

This section summarizes various parameters for Silver Bow Creek surface water not specifically discussed in the above subsections.

Table 4-14 presents the pH, conductivity, temperature, and dissolved oxygen information gathered during the rounds 1 and 2 surface water sampling. Measurements of these parameters were taken in the field.

The VOCs, in particular, benzene, toluene, ethylbenzene, and xylenes (BTEX), for round 1, were only found above the method detection limits at SW-007 (10.5 μg/l). For round 2, the BTEX concentrations ranged from 5.69 μg/l at SW-004, to 1.04 μg/l at SW-002. Total dissolved solids (TDS) for round 1 ranged from 300 mg/l at SW-001 to 409 mg/l at SW-005 and for round 2, 281 mg/l at SW-001 to 364 mg/l at SW-005. Total suspended solids (TSS) ranged from 4 mg/l at SW-007 to 11 mg/l at SW-004 for round 1 and for round 2, 21 mg/l at SW-002 to 28 mg/l at SW-005. Total organic carbon (TOC) ranged from 2.42 mg/l at SW-002 to 6.06 mg/l at SW-005 for round 1 and for round 2, 2.38 mg/l at SW-001 to 3.49 mg/l at SW-002.

4.4.6 Other Stream Bed Sediment Investigation Parameters

This section summarizes various parameters for Silver Bow Creek sediments not specifically discussed in the above subsections. These parameters include VOCs, polychlorinated biphenyls (PCBs), PCDD/PCDF, and particle size distribution (grain size).

For the VOCs, in particular benzene, toluene, ethylbenzene, and xylenes (BTEX), the concentrations ranged from 14.07 μg/kg at SD-004, to below detection limit at SD-005.

PCBs were sampled at SD-005 only and were below method detection limits. Dioxins were sampled at SD-005 only. The concentration of 2,3,7,8-TCDD was below method detection limits. Total dioxin concentrations ranged from 0.24 ppb for HpCDD to below the method detection limits for PeCDD. Total furans ranged from 0.05 ppb for HpCDF to below the method detection limit for PeCDF. Total 2,3,7,8-TCDD equivalent concentrations are provided on Table 4-6.

4.4.7 Sewerline Sampling

Three samples and one field duplicate were collected from the sewerline during sampling round 3. Samples were analyzed for phenolics, PAHs, hydrocarbon scan, aromatic volatiles, non CLP metals, TDS, and conductivity. Sample locations are shown on Figure 4-1.

PCP was detected in only the field duplicate of sample ML-001 at a concentration of 39.2 μg/l. The remaining samples, ML-001, ML-002 and ML-003, had PCP concentrations less than 10 μg/l. Total PAH concentrations were 2.28 μg/l (ML-001), 18.48 (ML-002), and 33.57 (ML-003). Total petroleum hydrocarbons were 4.29 mg/l (ML-001), 2.73 mg/l (ML-002), and 4.90 mg/l (ML-003). BTEX concentrations were below detection limits of 3 and 5 μg/l. Copper concentrations ranged from 208 to 413 μg/l. Lead concentrations ranged from 8.3 to 71.8 μg/l. Zinc concentrations ranged from 123 to 277 μg/l. Arsenic, cadmium and chromium concentrations were below detection limits of 10 μg/l, 5 μg/l and 10 μg/l respectively.

Based on these data, very little if any infiltration of contaminated groundwater to the sewer lines is occurring.

4.5 AMBIENT AIR QUALITY MONITORING

A description of the air quality sampling program is provided in Section 2.2.1. The results of the laboratory analyses of the ambient air samples can be found in Appendix L and in Tables 4-15 through 4-21. Due to problems encountered during laboratory analysis, which are described in the Data Summary Report (Keystone, 1992a), the majority of air data are of screening quality. Additionally, the upwind sampling location, although not known at the time the investigation took place, was located near a former waste disposal area which contains wood and depends on both the structure of the chemical, the amount of organic carbon in the soil and other physical and chemical properties of the soil and water. In general, a greater amount of organic material in the soil results in a higher K_D. Where the K_D is higher, more adsorption of organic chemicals will take place, slowing their movement through the environment. The retardation factor (R) is related to K_D; therefore, it is also influenced by site-specific factors. The retardation factor reflects the slowing of chemical migration by adsorption as compared to the movement of water. Specifically, it represents the rate of water movement divided by the rate of movement of dissolved chemicals in water. For example, a chemical with an R value of 1,000 will move 1,000 times more slowly through the environment than the groundwater.

Additional physical processes that affect the migration of chemicals include advection, dispersion, and molecular diffusion. Advection is the movement of a chemical by groundwater, wind, or other mobile medium. Advection tends to move chemicals in the direction of flow. Hydrodynamic dispersion, which consists of both mechanical dispersion and molecular diffusion, is a physical process that spreads out chemicals in both the longitudinal and transverse direction of flow. Mechanical dispersion of groundwater plumes is caused primarily by the movement of groundwater around soil particles that are in the flow path. These particles divert the forward motion of groundwater and tend to disperse concentrated plumes of chemicals in groundwater. Molecular diffusion, caused by intermolecular collisions, will also cause chemicals to spread out in groundwater. Therefore, as a groundwater plume moves further from its source, these physical processes, in combination with the chemical and biological processes described below, will cause the plume to spread out and gradually decrease in concentration (see Figures 4-12, 4-15, 4-21, and 4-24).

5.2.1.2 Chemical and Biological Processes. . Chemical and biological processes also affect the fate of a chemical in the environment. In general, these processes reduce the quantity of a chemical in the environment, usually by degradation or transformation of the chemical. Actual reduction of concentrations of chemicals by these processes depends on the influence of continued sources of contamination. In the absence or reduced state of continued sources of contamination, concentrations of chemicals in groundwater are primarily decreased by the processes of adsorption to soil particles and degradation. Volatilization can also be important, depending upon the specific chemical, concentrations and other factors such as temperature and aquifer characteristics. Degradation of a chemical may be caused either by chemical or biological influences in the environment. General processes of degradation and transformation of organic chemicals are discussed in this section; these processes are discussed in greater detail for the substances of concern at the MPTP site in following sections.

Chemical processes that may degrade chemicals in the environment include photolysis, hydrolysis, elimination reactions, and reactions with other chemicals. Photolysis may occur when chemicals are exposed to sunlight, which accelerates degradation of some chemicals. Hydrolysis reactions occur in water and tend to break apart molecules that are susceptible to such reactions. Aromatic compounds such as PAH compounds and phenols are resistant to hydrolysis reactions. In addition, a wide variety of other reactions, such as ring-cleavage reactions, can occur.

Chemical degradation of most substances is of lesser importance than biologically mediated reactions, known as biodegradation or biotransformation reactions. Typically, these reactions are facilitated by soil microorganisms that use carbon-containing substances as food. Many organic chemicals are naturally biodegraded in soils. The amount and rate of biodegradation that occurs depends on many factors, including the type and concentration of the chemicals being degraded, the pH and temperature of the soil, the presence of nutrients, the presence of oxygen, and the presence of other substances that could assist or inhibit the reactions, or be toxic to the microorganisms.

The presence or absence of oxygen is a key factor in determining the types of reaction products that may be formed because different types of microorganisms degrade chemicals in oxygen containing (aerobic) or oxygen lacking (anaerobic) environments. Many steps may be involved in completely degrading a chemical, however, most organic chemicals eventually degrade through a series of steps to simple molecules such as water, carbon dioxide, or methane.

average groundwater velocity across the site is estimated to be 0.3 ft/day (110 ft/year). The average groundwater velocity north of the interstate is estimated to be 0.48 ft/day (175 ft/year). The average groundwater velocity south of the interstate is estimated to be 0.18 ft/day (66 ft/year). Assuming a distance of 1,200 ft from the site of the plant process area to Silver Bow Creek, the corresponding groundwater flow travel time across the site is approximately 11 years. The actual rate of groundwater flow may be greater or less than these approximate ranges given the heterogeneity of the alluvial aquifer and assumptions implicit in this simplistic analysis.

As presented in Section 3.6.2.1, measured groundwater elevations of the well nests indicated a downward vertical gradient in seven well nests and an upward vertical gradient in three well nests near Silver Bow Creek. The downward vertical gradients ranged from 0.0070 ft/ft to 0.03 ft/ft. The upward vertical gradients ranged from 0.002 ft/ft to 0.017 ft/ft. Although there is generally a downward vertical gradient across the site, groundwater contamination is concentrated in the shallow portions of the alluvial aquifer as discussed in Section 4.3. Also, based on the analytical data presented in Figure 4-13, some migration of the dissolved contamination is occurring to the north side of Silver Bow Creek.

5.3.2 Rates of Migration of Substances of Concern

The rate of migration and concentration of dissolved chemicals depends on the groundwater velocity, dispersion, adsorption, and degradation. The combined effect of these processes is to reduce chemical concentrations in a downgradient direction and, for chemicals that are adsorbed, to retard the movement of substances of concern relative to the average groundwater velocity. For chemicals that are not readily adsorbed, the process of dispersion tends to increase the rate of movement at the leading edge of the plume, relative to the rate of groundwater flow.

For many of the organic compounds that are substances of concern at the site, adsorption to organic matter and dissolution rates may be the most significant factors limiting mobility and transport from a source area. For example, the retardation factor (R), a measure of a chemical's tendency to be slowed by sorption reactions, may be calculated using the following equation:

where: $R = 1 + (P_b/\theta) * K_D$

P_b = bulk density (typically 1.6 to 2.1 gm/cm^3, Freeze and Cherry, 1979)
θ = effective porosity
K_D = adsorption coefficient = K_{oc} - OCC

Lyman and Rosenblatt (1982) present a number of regression equations for estimating K_{oc} for neutral compounds (e.g., PAH compounds) from the octanol-water partitioning coefficient (K_{ow}), a chemical property for which chemical-specific values are readily available in the literature (e.g., USEPA, 1985 and 1990) and is related to the solubility of a chemical. Because it was derived from studies of similar chemicals, the equation most applicable to PAH and aromatic compounds at the MPTP site is:

$$\text{Log } K_{oc} = 1.00 \log K_{ow} - 0.21$$

where: K_{oc} = organic carbon partitioning coefficient
OCC = organic carbon content of the aquifer.
K_{ow} = octanol-water partitioning coefficient.

K_{oc} values for PAH compounds estimated using this method are presented in Table 5-2.

Because PCP is primarily ionized in groundwater at the pH measured at the MPTP site, the above equation for neutral compounds does not apply. An alternative method for estimating K_{oc} from K_{ow} for compounds that are wholly or partially ionized in groundwater is presented in Lee et al. (1990) and was used to derive a K_{oc} of 560 for PCP at the MPTP site.

The equation used for calculating the K_{oc} of pentachlorophenol is:

$$K_{oc,t} = K_{oc,n} \times \theta + K_{oc,I} \times (1-\theta)$$

where:

$K_{oc,t}$ = total organic carbon partition coefficient
$K_{oc,n}$ = organic carbon partition coefficient for neutral pentachlorophenol
$K_{oc,i}$ = organic carbon partition coefficient for ionized pentachlorophenol
θ = fraction of pentachlorophenol that is neutral

Values for $\log K_{oc,n}$ and $\log K_{oc,i}$ were obtained from Figure 1 in Lee et al. (1990). The fraction of pentachlorophenol that is neutral depends on the pH of the water and the pK_a of pentachlorophenol as reflected in the following equation:

$$0 = (1 + 10^{(pH - pKa)})^{-1}$$

From Lee et al. (1990), the pK_a is 4.70. At a pH of approximately 7, the K_{oc} for pentachlorophenol is estimated as 560.

The organic carbon content at the site is used to estimate K_D from K_{oc} values and was estimated from measurements of total organic carbon in saturated soils along the flowpath for substances at the MPTP site. The average organic carbon content of these soils is approximately 0.16 percent, or 0.0016 (from Appendix F, Keystone, 1991); the K_D values for substances at the site estimated using this organic carbon content are listed in Table 5-2. The organic carbon content is greater than 0.1 percent along the selected groundwater pathway. Actual K_D values vary from site to site and depend, to some degree, on soil type, pH, organic carbon content, the presence of other ions and competing solvents, and the ionic strength of the groundwater. However, the methods described above for estimating K_Ds using site- and chemical-specific data are well-accepted by the scientific community and provide useful information for evaluating chemical migration at the MPTP site.

Estimated R values for various PAH compounds range from 13.4 to 282,000 (see Table 5-2). These values indicate that sorption is an important retardation process that significantly retards the transport of dissolved PAH compounds in groundwater (up to approximately 282,000 times slower than the average groundwater velocity). The estimated R values for LPAHs are lower than for HPAHs (Table 5-2), suggesting that dissolved LPAHs would tend to be more mobile than dissolved HPAHs. The estimated R value for PCP is 6.1.

Estimated average migration velocities for PAH compounds and PCP are also presented in Table 5-2. For the PAH compounds, these values range from 0.0004 to 8.2 ft/year, depending upon the compound. PCP is estimated to move at a rate of approximately 18.1 ft/year. In performing these calculations, an average groundwater velocity across the site of 110 ft/year was assumed.

Migration of PCP and PAH compounds in the nonaqueous phase-PCP/oil would not be substantially affected by partitioning but would be affected by groundwater gradients, aquifer porosity, and nonaqueous phase viscosity. In general, the nonaqueous phase would tend to be more mobile than dissolved PAH compounds in groundwater.

Although not directly calculated, the R value for PCDDs and PCDFs is known to be very high (>1,000,000) because PCDDs and PCDFs partition very strongly onto soils. As a result, these chemicals would not be expected to be transported by groundwater.

PCP, PAH compounds, VOCs, dioxins and furans at the MPTP site have been associated with a number of source areas. These materials have entered the environment at the site from a number of source areas (Section 5.1.1) and have entered transport pathways (e.g., groundwater or surface water). As these substances migrate, they may change because of chemical, physical, and/or biological processes. In addition, these chemicals may enter other transport pathways (e.g., chemicals in groundwater may enter surface water).

The processes associated with the migration of PCP and PAH compounds in groundwater are generally consistent with site data. PCP is transported with the LNAPL and in the dissolved phase in groundwater. Site data indicate that PCP has migrated as shown in Figures 4-12 and 4-13.

surface on the northeast half of the site appears as a nearly horizontal plane with the lowest elevation at approximately 5395.0 feet above msl.

Groundwater occurrence within the vicinity of Butte is generally associated with two water-bearing units. These include: 1) the unconsolidated sediments associated with the Tertiary and Quaternary age valley fill deposits and 2) the weathered and fractured bedrock deposits associated with the Boulder Batholith. There has been minimal development of the water-yielding zones in the unconsolidated material in the Butte area as a water resource. This is primarily because most households and commercial businesses are supplied by a city-wide water distribution system, owned and operated by the Butte Water Company. Water for this system is derived from surface water sources located both within and outside of the Butte valley.

Evaluation of hydrogeology for the Montana Pole and Treating Plant site was developed primarily from installation of monitoring wells at varied depths across the site, and from stratigraphic information obtained during the soil boring/well installation program. Observations of water levels in wells installed as part of the RI, as well through the existing well network, provide data relative to the position of the potentiometric surface, water level fluctuations, and groundwater gradients across the site. Soil boring data were utilized to evaluate site hydrogeologic transmissive units and to characterize the lithology and geometry of the units.

The uppermost aquifer encountered at the site is composed of the Quaternary age, alluvial valley fill sediments. Groundwater is present at the site under unconfined conditions, with depth to water measurements ranging from approximately 5 to 20 feet.

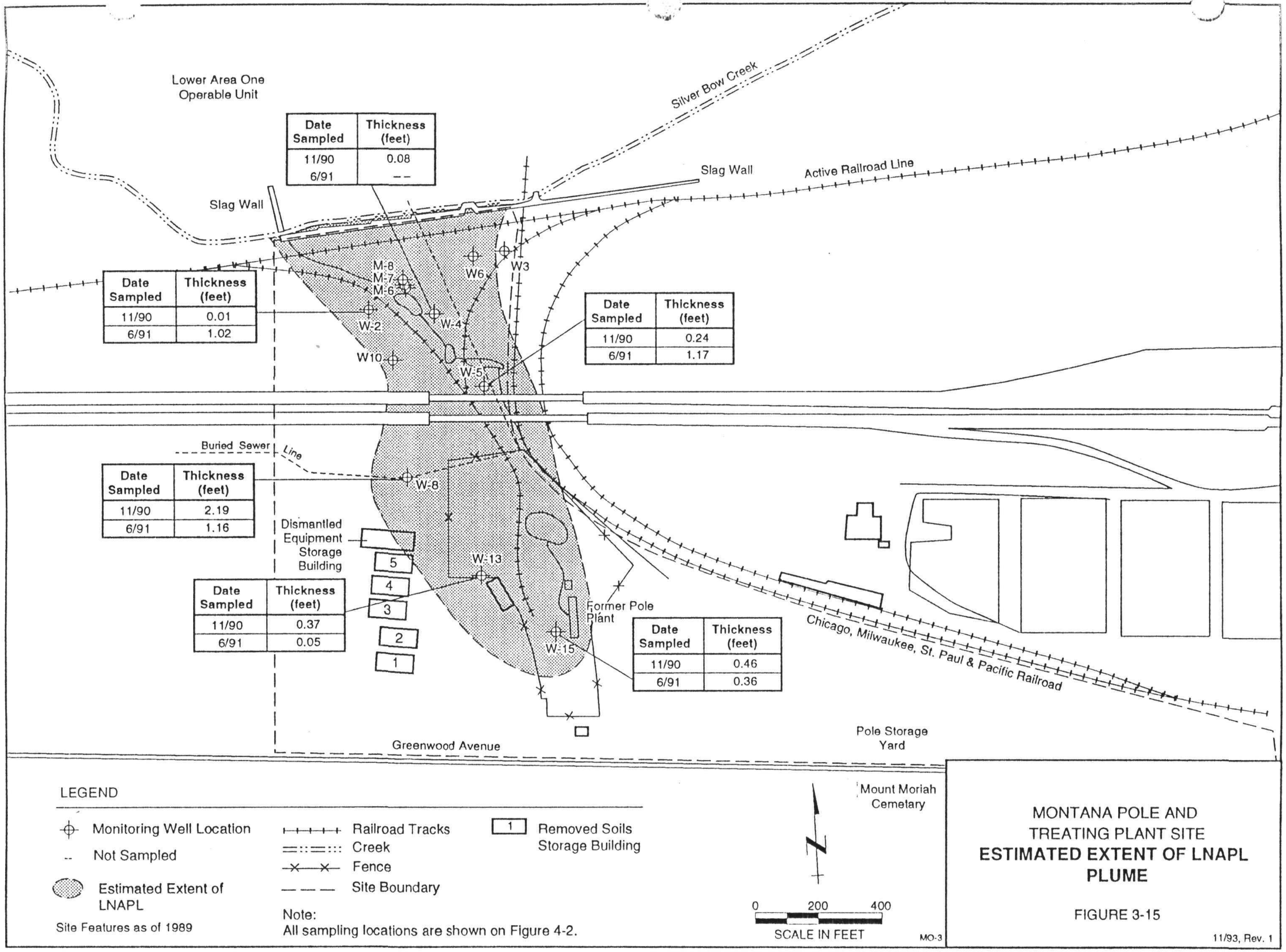
An assessment of the local hydrogeologic characteristics is based upon evaluation of groundwater data collected during the three sampling events. Groundwater elevation data for the wells monitoring the alluvial aquifer system indicate that the groundwater flow direction is generally toward the northwest. Potentiometric surface maps are shown in Figures 3-10, 3-11 and Figure 3-13. Figure 3-12, in combination with Figure 3-11, delineates the degree and extent of mounding in the area of the southeast infiltration gallery. The groundwater mounding investigation of the southeast infiltration gallery is further discussed in Section 3.7.

Surface water elevations measured in Silver Bow Creek compared to groundwater elevations measured in monitoring wells immediately adjacent to Silver Bow Creek indicate that groundwater is discharging to the creek. This is supported by the existence of site related NAPL discharging to the creek.

Contours of the potentiometric surface in the southeastern portion of the site show that the hydraulic gradient is equal to approximately 0.003 ft/ft, while within the northwestern portion of the site it is equal to approximately 0.007 ft/ft. The average hydraulic gradient across the entire site is approximately 0.005 ft/ft. These values are similar to those presented for the Lower Area One (LAO) (Chen-Northern and CH2M-Hill, 1990). The difference in gradients between the north and south portions of the site, which are divided by the interstate highway, may be due to compression of soils and an associated decrease in permeability beneath the highway. However, site groundwater flow patterns do not appear to be significantly affected by the interstate highway.

As presented in Section 5.3.1, the average estimated horizontal hydraulic conductivity of the alluvial aquifer is 12 ft/day (4.2 x 10^{-3} cm/sec). Average alluvial groundwater velocity across the site is estimated at 110 ft/year. Assuming a distance of 1200 feet from the site process area to Silver Bow Creek, the corresponding groundwater flow travel time across this area is approximately 11 years.

As presented in Section 3.6.2.1, measured groundwater elevations of the well nests indicated a downward vertical gradient in seven well nests and an upward vertical gradient in three well nests near Silver Bow Creek. The downward vertical gradients ranged from 0.007 ft/ft to 0.03 ft/ft. The upward vertical gradients ranged from 0.002 ft/ft to 0.017 ft/ft. Although there is generally a downward vertical gradient across the site, groundwater contamination is concentrated in the shallow portions of the alluvial aquifer as discussed in Section 4.3. Also,



Date Sampled	Thickness (feet)
11/90	0.08
6/91	--

Date Sampled	Thickness (feet)
11/90	0.01
6/91	1.02

Date Sampled	Thickness (feet)
11/90	0.24
6/91	1.17

Date Sampled	Thickness (feet)
11/90	2.19
6/91	1.16

Date Sampled	Thickness (feet)
11/90	0.37
6/91	0.05

Date Sampled	Thickness (feet)
11/90	0.46
6/91	0.36

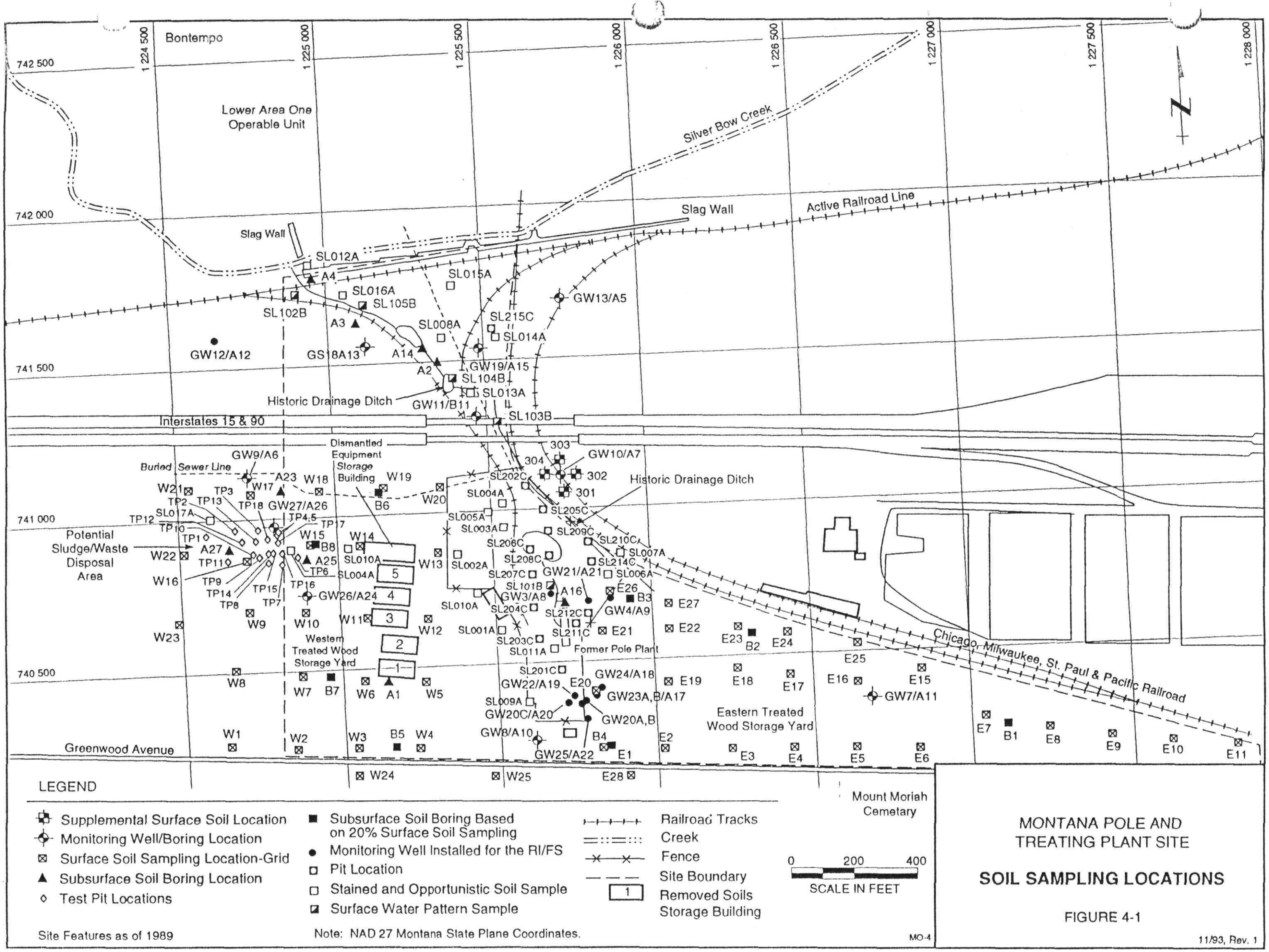
Note:
All sampling locations are shown on Figure 4-2.

MONTANA POLE AND TREATING PLANT SITE

ESTIMATED EXTENT OF LNAPL PLUME

FIGURE 3-15

11/93, Rev. 1

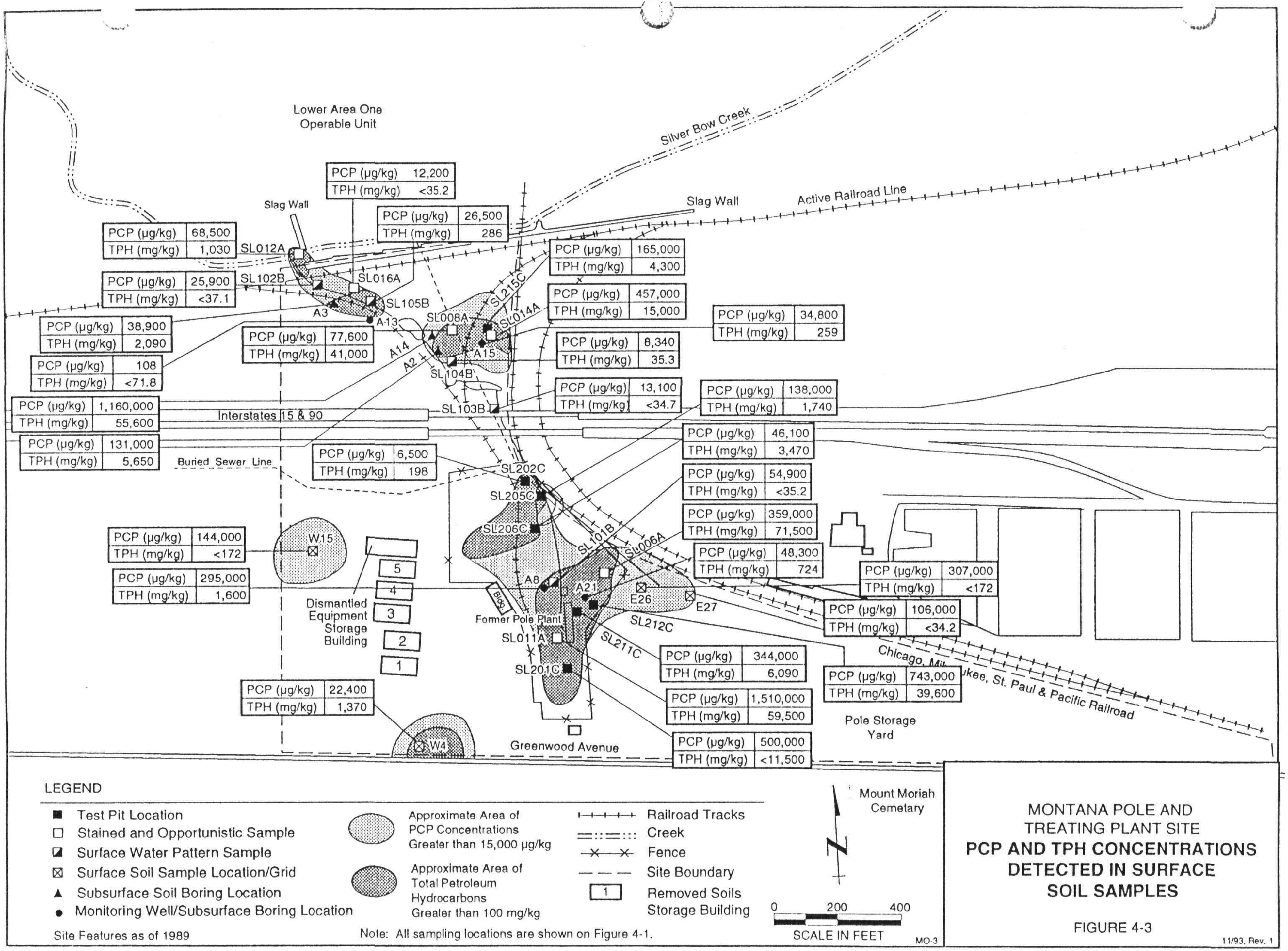


MONTANA POLE AND TREATING PLANT SITE

SOIL SAMPLING LOCATIONS

FIGURE 4-1

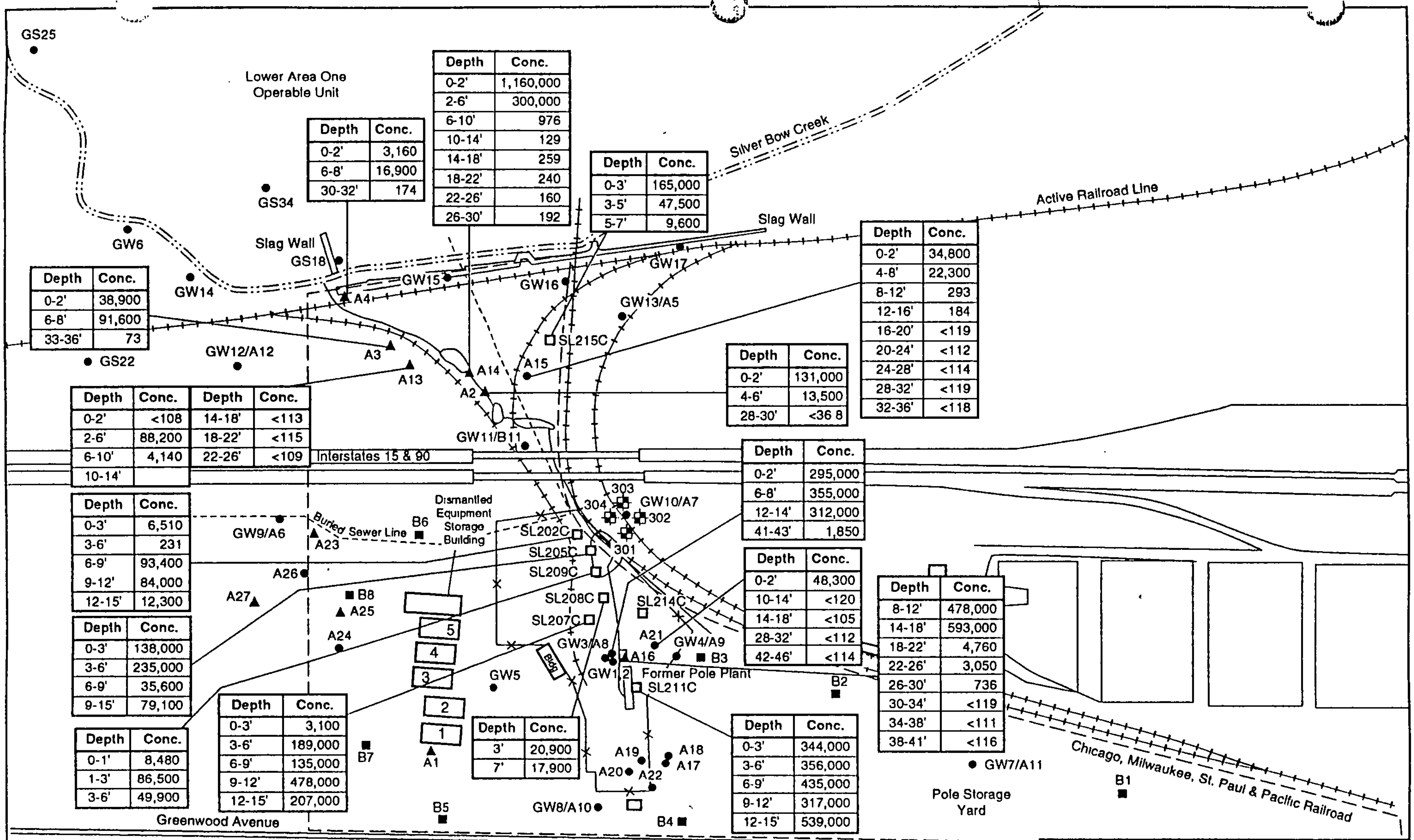
11/93, Rev. 1



MONTANA POLE AND
TREATING PLANT SITE
PCP AND TPH CONCENTRATIONS DETECTED IN SURFACE SOIL SAMPLES

FIGURE 4-3

11/93, Rev. 1



Depth	Conc.
0-2'	1,160,000
2-6'	300,000
6-10'	976
10-14'	129
14-18'	259
18-22'	240
22-26'	160
26-30'	192

Depth	Conc.
0-2'	3,160
6-8'	16,900
30-32'	174

Depth	Conc.
0-3'	165,000
3-5'	47,500
5-7'	9,600

Depth	Conc.
0-2'	34,800
4-8'	22,300
8-12'	293
12-16'	184
16-20'	<119
20-24'	<112
24-28'	<114
28-32'	<119
32-36'	<118

Depth	Conc.
0-2'	38,900
6-8'	91,600
33-36'	73

Depth	Conc.
0-2'	131,000
4-6'	13,500
28-30'	<36 8

Depth	Conc.	Depth	Conc.
0-2'	<108	14-18'	<113
2-6'	88,200	18-22'	<115
6-10'	4,140	22-26'	<109
10-14'			

Depth	Conc.
0-2'	295,000
6-8'	355,000
12-14'	312,000
41-43'	1,850

Depth	Conc.
0-3'	6,510
3-6'	231
6-9'	93,400
9-12'	84,000
12-15'	12,300

Depth	Conc.
0-2'	48,300
10-14'	<120
14-18'	<105
28-32'	<112
42-46'	<114

Depth	Conc.
8-12'	478,000
14-18'	593,000
18-22'	4,760
22-26'	3,050
26-30'	736
30-34'	<119
34-38'	<111
38-41'	<116

Depth	Conc.
0-3'	138,000
3-6'	235,000
6-9'	35,600
9-15'	79,100

Depth	Conc.
0-3'	3,100
3-6'	189,000
6-9'	135,000
9-12'	478,000
12-15'	207,000

Depth	Conc.
0-1'	8,480
1-3'	86,500
3-6'	49,900

Depth	Conc.
3'	20,900
7'	17,900

Depth	Conc.
0-3'	344,000
3-6'	356,000
6-9'	435,000
9-12'	317,000
12-15'	539,000

LEGEND

- ▲ Subsurface Soil Boring Location
- ■ Subsurface Boring Based on 20% Surface Borings
- ● Monitoring Well/Subsurface Boring Location
- ☐ Test Pit Samples
- ✣ Supplemental Surface Soil Location
- +-+-+-+ Railroad Tracks
- =::=::: Creek
- —x—x— Fence
- — — — Site Boundary

Conc. = Concentration in µg/kg

Site Features as of 1989

Note 0-2' measurements are also included in Figure 4-3
All sampling locations are shown on Figure 4-1

0 200 400
SCALE IN FEET

Mount Moriah
Cemetary

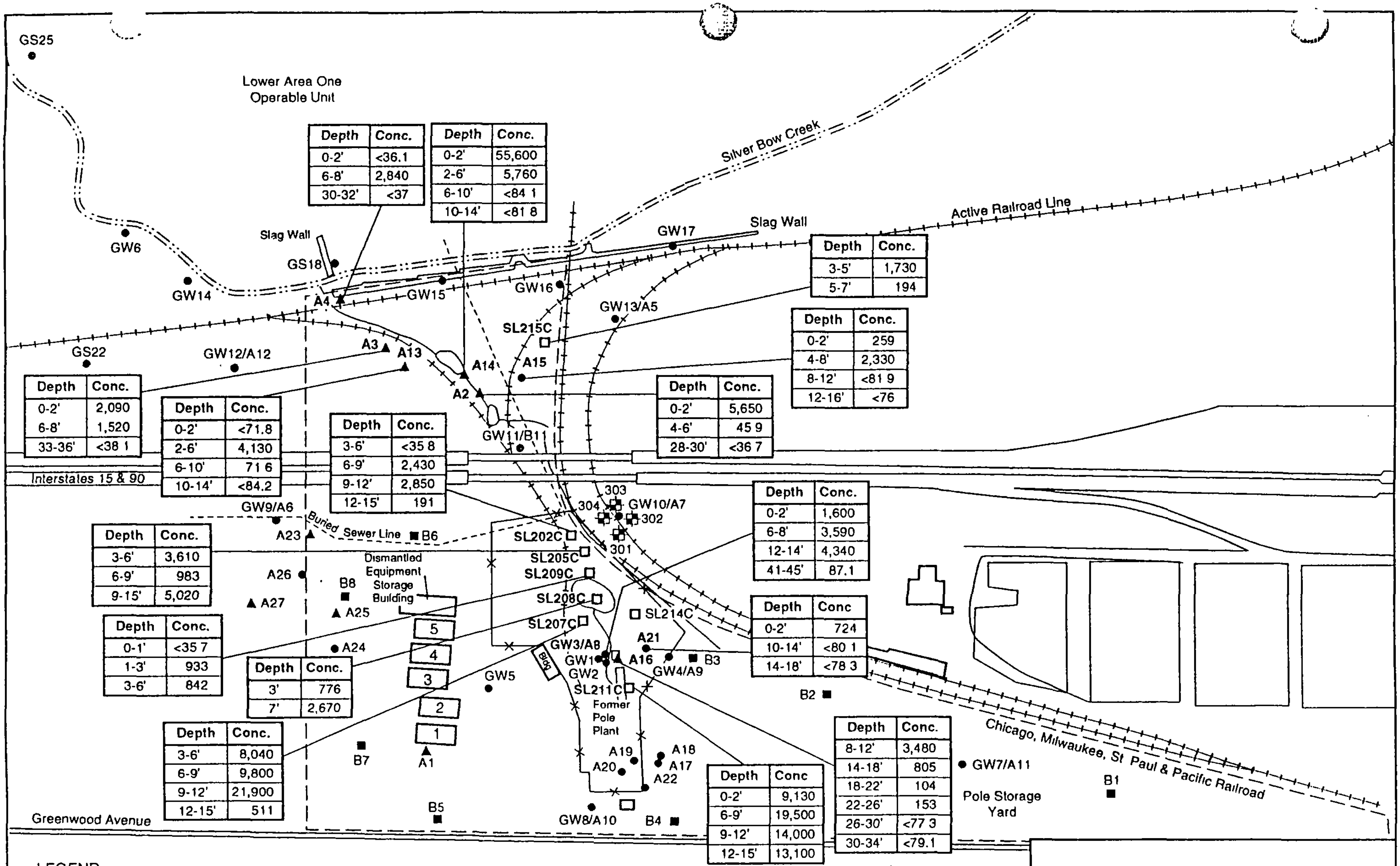
MO-3

MONTANA POLE AND
TREATING PLANT SITE

PCP CONCENTRATIONS DETECTED
IN SUBSURFACE SOIL SAMPLES

FIGURE 4-4

11/93, Rev 1



Depth	Conc.
0-2'	<36.1
6-8'	2,840
30-32'	<37

Depth	Conc.
0-2'	55,600
2-6'	5,760
6-10'	<84.1
10-14'	<81.8

Depth	Conc.
3-5'	1,730
5-7'	194

Depth	Conc.
0-2'	259
4-8'	2,330
8-12'	<81.9
12-16'	<76

Depth	Conc.
0-2'	2,090
6-8'	1,520
33-36'	<38.1

Depth	Conc.
0-2'	<71.8
2-6'	4,130
6-10'	71.6
10-14'	<84.2

Depth	Conc.
3-6'	<35.8
6-9'	2,430
9-12'	2,850
12-15'	191

Depth	Conc.
0-2'	5,650
4-6'	45.9
28-30'	<36.7

Depth	Conc.
0-2'	1,600
6-8'	3,590
12-14'	4,340
41-45'	87.1

Depth	Conc.
3-6'	3,610
6-9'	983
9-15'	5,020

Depth	Conc
0-2'	724
10-14'	<80.1
14-18'	<78.3

Depth	Conc.
0-1'	<35.7
1-3'	933
3-6'	842

Depth	Conc.
3'	776
7'	2,670

Depth	Conc.
3-6'	8,040
6-9'	9,800
9-12'	21,900
12-15'	511

Depth	Conc
0-2'	9,130
6-9'	19,500
9-12'	14,000
12-15'	13,100

Depth	Conc.
8-12'	3,480
14-18'	805
18-22'	104
22-26'	153
26-30'	<77.3
30-34'	<79.1

LEGEND

- ▲ Subsurface Soil Boring Location
- ■ Subsurface Boring Based on 20% Surface Borings
- ● Monitoring Well/Subsurface Boring Location
- ✣ Supplemental Surface Soil Location
- ☐ Test Pit Samples
- Conc = Concentration in mg/kg

- ┼┼┼┼ Railroad Tracks
- ═::═ Creek
- —×—×— Fence
- — — — Site Boundary

- 1 Removed Soils Storage Building

Site Features as of 1989

Note All sampling locations are shown on Figure 4-1
0-2' measurements are also included in Figure 4-3, PCP AND TPH CONCENTRATIONS DETECTED IN SURFACE SOIL SAMPLES

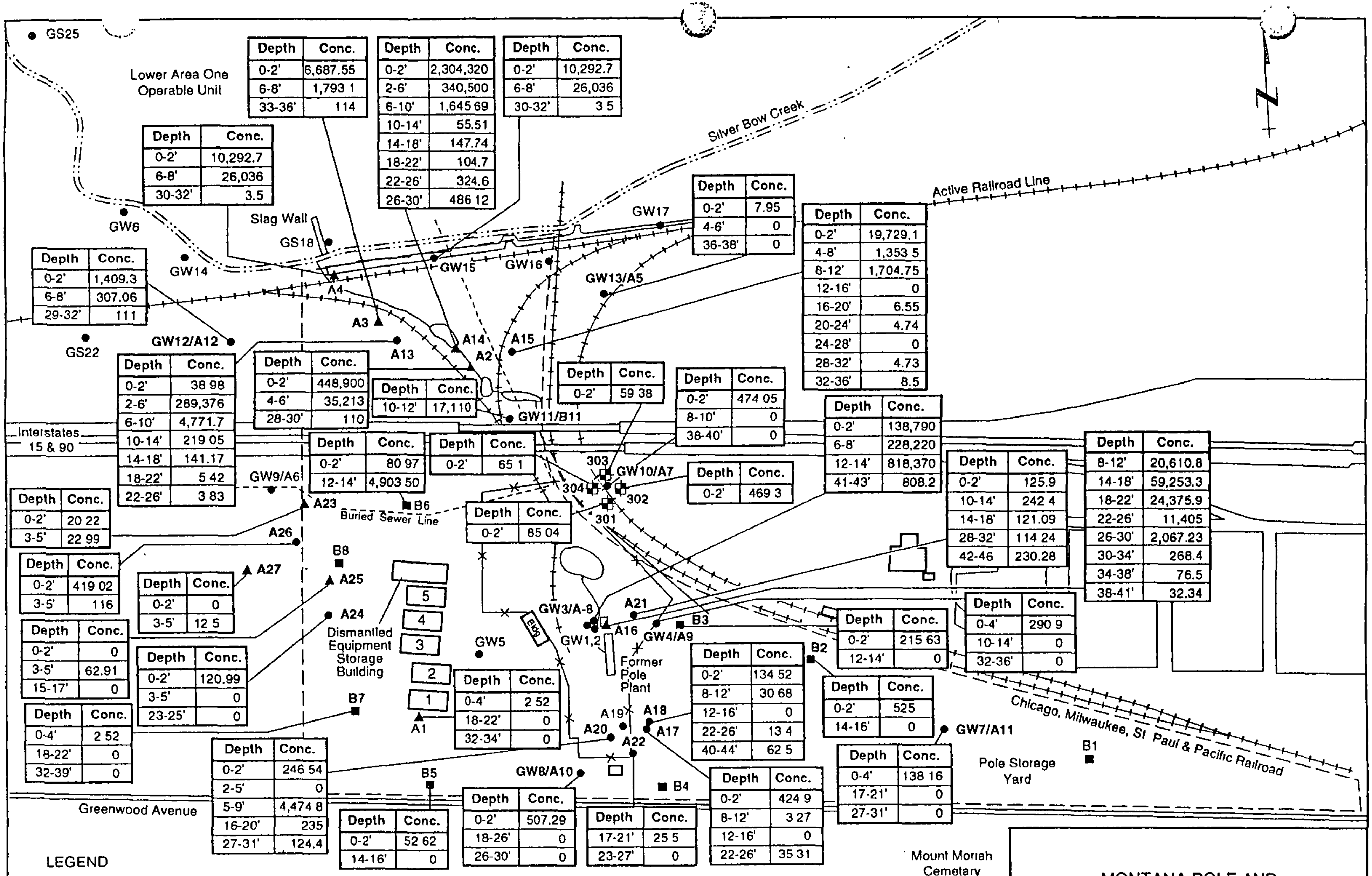
0 200 400
SCALE IN FEET

MO-3

MONTANA POLE AND
TREATING PLANT SITE
TPH CONCENTRATIONS DETECTED
IN SUBSURFACE SOIL SAMPLES

FIGURE 4-5

11/93, Rev 1



LEGEND

▲	Subsurface Soil Boring Location	┼┼┼┼┼	Railroad Tracks
■	Subsurface Boring Based on 20% Surface Borings	═::═ ∵	Creek
●	Monitoring Well/Subsurface Boring Location	─×─×	Fence
⊕	Supplemental Surface Soil Location	— — —	Site Boundary

Conc. = Concentration µg/kg

Site Features as of 1989

Note. Total PAH concentrations less than detection limits are indicated by a value of 0
All sampling locations are shown on Figure 4-1

0 200 400
SCALE IN FEET

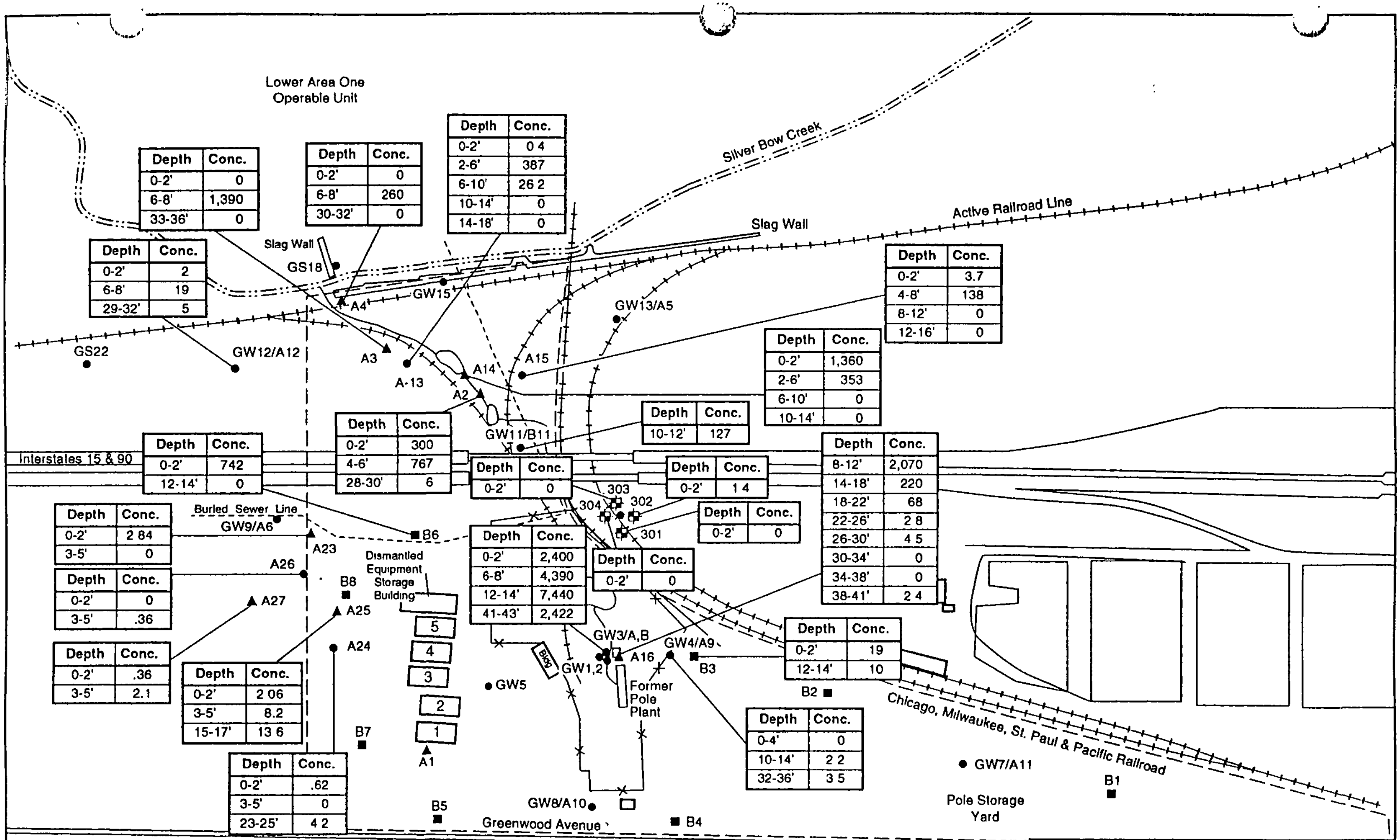
MO-3

MONTANA POLE AND
TREATING PLANT SITE

PAH CONCENTRATIONS DETECTED IN SUBSURFACE SOIL SAMPLES

FIGURE 4-6

11/93, Rev 1



Depth	Conc.
0-2'	0
6-8'	1,390
33-36'	0

Depth	Conc.
0-2'	0
6-8'	260
30-32'	0

Depth	Conc.
0-2'	0 4
2-6'	387
6-10'	26 2
10-14'	0
14-18'	0

Depth	Conc.
0-2'	2
6-8'	19
29-32'	5

Depth	Conc.
0-2'	3.7
4-8'	138
8-12'	0
12-16'	0

Depth	Conc.
0-2'	1,360
2-6'	353
6-10'	0
10-14'	0

Depth	Conc.
10-12'	127

Depth	Conc.
0-2'	300
4-6'	767
28-30'	6

Depth	Conc.
0-2'	742
12-14'	0

Depth	Conc.
8-12'	2,070
14-18'	220
18-22'	68
22-26'	2 8
26-30'	4 5
30-34'	0
34-38'	0
38-41'	2 4

Depth	Conc.
0-2'	0

Depth	Conc.
0-2'	1 4

Depth	Conc.
0-2'	0

Depth	Conc.
0-2'	2 84
3-5'	0

Depth	Conc.
0-2'	2,400
6-8'	4,390
12-14'	7,440
41-43'	2,422

Depth	Conc.
0-2'	0

Depth	Conc.
0-2'	0
3-5'	.36

Depth	Conc.
0-2'	19
12-14'	10

Depth	Conc.
0-2'	.36
3-5'	2.1

Depth	Conc.
0-2'	2 06
3-5'	8.2
15-17'	13 6

Depth	Conc.
0-4'	0
10-14'	2 2
32-36'	3 5

Depth	Conc.
0-2'	.62
3-5'	0
23-25'	4 2

LEGEND

- ▲ Subsurface Soil Boring Location
- ■ Subsurface Boring Based on 20% Surface Borings
- ● Monitoring Well/Subsurface Boring Location
- ✛ Supplemental Surface Soil Location
- ┼┼┼┼ Railroad Tracks
- =::=::: Creek
- —×—×— Fence
- — — — Site Boundary
- 1 Removed Soils Storage Building

Conc. = Concentration µg/kg

NOTE: A value of 0 is provided as the BTEX concentration if benzene, toluene, ethylbenzene and xylene are not detected All sampling locations are shown on Figure 4-1.

Site Features as of 1989

Mount Moriah Cemetary

N

0 200 400
SCALE IN FEET

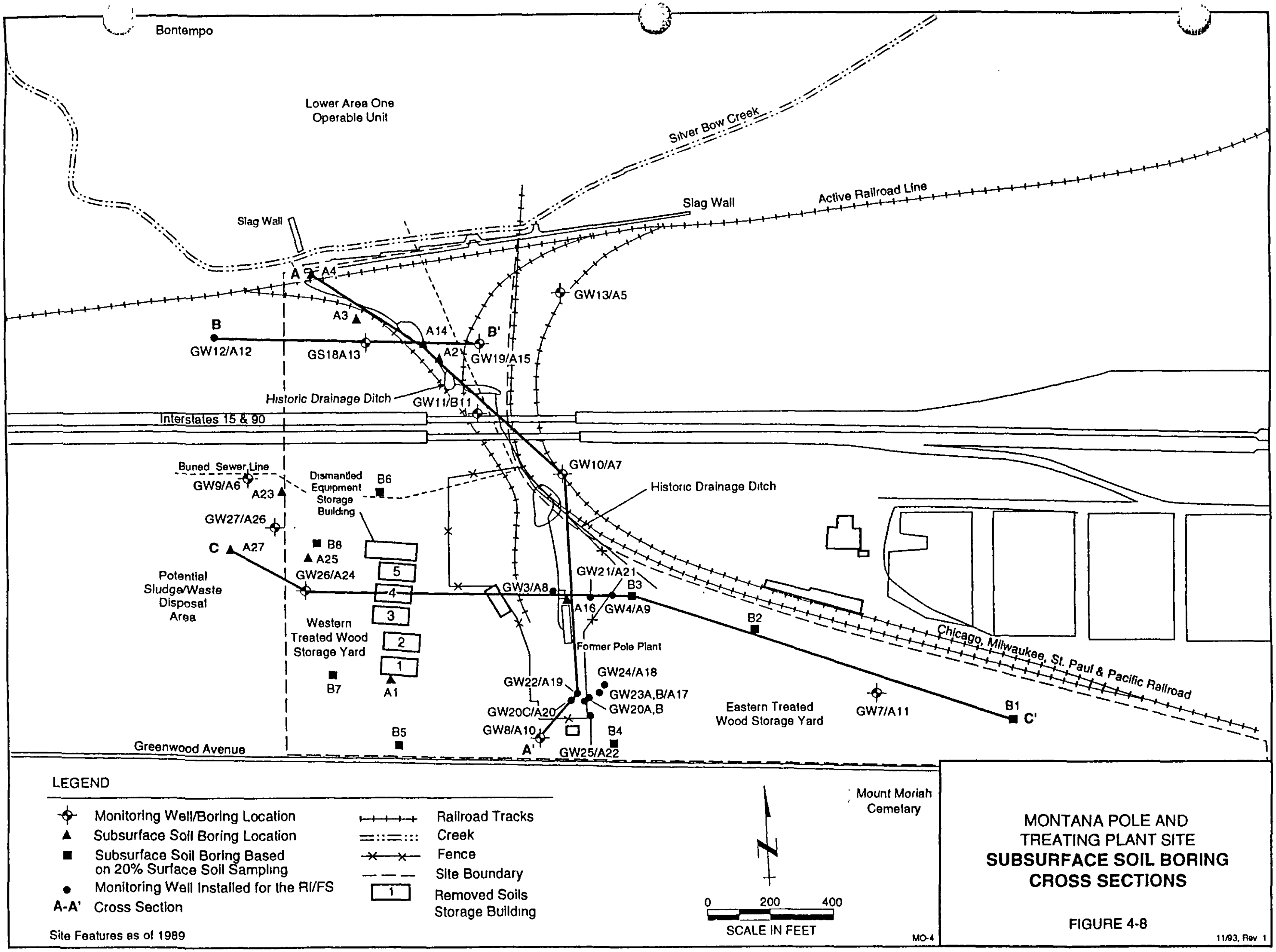
MO-3

MONTANA POLE AND
TREATING PLANT SITE

BTEX CONCENTRATIONS DETECTED IN SUBSURFACE SOIL SAMPLES

FIGURE 4-7

11/93, Rev 1

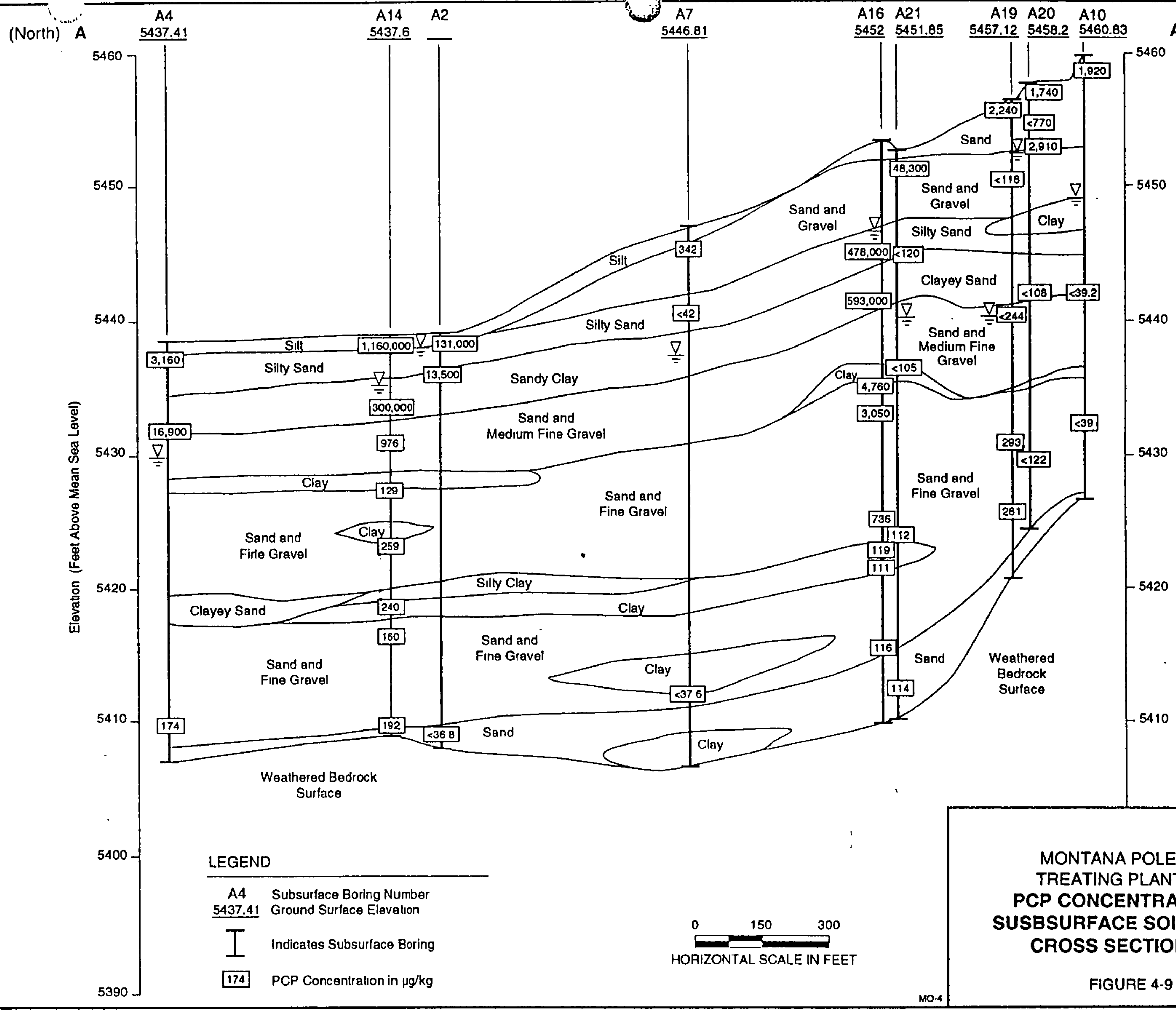


MONTANA POLE AND
TREATING PLANT SITE

**SUBSURFACE SOIL BORING
CROSS SECTIONS**

FIGURE 4-8

11/93, Rev 1

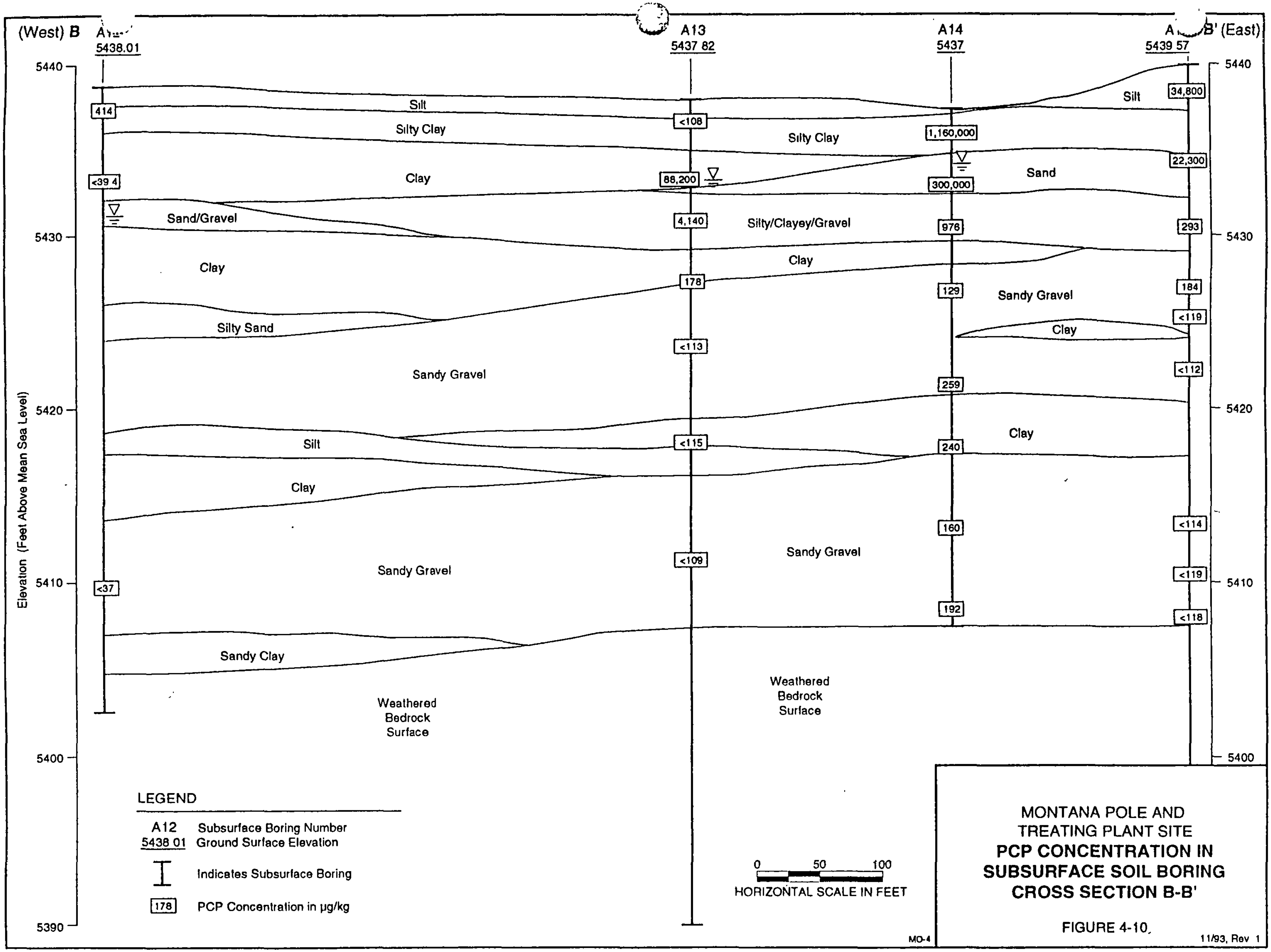


MONTANA POLE AND TREATING PLANT SITE

PCP CONCENTRATION IN SUSBSURFACE SOIL BORING CROSS SECTION A-A'

FIGURE 4-9

11/93, Rev 1

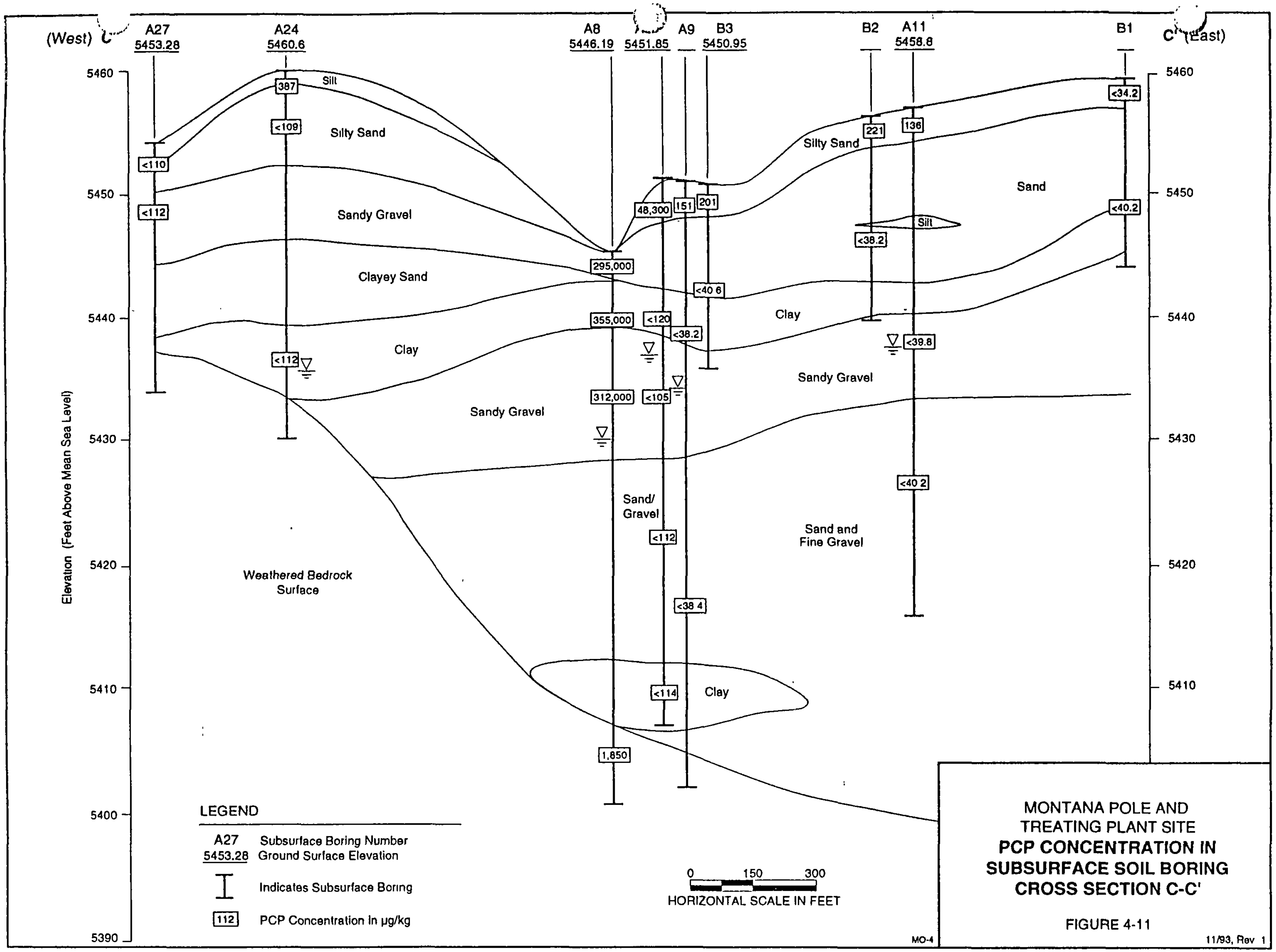


MONTANA POLE AND TREATING PLANT SITE

PCP CONCENTRATION IN SUBSURFACE SOIL BORING CROSS SECTION B-B'

FIGURE 4-10

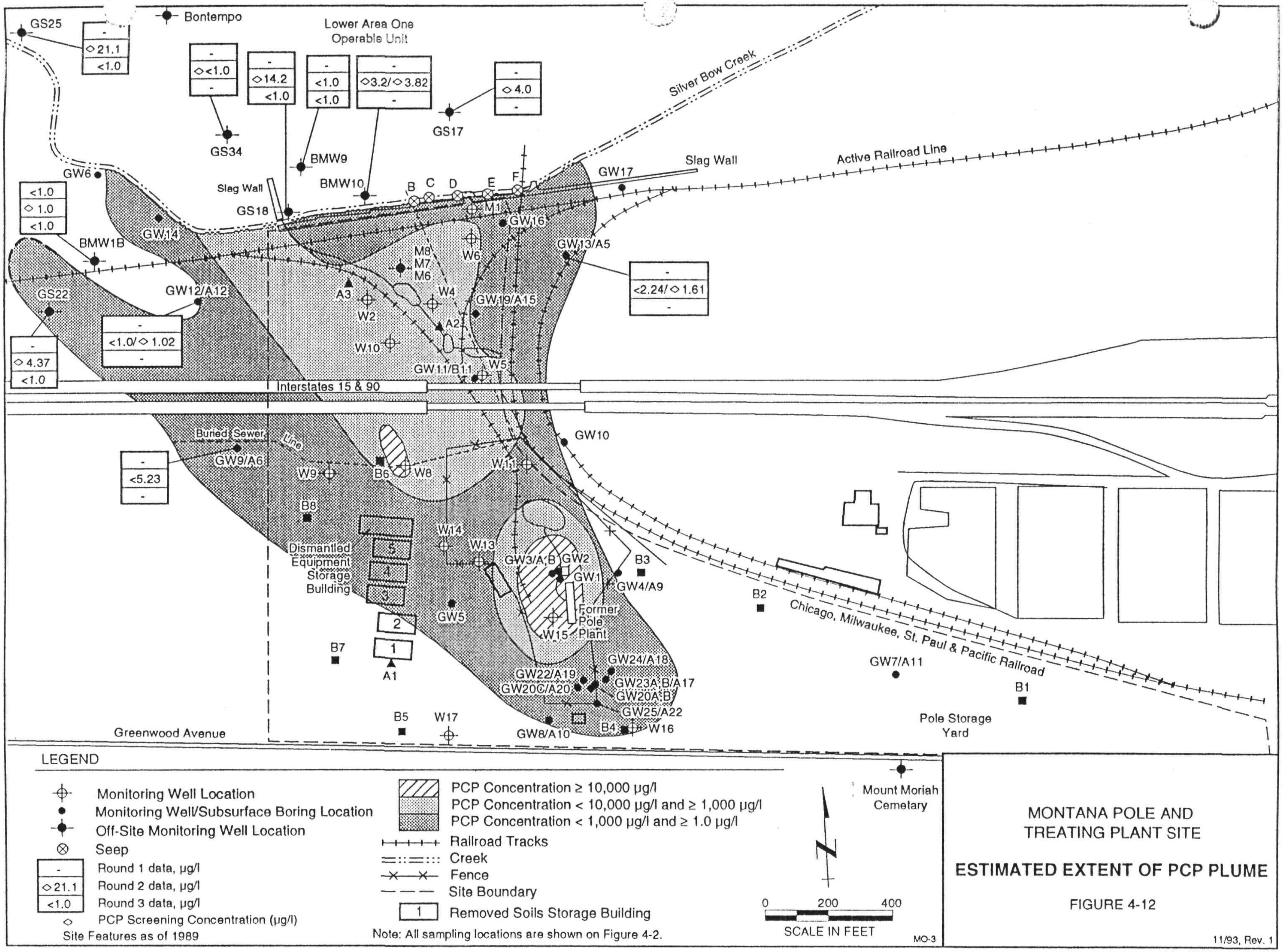
11/93, Rev 1



MONTANA POLE AND
TREATING PLANT SITE
**PCP CONCENTRATION IN
SUBSURFACE SOIL BORING
CROSS SECTION C-C'**

FIGURE 4-11

11/93, Rev 1

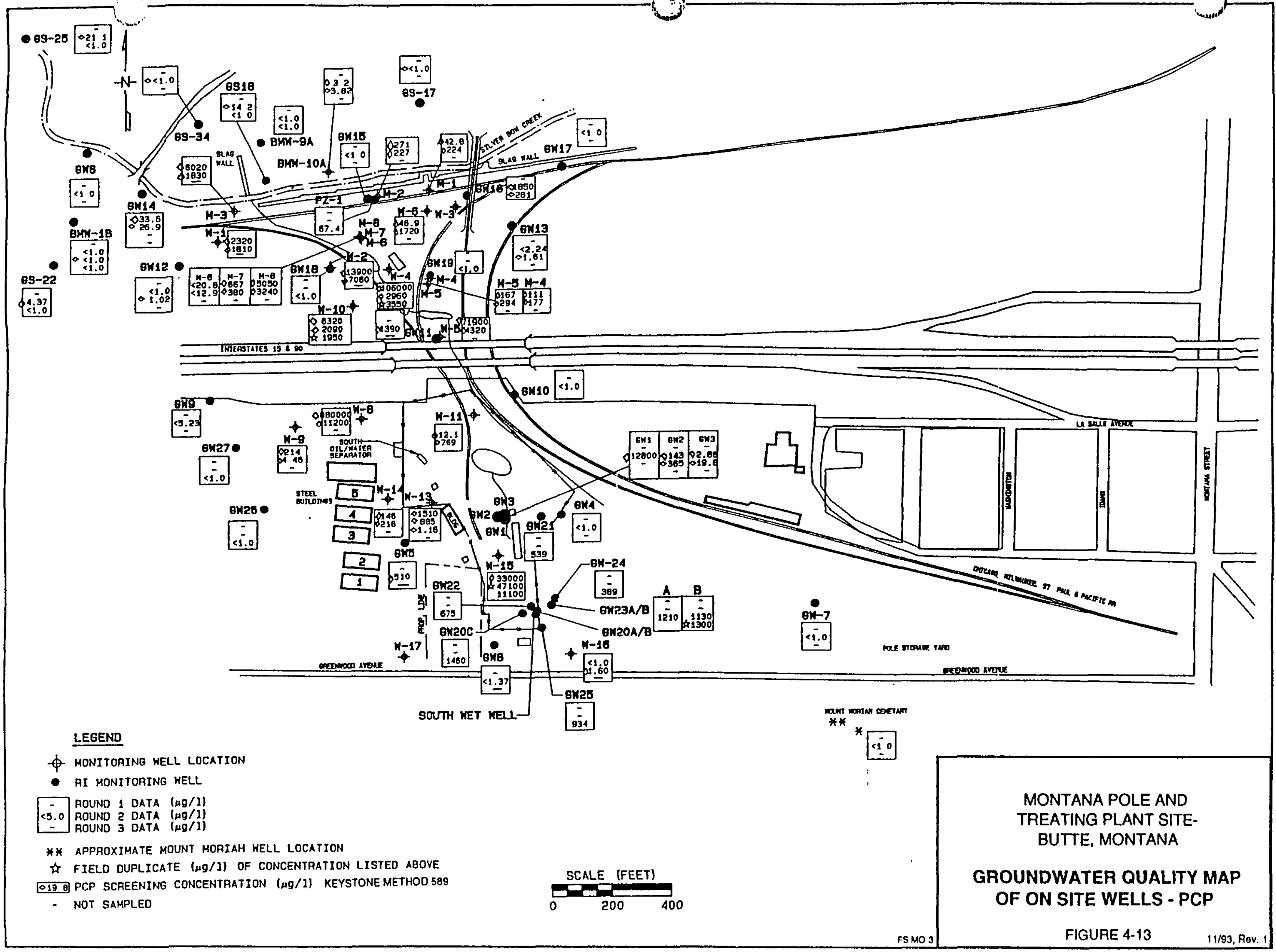


MONTANA POLE AND TREATING PLANT SITE

ESTIMATED EXTENT OF PCP PLUME

FIGURE 4-12

11/93, Rev. 1



LEGEND

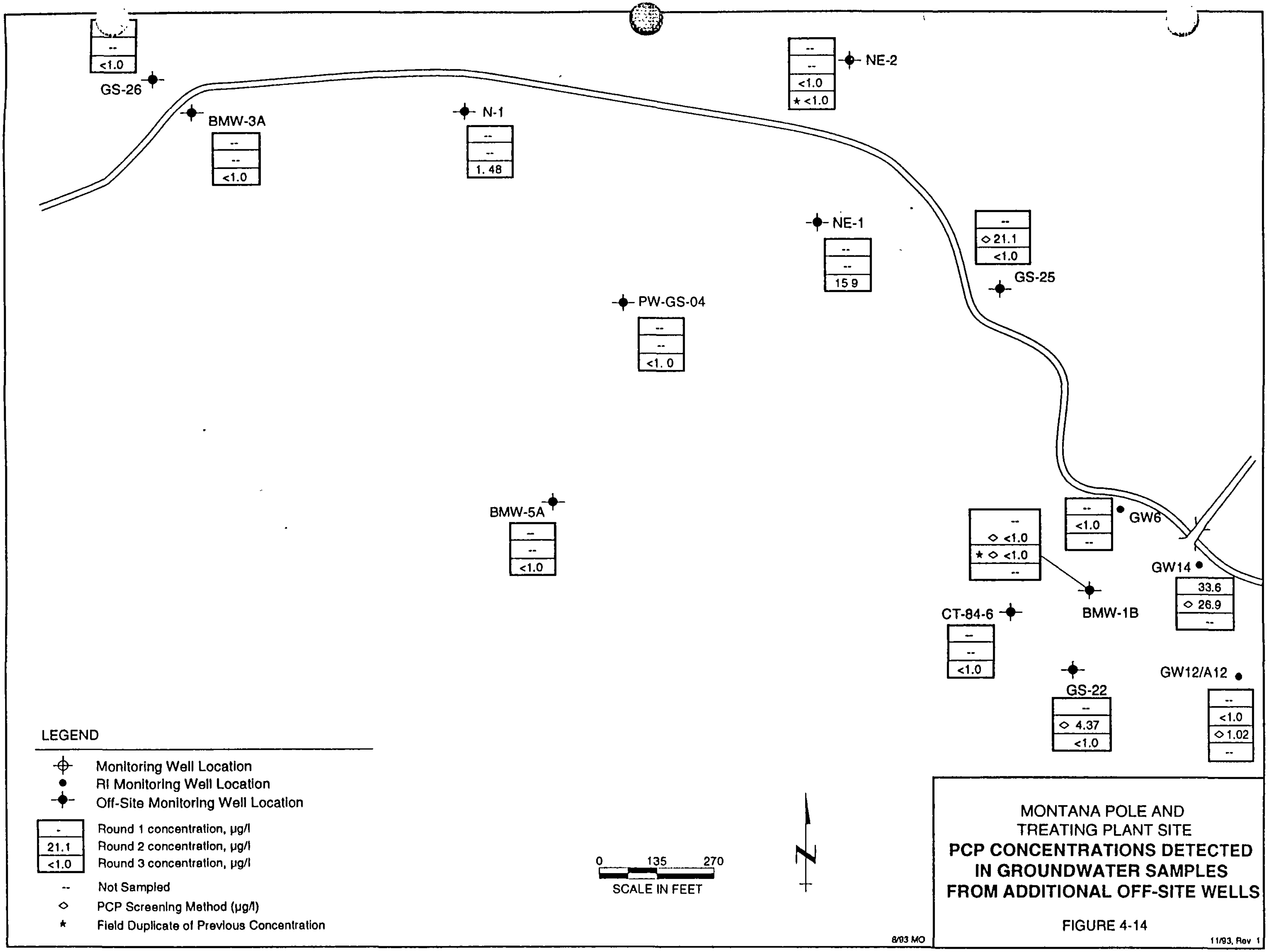
- ⌖ MONITORING WELL LOCATION
- ● RI MONITORING WELL
- ROUND 1 DATA (µg/l)
- ROUND 2 DATA (µg/l)
- ROUND 3 DATA (µg/l)
- ✱✱ APPROXIMATE MOUNT MORIAH WELL LOCATION
- ☆ FIELD DUPLICATE (µg/l) OF CONCENTRATION LISTED ABOVE
- ◇19.8 PCP SCREENING CONCENTRATION (µg/l) KEYSTONE METHOD 589
- \- NOT SAMPLED

MONTANA POLE AND
TREATING PLANT SITE-
BUTTE, MONTANA

GROUNDWATER QUALITY MAP OF ON SITE WELLS - PCP

FIGURE 4-13

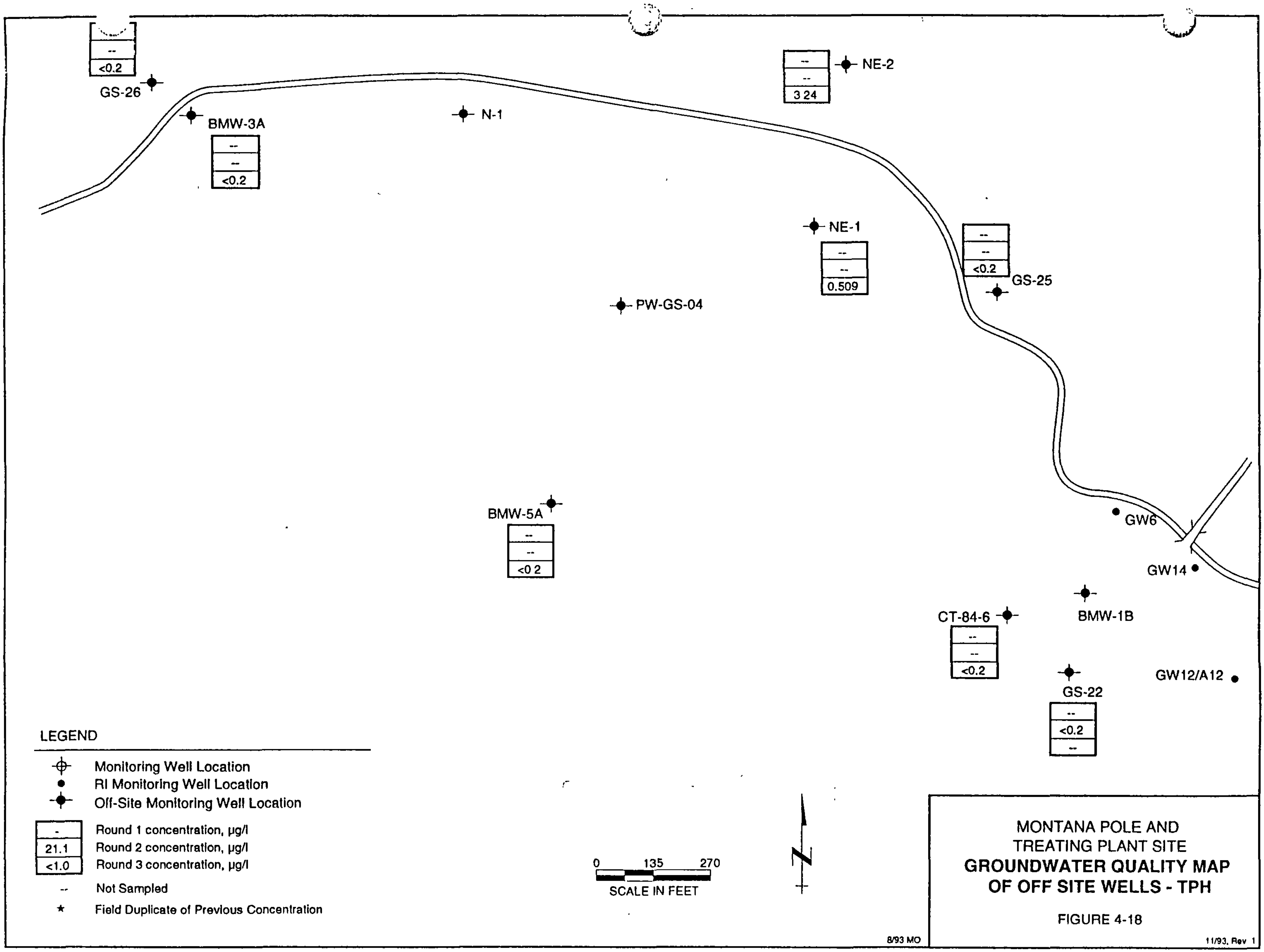
11/93, Rev. 1



MONTANA POLE AND
TREATING PLANT SITE
PCP CONCENTRATIONS DETECTED
IN GROUNDWATER SAMPLES
FROM ADDITIONAL OFF-SITE WELLS

FIGURE 4-14

11/93, Rev 1

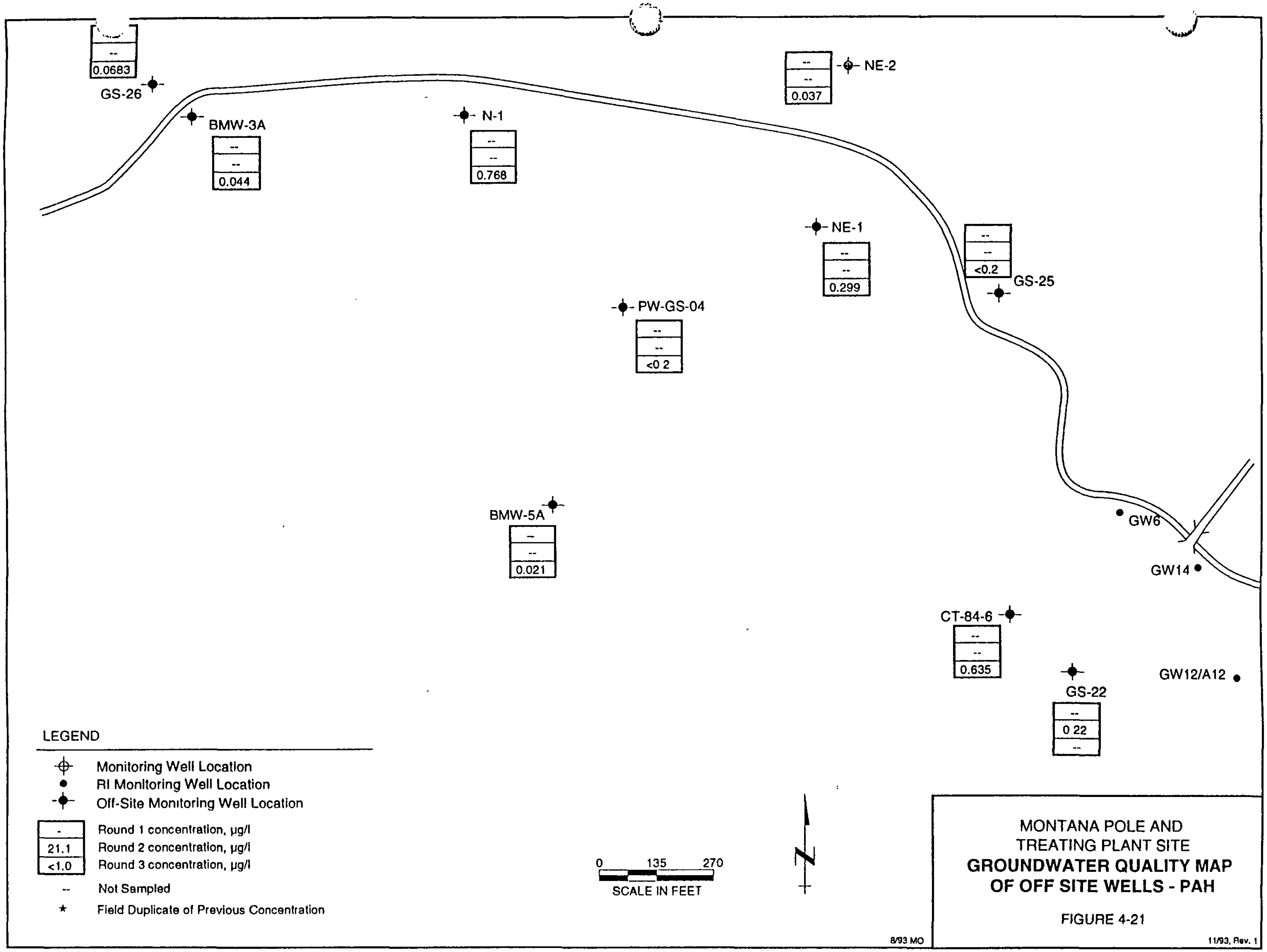


MONTANA POLE AND
TREATING PLANT SITE

GROUNDWATER QUALITY MAP
OF OFF SITE WELLS - TPH

FIGURE 4-18

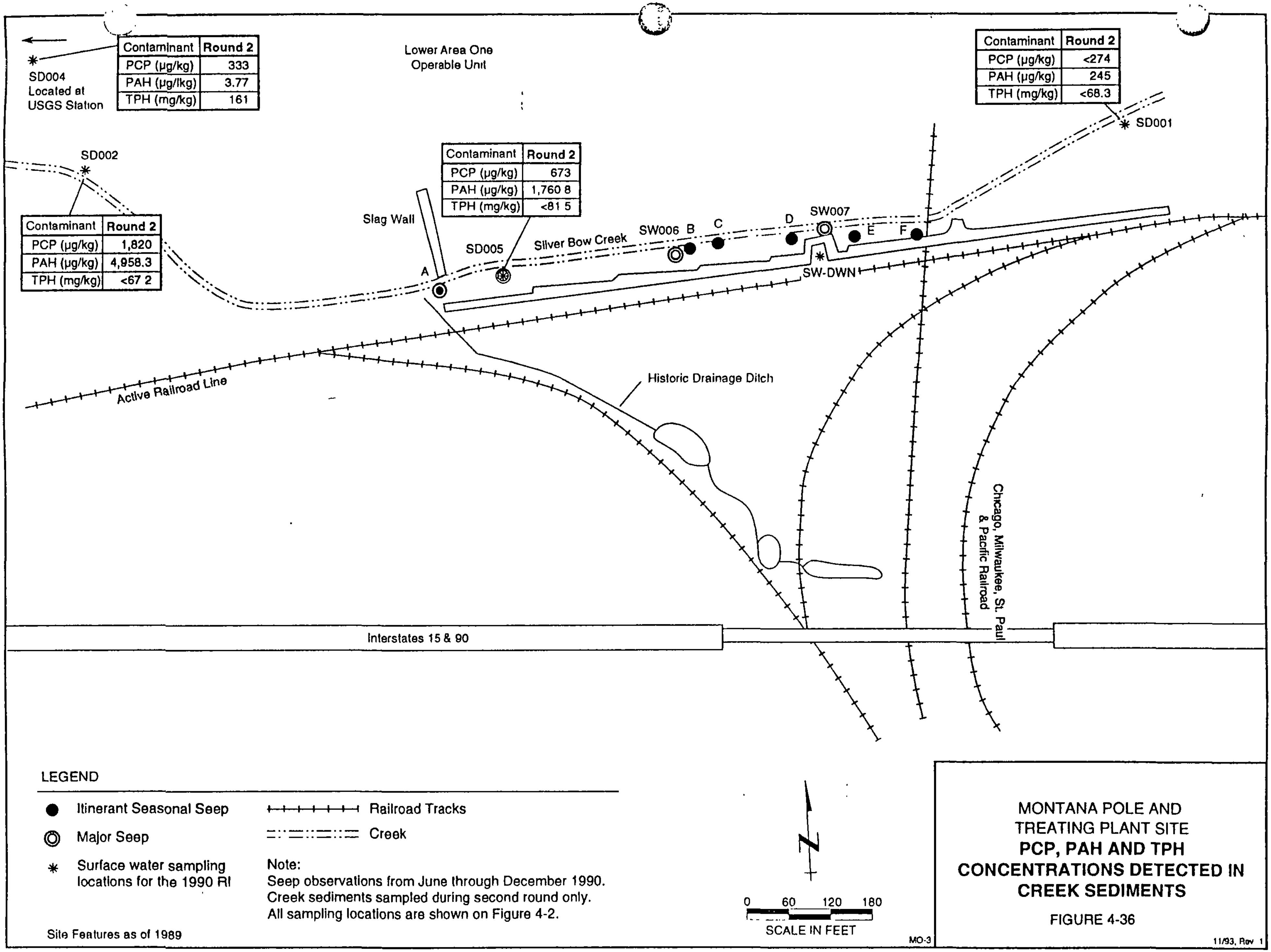
11/93, Rev 1



MONTANA POLE AND
TREATING PLANT SITE
GROUNDWATER QUALITY MAP
OF OFF SITE WELLS - PAH

FIGURE 4-21

11/93, Rev. 1



SD004

Contaminant	Round 2
PCP (µg/kg)	333
PAH (µg/lkg)	3.77
TPH (mg/kg)	161

SD001

Contaminant	Round 2
PCP (µg/kg)	<274
PAH (µg/kg)	245
TPH (mg/kg)	<68.3

SD005

Contaminant	Round 2
PCP (µg/kg)	673
PAH (µg/kg)	1,760 8
TPH (mg/kg)	<81 5

SD002

Contaminant	Round 2
PCP (µg/kg)	1,820
PAH (µg/kg)	4,958.3
TPH (mg/kg)	<67 2

LEGEND

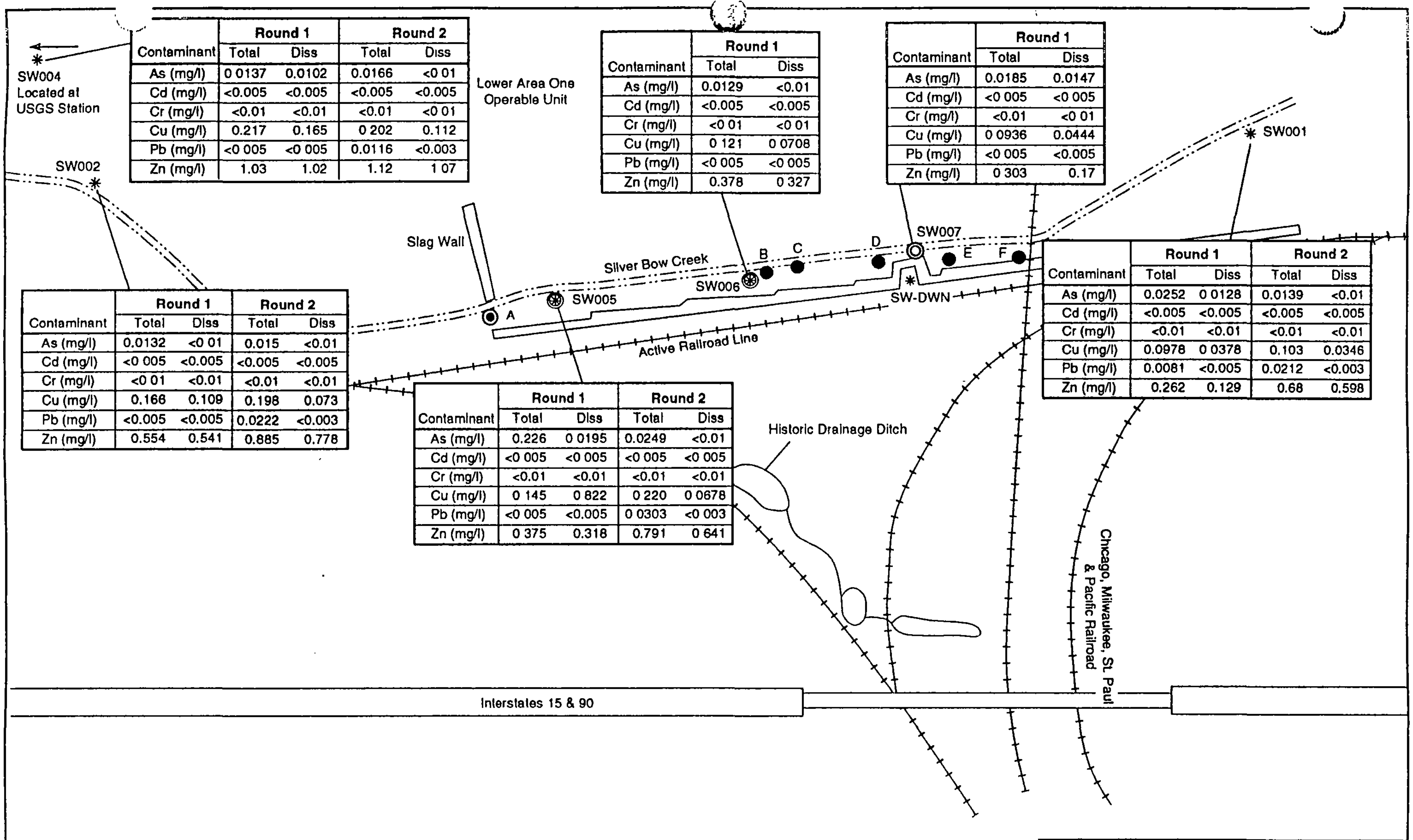
- ● Itinerant Seasonal Seep
- ◎ Major Seep
- ✳ Surface water sampling locations for the 1990 RI
- ┼┼┼┼┼┼┼ Railroad Tracks
- =·:==·:==·:= Creek

Note:
Seep observations from June through December 1990.
Creek sediments sampled during second round only.
All sampling locations are shown on Figure 4-2.

MONTANA POLE AND
TREATING PLANT SITE

PCP, PAH AND TPH CONCENTRATIONS DETECTED IN CREEK SEDIMENTS

FIGURE 4-36



Contaminant	Round 1		Round 2	
	Total	Diss	Total	Diss
As (mg/l)	0 0137	0.0102	0.0166	<0 01
Cd (mg/l)	<0.005	<0.005	<0.005	<0.005
Cr (mg/l)	<0.01	<0.01	<0.01	<0 01
Cu (mg/l)	0.217	0.165	0 202	0.112
Pb (mg/l)	<0 005	<0 005	0.0116	<0.003
Zn (mg/l)	1.03	1.02	1.12	1 07

Contaminant	Round 1	
	Total	Diss
As (mg/l)	0.0129	<0.01
Cd (mg/l)	<0.005	<0.005
Cr (mg/l)	<0 01	<0 01
Cu (mg/l)	0 121	0 0708
Pb (mg/l)	<0 005	<0 005
Zn (mg/l)	0.378	0 327

Contaminant	Round 1	
	Total	Diss
As (mg/l)	0.0185	0.0147
Cd (mg/l)	<0 005	<0 005
Cr (mg/l)	<0.01	<0 01
Cu (mg/l)	0 0936	0.0444
Pb (mg/l)	<0 005	<0.005
Zn (mg/l)	0 303	0.17

Contaminant	Round 1		Round 2	
	Total	Diss	Total	Diss
As (mg/l)	0.0132	<0 01	0.015	<0.01
Cd (mg/l)	<0 005	<0.005	<0.005	<0.005
Cr (mg/l)	<0 01	<0.01	<0.01	<0.01
Cu (mg/l)	0.166	0.109	0.198	0.073
Pb (mg/l)	<0.005	<0.005	0.0222	<0.003
Zn (mg/l)	0.554	0.541	0.885	0.778

Contaminant	Round 1		Round 2	
	Total	Diss	Total	Diss
As (mg/l)	0.226	0 0195	0.0249	<0.01
Cd (mg/l)	<0 005	<0 005	<0 005	<0 005
Cr (mg/l)	<0.01	<0.01	<0.01	<0.01
Cu (mg/l)	0 145	0 822	0 220	0 0678
Pb (mg/l)	<0 005	<0.005	0 0303	<0 003
Zn (mg/l)	0 375	0.318	0.791	0 641

Contaminant	Round 1		Round 2	
	Total	Diss	Total	Diss
As (mg/l)	0.0252	0 0128	0.0139	<0.01
Cd (mg/l)	<0.005	<0.005	<0.005	<0.005
Cr (mg/l)	<0.01	<0.01	<0.01	<0.01
Cu (mg/l)	0.0978	0 0378	0.103	0.0346
Pb (mg/l)	0.0081	<0.005	0.0212	<0.003
Zn (mg/l)	0.262	0.129	0.68	0.598

LEGEND

● Itinerant Seasonal Seep

◎ Major Seep

✳ Surface water sampling locations for the 1990 RI

+-+-+-+ Railroad Tracks

=::=::: Creek

Note:
Seep observations from June through December 1990.
All sampling locations are shown on Figure 2-2.
Diss = Dissolved.

Site Features as of 1989

0 60 120 180
SCALE IN FEET

MO-3

MONTANA POLE AND
TREATING PLANT SITE

METALS CONCENTRATIONS DETECTED IN SURFACE WATER SAMPLES

FIGURE 4-37

11/93, Rev 1

TABLE [illegible]-11

SUMMARY OF MONITORING WELL CONSTRUCTION DATA
MONTANA POLE AND TREATING PLANT SITE
BUTTE, MONTANA
(Page 3 of 4)

Well No.	Top of PVC Casing Elevation[1] (feet msl)	Total Depth (feet)	Diameter (inches)	Screened Interval[2] (feet)	Sand Pack Interval[3] (feet)	Construction Date
W-11	5447.71	26.04	4	9.0 to 25.0	7.0 to 25.0	8-8-85
W-12[4]		30.00	4	15.0 to 25.0	14.0 to 25.0	8-9-85
W-13	5451.67	27.5	4	10.0 to 22.0	10.0 to 25.0	8-13-85
W-14	5451.19	26.94	4	13.0 to 25.0	12.0 to 25.0	8-13-85
W-15	5451.54	29.84	4	12.5 to 30.0	9.5 to 30.0	8-12-85
W-16	5457.76	31.6	4	18.0 to 30.0	17.0 to 30.0	8-8-85
W-17	5463.99	23.5	4	12.0 to 22.0	11.0 to 22.0	8-12-85
PZ-1	5437.65	8.51	2	NA	NA	6-6-91
Silver Bow Creek CERCLA Monitoring Wells[5]						
BMW-1B	5433.90	59.3	4.5	38.7 to 58.7	NA	6-28-89
BMW-3A	5421.91	19.62	NA	NA	NA	NA
BMW-5A	5434.56	9.53	NA	NA	NA	NA
BMW-9A	5437.40	27.0	4.5	15.5 to 25.5	NA	7-11-90
BMW-10A	5437.70	7.0	4.5	4.0 to 7.0	NA	7-11-90
GS-17S	5434.70	10.3	2	3 to 8	NA	6-29-89
GS-17D	5434.10	28.0	2	17.7 to 27.7	NA	7-31-89
GS-18	5439.10	20.0	2	11 to 16	NA	6-30-89
GS-22	5435.90	20.3	2	5 to 15	NA	7-06-89
GS-25	5427.80	12.5	2	4.5 to 9.5	NA	7-06-89
GS-26	5424.44	15.02	NA	NA	NA	NA
GW-34S	5434.60	19.2	2	12.3 to 17.3	NA	7-27-89
GS-34D	5434.50	33.0	2	21.2 to 31.2	NA	7-27-89
PW-GS-04	5427.98	21.44	NA	NA	NA	NA

TABLE 2-16

SUMMARY OF SUBSURFACE SOIL SAMPLING COLLECTION DEPTHS
MONTANA POLE AND TREATING PLANT SITE
BUTTE, MONTANA
(Page 1 of 2)

Location	Sample Depths[1]
Test Pits	
SL201C	0-3
SL202C	0-3, 3-6, 6-9, 9-12, 12-15
SL205C	0-3, 3-6, 6-9, 9-15
SL206C	0-0.5, 1-6
SL207C	0-3, 3-6, 6-9, 9-12, 12-15
SL208C	2.5-3.5, 6.5-7.5
SL209C	0-1, 1-3, 3-6
SL211C	0-3, 3-6, 6-9, 9-12, 12-15
SL212C	0-3
SL214C	0-1.5, 1.5-3
SL215C	0-3, 3-5, 5-7
TP-1 through -18	Not sampled; see Section 2.2.4.1 for explanation
Auger Borings	
A-1	0-4, 18-22, 32-34
A-2	0-2, 6-8, 28-30
A-3	0-2, 68, 33-36
A-4	0-2, 6-8, 30-32
A-5	0-2, 4-6, 36-38
A-6	0-2, 14,16, 28-30
A-7	0-2, 8-10, 38-40
A-8	0-2, 6-8, 12-14, 41-43
A-9	0-2, 10-14, 32-36
A-10	0-2, 18-22, 26-30
A-11	0-4, 17-21, 27-31
A-12	0-2, 6-8, 29-32
A-13	0-2, 2-6, 6-10, 10-14, 14-18, 18-22, 22-26
A-14	0-2, 2-6, 6-10, 10-14, 14-18, 18-22, 22-26, 26-30
A-15	0-2, 4-8, 8-12, 12-16, 16-20, 20-24, 24-28, 28-32, 32-36
A-16	8-12, 14-18, 18-22, 22-26, 26-30, 30-34, 34-38, 38-41
A-17	0-2, 8-12, 12-16, 22-26
A-18	0-2, 8-12, 12-16, 22-26, 40-44
A-19	0-2, 14-18, 18-22, 24-28, 30-34

TABLE 2-23

CONSTITUENTS OF CONCERN
SEWERLINE SAMPLING
MONTANA POLE AND TREATING PLANT SITE
BUTTE, MONTANA

Parameter	Analytical Method	Comments
Phenols	EPA 8040	Three sewerline samples were analyzed.
PAH	EPA 8310	
Volatile Aromatics	EPA 8020	
Total and Dissolved Metals		
As	EPA 7060	
Cr	EPA 6010	
Cv	EPA 6010	
Cd	EPA 6010	
Pb	EPA 7421	
Zn	EPA 6010	
Total Petroleum Hydrocarbons	NYS 310.3	
Total Dissolved Solids	EPA 160.1	

TABLE 3-5

SUMMARY OF HYDRAULIC PROPERTIES DETERMINED THROUGH SLUG TESTING
MONTANA POLE AND TREATING PLANT SITE
BUTTE, MONTANA

	Hydraulic Conductivity (cm/sec)[1]			Calculated Transmissivity (gpd/ft)[4]
	Slug In	Slug Out	Average	
GW-1	6.8E-04	6.8E-04	6.8E-04	575
GW-2	2.7E-03	2.7E-03	2.7E-03	2,262
GW-3	1.7E-04	3.4E-04	2.6E-04	NC
GW-4	1.8E-03	1.1E-03	1.5E-03	1,486
GW-5	9.7E-04	1.1E-03	1.0E-03	775
GW-7	1.9E-03	4.1E-03	3.0E-03	2,779
GW-9	2.9E-03	2.4E-03	2.7E-03	1,616
GW-10	1.5E-02	1.5E-02	1.5E-02	12,279
GW-11	1.2E-03	8.6E-04	1.0E-03	969
GW-12	1.1E-02	1.4E-02	1.3E-02	8,401
GW-13	2.4E-04	2.8E-04	2.6E-04	2,068
GW-17	2.1E-03	2.2E-03	2.2E-03	110
M-1-87	2.6E-03[2]	NC	2.6E-03	2,197
M-2-87	2.7E-03[2]	NC	2.7E-03	2,262
M-3-87	2.8E-04[2]	NC	2.8E-04	237
M-4-87	2.4E-02[2]	NC	2.4E-02	20,035
M-5-87	3.1E-03[2]	NC	3.1E-03	2,650
M-6-87	4.2E-02[2]	NC	4.2E-02	2,650
M-7-87	1.1E-02[2]	NC	1.1E-02	85,957
M-8-87	3.8E-05[2]	NC	3.8E-05	32
W-1	2.4E-03[2]	NC	2.4E-03	2,204
W-3	[2, 3]	NC	NC	NC
W-6	[2, 3]	NC	NC	NC
W-9	3.6E-03[2]	NC	3.6E-03	3,038
W-11	3.5E-03[2]	NC	3.5E-03	2,910
W-13	4.2E-04[2]	NC	4.2E-04	355
W-14	1.8E-03[2]	NC	1.8E-03	1,525
W-16	[2, 3]	NC	NC	NC

Notes:

[1] Calculated using the method described in Bouwer and Rice (1976).

[2] Test involved injection of a known quantity of distilled water into the well.

[3] Data was not usable due to no displacement of the s.w.l.

[4] Calculated using the thickness and hydraulic conductivity measurements.

NC Not calculated, slug out tests were not performed.

TABLE 4-2

CONCENTRATIONS OF CONTAMINANTS IN MISCELLANEOUS OILS AND SLUDGES
(Page 1 of 2)

						Misc. Liquid with Sludge	
Chemical	Separator Oil Recovered (μg/l)	KPEG Treated Oils (μg/l)	KPEG Reagent Sludge (mg/kg)	Misc. Sludge (mg/kg)	Misc. Liquid (μg/l)	Oil Phase (μg/l)	Sludge Phase (mg/kg)
PCP	1,900 - 2,700	BDL	BDL	7,500	BDL - 160,000	8,800 - 11,000	6,500 - 17,000
PAHs	5,710 - 5,924	1,152 - 6,730	2,046 - 14,180	2,350	246,800 - 748,000	2,800 - 6,220	3,520 - 13,380
VOCs	57,000 - 304,000	34,300 - 43,500	60,000 - 253,000	27,000	42,100 - 321,800	105,200 - 390,000	BDL - 86
TCL and TCLP Pesticides							
Aldrin	1.0 - 1.3[a]	3.4 - 9.39[a]	BDL	BDL	BDL	2.0 - 24.0[a]	29
4,4-DDT	2.4 - 3.1[a]	BDL	BDL	BDL	BDL	BDL	BDL
Heptachlor	299	27.40	NA	NA	NA	NA	NA
Heptachlor epoxy	299	2.43	NA	NA	NA	NA	NA
Methoxychlor	NA	6.62	NA	NA	NA	NA	NA
TCLP Herbicide 2,4-TP	9.78 - 6,500	NA	NA	NA	NA	0.15	NA
2,3,7,8-TCDD (equiv.)	0.214 - 0.424	0.00	NA	0.195 - 0.206	0.283 - 280	0 - 3.11	NA
TCLP Metals							
Arsenic	BDL	BDL	NS	BDL	NS	BDL	BDL
Barium	<200	BDL	NS	310	NS	BDL	BDL
Cadmium	BDL	BDL	NS	BDL	NS	BDL	BDL
Chromium	BDL	BDL	NS	11.5	NS	1,630	BDL
Lead	BDL	BDL	NS	BDL	NS	BDL	BDL
Mercury	BDL	BDL	NS	BDL	NS	BDL	BDL
Silver	BDL	BDL	NS	BDL	NS	BDL	BDL

TABLE 4-2

CONCENTRATIONS OF CONTAMINANTS IN MISCELLANEOUS OILS AND SLUDGES
(Page 2 of 2)

						Misc. Liquid with Sludge	
Chemical	Separator Oil Recovered (μg/l)	KPEG Treated Oils (μg/l)	KPEG Reagent Sludge (mg/kg)	Misc. Sludge (mg/kg)	Misc. Liquid (μg/l)	Oil Phase (μg/l)	Sludge Phase (mg/kg)
TCLP Semivolatile Organic Compounds							
2,4,6-trichlorophenol	497 - 128,000	BDL	NS	0.964	NS	BDL	BDL
Pentachlorophenol	BDL - 4,920	BDL	NS	14.3	NS	BDL	BDL
Non-TCLP Metals[a]							
Cadmium	BDL	14	NS	NA	NS	BDL	BDL
Chromium	- - - - - - - - - - - - - - - - Ranged from BDL (6 to 10 mg/kg) - 720 - - - - - - - - - - - - - - - -						
Copper	BDL	BDL	NS	290	NS	NA	NA
Lead	1,200	1,200	NS	NA	NS	BDL	NA
Zinc	NA	NA	NS	NA	250	NA	NA
Corrosivity	corrosive	corrosive	NS	non-corrosive	NS	non-corrosive	non-corrosive

[a] Reported as mg/kg in draft RI (Keystone, 1992e)

BDL	below detection limit	PCP	pentachlorophenol
PAH	polycyclic aromatic compounds	NA	Information not available
VOC	volatile organic compounds	NS	Not Sampled

TABLE 4-6

CONCENTRATION OF CONTAMINANTS IN REMOVED SOILS
MONTANA POLE AND TREATING PLANT SITE
BUTTE, MONTANA

Contaminant	Range in Concentration
Chlorobenzene (μg/kg)	ND-2.2
PCP (μg/kg)	116,000 - 1,450,000
PAH (μg/kg)	16,558 - 441,595
TPH (mg/kg)	ND - 23,600
2,3,7,8-TCDD equivalent (μg/kg)	2.12 - 9.77
Metals Total	
Cu (μg/kg)	ND - 183,000
Cd μg/kg)	644 - 742
Zn (μg/kg)	ND - 194,000
TCLP Extract for Metals	
As (μg/l)	112 - 118
Ba (μg/l)	1,080 - 1,560
Cd (μg/l)	11.7 - 12.5

ND = Not Detected

TABLE 4-10

CONCENTRATION OF CONTAMINANTS IN SUBSURFACE SOIL SAMPLES
MONTANA POLE AND TREATING PLANT
BUTTE, MONTANA

Contaminant	Range in Concentration	Average Concentration	Number of Samples
PCP (μg/kg)	38.1 - 1,160,000	26,835	150
TPH (mg/kg)	17.1 - 55,600	1,629	133
PAH (μg/kg)	1 - 2,304,320	37,874	128
BTEX (μg/kg)	0.36 - 7,440	254	93
2,3,7,8-TCDD equivalent (μg/kg)	0 - 16,383		7

TABLE 4-13

SUMMARY OF OFF-SITE WELL LOCATIONS
ANALYTICAL RESULTS FOR ROUND 3
MONTANA POLE AND TREATING PLANT
BUTTE, MONTANA
(Sheet 1 of 2)

Parameter	GS-26[a]	BMW-3A[a]	BMW-5A[a]	CT-84-6[a]	N-1[a]	NE-1[a]	NE-2[a]	PW-GS-04[a]
PCP (µg/l)	<1 U	<1 U	<1 U	<1 U	1.48 U	15.9	<1 U	<1 U
PAH (mg/l)	0.683	0.044	0.021	0.635	0.768	0.299	0.037	<2 U
TPH (mg/l)	<.2	<.2	<.2	<.2	NA	0.509	3.24	NA
Metals								
As (µg/l)	37.5	124	<10 U	57.9	41.2	406	<10 U	1,570
Cd (µg/l)	230	<5 U	<5 U	72.3	213	<5 U	<5 U	232
Cu (µg/l)	21,500	<25 U	<25 U	2,120	21,900	744	<25 U	14,800
Cr (µg/l)	<10 U	<10 U	<10 U	<10 U	<10 U	<10 U	<10 U	<10 U
Pb (µg/l)	159	<3 U	<3 U	<3 U	<3 U	<3 U	<3 U	1,570
Zn (µg/l)	75,200	7,140	<20 U	36,200	61,000	9,140	135	68,700
Total Organic Carbon (mg/l)	5.94	5.42	4.01	18.9	1.85	5	2.88	7.22
Total Dissolved Solids (mg/l)	2,070	564	696	759	1,500	1,390	783	1.64
Conductance (µmhos/cm)	1,033	518	505	454	853	795	555	575

TABLE 4-13

SUMMARY OF OFF-SITE WELL LOCATIONS ANALYTICAL RESULTS FOR ROUND 3 MONTANA POLE AND TREATING PLANT BUTTE, MONTANA

(Sheet 2 of 2)

Parameter	GS-18	GS-22	GS-25	BMW-9A
PCP (μg/l)	14.2	4.37	21.1	<1 U
PAH (mg/l)	<2 U	0.22	<2 U	<2 U
TPH (mg/l)	0.287	<.2 U	<.2 U	<.2 U
Metals				
As (μg/l)	<10	33.4	24.5	47.5
Cd (μg/l)	106	<5	79.6	5.99
Cu (μg/l)	5,670	<25	<25	<25
Cr (μg/l)	<10	<10	<10	<10
Pb (μg/l)	<3	<3	<3	<3
Zn (μg/l)	39,400	173	33,400	42,200
Total Organic Carbon (mg/l)	3.59	3.58	3.92	4.77
Total Dissolved Solids (mg/l)	1,230	762	1,030	1,570
Conductance (μmhos/cm)	803	500	695	1,200

GS - shallow groundwater monitoring well
U - The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.
[a] - Sampling locations area shown on Figure 2-7.

TABLE 5-2

SUMMARY OF CHEMICAL MIGRATION VELOCITY CALCULATIONS FOR SELECTED SUBSTANCES OF CONCERN MONTANA POLE AND TREATING PLANT BUTTE, MONTANA

Constituent	K_{ow}[a] (mℓ/g)	K_{oc}[b] (mℓ/g)	K_D[c] (mℓ/g)	Estimated R Value[d]	Estimated Average Migration Velocity ft/yr[e]
LPAH	$2.3 \times 10^3 - 2.9 \times 10^4$	$1.4 \times 10^3 - 1.8 \times 10^4$	2.2 - 29	13.4 - 164	0.7 - 8.2
HPAH	$7.6 \times 10^4 - 5.0 \times 10^7$	$4.7 \times 10^4 - 3.1 \times 10^7$	75 - 50,000	423 - 282,000	0.0004 - 0.26
Pentachlorophenol	1.0×10^5	5.6×10^2	0.9	6.1	18.1
BTEX	$8.9 \times 10^4 - 1.4 \times 10^3$	$5.5 \times 10^1 - 8.9 \times 10^2$	$8.8 \times 10^{-2} - 1.4$	1.5 - 8.9	12.4 - 74

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[a] Source: U.S. EPA (1985, 1990).

[b] See text for derivation of K_{oc} values.

[c] $K_D = K_{oc} * OCC = K_{oc} * 0.0016$.

[d] Retardation Factor (R) = $1 + K_D \rho_b/\Theta$

where:

ρ_b = bulk density = $(1-\Theta)(ps)$ = 1.80 g/cm^3

Θ = porosity = 0.32

ps = particle density = 2.65 g/cm3 (estimated value)

[e] Assuming an average groundwater velocity of 110 ft/yr.