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**INSTALLATION RESTORATION PROGRAM
PHASE II-CONFIRMATION/QUANTIFICATION
STAGE 1**

**FOR
AIR FORCE PLANT PJKS WATERTON,
COLORADO
VOLUME I**

**PREPARED BY:
ENGINEERING-SCIENCE
DESIGN • RESEARCH • PLANNING
1100 STOUT STREET, SUITE 1100
DENVER, COLORADO 80204**

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**OCTOBER 1986
FINAL REPORT FOR PERIOD OCTOBER 1985
TO OCTOBER 1986**

Approved for Public Release, Distribution is Unlimited

**PREPARED FOR:
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION
FACILITIES MANAGEMENT DIVISION (ASD/PMDA)
OHIO 45433-6503**

AND

**HEADQUARTERS AIR FORCE SYSTEMS COMMAND
COMMAND BIOENVIRONMENTAL ENGINEER (AFSC/SGPB)
ANDREWS AIR FORCE BASE, D.C. 20334-5000**

**UNITED STATES AIR FORCE
OCCUPATIONAL & ENVIRONMENTAL HEALTH
LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501**

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ENGINEERING-SCIENCE

INSTALLATION RESTORATION PROGRAM PHASE II - CONFIRMATION/QUANTIFICATION STAGE 1

FOR

AIR FORCE PLANT PJKS,
WATERTON, COLORADO

VOLUME I

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DENVER, COLORADO

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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 1

Final Report
For

Air Force Plant PJKS,
Waterton, Colorado

Headquarters Aeronautical Systems Division
Facilities Management Division (ASD/PMDA)
Wright-Patterson AFB,
Ohio 45433-6503

And

Headquarters Air Force Systems Command
Command Bioenvironmental Engineer (AFSC/SGPB)
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Occupational & Environmental Health Laboratory (USAFOEHL)
Technical Services Division (TS)
Brooks Air Force Base, Texas 78235-5501

October 1986

PREPARED BY
Engineering-Science, Inc.
Denver, Colorado

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)				
<p>A field investigation was conducted to confirm or deny the presence of hazardous wastes at eight sites at Air Force Plant PJKS near Waterton, Colorado. Activities at the plant that could have generated hazardous wastes include the development and testing of rocket engines. The field program included sampling of surface waters, soils, and sediments, and the installation and sampling of eight ground water monitoring wells. Hazardous substances found at the eight sites included TCE and other halocarbons, NDMA (a decomposition product of hydrazine), phenols, and trace amounts of heavy metals, including arsenic, hexavalent chromium, and selenium. Elevated levels of radiation were detected in ground waters downgradient from a landfill known to contain a small amount (25 kilograms) of low-level radioactive magnesium-thorium alloy. Since natural uranium mineralization occurs within the area, the background level of radiation needs to be established before the significance of the measured radiation can be determined. Contamination of soils and sediments was determined to be of low significance because of the low levels of contamination and a lack of pathways for offsite migration. Contamination of surface and ground waters at sites 1, 2, 4, 5, and 11 was judged to be moderately significant because the contaminants occurred at concentrations exceeding standards or guidelines to protect human health, and the potential for contaminant migration exists. Plans for future studies to determine the sources and extent of surface and ground water contamination were developed.</p>				
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IRP - PHASE II

FINAL 10/6/86

EXECUTIVE SUMMARY

The Department of Defense (DOD) has developed a program to identify and evaluate past hazardous waste disposal sites on DOD facilities. The program is structured to sequentially assess potential hazards to public health and the environment, confirm the presence of such hazards, and evaluate and implement applicable corrective measures. The program, entitled the Installation Restoration Program (IRP) consists of four phases, including:

Phase I - Installation Assessment/Records Search;

Phase II - Confirmation/Quantification;

Phase III - Technical Base Development; and

Phase IV - Operations/Remedial Actions.

The IRP Phase II is divided into an initial assessment of contamination for purposes of determining the presence or absence of contamination, and a more comprehensive assessment designed to quantify the extent, direction, and rate of contaminant migration. This investigation constitutes the Phase II, initial stage at Air Force Plant (AFP) PJKS, located near Waterton, Colorado. The objectives of the investigation were to 1) determine the presence or absence of contamination at suspected sites identified in the Phase I records search conducted by JRB Associates, Inc. in 1984; 2) identify specific requirements, if any, for additional work to determine the magnitude, extent, and direction and rate of movement of detected contaminants; and 3) assess the need for remedial action under Phase IV. This report presents the results of these Phase II objectives.

IRP - PHASE II

FINAL 10/6/86

INSTALLATION DESCRIPTION

AFP PJKS is located on 464 acres of land in the foothills of the Rocky Mountains, approximately 20 miles south-southwest of Denver (Figure 1). From 1957 until the present, AFP PJKS plant activities have consisted of missile assembly (Titan I, II, and III), engine testing, and research and development. Fuels development, purification, and testing activities in support of the Titan III program were also conducted.

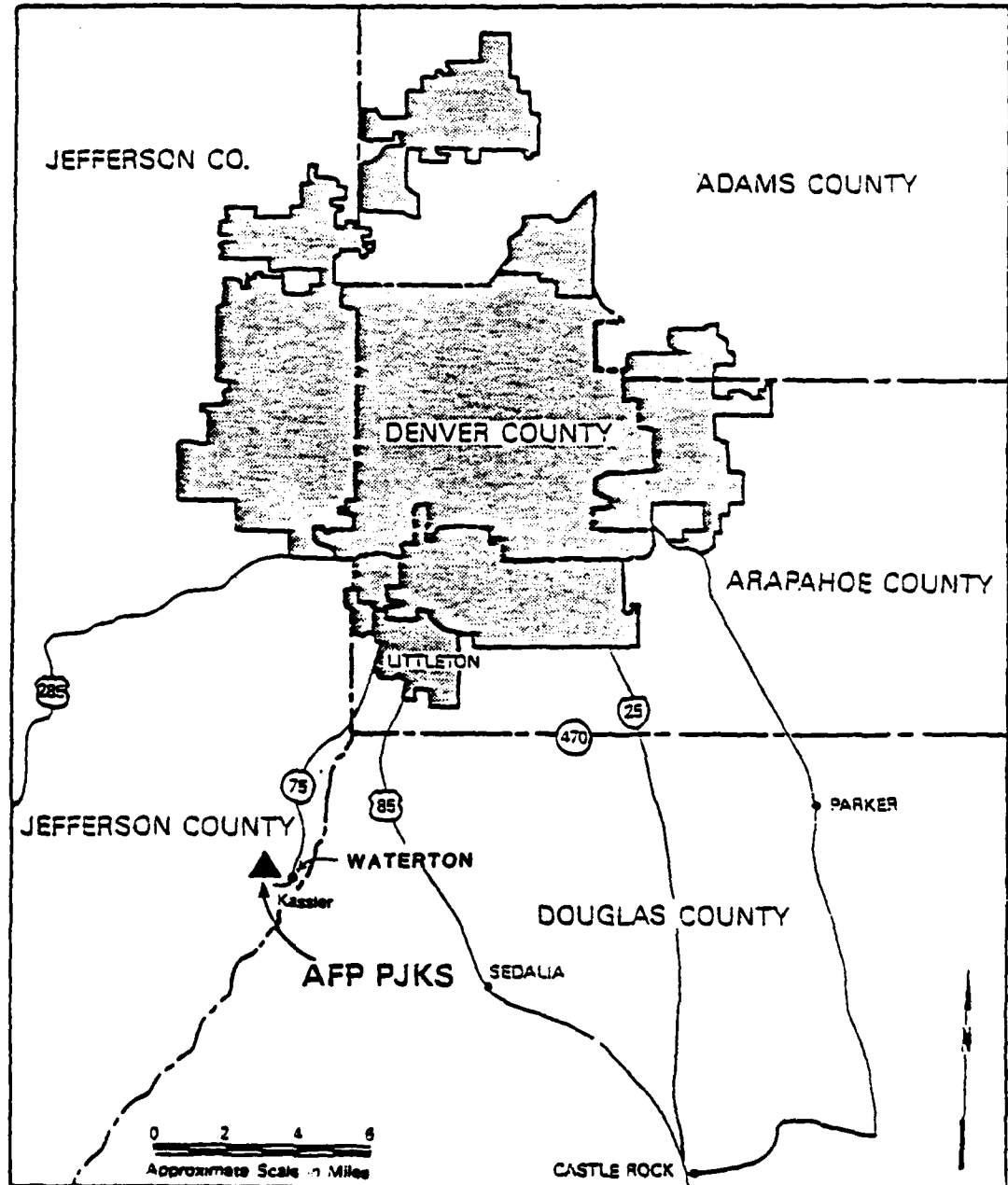
The AFP PJKS site is surrounded by approximately 4,700 acres of land owned by the Martin Marietta Company, as illustrated on Figure 2. All of Martin Marietta's production, testing, and storage facilities are located southeast of and at a lower elevation than the Air Force property. Ground water contamination was recently discovered beneath the Martin Marietta property, downgradient from the Air Force property. Subsequent investigations revealed surface water contamination downstream from AFP PJKS.

This IRP Phase II investigation represents the first determination of possible contamination on the Air Force property. The IRP Phase I records search recommended that six sites be further investigated under Phase II. During the course of this Phase II study, two other sites were identified as potential sources of contamination. The potential sources of contaminants at the eight sites are summarized in Table 1 and the site locations are shown on Figures 3 and 4.

METHODOLOGIES

Contaminant investigation was accomplished through sampling and analysis of site soils, ground waters, surface waters, and sediments. Eight ground water wells were drilled and constructed. These wells, in conjunction with 11 soil borings, 11 surface water stations, and 20

FIGURE 1
AIR FORCE PLANT PJKS
WATERTON, COLORADO
AREA LOCATION



NOTE: SHADED PATTERN INDICATES THE DENVER METROPOLITAN AREA

SOURCE: JRB ASSOCIATES, INC., 1984

FIGURE 2
LOCATION OF AFP PJKS
RELATIVE TO MARTIN MARIETTA PROPERTY

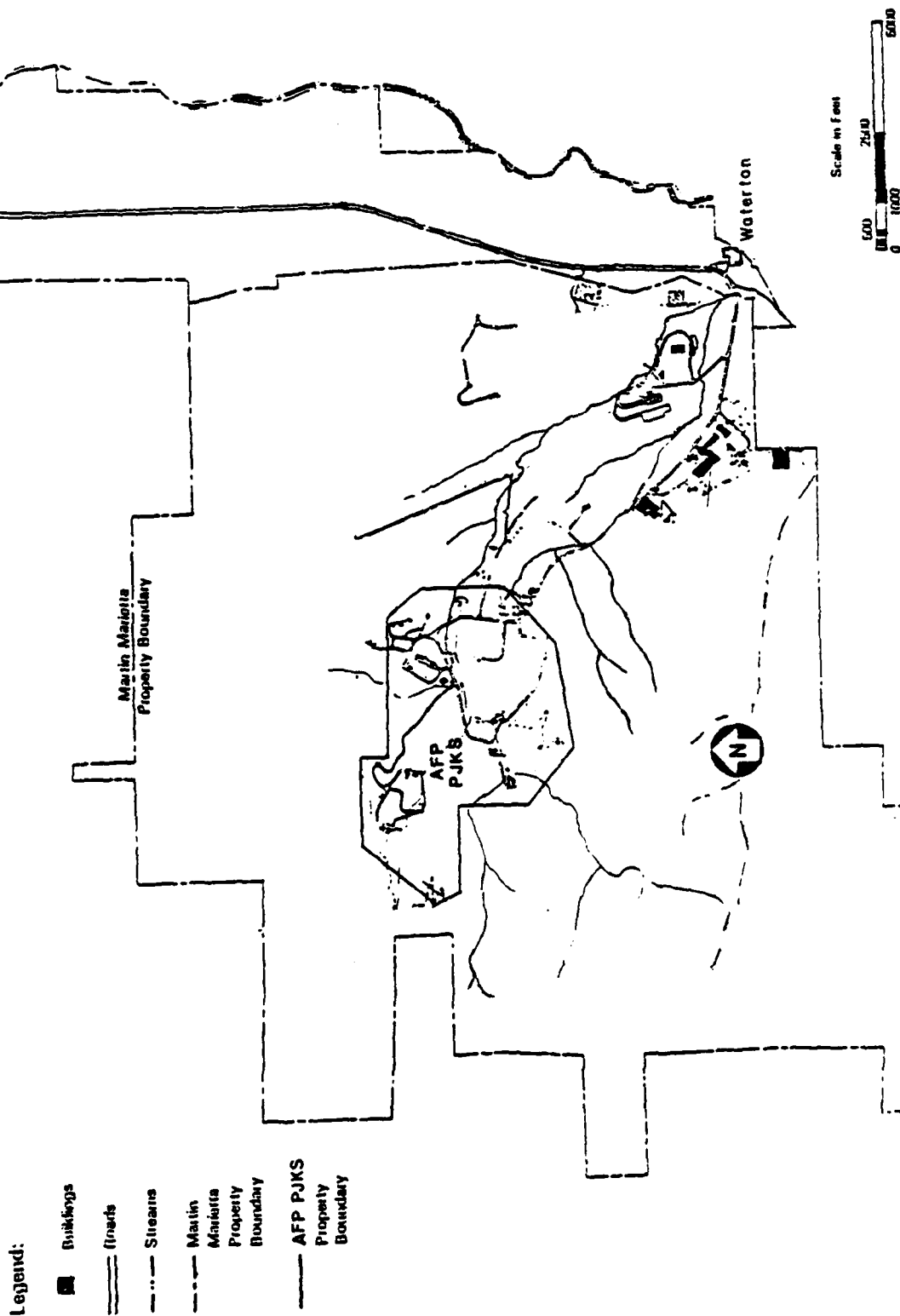


TABLE 1
SUMMARY OF SITES AND POTENTIAL SOURCES OF CONTAMINANTS AT AFP PJKS

<u>Site</u>	<u>Period of Use</u>	<u>Potential Sources of Contaminants</u>
Site 1: T-8A Containment Pond	1957 - early 1960's	. Deluge water from test stands containing hydrazine and N_2O_4 .
	1957-1985	. East Fork Brush Creek water.
	1957 - present	. Process water ^{1/} from EPL Test Cells. ^{2/} Surface runoff.
	1960 - 1983	. Treated waters from Systems and Components Test Facilities.
	1961 - 1985	. Cooling water from refrigeration system at T-28 (Site 7). ^{3/}
Site 2: EPL Test Cells, Valve Shop, Ready Storage Area, and Soil Cones	1961 - present	. Limited testing of propulsion systems using hydrazine type fuels, oxidizers, isopropyl alcohol and freon. ^{2/}
	1957 - present	. Cleaning wastes, including TCE ^{4/} (1957-1964), Oakite ^{5/} (mid-70's), 1,1,1-trichloroethane (1964-present), isopropyl alcohol (1957-present), toluene (late-60's), freon (1957-present), methyl ethyl ketone (1957-present), nitric and hydrofluoric acids (late 70's-present) ^{2/} .
	1957 - present	. Thermotransfer agent - ethylene glycol. ^{2/}
Site 3: EPL Building T-6 and Building T-20A	1958 - 1965	. TCE for pump cleaning.
	1960 - 1970	. Isopropyl alcohol and sodium dichromate from testing.
Site 4: Tank T-31	1961 - 1964	. Storage and treatment of deluge water from test stands D-1 and D-2 containing hydrazine and N_2O_4 .

TABLE 1 (Continued)

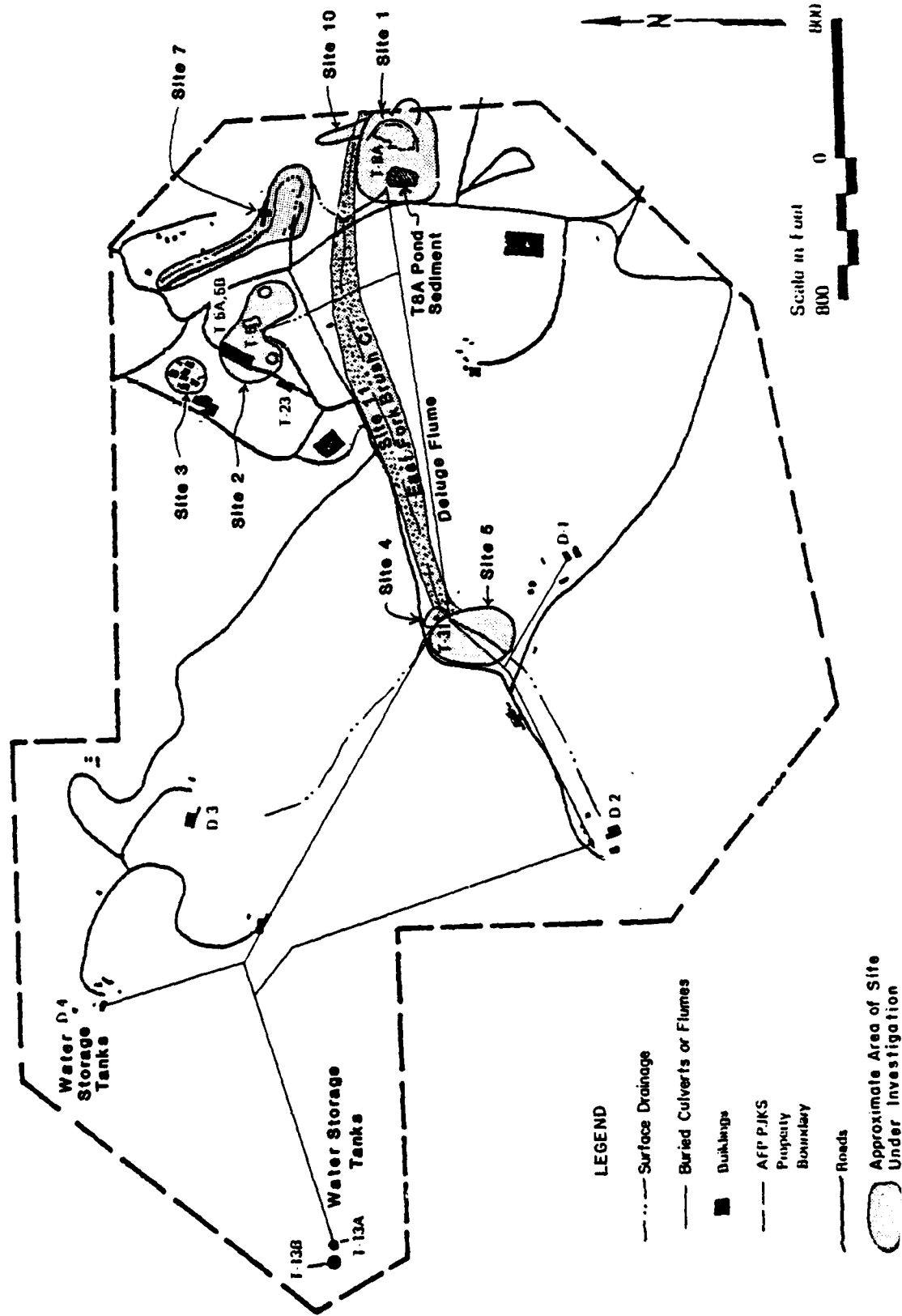
SUMMARY OF SITES AND POTENTIAL SOURCES OF CONTAMINANTS AT AFP PJKS

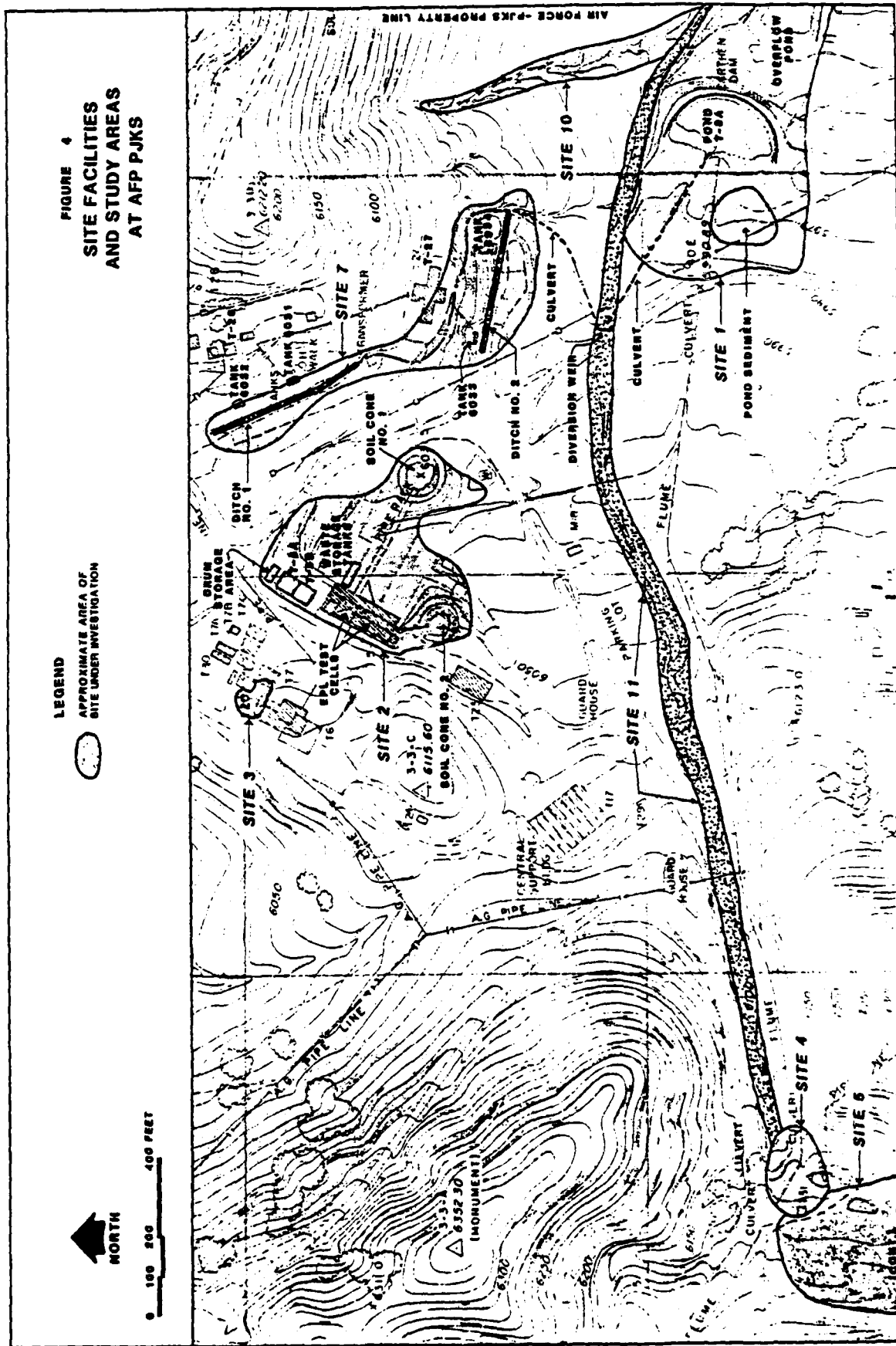
<u>Site</u>	<u>Period of Use</u>	<u>Potential Sources of Contaminants</u>
Site 4 (cont)	1964	. Accidental spill of water containing hydrazine.
Site 5:	1964 - 1985	. Storage of No. 6 diesel fuel.
D-1 Landfill	1970 - mid-1974	. Copper wire, empty drums, demolition wastes, low level radioactive wastes and, possibly, chemical wastes.
Site 7: Systems and Components Test Facilities Storage Tanks	1960 - 1983	. Hydrazine, amine fuel, and N_2O_4 contaminated waters, treated ² prior to release to T-8A pond.
Site 10: Construction Material Fill Area	Early 1980's	. Construction fill and possibly other wastes.
Site 11: East Fork of Brush Creek	1957 - present	. Runoff from all sites and overflow from T-8A containment pond.
	1961 - present	. Cooling water from refrigeration system at T-28 (Site 7). ^{5/}

Sources: Unless otherwise noted, information was obtained from the IRP Phase I report (Sites 1-7) and Engineering-Science interviews and observations, 1985-1986 (Sites 10, 11).

- 1/ Process water has varied in quality depending on tests performed over the 29 years of operation.
- 2/ McKenna, 1986.
- 3/ LaBonte, 1986. The source of this water is the domestic supply. Waters are presently released into the East Fork of Brush Creek.
- 4/ Trichloroethene (TCE).
- 5/ Oakite products used at AFP PJKS were Oakite Stripper 157, Oakite Aluminum Cleaner 166, and Oakite 33. The major components of these products are:
 Oakite Stripper 157 - methylene chloride and isopropyl alcohol.
 Oakite Aluminum Cleaner 166 - borates and polyphosphate.
 Oakite 33 - phosphoric acid and 2-butoxyethanol.

FIGURE 3
LOCATIONS OF SITES UNDER INVESTIGATION AT AFP PJKS





SOURCE: MODIFIED FROM MARTIN MARIETTA BASE MAP

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sediment stations were sampled throughout the eight sites investigated. A summary of field activities by site is provided in Table 2. The suspected pollutants analyzed at each site are also listed in the table.

In addition to the chemical parameters analyzed, subsurface geologic and hydrogeologic conditions were examined to identify possible contaminant migration pathways. Seepage runs along the East Fork of Brush Creek (Site 11) were conducted to establish recharge/discharge relationships between surface and ground waters.

Surface geophysical surveys were performed at Sites 4, 5, and 11 to aid in characterizing subsurface conditions and locating monitor wells. Subsurface conditions identified from the survey included buried metallic objects, buried trenches, and the depth and extent of subsurface saturation.

SUMMARY OF RESULTS

A summary of analytical results for substances found at AFP PJKS at concentrations which equal or exceed regulatory guidelines is provided in Table 3. Concentrations of oil and grease and gross gamma radiation, for which no guidelines are available, are also presented. Concentrations of all other analytical parameters were either below the detection limit specified for the analytical procedure or were less than the most stringent of regulatory guidelines.

The pollutants of concern include nitroso dimethylamine (NDMA), trichloroethene (TCE), oil and grease, and gross alpha, beta, and gamma radiation. Concentrations of these parameters were detected primarily in surface and ground waters. Because regulatory guidelines for oil and grease and gross gamma radiation are unavailable, the significance of these parameters cannot be determined.

TABLE 2
AIR FORCE PLANT PJFS
FIELD PROGRAM SUMMARY

<u>Site</u>	<u>Field Activities</u>	<u>Medium Sampled</u>	<u>Analyte:</u>
T-8A Containment Pond (Site 1)	Install two monitoring wells.		
	Sample ground waters.	Ground water	Hydrazine, purgeable organics, phenols, base/neutral/acid, extractable organics, MEK, oil and grease, pH, temperature, specific conductance, TDS, NDMA, metal scan, Kjeldahl nitrogen, nitrate, nitrite.
	Drill five 20-foot soil borings.	Sample soils	Hydrazine, purgeable organics, phenols, hexavalent chromium, NDMA, Kjeldahl nitrogen, nitrate, nitrite.
	Sample pond water and sediment (1 sample each).	Surface water	Same as for ground water.
EPL Test Cells, Valve Shop, Ready Storage Area, and Soil Cones (Site 2)		Sediment	Hydrazine, phenols, purgeable organics, base/neutral/acid extractable organics, MEK, oil and grease, NDMA, metal scan, Kjeldahl nitrogen, nitrate, nitrite.
	Install two monitoring wells.		
	Sample ground waters.	Ground water	Hydrazine, phenols, purgeable organics, oil and grease, base/neutral/acid extractable organics, MEK, pH, temperature, specific conductance, NDMA, metal scan, TDS, Kjeldahl nitrogen, nitrate, nitrite.
	Drill four 15-foot soil borings.	Soil	NDMA, purgeable organics, hydrazine, Kjeldahl nitrogen, nitrate, nitrite.
EPL Building T-6 and T-20A (Site 3)			
	Drill two 15-foot soil borings.	Soil	Purgeable organics, hexavalent chromium.

TABLE 2 (Continued)
AIR FORCE PLANT PJKS
FIELD PROGRAM SUMMARY

<u>Site</u>	<u>Field Activities</u>	<u>Medium Sampled</u>	<u>Analyte:</u>
T-31 Storage Tank and D-1 Landfill (Sites 4 and 5)	Conduct geophysical survey. Install three monitoring wells. Sample ground water.	Ground water	Purgeable organics, gross alpha and beta and high resolution gamma radiation, hydrazine, pH, temperature, specific conductance, TDS, NDMA, metal scan, thorium, oil and grease, Kjeldahl nitrogen, nitrate, nitrite.
Systems and Components Test Facilities Storage Tanks (Site 7)	Collect sediment samples.	Sediment	Hydrazine, purgeable organics, phenols, hexavalent chromium, NDMA, Kjeldahl nitrogen, nitrate, nitrite.
Construction Materials Fill Area (Site 10)	Conduct geophysical survey. Install one monitoring well. Sample ground water.	Ground water	Hydrazine, phenols, purgeable organics, pH, specific conductance, temperature, TDS, NDMA, Kjeldahl nitrogen, nitrate, nitrite.
Brush Creek (Site 11)	Perform flow measurements. Collect surface water and sediment samples (10 samples each).	Surface water	Hydrazine, phenols, hexavalent chromium, purgeable organics, NDMA, oil and grease, TDS, Kjeldahl nitrogen, nitrate, nitrite.
		Sediment	Hydrazine, phenols, hexavalent chromium, purgeable organics, NDMA, Kjeldahl nitrogen, nitrate, nitrite.

- 1/ MEK = methyl ethyl ketone
2/ TDS = total dissolved solids
3/ NDMA = Nitroso Dimethylamine

TABLE 3
CONCENTRATIONS OF CONTAMINANTS EXCEEDING REGULATORY STANDARDS OR HEALTH GUIDELINES^{1/}
AFP PJKS

Standard/Criteria	NDMA	TCE	Oil and Grease	Gross Alpha	Gross Beta	Gross Gamma	Thorium
Water	0.014 ug/L ^{2/}	5 ug/L ^{3/}	None	15 pCi/L ^{4/}	50 pCi/L ^{5/}	None	None
Soil or sediment	None	None	None	None	None	None	None
Site 1							
Pond water	6/ 7/	ND	ND ^{8/}	---	---	---	---
Pond sediment	ND	ND	584 ug/L	---	---	---	---
Soils	ND	ND	---	---	---	---	---
Ground water	0.23-0.61 ug/L	67-130 ug/L	ND	---	---	---	---
Site 2							
Soils	ND	ND	ND	---	---	---	---
Ground water	0.28 ug/L	<1.0-1110 ug/L	ND	---	---	---	---
Site 3							
Soils	ND	ND	---	---	---	---	---
Sites 4 & 5							
Ground water	ND	67-190 ug/L	<1.0-4,070 mg/L	130-270 pCi/L ^{9/}	120-250 pCi/L ^{9/}	70-140 pCi/L ^{9/}	0.3-8.2 pCi/L ^{9/14/} 0.16-0.38 pCi/L ^{10/15/}
Site 7							
Sediment	ND	ND	---	---	---	---	---
Site 10							
Ground water	5.2 ug/L	490 ug/L	---	---	---	---	---
Site 11							
Surface water	0.34-0.42 ug/L	1.3-5.5 ug/L	1.3-2.4 mg/L	<1.8-1.9 pCi/L ^{12/}	10.4-41.9 pCi/L ^{12/}	20 pCi/L ^{12/13/}	0.05-0.18 pCi/L ^{12/15/}
Sediment	ND	ND	---	---	---	---	---

1/ Except as indicated, detection limits are as follows:

	Water	Solids
NDMA	0.25 ug/L	0.250 ug/g
TCE	1 ug/L	10 ug/g
Oil and Grease	1 mg/L	1 ug/g

2/ Lifetime cancer risk of 10⁻⁵ for a concentration of 0.014 ug/L (U.S. Environmental Protection Agency, 1980a).

3/ Proposed maximum contaminant level (MCL) of EPA (40 CFR Part 141).

4/ EPA MCL including Radium-226, but excluding radon and uranium.

5/ EPA MCL as strontium.

6/ ND = none detected; --- indicates analyses were not conducted for this substance at this site.

7/ Detection limit of 5 ug/L.

8/ Detection limit of 5 mg/L.

9/ Natural uranium mineralization is known to exist in the area (Nelson-Moore et al., 1978) and may explain, at least partially, these high levels.

10/ Radiation ranges for May 1986 sampling.

11/ Gross gamma not analyzed for May 1986 sampling.

12/ Data from limited sampling in May, 1986.

13/ Gross gamma not analyzed; however, the gamma nuclide lanthanum-140 was detected at 20 pCi/L. All others below detection limit.

14/ Data range for thorium-228, thorium-230, and thorium-232.

15/ Data range for thorium-228 and thorium-232 only.

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CONCLUSIONS

The significance of findings on the AFP PJKS property was evaluated for each site by assessing 1) whether contaminants exceed maximum contaminant levels (MCL) or other health guidelines, 2) if pathways for contaminant migration exist, and 3) if human receptors exist in the study area. If all three of these conditions are met, then the significance of contamination at a specific site is rated as high; if two or one conditions are met, then the significance is rated as moderate or low, respectively.

The regulatory standards and guidelines presented in Table 3 were used for comparison purposes. The only enforceable standard is the maximum contaminant level (MCL). Proposed MCL's have been recommended by the EPA, but have not undergone the public review and comment period.

For a few parameters, lifetime cancer risk data are the only health information available. Data are generated from research with laboratory animals and are used by EPA in a linear non-threshold model to establish actual risks (that is, the risks are not likely to be higher, but could be lower) (Anderson, 1983). The risk estimates are expressed as a probability of cancer after a 70-year lifetime consumption by a 70-kilogram human of 2 liters of water per day containing a certain concentration of the compound. Using NDMA as an example, the 70-year lifetime cancer risk for consuming 2 liters of water per day containing 0.014 ug/L of NDMA is 1 in 100,000 (1×10^{-5}). For purposes of continuity with the literature, a cancer risk of 10^{-5} is taken as the accepted risk.

The significance of contamination was first evaluated for on-plant locations on a site-by-site basis. These examinations are presented in the following paragraphs. Following these discussions is an assessment of possible contamination significance offsite where public receptors exist.

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Significance of Contamination at AFP PJKS

Contamination of soils and sediments was determined to be of low significance at AFP PJKS based on the low levels of contamination, the low probability that pollutants are migrating offsite via either ground or surface waters, and the low level of opportunity for human contact with contaminated soils. Contamination of ground and surface waters was judged to be moderately significant at AFP PJKS. Some of the contaminants occurred in surface and ground waters at concentrations exceeding proposed regulatory standards or health guidelines and the potential for contaminant migration exists. However, because neither surface nor ground waters are used as water supply sources onsite, there is little opportunity for human contact with the contaminated waters. Brief descriptions of the problems judged to be moderately significant are provided below.

Site 1 - Ground Water

Ground waters beneath Site 1 contain TCE and, possibly, NDMA at levels which exceed standards or health guidelines (Table 3). TCE concentrations (130 ug/L and 67 ug/L in MW-1 and MW-2, respectively) in ground waters exceed the proposed MCL of 5 ug/L. NDMA contents in both of the wells (0.61 and 0.23 ug/L for MW-1 and MW-2, respectively) exceed the 1 in 100,000 lifetime cancer risk concentration of 0.014 ug/L. However, these concentrations are below the practical quantification level (PQL) of 0.75 ug/L. The PQL is defined as three times the detection limit and is the limit below which it is not certain that the compound exists.

Alluvial ground waters beneath Site 1 generally flow toward the East Fork of Brush Creek. The alluvial aquifer consists of moderately permeable sands. It is highly probable, therefore, that contaminated

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ground waters discharge to surface waters adjacent to the T-8A pond and/or downstream from the AFP PJKS property boundary. In addition, contaminated ground waters may recharge the bedrock aquifer.

Site 2 - Ground Water

The Site 2 monitoring wells, positioned downgradient from Sites 2, 3, and 7, produced waters containing TCE and, possibly, NDMA at levels which exceed proposed water quality standards or health guidelines. Well MW-3 contained TCE (1,110 ug/L) at a level considerably above the proposed MCL of 5 ug/L. Well MW-3 may also contain NDMA (0.28 ug/L) at a level which exceeds the lifetime cancer risk guideline of 0.014 ug/L, but is below the PQL of 0.75 ug/L. The direction of contaminant migration in this portion of the alluvial aquifer is southeastward toward the East Fork of Brush Creek. The aquifer consists of moderately permeable sands.

Contaminated ground waters may discharge to the East Fork of Brush Creek. Ground water contributions to surface flow were discovered in the East Fork reach near Site 2. In addition, alluvial ground water may recharge the bedrock aquifer.

Sites 4 and 5 - Ground Water

Three monitoring wells, constructed immediately downgradient from the T-31 storage tank and D-1 landfill, yielded waters containing TCE at levels which exceed the proposed water quality standard. Concentrations of TCE in MW-4 and MW-6 (67 ug/L and 190 ug/L, respectively) exceeded the 5 ug/L proposed MCL. All three well waters also contained relatively high radiation levels.

Ground waters sampled in December 1985 contained from 130 to 270 pCi/L of gross alpha radiation which exceeds the MCL of 15 pCi/L. Gross beta radiation ranged from 120 to 250 pCi/L which exceeds the MCL of 50 pCi/L. Only the gross alpha activity of MW-4 (53.5 pCi/L) from the May, 1986 sampling exceeded the MCL of 15 pCi/L. The gross beta

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activity of the three wells, however, did not exceed the gross beta MCL. In addition, waters from MW-4 and MW-5 contained detectable amounts of potassium-40 and lanthanum-140, respectively. The thorium isotopes analyzed in the May sampling were considerably lower than the December sampling. The difference in activity levels between sampling episodes may be attributed to seasonal variation. Since uranium mineralization exists in the area, background levels of radiation need to be determined before the effects of the disposal of low-level radioactive waste (magnesium thorium alloy) in the D-1 landfill can be determined.

Ground waters emanating from beneath the landfill discharge to the East Fork of Brush Creek. Surface water in the East Fork at the station immediately downstream from the landfill contains organic contamination, which dissipates to below detection levels approximately 400 feet downstream. In addition, ground waters may recharge underlying bedrock aquifers.

Site 10 - Ground Water

Ground water collected from well MW-8 immediately downgradient from Site 10 contained NDMA and TCE at levels which exceed proposed water quality standards or health guidelines. The NDMA concentration found in well MW-8 (5.2 ug/L) is considerably greater than the cancer risk guideline of 0.014 ug/L. Well MW-8 water also contained TCE (490 ug/L) at levels well above the proposed MCL of 5 ug/L.

Local directions of alluvial ground water movement are south and southeast toward the East Fork of Brush Creek. The alluvial aquifer consists of moderately permeable sands. In addition, contaminated ground waters may recharge the underlying sandstone bedrock aquifer.

Site 11 - Surface Water

Various amounts of NDMA and TCE were detected along the East Fork of Brush Creek between Site 5 and the eastern property boundary of AFP PJKS. Possible sources of these contaminants include Sites 1, 2, 3, 4,

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5, 7, and 10. NDMA has been found to undergo photolysis with exposure to sunlight (U.S. Environmental Protection Agency, 1979a), which may be important in reducing levels of NDMA downstream.

Radiation levels for three surface water samples collected in May 1986 along the East Fork of Brush Creek (stations 11-0, 11-1, and 11-9) were below the MCL's for both gross alpha and gross beta activities. The highest gross beta activity detected was at station 11-0 upstream from Sites 4 and 5 (D-1 landfill). The only gamma nuclide detected in the three samples was lanthanum-140 (20 pCi/L) at station 11-0. Thorium-228 and thorium-232 contents were highest in the sample at station 11-0. These data indicate that natural radiation exists in the East Fork of Brush Creek above the D-1 landfill and dissipates downstream.

Evaluation of Contaminant Migration Offsite

Possible pathways for contaminant migration from AFP PJKS are via the East Fork of Brush Creek and through the alluvial and bedrock ground water systems. Brush Creek is tributary to the South Platte River. Surface water in the East Fork at the sampling station immediately downstream from the AFP PJKS property boundary contained trace to elevated concentrations of several organic compounds. However, concentrations of these substances dissipated to below detection levels within a relatively short distance downstream (1,500 feet).

Organic contamination was detected in waters from Martin Marietta well GM-89, located immediately downgradient from Site 1, and to a much lesser degree in well GM-15, located 500 feet downgradient from well GM-89. The presence of this contamination in the alluvial ground water system suggests that some migration onto Martin Marietta property has occurred.

The significance of contaminant migration offsite is low based on the dissipation and dispersion of contaminants in surface and ground

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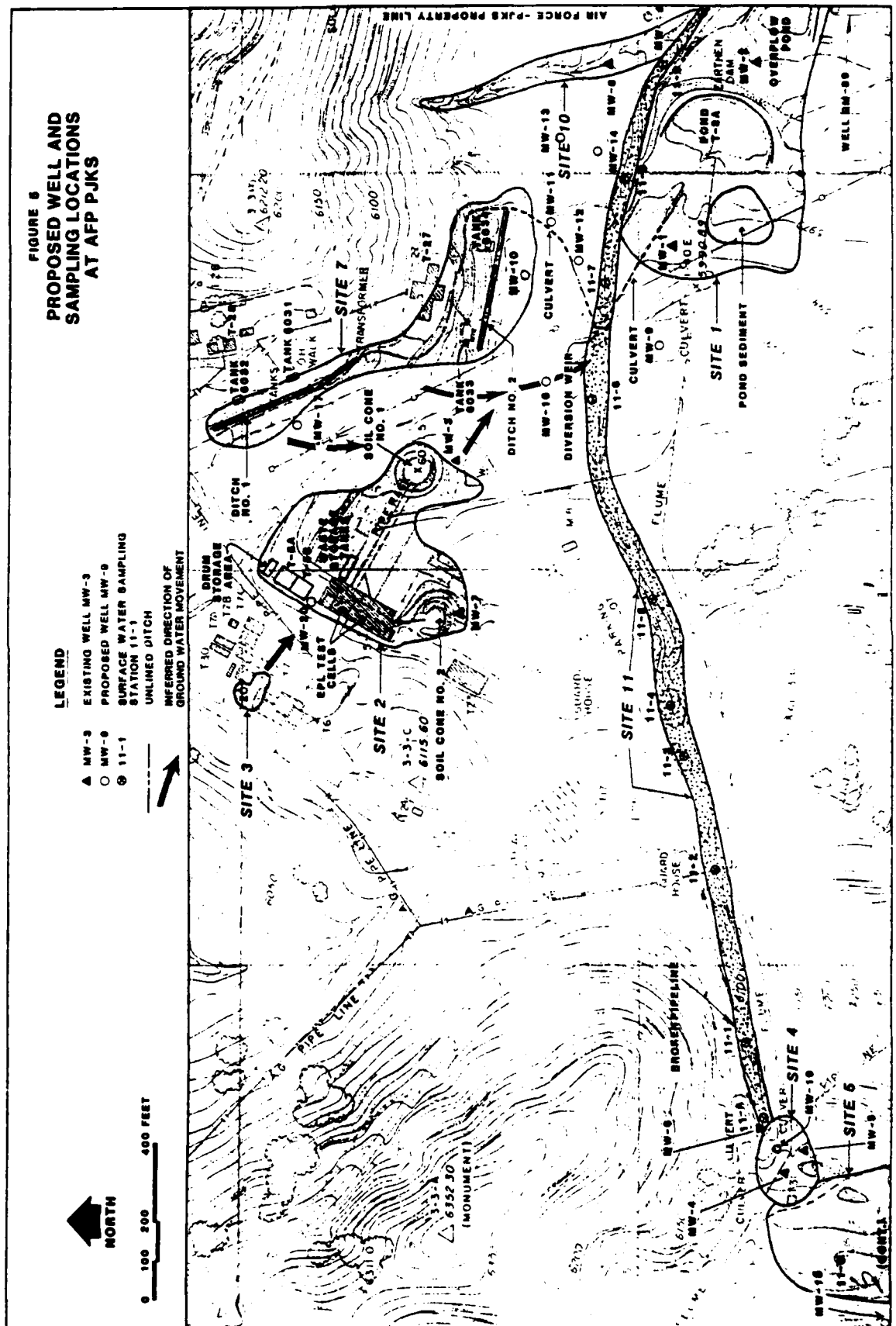
waters as discussed above and the large distance (several miles) between potential receptors and AFP PJKS. However, pathways for contaminant migration offsite do exist and should be further investigated.

RECOMMENDATIONS

The investigative tasks summarized on Table 4 are recommended to further determine the contaminant nature, extent, and rate of migration and the relative significance of the identified contamination. Proposed well and surface water sampling locations are shown on Figure 5.

TABLE 4
SUMMARY OF RECOMMENDATIONS

Location	Recommended Action	Rationale
Site 1	<ul style="list-style-type: none"> Resample wells MW-1 and MW-2 and analyze for NDMA, hydrazine, and halocarbons. Monitor water levels and conduct aquifer tests. Map structural geology and drill, construct and sample proposed well MW-9. Analyze for NDMA, hydrazine and halocarbons. Monitor water levels and perform aquifer tests. 	<ul style="list-style-type: none"> Confirm contamination and determine hydrogeologic characteristics. Identify contaminant source and determine hydrogeologic characteristics.
Sites 2 and 7	<ul style="list-style-type: none"> Resample wells MW-3 and MW-7 and analyze for NDMA, hydrazine and halocarbons. Monitor water levels and conduct aquifer tests. Map structural geology and drill, construct and sample proposed wells MW-16, MW-17, and MW-20. Analyze for NDMA, hydrazine and halocarbons. Monitor water levels and conduct aquifer tests. 	<ul style="list-style-type: none"> Confirm contamination and determine hydrogeologic characteristics. Qualify contamination source(s) and determine hydrogeologic characteristics.
Sites 7 and 10	<ul style="list-style-type: none"> Resample well MW-8 and analyze for NDMA, hydrazine and halocarbons. Monitor water levels and conduct aquifer test. Map structural geology and drill, construct and sample proposed wells MW-10, 11, 12, 13, 14 and 15. Analyze for NDMA, hydrazine and halocarbons. Monitor water levels and conduct aquifer tests. Drill, construct and sample two bedrock wells where alluvial contamination is found to be greatest. Analyze for the parameters of concern. Monitor water levels and conduct aquifer tests. 	<ul style="list-style-type: none"> Confirm contamination and determine hydrogeologic characteristics. Identify contaminant source(s), delineate extent of contamination and determine direction and rate of migration. Evaluate vertical migration potential into bedrock aquifer.
Sites 4 and 5	<ul style="list-style-type: none"> Resample wells MW-4, 5 and 6 and analyze for halocarbons, gross alpha, total uranium, and gamma spectroscopy. Monitor water levels and conduct aquifer tests. Map structural geology and drill, construct and sample one background alluvial well (MW-18) upstream from the D-1 landfill. Analyze for halocarbons, gross alpha, total uranium, and gamma spectroscopy. Drill, construct and sample one bedrock well (MW-19) in faulted bedrock where alluvial contamination is found to be greatest. Analyze for halocarbons, gross alpha, total uranium, and gamma spectroscopy. Monitor water levels and conduct aquifer tests. 	<ul style="list-style-type: none"> Characterize nature of contamination associated with elevated radiation and determine rate of contaminant migration. Characterize background radiochemistry in vicinity of D-1 landfill. Evaluate vertical migration potential into bedrock aquifer.
Site 11	<ul style="list-style-type: none"> Resample and analyze the lower reaches of the East Fork of Brush Creek (stations 11-6 through 11-10) for NDMA, hydrazine and halocarbons. Collect and analyze East Fork waters at all stations for gross alpha, total uranium and gamma spectroscopy. 	<ul style="list-style-type: none"> Confirm surface water contamination along suspect reaches of East Fork. Quantify radioactive daughter products present in surface waters.



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SECTION 1.0
INTRODUCTION

1.1 BACKGROUND AND AUTHORITY

The United States Air Force, in its conduct of its primary mission of defense of the United States, has long been engaged in a wide variety of operations that involve toxic and hazardous materials. Federal, state, and local governments have developed strict regulations requiring disposers to identify the locations and contents of past disposal sites and take action to eliminate hazards in an environmentally responsible manner. The primary Federal legislation governing disposal of hazardous waste is the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. Under Section 6003 of the Act, Federal agencies are directed to assist the Environmental Protection Agency (EPA) and under Section 3012, state agencies are required to inventory past disposal sites, and Federal agencies are required to make the information available to the requesting agencies. To assure compliance with these hazardous waste regulations, the Department of Defense (DOD) developed the Installation Restoration Program (IRP). The current DOD IRP policy is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated 11 December 1981 and implemented by Air Force message dated 21 January 1982. DEQPPM 81-5 reissued and amplified all previous directives and memoranda on the Installation Restoration Program. DOD policy is to identify and fully evaluate suspected problems associated with past hazardous materials contamination, and to control hazards to health and welfare that have resulted from these past operations. The IRP is the basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, clarified by Executive Order 12316. CERCLA is the primary legislation governing remedial action at past hazardous waste disposal sites.

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1.2 PURPOSE AND SCOPE

The Installation Restoration Program is a four-phased program designed to assure that identification, confirmation/quantification, and remedial actions are performed in a timely and cost-effective manner. Each phase is briefly described below:

- . Phase I - Installation Assessment/Records Search - The purpose of Phase I is to identify past disposal sites that may pose a hazard to public health or the environment as a result of contaminant migration to surface or ground waters, or that may have an adverse effect by the persistence of contaminants in the environment. In this phase it is determined whether a site requires further action to confirm an environmental hazard. If a site requires immediate remedial action, such as removal of abandoned drums, the action can proceed directly to Phase IV. Phase I is a basic background document for the Phase II study.
- . Phase II - Confirmation/Quantification. The purpose of Phase II is to define and quantify, by preliminary and comprehensive environmental and/or ecological survey, the presence or absence of contamination, the extent of contamination, waste characteristics (when required by the regulatory agency), and the sites or locations where remedial action is required. Phase II consists of an initial assessment of contamination to determine if contamination is present at a site. For those sites which are found to be contaminated, further investigation is conducted to assess the extent of contamination. Any IRP sites warranting immediate remedial

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action can be transferred to Phase IV. Otherwise, research requirements identified during Phase II will be included in the Phase III effort of the program.

- . Phase III - Technology Base Development - The purpose of Phase III is to develop new technologies for treating pollutants which have no currently or economically available treatment methodologies. This phase includes implementation of research requirements and technology development. A Phase III requirement can be identified at any time during the program.
- . Phase IV - Remedial Actions - Phase IV includes the preparation and implementation of the remedial action plan.

This investigation constitutes the initial stage of the IRP Phase II, Confirmation/Quantification at Air Force Plant (AFP) PJKS. The objectives of the investigation were to (1) determine the presence or absence of contamination at suspected sites identified in the Phase I records search conducted by JRB Associates, Inc. in 1984; (2) identify specific requirements, if any, for additional work to determine the magnitude, extent, and direction and rate of movement of detected contaminants; and (3) assess the need for remedial action under Phase IV. The subject delivery order describing this work scope is provided in Appendix C.

To satisfy these objectives, interviews were conducted with current AFP PJKS and Martin Marietta employees to confirm the areas of suspected contamination and to identify other areas of concern. Determination of the presence or absence of contamination was then accomplished through sampling and analysis of site soils, ground waters, surface waters and sediments. The findings of these investigations were then used to define the requirements and scope of subsequent phases of the IRP investigation.

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1.3 PROGRAM DURATION

The Phase I records search of the AFP PJKS IRP program was completed in September 1984 by JRB Associates, Inc. Phase II, Stage I was initiated on 30 September 1985, and began with a literature review, project mobilization, and subcontractor procurement. Onsite field work began in mid-November 1985 and continued until May 1986. Laboratory results were finalized in August 1986.

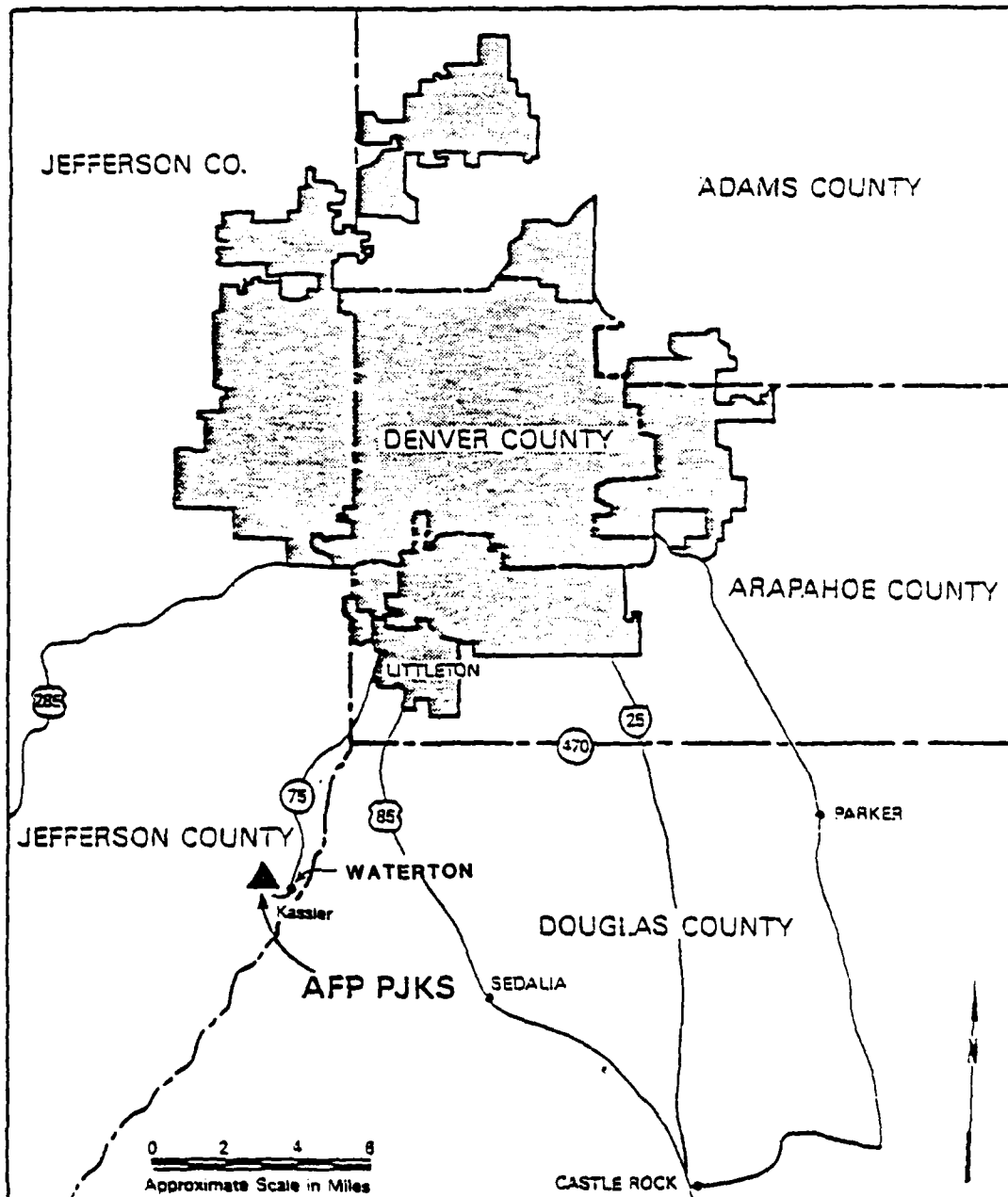
1.4 BACKGROUND INFORMATION

AFP PJKS is located on 464 acres of land in the foothills of the Rocky Mountains. The property lies northwest of Waterton, Colorado, approximately 20 miles south-southwest of Denver, as illustrated on Figure 1.1. From 1957 until the present, PJKS plant activities have consisted of missile assembly (Titan I, II, and III), engine testing, and research and development. Fuels development, purification, and testing activities in support of the Titan III program were also conducted.

The AFP PJKS site is surrounded by approximately 4,700 acres of land owned by the Martin Marietta Company, as illustrated on Figure 1.2. All of Martin Marietta's production, testing, and storage facilities are located southeast of and at a lower elevation than the Air Force property. Ground water contamination was recently discovered beneath the Martin Marietta property, downgradient from the Air Force property. Subsequent investigations revealed surface water contamination downstream from AFP PJKS.

This IRP Phase II investigation represents the first determination of possible contamination on the Air Force property. The IRP Phase I records search recommended that six sites be further investigated under Phase II. During the course of this Phase II study, two other sites were identified as potential sources of contamination. The potential

FIGURE 1.1
AIR FORCE PLANT PJKS
WATERTON, COLORADO
AREA LOCATION

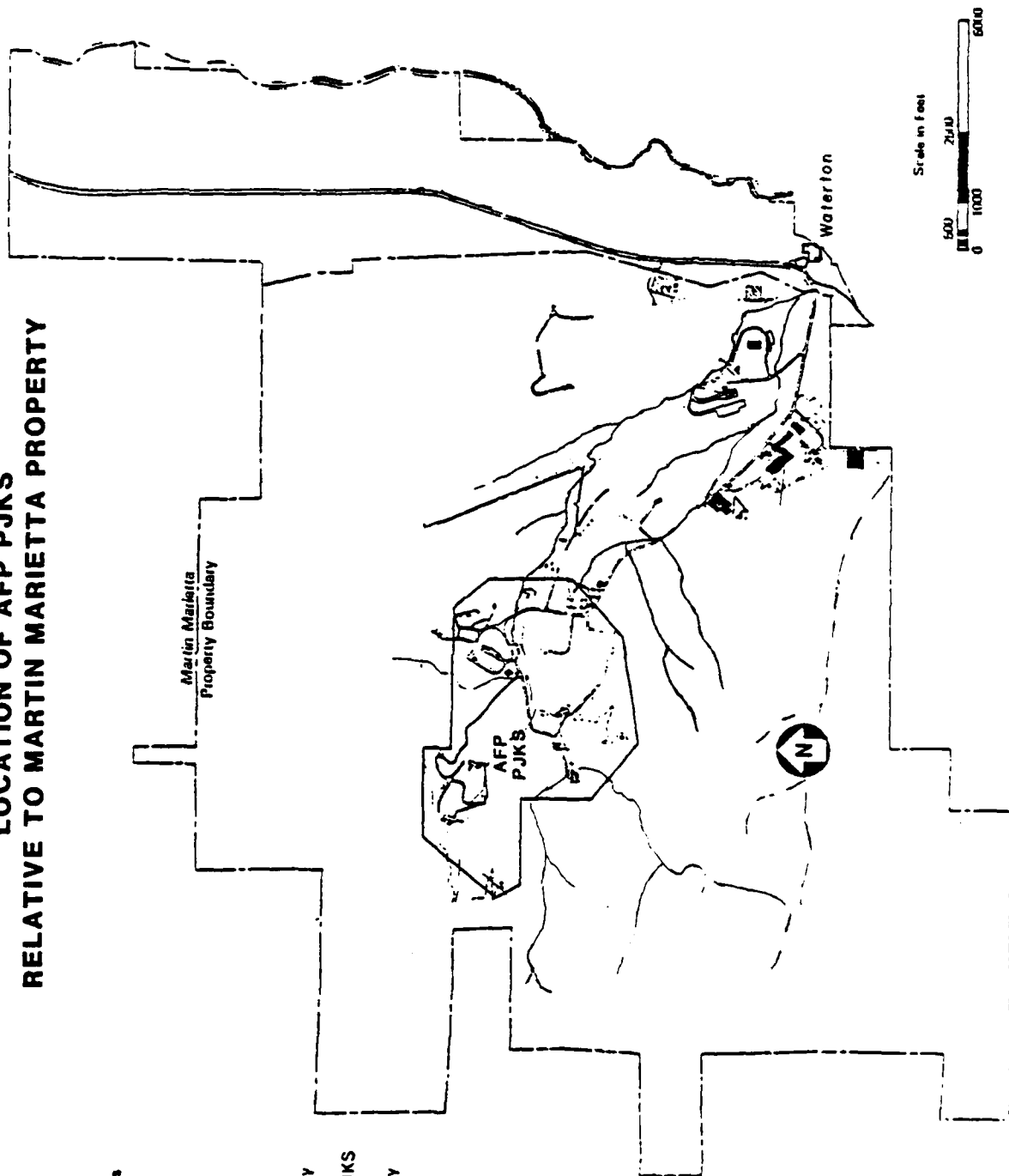


NOTE: SHADED PATTERN INDICATES THE DENVER METROPOLITAN AREA

SOURCE: JRB ASSOCIATES, INC., 1984

FIGURE 1.2
LOCATION OF AFP PJKS
RELATIVE TO MARTIN MARIETTA PROPERTY

- Legend:
- Buildings
 - == Roads
 - Streams
 - - - Martin Marietta Property Boundary
 - AFP PJKS Property Boundary



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sources of contaminants at the eight sites are summarized in Table 1.1 and the site locations are shown on Figures 1.3 and 1.4. A history and description of each site, based on the Phase I records search and other references, as noted, are provided below.

1.4.1 T-8A Containment Pond Area (Site 1)

The T-8A containment pond has been in use since 1957 and is the terminus of a network of ditches, flumes, and drainage pipes from the AFP PJKS facilities (Figure 1.3). In approximately 1974, the T-8A pond was lined with concrete. Between 1974 and the early 1980's, sediment which had accumulated in the pond was dredged out and deposited in the area designated in Figure 1.4 as "pond sediment". Since 1983, most AFP PJKS plant process wastewaters have been conveyed to Martin Marietta for treatment. Cooling water from the refrigeration system at building T-28 (Site 7) was occasionally diverted to T-8A pond during the period from 1961 to 1985. The only liquids currently entering the T-8A containment pond have been surface runoff, EPL process water (non-potable), and accidental tank spills and overflows.

1.4.2 EPL Test Cells, Valve Shop, Ready Storage Area, and Soil Cones (Site 2)

At Site 2, waste has been generated primarily from equipment cleaning and check-out operations. Chemicals used for these activities included isopropyl alcohol, 1,1,1-trichloroethane, trichloroethene (TCE), freon, several cleaners produced by the Oakite Company, toluene, methyl ethyl ketone (MEK), and acids. The components of Oakite cleaning products used at AFP PJKS are listed in Table 1.1. Spent chemicals were placed in 5- to 55-gallon containers for disposal by Martin Marietta. Small quantities of these wastes were reportedly spilled onto the ground or leaked from drums.

TABLE 1.1
SUMMARY OF SITES AND POTENTIAL SOURCES OF CONTAMINANTS AT AFP PJKS

<u>Site</u>	<u>Period of Use</u>	<u>Potential Sources of Contaminants</u>
Site 1: T-8A Containment Pond	1957 - early 1960's	. Deluge water from test stands containing hydrazine and N_2O_4 .
	1957-1985	. East Fork Brush Creek water.
	1957 - present	. Process water ^{1/} from EPL Test Cells. ^{2/} Surface runoff.
	1960 - 1983	. Treated waters from Systems and Components Test Facilities.
	1961 - 1985	. Cooling water from refrigeration system at T-28 (Site 7). ^{3/}
Site 2: EPL Test Cells, Valve Shop, Ready Storage Area, and Soil Cones	1961 - present	. Limited testing of propulsion systems using hydrazine type fuels, oxidizers, isopropyl alcohol and freon. ^{2/}
	1957 - present	. Cleaning wastes, including TCE ^{4/} (1957-1964), Oakite ^{5/} (mid-70's), 1,1,1-trichloroethane (1964-present), isopropyl alcohol (1957-present), toluene (late-60's), freon (1957-present), methyl ethyl ketone (1957-present), nitric and hydrofluoric acids (late 70's-present) ^{2/} .
	1957 - present	. Thermotransfer agent - ethylene glycol. ^{2/}
Site 3: EPL Building T-6 and Building T-20A	1958 - 1965	. TCE for pump cleaning.
	1960 - 1970	. Isopropyl alcohol and sodium dichromate from testing.
Site 4: Tank T-31	1961 - 1964	. Storage and treatment of deluge water from test stands D-1 and D-2 containing hydrazine and N_2O_4 .

TABLE 1.1 (Continued)

SUMMARY OF SITES AND POTENTIAL SOURCES OF CONTAMINANTS AT AFP PJKS

<u>Site</u>	<u>Period of Use</u>	<u>Potential Sources of Contaminants</u>
Site 4 (cont)	1964	. Accidental spill of water containing hydrazine.
	1964 - 1985	. Storage of No. 6 diesel fuel.
Site 5: D-1 Landfill	1970 - mid-1974	. Copper wire, empty drums, demolition wastes, low level radioactive wastes and, possibly, chemical wastes.
Site 7: Systems and Components Test Facilities Storage Tanks	1960 - 1983	. Hydrazine, amine fuel, and N_2O_4 contaminated waters, treated ² prior to release to T-8A pond.
Site 10: Construction Material Fill Area	Early 1980's	. Construction fill and possibly other wastes.
Site 11: East Fork of Brush Creek	1957 - present	. Runoff from all sites and overflow from T-8A containment pond.
	1961 - present	. Cooling water from refrigeration system at T-28 (Site 7). ^{3/}

Sources: Unless otherwise noted, information was obtained from the IRP Phase I report (Sites 1-7) and Engineering-Science interviews and observations, 1985-1986 (Sites 10, 11).

- 1/ Process water has varied in quality depending on tests performed over the 29 years of operation.
- 2/ McKenna, 1986.
- 3/ LaBonte, 1986. The source of this water is the domestic supply. Waters are presently released into the East Fork of Brush Creek.
- 4/ Trichloroethene (TCE).
- 5/ Oakite products used at AFP PJKS were Oakite Stripper 157, Oakite Aluminum Cleaner 166, and Oakite 33. The major components of these products are:
 Oakite Stripper 157 - methylene chloride and isopropyl alcohol.
 Oakite Aluminum Cleaner 166 - borates and polyphosphate.
 Oakite 33 - phosphoric acid and 2-butoxyethanol.

FIGURE 1.3



FIGURE 1.4



1-11

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1.4.3 EPL Building T-6 and T-20A (Site 3)

The pump house (T-20A) at Site 3 was used between 1958 and 1965 for equipment cleaning with the solvent TCE. Between 1958 and 1965, an estimated 300 gallons per year of TCE were reportedly allowed to drain directly onto the ground. Testing operations at building T-6 generated spent isopropyl alcohol and sodium dichromate. Between 1960 and 1970, an estimated total of 25 gallons of the substances were disposed directly on the ground.

1.4.4 T-31 Storage Tank (Site 4)

During the Titan II testing period (1961 to 1964), a 1-million-gallon underground tank (T-31) was installed downstream from test stands D-1 and D-2 to capture the deluge water containing hydrazine from rocket firings. Deluge waters from the test stands flowed via concrete flumes into the tank where treatment occurred prior to reuse or release to containment pond T-8A. In 1964, the tank was converted to storage of No. 6 diesel fuel. In November 1985, residual diesel fuel was pumped from the tank and the tank was steam cleaned.

In approximately 1964, prior to conversion of the tank to diesel fuel storage, an undetermined amount of water containing hydrazine was accidentally released onto the ground. Site personnel responded to the release by pouring hydrogen peroxide on the ground to oxidize the hydrazine.

1.4.5 D-1 Landfill (Site 5)

The D-1 landfill, located in the valley below test stand D-1, is approximately 4 acres in size. Between 1970 and mid-1974, the D-1 landfill received nonhazardous wastes including paper, concrete, copper wire, plastic, asphalt, and food, generated from AFP PJKS and Martin Marietta activities. Detailed records of the types and quantities of wastes disposed in the landfill do not exist. Hazardous materials that may have been disposed in the landfill include asbestos from demolition

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activities, small PCB-filled electrical equipment, and various waste chemicals.

In 1971, small quantities of low-level radioactive wastes (magnesium thorium alloy), were disposed in the landfill. Records indicate that 25 kilograms of alloy with a total of 55.5 microcuries of radioactivity were buried. Following site closure in 1974, overburden was placed on the landfilled wastes to an estimated depth of 6 feet.

1.4.6 Systems and Components Test Facilities Storage Tanks (Site 7)

Between 1960 and 1983, the Systems Test Facility (T-28) and the Components Test Facility (T-27) generated wastewaters containing hydrazine fuels, including the decomposition products nitroso dimethylamine (NDMA) and nitrosamines, and nitrous oxide (N_2O_4) oxidizers. Treatment occurred inside several large above-ground tanks. Treated wastewaters and overflows were directed through lined and unlined ditches to a diversion weir in the East Fork of Brush Creek, where they were diverted into pond T-8A.

Two ditches were identified as being of particular concern because they lie downhill from the treatment/storage tanks. Ditch 1 is approximately 400 feet long and Ditch 2 is approximately 350 feet long (Figure 1.4). Flow in Ditch 1 is conveyed through a series of lined and unlined segments past the Components Test Facility to Ditch 2. Ditch 2 drains into a corrugated metal culvert which discharges via lined and unlined segments to the diversion weir in the East Fork of Brush Creek.

1.4.7 Construction Material Fill Area (Site 10)

The Construction Material Fill Area was identified by ES as a potential hazardous materials burial area. It is located north of the T-8A containment pond immediately north of the East Fork of Brush Creek at the eastern edge of the AFP PJKS property. The site was a former north-south oriented gulch, approximately of 15 feet deep, 100 feet

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wide, and 720 feet long, that intersected the northern bank of the East Fork of Brush Creek.

In order to control erosion, construction fill material was dumped into the gulch. The material consisted of broken concrete, broken asphalt from road repairs, and fill dirt from a construction site. The concrete and asphalt were placed in the bottom of the gulch and overlain by fill dirt (Miller, 1986). According to unidentified EPA sources, other waste materials may have been buried during the backfilling operations.

1.4.8 East Fork of Brush Creek (Site 11)

The majority of the land occupied by AFP PJKS and all of the sites investigated for hazardous materials lie within the upper drainage of the East Fork of Brush Creek. Process wastewaters from Sites 2, 3, and 7, and deluge water from past rocket engine testing were discharged through a network of pipes, flumes, and ditches into the containment pond T-8A. Discharge from the pond to Brush Creek, however, was typically not allowed.

1.5 POTENTIAL CONTAMINANTS

The field program described in Section 3.0 of this report involved sampling of soils, ground waters, surface waters, and sediments for materials which may have been disposed, spilled, or stored at the various study sites. A list of these materials is provided below.

Hydrazine
Nitroso dimethylamine (NDMA)
Monomethyl hydrazine (MMH)
Unsymmetrical dimethyl hydrazine (UDMH)
Methyl ethyl ketone (MEK)
Phenols
Purgeable organics
Base/neutral/acid extractable organics
Oil and grease
Arsenic

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Cadmium
Chromium (total and hexavalent)
Lead
Mercury
Selenium
Thallium
Thorium
Gross alpha, beta, and high resolution gamma radiation

1.6 PROJECT TEAM

The Phase II, Stage 1 investigation was conducted by Engineering-Science, Inc. (ES). The ES project team consisted of the following professionals:

Ernest J. Schroeder: BS in civil engineering, MS in sanitary engineering, with 19 years of experience; served as project coordinator.

Timothy C. Shangraw: Registered Professional Engineer in Colorado, BS and MS degrees in civil engineering, with 9 years of experience; served as project manager.

Lisa A. Korner: BS in geology, MS in geochemistry, with 9 years of experience; was the project geologist and field team leader.

Ernest L. Daly, Jr.: BS in chemistry and biology, MS in biology, with 9 years of experience; was the laboratory QA/QC officer.

Phillip C. Sirles: BS in geology, MS in geophysics with 3 years of experience; was the field geologist.

Ola A. Awosika: BS in geological engineering, MA in geophysics, with 4 years of experience; conducted the geophysical survey.

Timothy S. Mustard: BS in botany, MS in plant systematics, with 7 years of experience; was the health and safety officer.

Frank N. Repplier: BS in geology, with 8 years of experience; provided technical assistance in the field and office.

Resumes for these professionals are provided in Appendix D.

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The Phase II program required use of several subcontractors for drilling, surveying, and analytical purposes. The drilling contractor was Arrow Drilling Company (Arrow) of Golden, Colorado. Arrow was experienced with specialized drilling techniques required by subsurface conditions at the site. The surveyor was International Technology Limited of Englewood, Colorado. Two analytical laboratories were retained to conduct radiometric analyses and analysis of hydrazine and associated compounds. The radiometric analyses were performed by EAL Corporation of Richmond, California, and the hydrazine and associated compounds analyses were conducted by California Analytical Laboratories of West Sacramento, California. A third analytical laboratory, APPL, Inc., of Fresno, California, assisted in the analysis of base/neutral/acid extractable compounds. Purgeable organics in ground waters were analyzed by International Technology Corporation of Cerritos, California. All remaining analyses were performed by the ES laboratory located in Atlanta, Georgia.

1.7 FACTORS OF CONCERN

The AFP PJKS property is located approximately 2 miles northwest of the Kassler Water Treatment Plant (Figure 1.1). Until December 1985, the treatment facility was operated by the Denver Water Department (DWD) to provide domestic water to the Denver metropolitan area. At that time, the Kassler Plant was placed on standby status because the new Foothills Water Treatment Plant, located approximately 2 miles southeast and upgradient of the Kassler Plant, and other DWD treatment facilities replaced the treatment capacity of the 86-year-old Kassler facility. This action was part of the DWD's systemwide plan for servicing the Denver metropolitan area.

At approximately the same time the Kassler Plant was removed from service, trace concentrations of TCE (less than the U.S. Environmental Protection Agency's (EPA) proposed MCL of 5 micrograms per liter) were

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detected in the facility's infiltration gallery water. The infiltration gallery periodically had been used to supplement the facility's primary raw water supply (the South Platte River) during summer months. The galleries are constructed in the South Platte River alluvium, which is hydraulically connected to the East Fork of Brush Creek. The source of contamination has been the subject of considerable investigation since that time (Geraghty and Miller, 1986). Contaminant migration pathways currently being evaluated include surface water flow and alluvial ground water movement along the East Fork of Brush Creek and other gulches which drain into the South Platte River near the infiltration gallery. Deeper ground water movement beneath the Martin Marietta property is also the subject of investigation (Kisling, 1986).

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SECTION 2.0

ENVIRONMENTAL SETTING

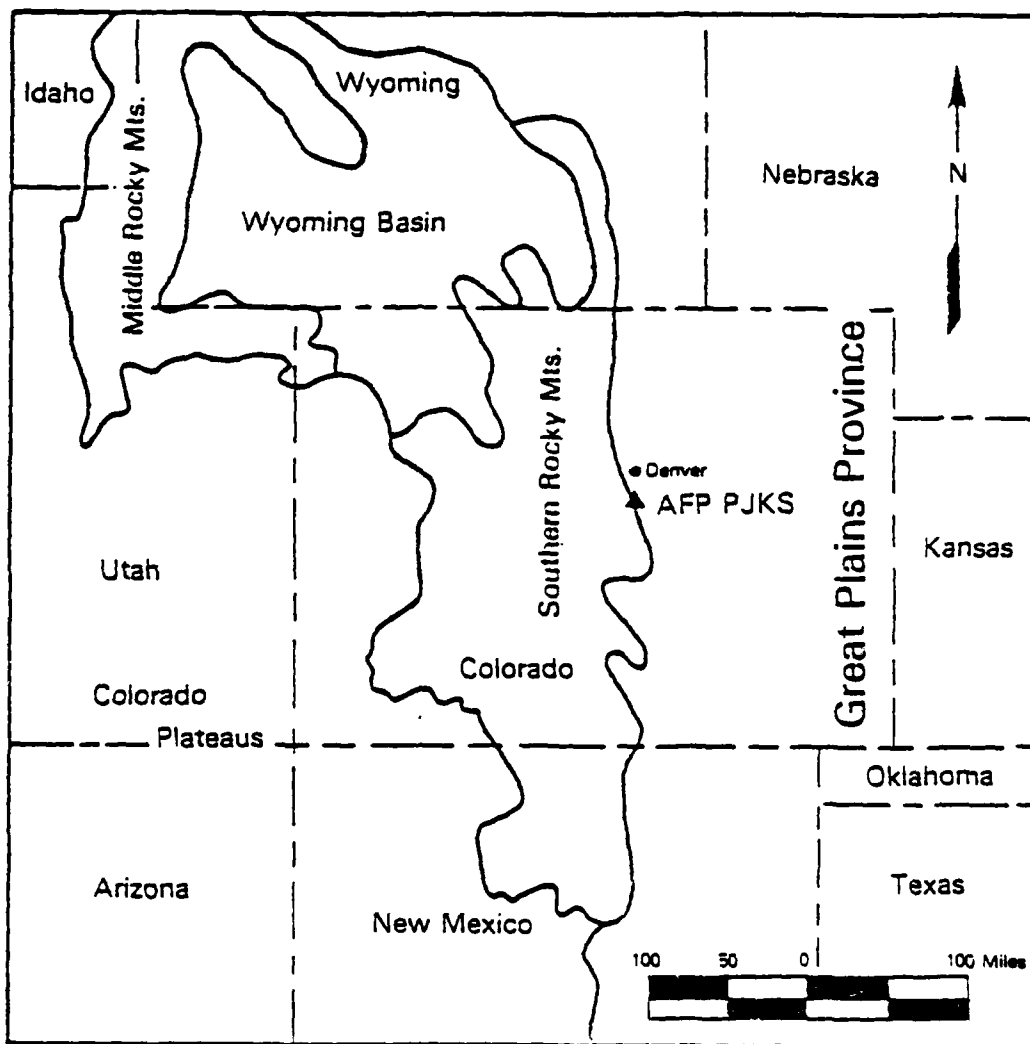
2.1 GEOGRAPHY AND TOPOGRAPHY

Air Force Plant PJKS is located in the foothills of the Rocky Mountains, as illustrated in Figure 2.1. The site lies within the Colorado Piedmont section of the Great Plains physiographic province at its border with the east flank of the Front Range of the Southern Rocky Mountain physiographic province (Fenneman, 1931). Elevations of the Colorado Piedmont and Southern Rocky Mountain Front Range are from 5,000 to 6,500 feet above mean sea level (MSL), and 5,600 to 14,260 feet MSL, respectively. As illustrated on Figure 2.2, the PJKS plant is situated within an alluvium-filled northwesterly-trending strike valley which is bordered by sharp ridges of upturned sedimentary rocks (hogbacks) to the east, and rugged, irregular mountains, composed of igneous and metamorphic rocks, to the west. Elevations within the plant boundaries range from approximately 7,000 feet MSL at the extreme western boundary line to 5,925 feet MSL at the southeast boundary of the site.

2.2 METEOROLOGY

The climate at AFP PJKS is characterized as continental and temperate. Average annual precipitation in the vicinity of the plant is approximately 17 inches (Scott, 1963). Evaporation is high, and the climate is rated semi-arid. Precipitation is well distributed, with most occurring between March and October. Precipitation in the winter months occurs as snow. The rainfall depth of the 10-year, 1-hour precipitation event is 1.5 inches, while that of the 100-year, 24-hour event is 4 inches (Denver Regional Council of Governments, 1969). The average frost depth is 2 feet but frost penetrations are typically deeper on north-facing slopes (Scott, 1963).

FIGURE 2.1
PHYSIOGRAPHIC PROVINCE MAP SHOWING
THE LOCATION OF AFP PJKS



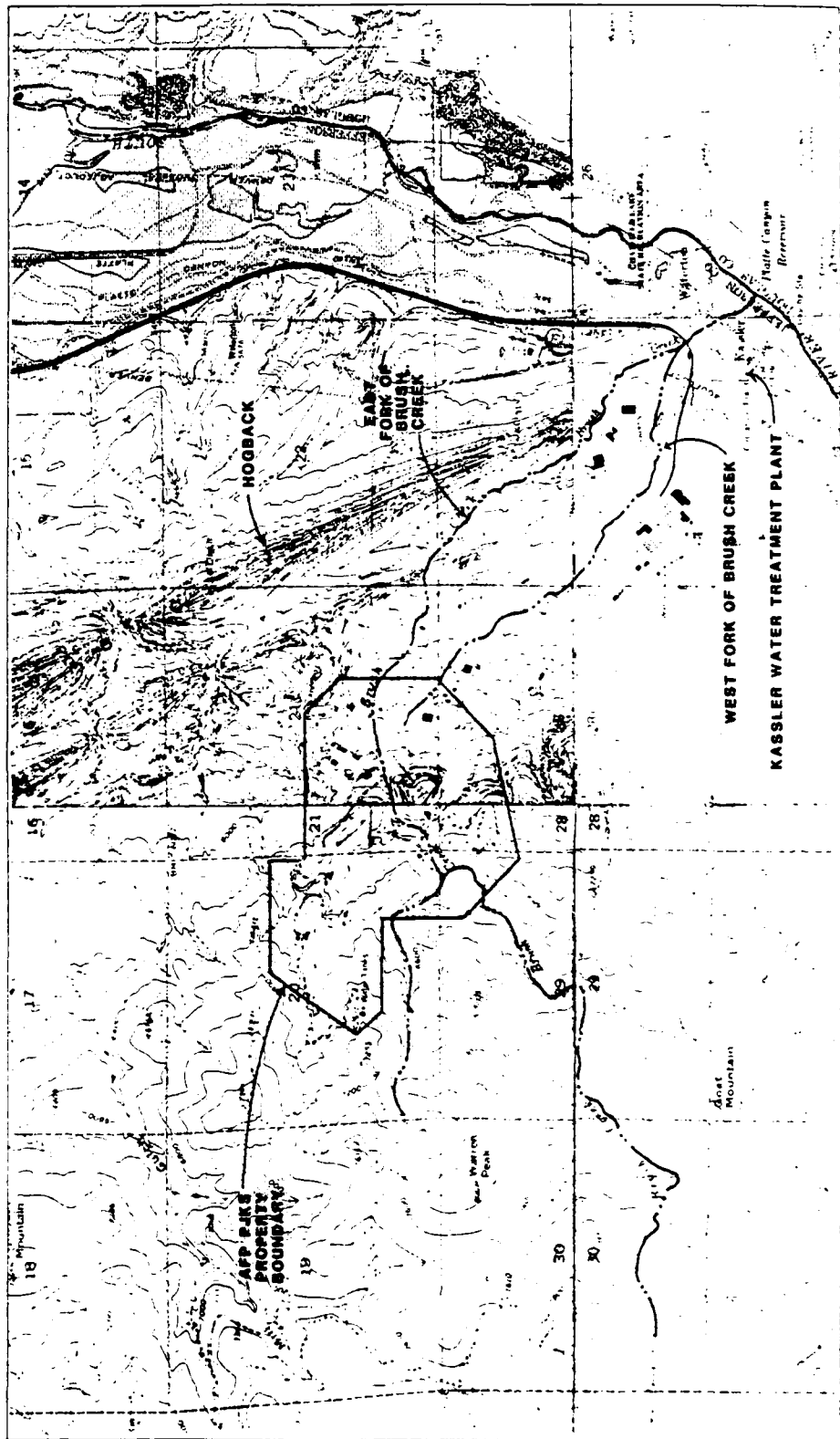
SOURCE: FENNEMAN, 1931



NORTH

0 1000 2000 3000

SCALE IN FEET



SOURCE: MODIFIED FROM USGS TOPOGRAPHIC MAPS

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2.3 SURFACE WATER HYDROLOGY

2.3.1 Surface Water Drainages

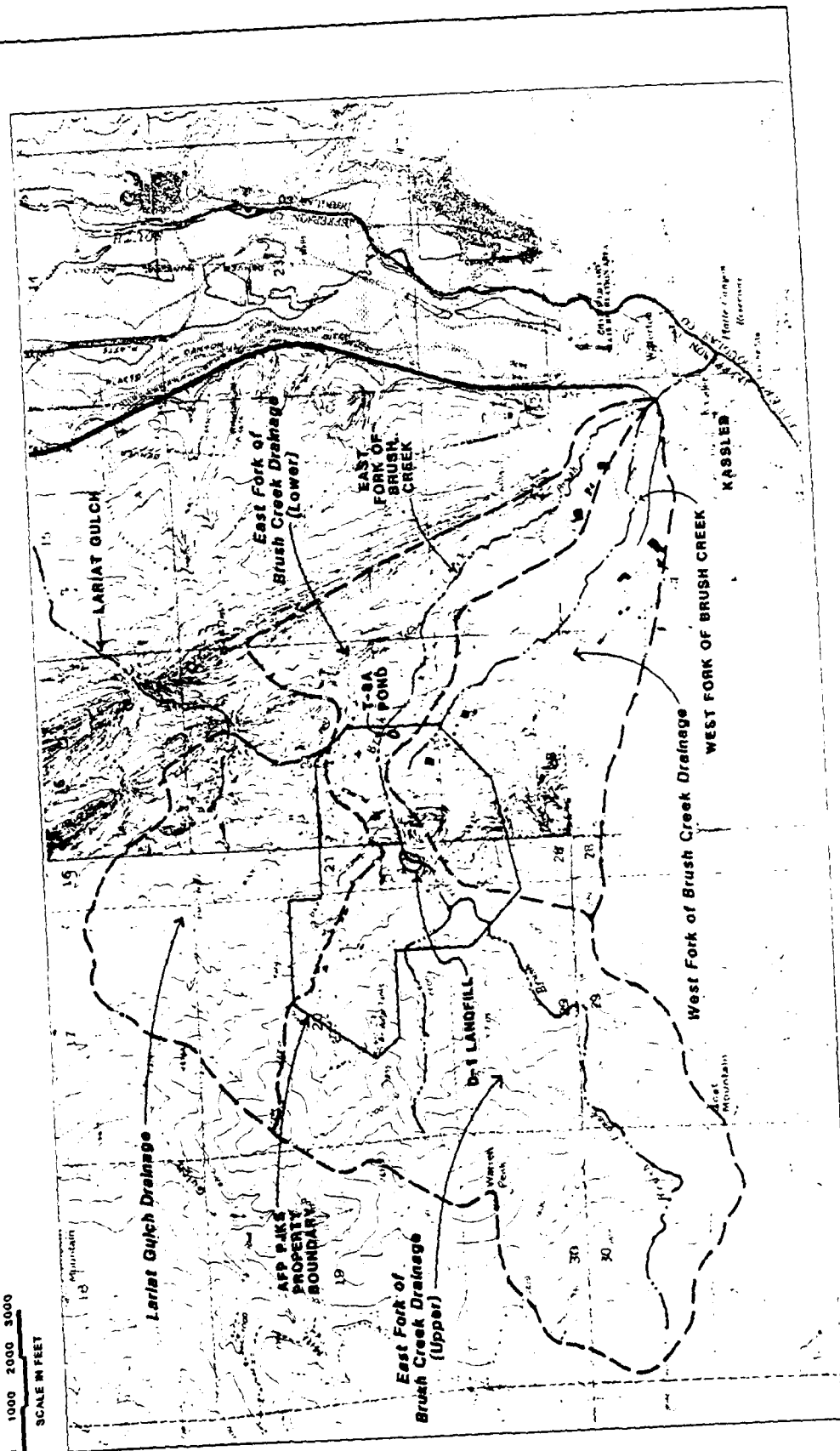
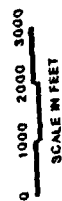
AFP PJKS is located within the South Platte River basin which covers approximately 24,000 square miles. Of this total, 19,000 square miles are located in Colorado, 3,000 square miles are in Nebraska, and 2,000 square miles are in Wyoming (U.S. Army Corps of Engineers, 1975). The South Platte River originates along the Continental Divide of the Rocky Mountains near Fairplay, Colorado. It flows northeastward through Waterton, Colorado, near AFP PJKS, to Chatfield Reservoir, a flood control reservoir. Downstream from Chatfield Reservoir, the South Platte River flows through the Denver metropolitan area. Waters from the South Platte River are used for domestic, agricultural, commercial, and recreational purposes.

Average annual streamflow in the South Platte River at Waterton, Colorado, is 176 cubic feet per second (cfs) for a 54-year period of record (U.S. Geological Survey, 1982). Extreme high and low flows recorded at Waterton are 5,700 cfs (1942) and 0.1 cfs (1933, 1938), respectively. The minimum low flow permitted at Waterton is currently 30 cfs (Denver Water Department, 1978).

The majority of AFP PJKS is drained by the East and West Forks of Brush Creek, as shown on Figure 2.3. A small northern portion of the site is drained by Lariat Gulch (informal name). Waters from both Brush Creek and Lariat Gulch discharge to the South Platte River downstream from the Kassler Water Treatment Plant.

The East Fork of Brush Creek watershed encompasses 1,875 acres and drains 60 percent of the AFP PJKS property, including all of the sites investigated for hazardous materials. Approximately 75 percent of the East Fork drainage lies upstream from the D-1 landfill, roughly 5 percent falls between the D-1 landfill and the T-8A Pond, and the remainder is situated downstream from the Air Force property. The East Fork

FIGURE 2.3



SOURCE: MODIFIED FROM USGS TOPOGRAPHIC MAPS

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is an ephemeral water course, flowing only after precipitation or from snowmelt runoff. Surface flow on or upstream from the plant property does not normally occur during dry summer months. However, during the early fall of 1985, a continuous flow was observed downstream from the D-1 landfill. It is suspected that a broken water line underlying the streambed partially contributed to the flow. Flow in the East Fork was also observed during subsequent site visits through April, 1986.

The southern portion of the AFP PJKS property is drained by the West Fork of Brush Creek. The contributing watershed encompasses 710 acres and drains much of Martin Marietta's manufacturing and headquarters areas. AFP PJKS lies at the higher elevation of the watershed and accounts for only 20 percent of the watershed area. The West Fork is also an ephemeral drainage and converges with the East Fork near Waterton, Colorado.

2.3.2 Surface Water Quality

No surface water field investigations at AFP PJKS were conducted prior to this study. However, some surface water quality data are available for downstream surface waters on the Martin Marietta property. Several sampling stations close to AFP PJKS are shown on Figure 2.4. Water samples from these stations were analyzed for volatile organic compounds using EPA methods 601, 602, and 604 as specified in Appendix A of 40 CFR Part 136. The results are summarized in Table 2.1. Only those compounds which were detected are listed in the table.

The compounds 1,1,1-trichloroethane, TCE, and cis-1,2-dichloroethylene were detected in samples from station SW-24G. Concentrations of TCE at this station ranged from 15 micrograms per liter (ug/L) to 32 ug/L with no apparent correlation with streamflow. The probable source of this and other contaminants is unknown. Organic compounds in samples from station SW-23G, located downstream from SW-24G, are all

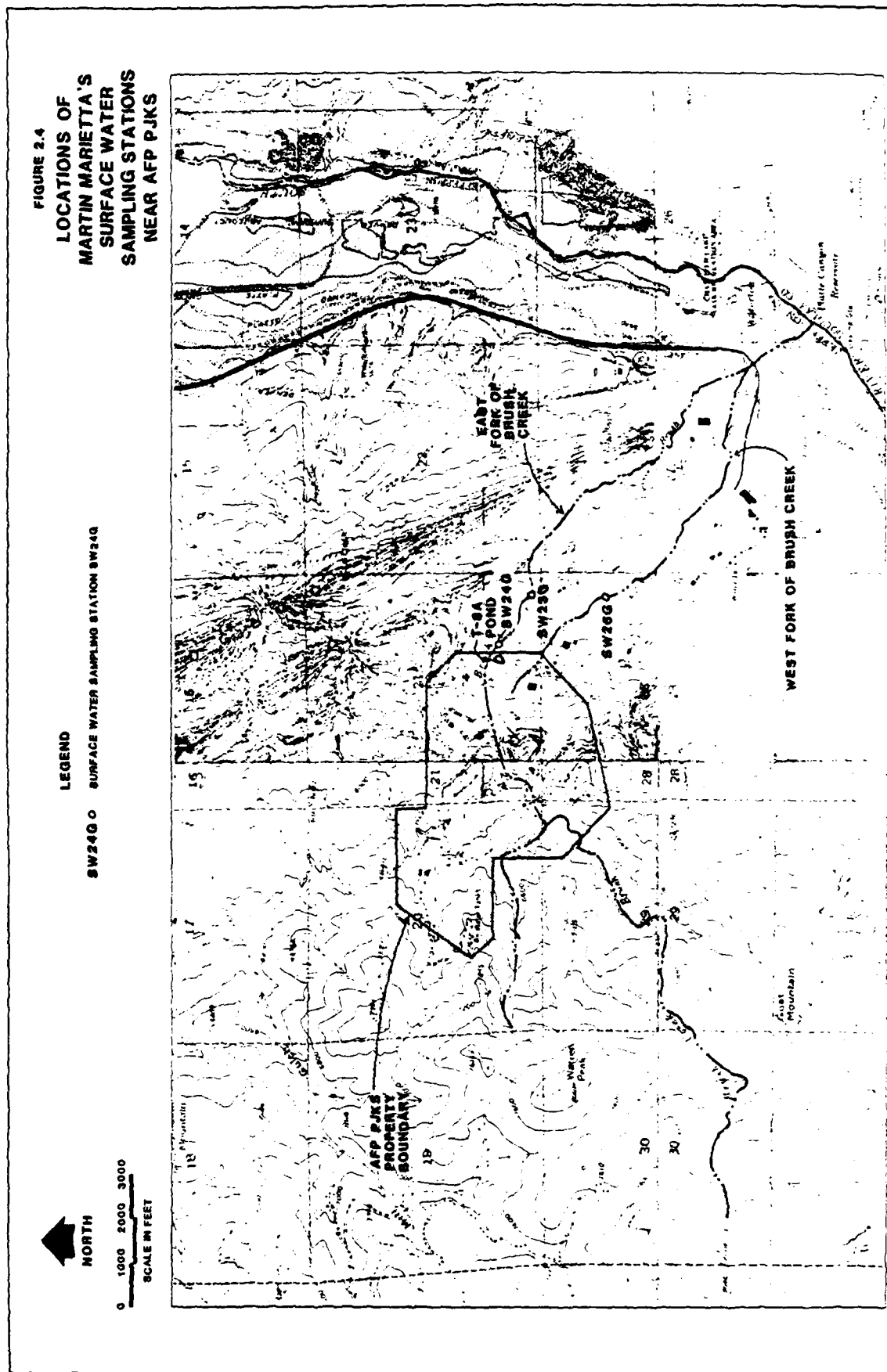


TABLE 2.1
RESULTS OF MARTIN MARIETTA'S SURFACE WATER SAMPLING FOR EAST AND WEST FORKS
OF BRUSH CREEK NEAR APP PJKS
(Micrograms per liter)

Organic Compound	SW-23G		SW-24G		SW-26G	
	7/85	10/85	7/85	10/85	7/85	10/85
1,1,1 trichloroethane	ND ^{1/}	ND	5	ND	ND	ND
trichloroethene (TCE)	ND	ND	27	15	ND	ND
cis-1,2-dichloro-ethylene	ND	ND	18	5.2	ND	ND
Flow Rate (gpm)	17	14.5	18	20	24	14
		34		45		13

1/ Not detected. Detection limit was <5 ug/L.

Note: Only detected compounds are reported. All concentrations reported in ug/L.

Source: Martin Marietta Environmental Systems; Results of Analysis for Volatile Organic Compounds in Water Samples Collected from Martin Marietta Denver Aerospace, Waterton Facility; 15 August 1985; November 1985; 14 February 1986.

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less than detection limits. This indicates contaminants found at station SW-24G have dissipated by aeration, dilution, and/or adsorption. Similarly, no volatile organic compounds were detected in the West Fork of Brush Creek at Station SW-26G.

2.4 GEOLOGY

2.4.1 Regional Geology

AFP PJKS is located on the eastern flank of the Colorado Front Range. The Front Range is a complexly faulted anticlinal arch of primarily Precambrian crystalline rock. Where the mountains join the Great Plains, the foothills region consists of steeply dipping Paleozoic and Mesozoic sedimentary rocks forming hogback ridges and gravel-covered pediments. To the east is the Denver Basin which is a north-south trending asymmetrical basin with a gently dipping eastern flank.

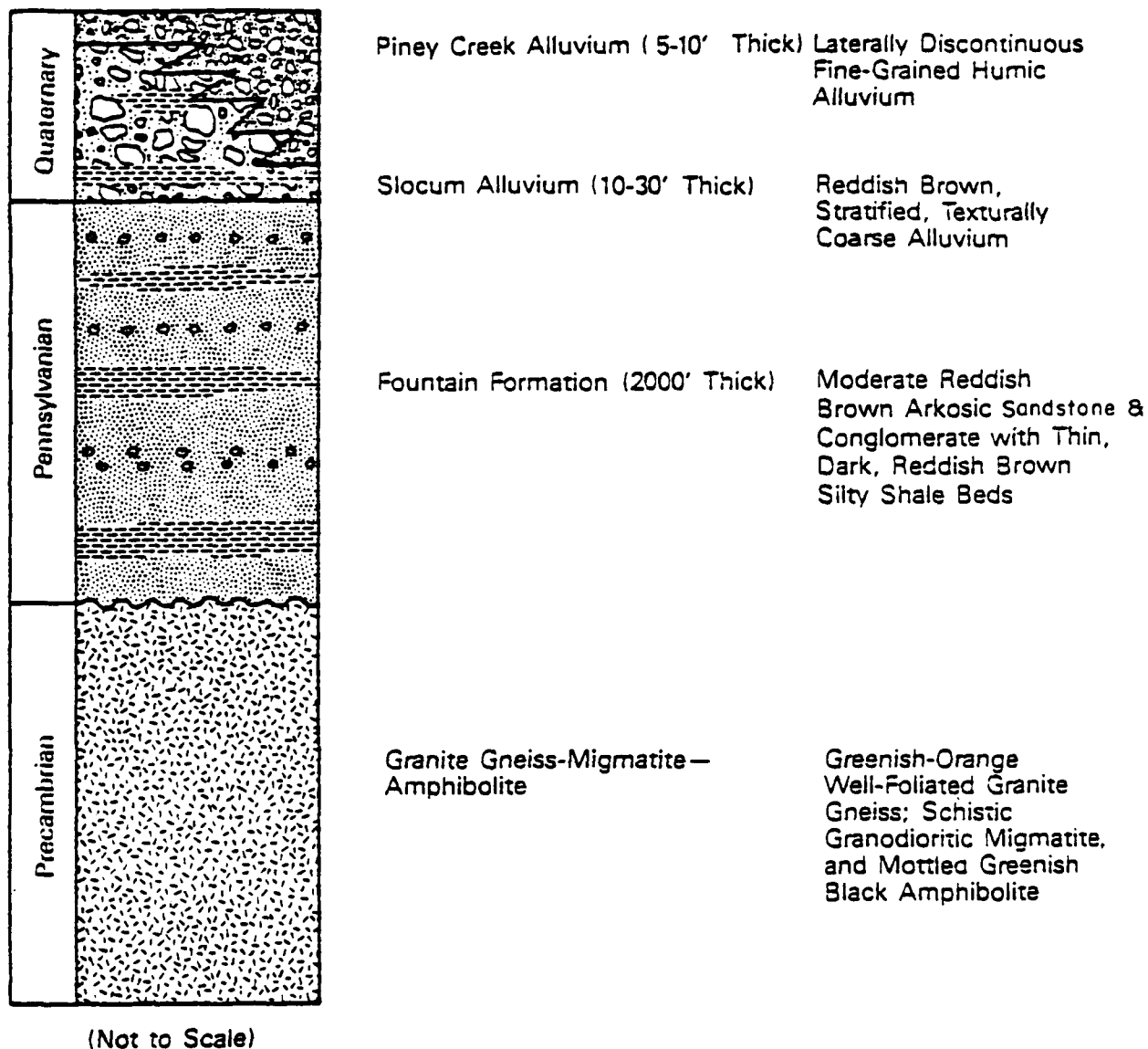
2.4.2 Site Geology

The major lithologies at the PJKS site are, from oldest to youngest, Precambrian metamorphic and igneous rocks, the Pennsylvanian-age Fountain Formation, and Quaternary alluvium. A generalized stratigraphic column is provided on Figure 2.5. The surficial geology of the site is illustrated in Figure 2.6.

2.4.2.1 Stratigraphy

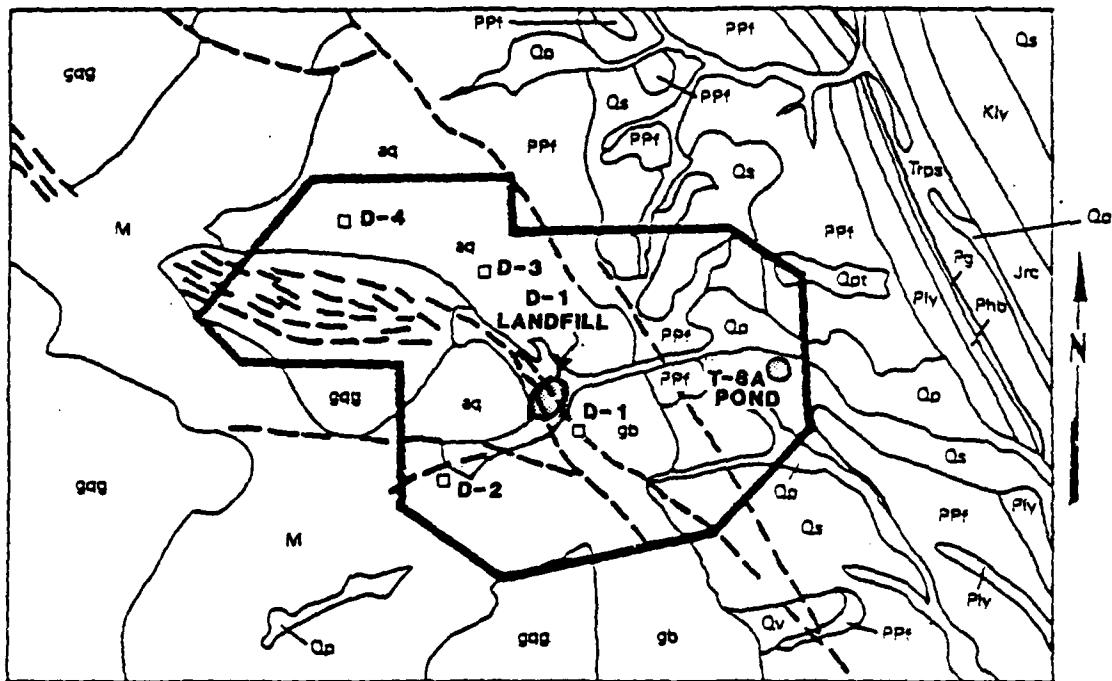
As shown in Figure 2.6, the western portion of the PJKS property consists of Precambrian metamorphic and igneous rocks including migmatite, amphibolite and quartzite, biotite-muscovite granite, and gneissic quartz monzonite and granodiorite (Scott, 1963). Sedimentary rocks are the oldest of the Precambrian formations and have been metamorphosed to quartzite, and possibly amphibolite and migmatite. These rocks were then intruded by igneous rocks, including biotite-muscovite granite and gneissic quartz monzonite. Gradational contacts between these lithologies are common. Test stands D-1 through D-4 and the D-1 landfill are underlain by the Precambrian rock.

FIGURE 2.5
GENERALIZED STRATIGRAPHIC COLUMN
FOR LITHOLOGIES PRESENT AT AFP PJKS



Modified after
Source: Scott, 1963

FIGURE 2.6
SURFICIAL GEOLOGY MAP
OF AFP PJKS



Legend

Qp	Piney Creek Alluvium	Ply	Lyons Formation
Qs	Siocum Alluvium	PPf	Fountain Formation
Qpt	Rocky Flats Alluvium	M	Migmatite (Precambrian)
Klv	Lytle Formation	aq	Amphibolite and Quartzite (Precambrian)
Jrc	Ralston Creek Formation	gb	Biotite-Muscovite Granite (Precambrian)
Trps	Lykins Formation	gqq	Gneissic Quartz Monzonite and Granodiorite (Precambrian)
Pg			
Phb			

— Fault

□ D-1 Test Stand D-1

0 1000 2000
Scale in feet

Sources: Scott, 1963; Bryant et. al., 1973

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The eastern portion of the PJKS site consists of the Pennsylvanian-age Fountain Formation, an arkosic sandstone and conglomerate with thin silty shale beds (Scott, 1963). The Fountain Formation is approximately 2,000 feet thick at PJKS. Its strike is N25-30°W and dip is 50 to 60 degrees to the northeast. The steep dip of the Fountain Formation is related to the uplifting of the Precambrian units that occurred to the west. The contact between the Fountain Formation and the underlying Precambrian rock is an unconformable surface. The Fountain Formation underlies the alluvial material in the main PJKS facilities area.

The alluvium consists of two episodes of deposition, the Pleistocene-age Slocum Alluvium and the Recent Piney Creek Alluvium. The Slocum Alluvium consists mainly of reddish-brown, gravelly, clayey sands with some cobbles and gravel and generally ranges from 5 to 10 feet thick (Scott, 1963). However, the total thickness of the Slocum Alluvium may be up to 45 feet in the vicinity of Brush Creek (Bryant et al., 1973). The Slocum Alluvium is laterally continuous within the valley of Brush Creek (Scott, 1963) with the exception of localized spires where bedrock outcrops exist and areas where channelization has occurred during the more recent Piney Creek erosion. The areal extent of the Slocum Alluvium is illustrated in Figure 2.6.

The Piney Creek Alluvium was derived principally from sheet erosion of soil-covered slopes and was deposited in previously cut arroyos along the small streams or on broad flood plains along the large streams (Scott, 1962). The Piney Creek Alluvium is a dark gray, humic-rich silt and sand with thin layers of clay and pebbles. Piney Creek Alluvium is generally less than 5 feet thick locally along small drainages such as Brush Creek and its tributaries (Bryant et al., 1973). The areal extent of the Piney Creek Alluvium is also depicted on Figure 2.6.

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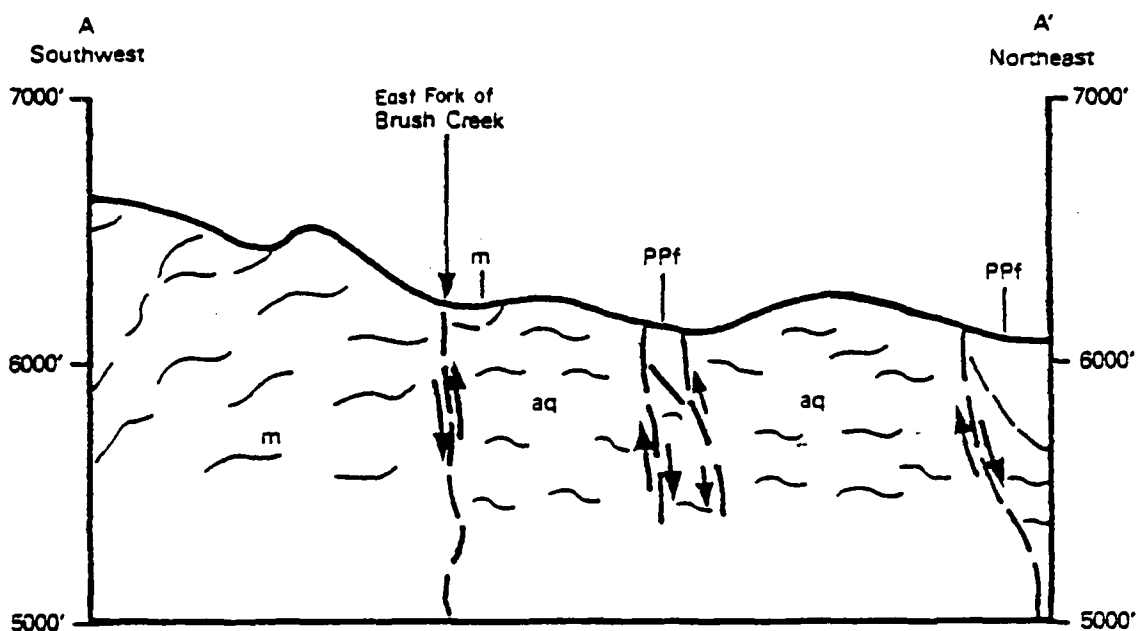
2.4.2.2 Structure

Rocks of the Front Range were deformed as early as Precambrian time and as late as Pliocene time. Structural events were associated with Precambrian metamorphism and intrusion. In latest Precambrian time, mountains were slightly raised and a system of northwest and northeast-trending faults was formed (Scott, 1962). In Early Pennsylvanian time, the ancestral Rockies were uplifted and the Precambrian faults were locally reactivated. During the Laramide event, the Precambrian faults were again reactivated and some new faults were formed in both the crystalline rocks and in sedimentary rocks. The last major structural event was in late Pliocene time when the Rocky Mountains were slightly uplifted.

Several northwest-oriented faults trend through the PJKS property as shown on Figure 2.6. The D-1 landfill and test stand D-1 lie in an apparent fault valley. Faults striking approximately N80°W and N65°E converge in this part of the Brush Creek valley. Figure 2.7 shows a cross section through this portion of the property and depicts the attitude of faults in the area. The vertical extent and subsurface attitude of faults in the western portion of the PJKS property is highly speculative. However, based on the work of Bryant et al. (1973), the near verticality of the fault surfaces in the shallow subsurface is probable.

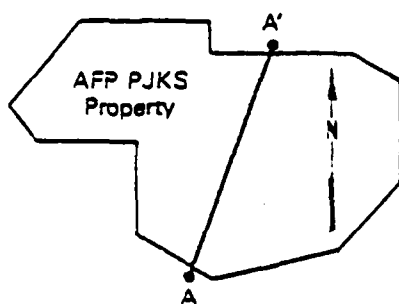
Another northwest-trending fault which displaces the Fountain Formation occurs along the boundary of the Front Range. The approximate location of this fault is the eastern-most fault line shown on Figure 2.6. According to Bryant et al. (1973), the displacement was nearly vertical along bedding planes with the east side displaced upward approximately 800 to 1,000 feet. The Ken Caryl fault, located 2 miles to the northwest, and the northwest-trending fault at Brush Creek have similar trends and displacements, but it is not known whether they are connected.

FIGURE 2.7
CROSS-SECTION A-A'
THROUGH AFP PJKS



Legend

Scale: 1" = 667'



- | | |
|---|---------------------------------------|
| PPf | Fountain Formation |
| aq | Precambrian Amphibolite and Quartzite |
| m | Precambrian Migmatite |
| ↔ | Fault with Relative Movement |

Source: Bryant et al., 1973

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2.4.2.3 Economic Geology

The potential for uranium mineralization associated with fault zones in Precambrian rocks exists in the western portion of AFP PJKS. Several mining companies, including Energy Fuels Exploration Company and French American Metals Corporation, have explored for uranium on a claim block which extended northward to the upper portions of the East Fork of Brush Creek (upstream of the D-1 landfill) and southward approximately 2 miles to the South Platte River. Samples from some adits and pits of the Bonzo prospect near the South Platte River (SE 1/4, Sec. 33, T.6S, R.69W) contain from 0.16 to 11.2 percent U_3O_8 (Nelson-Moore et al., 1978). Between 1958 and 1960, a total of 1,143 tons of ore with a grade of 0.44 percent U_3O_8 were mined at Stone Placer (Sect. 5, T.7N, R.69W).

2.5 HYDROGEOLOGY

2.5.1 Regional Hydrogeology

Two distinct ground water regions occur in the vicinity of the AFP PJKS property: the Western Mountain Range region and Nonglaciaded Central region, as defined by Heath (1982) (see Appendix B for the definition of ground water regions). The Western Mountain Range region is characterized as mountainous, with thin soils, fractured and faulted igneous and metamorphic bedrock, and narrow alluvial valleys which are partially glaciaded. Ground water occurrence is restricted primarily to the sparse alluvial valley deposits and secondarily to occurrences within fractures and faults in the Precambrian crystalline bedrock.

The Nonglaciaded Central region is comprised of a thin regolith (i.e., a layer of loose, noncoherent rock material of various origins) underlain by sedimentary rock. Ground water occurrence in this region is predominantly in the sedimentary rock. Appreciable quantities of ground water in the regolith are likely to be present only during seasonal high precipitation events.

2.5.2 Site Hydrogeology

Ground water occurrence, flow direction, and flow rate vary locally within the PJKS property based on the diverse lithologies present and the geologic controls specific to each. From youngest to oldest, the hydrogeologic units and associated ground water systems are described below.

2.5.2.1 Quaternary Deposits

The Quaternary deposits, consisting of the Pleistocene-age alluvial deposition (Slocum) and Recent channel deposits (Piney Creek), are essentially heterogeneous silt and sand deposits. Overall ground water flow within the alluvial materials at the plant property is probably controlled by topography. Therefore, the net flow direction within the plant facilities area is probably to the south-southeast. Variations in the thicknesses of the alluvium as well as subtle changes in composition, particularly within the Slocum Alluvium, are expected to result in localized anomalies in ground water flow direction.

Distribution of the Piney Creek Alluvium is localized to areas of recent intermittent stream channels or arroyos. Appreciable quantities of ground water in the thin Piney Creek horizon are likely only during seasonal high precipitation events. During such events, ground water flow discharges to the surface water system.

Martin Marietta recently investigated a portion of the alluvial ground water system immediately downgradient from AFP PJKS. The alluvium intercepted downstream from pond T-8A is described as fine to coarse sand with varying amounts of silt and clay. Hydraulic conductivities of these types of materials range from 0.07 to 13 feet per day (Freeze and Cherry, 1979). The saturated thickness of alluvium in these areas ranges from 10 to 37 feet.

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2.5.2.2 Fountain Formation

The depth to the Fountain Formation ranges from zero feet at surface outcrops to approximately 45 feet in areas of thick alluvium. According to Pearl (1980), seasonal recharge variations, ranging from 2 to 20 inches per year, occur on the PJKS property, with yields characterized locally as small. The Fountain Formation is of low porosity and has only moderate transmissivity, with bedding planes and fractures possibly representing conduits for ground water transport. Assuming that bedding planes and fractures control ground water flow direction, net flow may be influenced by the strike direction (north-northwest), the dip direction (east-northeast), and fractures (northeast). Field data are needed to establish ground water flow directions.

2.5.2.3 Precambrian Units

Ground water is primarily restricted to occurrences within fractures and faults in the Precambrian metamorphic and igneous bedrock. Ground water recharge rates are extremely small, less than 2 inches per year (Heath, 1982). Expected well yields are limited to 1 to 10 gallons per minute. Common ranges for bedrock aquifer transmissivity and hydraulic conductivity are 5 to 1,000 square feet per day and 0.001 to 50 feet per day, respectively (Freeze and Cherry, 1979). The upper range of these values represents the ground water movement potential in the fractured or faulted zones only.

In the vicinity of Sites 4 and 5, significant evidence exists that the valley is faulted as described earlier (JRB, 1984). The fault surface is assumed to be nearly vertical, with a strike trend of approximately N75°E, or parallel to the valley. Hydraulic gradients and conductivities in the faulted or fractured crystalline rock are unknown. The depth to the water table will probably vary seasonally.

2.5.3 Locations of Nearby Wells

A survey of water wells located within a 2-mile radius of the PJKS site has revealed 198 wells. Approximately 155 of these are monitoring wells located south and southeast of the PJKS property on Martin Marietta property. These and possibly additional wells on Martin Marietta property are the result of an ongoing hydrogeologic investigation. The monitoring well construction details are available from Martin Marietta and, for purposes of brevity, are omitted from this report. The remaining 43 wells are located on Figure 2.8 and well construction details are provided in Appendix E.

A well system consisting of four wells is located immediately upstream from Chatfield Lake. The system, represented by wells 23-1, 2, 3, and 4, was permitted between 1954 and 1955. According to the Denver Water Department (Dice, 1986) these four wells have not been used in the past 14 years. A domestic well for a caretaker's house (well 34-2) of the Highline Canal at Waterton is still in use.

Several other wells are located downstream from or south of the Kassler Water Treatment Plant within the 2-mile radius of the PJKS plant boundary. Two wells have been permitted for municipal use (wells 26-1 and 34-1) and one is permitted for stock watering (well 26-2). It is not known whether these wells are still in use.

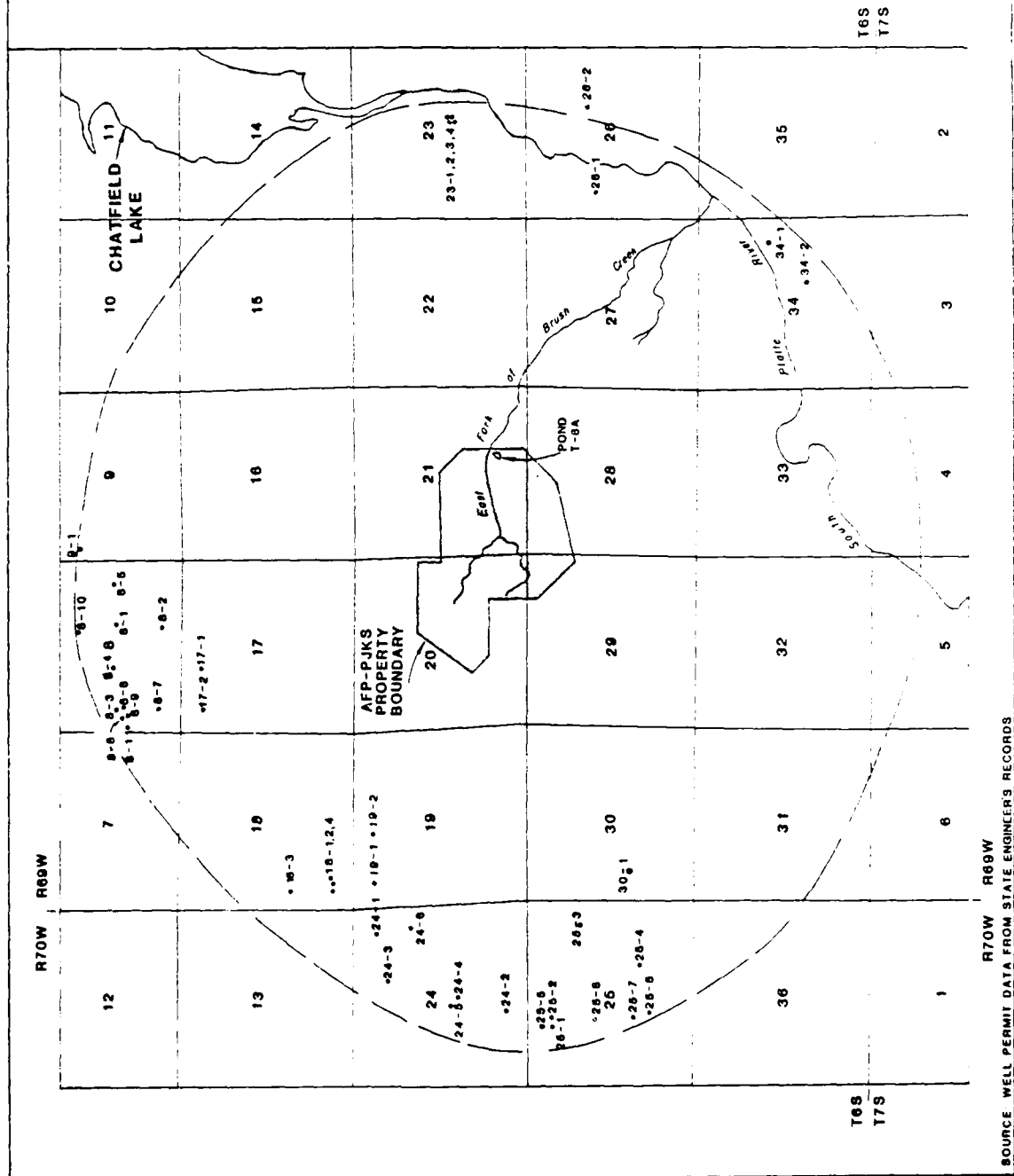
Thirty-five domestic wells are identified as lying upstream from the PJKS property. Fourteen lie to the northwest and 21 lie to the west of the property. All wells service individual residences located in the nearby foothills.

2.5.4 Ground Water Quality

Ground water quality investigations at AFP PJKS began with this study. However, since 1984 Martin Marietta has devoted considerable effort toward characterizing ground waters on their property. Preliminary reports indicate that organic and inorganic contaminants are

FIGURE 2.8
WELL LOCATIONS WITHIN
2 MILE RADIUS OF PJKS
BOUNDARY

LEGEND
•28-1 LOCATION OF WELL 28-1
(SEE APPENDIX FOR
WELL CONSTRUCTION DETAIL 8)



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present in various concentrations in alluvial ground waters (Geraghty and Miller, 1985). Ground water sampling locations lie at varying distances downstream from the AFP PJKS property.

2.6 ISSUES OF CONCERN

Residual contaminants from past storage, processing, and rocket testing activities may be present in AFP PJKS soils, sediments, surface waters, and ground waters. Migration pathways of these contaminants relevant to the PJKS property include surface runoff, streamflow in the East Fork of Brush Creek, and ground water. Surface runoff that may contact contaminated site soils and/or sediments drains into the East Fork of Brush Creek, and is eventually discharged into the South Platte River downstream from the Kassler Water Treatment Plant. Streamflow in the East Fork contacts streambed deposits that may contain residual contaminants. East Fork flow is also channeled beneath the D-1 landfill, which may be a source of contamination.

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SECTION 3.0

FIELD PROGRAM

The purposes of this IRP Phase II, Stage 1 investigation were to confirm or deny the presence of contamination at the previously described sites and to determine, to the extent possible, the extent of any contamination found. This study was organized to assess the conditions at individual sites and, collectively, evaluate the overall plant environment.

The field investigation methods included:

- . Surface geophysical surveys using electrical resistivity and magnetometer methods;
- . Monitoring well installation, ground water sampling, and analysis;
- . Soil sampling and analysis;
- . Surface water and sediment sampling and analysis; and
- . Surface water flow measurements.

A five-part sample numbering system was used to identify each sample collected during the field investigation. The numbering system provided a tracking procedure to allow retrieval of information about a specific site and assured that each sample was uniquely numbered. The sample number consisted of:

- . Project identification - PJKS,
- . Site identification,
- . Well or boring number,
- . Sequence number (sample depth, if appropriate), and
- . Split sample identification.

A detailed description of the sample numbering system is presented in Appendix H.

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3.1 PROGRAM DEVELOPMENT

Site-specific field investigations were designed using one or more of the methods listed above. Descriptions of each method and the method's applicability to the eight sites described in Section 1.0 are provided in the following paragraphs.

3.1.1 Surface Geophysical Surveys

Electrical resistivity and magnetometry were used as an aid in determining monitoring well locations, delineating buried trenches, assessing the depth and extent of subsurface saturation, and locating buried metallic objects.

3.1.2 Monitor Well Installation and Ground Water Sampling

Eight monitoring wells were constructed and sampled in order to quantify subsurface geologic and hydrologic conditions and to assess the presence of contamination. Each well was completed in the saturated alluvium immediately overlying bedrock.

3.1.3 Soil Sampling

Soils at 11 sites were drilled and sampled to an average depth of 17 feet. The borings were located to test areas where sediment suspected of being contaminated was placed or where spills had occurred on undisturbed soils.

3.1.4 Surface Water and Sediment Sampling

Eleven surface water and 20 sediment samples were collected and analyzed to assess the presence of contaminants.

3.1.5 Flow Measurements of Brush Creek

Surface water flow rates were measured along the East Fork of Brush Creek at sites corresponding to surface water and sediment sampling locations. Flow information was necessary to determine which reaches of the stream were gaining or losing water to the ground water system, and to correlate water quality data with surface flow.

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3.1.6 Analytical Program

Specific chemical parameters for the sampling programs discussed above were selected based on suspected contaminants released on the AFP PJKS property. The analytical program was designed to determine the nature of contamination at the AFP PJKS site and, if possible, to determine the extent of contamination. All of the parameters listed in Section 1.5, Potential Contaminants, were analyzed with the exception of monomethyl hydrazine (MMH) and unsymmetrical dimethyl hydrazine (UDMH) because reliable analytical techniques for these species of hydrazine are unavailable. As an alternative, the analyte hydrazine was utilized as a general indicator of hydrazine contamination.

3.2 PROGRAM IMPLEMENTATION

3.2.1 Schedule of Activities

The field program was conducted between 11 November 1985 and 24 April 1986. Analytical work commenced in mid-November 1985 and continued until mid-May 1986. Air Force personnel collected additional samples in May 1986. These laboratory results were finalized in August 1986.

3.2.2 Geophysical Surveys

3.2.2.1 Magnetometer Survey

The magnetometer survey consisted of station-to-station measurements using a grid system for each site. The stations were set 25 feet apart using a measuring tape and a Brunton compass. The measurements were obtained with a Geometrics G816/826A Proton Magnetometer which indicated the total magnetic field intensity of the earth in gammas. The field measurements and surface topographic features were recorded in the field notebook.

3.2.2.2 Electrical Resistivity Survey

The electrical resistivity survey consisted of both vertical and horizontal resistivity measurements. These measurements, obtained with a Bison Earth Resistivity Model 2350B meter, are indicative of the electrical resistance of the earth to an induced electric current.

Vertical resistivity measurements (soundings) indicate the variation of resistivity at various depths at one ground surface point. In the Modified Wenner Electrode Array (Carrington and Watson, 1981) used at AFP PJKS, the potential electrode distance closely approximates the depth of investigation into the subsurface. Soundings were conducted at three stations on each site investigated.

Horizontal resistivity measurements, called profiles, indicate the variation of resistivity at one approximate depth at many ground surface locations. The electrode configuration used during profiling was the standard Wenner Array (Bison, 1975). The depth of investigation is a zone of the subsurface approximately three-fourths to one times the electrode spacing. Three to five Wenner arrays per site were used to distinguish shallow and deep subsurface variations in resistivity. Data collected from both types of resistivity methods were recorded in the field notebook. A summary of the results from the geophysical survey is presented in Appendix G.

3.2.3 Drilling and Sampling Program

3.2.3.1 Drilling and Soil Sampling

An Ingersol Rand Cyclone 750 drill rig equipped with hollow-stem auger, air rotary, air rotary drilling concurrent with driving steel casing, and continuous coring was used during the drilling program. The preferred method for drilling was with hollow-stem auger unless field conditions warranted use of other methods. In many cases, large cobbles and boulders were encountered. If augers could not penetrate these materials, air rotary drilling was employed. The third choice, drilling and driving steel casing, was employed when borings would not

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remain open during drilling. The continuous coring method was used for drilling of soil borings where no cobbles or boulders were present and a small diameter hole was preferred.

The different drilling methods produced varied boring diameters. The hollow stem augers produced a 10-inch-diameter hole. Air rotary drilling produced 6-1/8-inch-diameter borings, and the drilling and driving casing method produced borings with diameters ranging from 6 to 8 inches, depending on the size of the steel casing used. The continuous coring method produced 3-inch-diameter borings.

During drilling operations, a qualified geologist/engineer was present to direct operations and to log and prepare samples. During drilling of the exploration soil borings, soil samples for laboratory analysis were collected with a 2-inch-diameter split spoon sampler at intervals of 1, 3, 6, 10, 15, and 20 (if applicable) feet. The fall-in material in the upper portion of the sampler was discarded, and the remainder of the sample from that depth was composited and split among Engineering-Science, USAF Occupational and Environmental Health Laboratories (USAFOEHL), and Martin Marietta (if present) containers. Soil borings to be completed as wells were sampled for visual classification purposes only. Samples from these borings were collected with the split spoon sampler every 2.5 feet from the surface to a depth of 15 feet and every 5 feet from 15 feet to total depth. Soil gas vapors were constantly monitored with an organic vapor (HNU) meter during all drilling operations.

Soils were classified with respect to color, type, grain size and shape, density, mineralogy when pertinent, moisture, relative permeability, and odor. Geologic information, drilling pressure, Unified Soil Classification System (USCS) descriptions, sampling types and depths, and HNU measurements were recorded on the boring logs. Any additional notes were recorded in the field notebook. The ground surface elevation adjacent to each soil boring was then surveyed.

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Care was exercised to prevent cross contamination prior to, during, and following drilling operations. A drilling hierarchy from least contaminated (suspected) to most contaminated (suspected) borings was implemented. Prior to drilling the first boring, the drill rig was cleaned using high-pressure steam. Drill bits, split spoon samplers, drill rods, augers, and other downhole equipment were decontaminated prior to the first use and immediately following completion of each boring thereafter. Decontamination procedures involved:

- . Rinsing with high-pressure steam,
- . Washing with an Alconox solution and a stiff brush,
- . Rinsing with high pressure tap water,
- . Air drying,
- . Rinsing with methanol,
- . Rinsing with distilled water, and
- . Air drying.

If cleaned equipment was not used immediately, it was wrapped in plastic or aluminum foil and stored in a clean area. All wash water from washings and rinsings was collected in 55-gallon drums and stored onsite. Upon completion of the last boring, the drill rig was again steam cleaned.

3.2.3.2 Well Construction and Development

All monitor wells were cased with 2-inch-diameter, Schedule 80 polyvinyl chloride (PVC) casing with threaded, non-glued fittings. Up to 20 feet of the saturated zone were screened with machine-slotted 2-inch-diameter PVC pipe having slot openings of 0.020 inches. The casing and screen were steam cleaned and Alconox-washed prior to installation. The screen was capped at the bottom, and a vented cap was emplaced at the top.

The screened portion of the well was sand packed with a washed, rounded, silica sand having a grain size distribution between 0.05 and 0.025 inches. The sand pack was placed from the bottom of the borehole

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to 2 feet above the top of the screen. Coarse-grained crushed bentonite was introduced above the sand pack to a minimum thickness of 5 feet. A Type I Portland cement and bentonite grout slurry was placed above the top of the bentonite to the ground surface using a tremie pipe. The grout slurry consisted of 3 to 5 pounds of bentonite per 94-pound sack of cement mixed with 6.5 gallons of water. A 6-inch-diameter steel surface casing with a locking cap was cemented in place around the monitoring well. Well construction details were recorded on a well completion form in the field by the attendant geologist/engineer.

Following well construction, the vertical and horizontal locations of the well riser pipe were surveyed. The reference point was the top of the PVC casing. In addition, ground surface elevations adjacent to each well were located.

The wells were developed by first removing solids from the well with a sludge bailer, and then by pumping with a centrifugal above-ground pump until waters cleared of suspended solids. In some cases, however, waters contained fine suspended particles which could not be completely removed. Solids and waters evacuated during development were placed in containers and stored onsite. Well development details were recorded in the field notebook by the site geologist/engineer.

Figure 3.1 illustrates the locations of the various soil borings, wells, and sampling locations for each site. Soil boring and well construction details are summarized in Table 3.1. Soil boring logs, well construction details, and survey results are provided in Appendix F.

3.2.3.3 Ground Water Sampling

Ground water samples were collected from the wells after purging three times the volume of water standing in the well. A pre-cleaned teflon bailer (washed in distilled water with Alconox, then rinsed first with distilled water, then methanol and finally with distilled

FIGURE 3.1



SOURCE: ENGINEERING - SCIENCE DATA

TABLE 3.1
WELL CONSTRUCTION AND SOIL BORING DATA APP PJKS

Well	Site	Date Completed	Total Depth ^{1/} (feet)	Stickup (feet)	Depth to 2/ Water Table (feet)	Top of 1/ Screen (feet)	Bottom of Screen (feet)	Screened Interval (feet)
MONITORING WELLS								
MW-1	1	12/6/85	29.0	2.7	3/	14.0	29.0	15
MW-2	1	12/9/85	37.0	2.0	21	17.0	37.0	20
MW-3	2	12/23/85	34.8	3.2	16	19.8	34.8	15
MW-4	4/5	1/8/86	34.0	1.3	20.5	19.0	34.0	15
MW-5	4/5	1/9/86	19.7	1.8	18	9.7	19.7	10
MW-6	4/5	1/6/86	22.0	1.4	4.75	7.0	22.0	15
MW-7	2	12/27/85	25.0	2.0	8	10.0	25.0	15
MW-8	10	12/18/85	35.0	2.3	25	15.0	35.0	20
SOIL BORINGS								
ES-3	1	12/13/85	20.5		--			
ES-4	1	12/13/85	20.5		--			
ES-5	1	12/16/85	21.5		18			
ES-6	1	12/17/85	20.8		--			
ES-7	1	12/17/85	21.0		21			
ES-9	2	12/19/85	16.0		5			
ES-11	2	12/30/85	15.0		--			
ES-13	2	12/31/85	8.2		6			
ES-14	2	12/31/85	14.8		13			
ES-15	3	1/9/86	15.4		--			
ES-16	3	1/2/86	15.0		--			

1/ Below ground surface.

2/ Measured at time of drilling and referenced to ground surface.

3/ Moistness first observed at 13 feet. Water table later stabilized at about 21 feet below ground surface.

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water) was used to remove the water. Containers for samples not requiring filtering were filled directly from the bailer. Samples to be filtered were placed in a pre-cleaned teflon churn splitter. The sample was then pumped through a pre-filter and a 0.45-micron filter using a Geotech peristaltic pump. Sample bottles were filled directly from the pump outlet.

Field measurements, including temperature, pH, and electrical conductivity, were performed on the unfiltered sample. The pH meter was an Orion Model 211, which was calibrated daily with 4.0 and 7.0 buffer standards. Electrical conductivity was measured with a YSI Model 33 EC meter. The EC meter was also calibrated daily with a standardized solution.

Sample descriptions and locations, including sampling times, HNU measurements, parameters for analyses, water levels, and field measurements, were recorded in the field notebook.

3.2.3.4 Surface Water Sampling

Surface water samples were collected from the East Fork of Brush Creek and from pond T-8A. Sample containers were filled directly from the stream at the sample station. Field measurements, including temperature, pH, and electrical conductivity, were performed on unfiltered samples. The equipment used for these measurements was described in the preceding section. Sample location descriptions and other pertinent information were recorded in the field notebook.

Pond T-8A was covered with approximately 6 inches of ice when sampled. Consequently, a hole was chipped through the ice with a decontaminated rock pick. A 3.5-foot-long teflon well bailer was used to sample the pond water. Several full bailers of water were composited in a pre-cleaned bucket, and then poured into sample jars. A subsequent surface water sampling for organics occurred in April after the ice had melted. During this sampling, a teflon well bailer was used to collect the sample and the sample was poured directly into the sample vials.

3.2.3.5 Sediment Sampling

Sediment samples were collected from the East Fork of Brush Creek, pond T-8A, and the drainage ditches at Site 7. East Fork and Site 7 sediment samples were collected from three separate sampling points at each station using a small steel shovel and composited in a large stainless steel bowl. The composited sample was then placed into sample containers. The pond sediment was collected with a pre-cleaned hardened steel soil auger which was lowered through the surface water sampling hole in the ice. The pond sediment was extracted from the soil auger and composited in a large plastic container. Sample containers were filled with this composited material. All sampling equipment, including small steel shovels and the steel bowls, were decontaminated between sampling stations. Sample descriptions and locations, including the type of sample material, grain size, and water content were recorded in the field notebook.

3.2.3.6 Flow Measurements

Most flow measurements were made using a portable cutthroat flume. The flume was leveled in the streambed and the flow depth was recorded in the field notebook. Flow depth data were converted to flow at a later date. In one case, a very low flow was computed using a 300 milliliter beaker and a stop watch.

3.2.4 Site-Specific Field Program Details

A summary of the site-specific field investigations is provided in Table 3.2. Substances for which the sample media were tested are also included in this table. Activities at each site are described in the following paragraphs.

3.2.4.1 T-8A Containment Pond Area (Site 1)

Two alluvial monitoring wells were installed at Site 1. Well MW-1 lies uphill from pond T-8A and well MW-2 lies immediately downhill from pond T-8A (Figure 3.1). Martin Marietta well GM-89 is located

TABLE 3.2
AIR FORCE PLANT RIJKS
FIELD PROGRAM SUMMARY

<u>Site</u>	<u>Field Activities</u>	<u>Medium Sampled</u>	<u>Analyte:</u>
T-8A Containment Pond (Site 1)	Install two monitoring wells.		
	Sample ground waters.	Ground water	Hydrazine, purgeable organics, phenols, base/neutral/acid, extractable organics, MEK, oil and grease, pH, temperature, specific conductance, TDS, NDMA, metal scan, Kjeldahl nitrogen, nitrate, nitrite.
	Drill five 20-foot soil borings.		
		Sample soils	Hydrazine, purgeable organics, phenols, hexavalent chromium, NDMA, Kjeldahl nitrogen, nitrate, nitrite.
EPL Test Cells, Valve Shop, Ready Storage Area, and Soil Cones (Site 2)	Sample pond water and sediment (1 sample each).	Surface water	Same as for ground water.
		Sediment	Hydrazine, phenols, purgeable organics, base/neutral/acid extractable organics, MEK, oil and grease, NDMA, metal scan, Kjeldahl nitrogen, nitrate, nitrite.
	Install two monitoring wells.		
	Sample ground waters.	Ground water	Hydrazine, phenols, purgeable organics, oil and grease, base/neutral/acid extractable organics, MEK, pH, temperature, specific conductance, NDMA, metal scan, TDS, Kjeldahl nitrogen, nitrate, nitrite.
EPL Building T-6 and T-20A (Site 3)	Drill four 15-foot soil borings.		
	Sample soils.	Soil	NDMA, purgeable organics, hydrazine, Kjeldahl nitrogen, nitrate, nitrite.
	Drill two 15-foot soil borings.		
	Sample soils.	Soil	Purgeable organics, hexavalent chromium.

TABLE 3.2 (Continued)
AIR FORCE PLANT PJKS
FIELD PROGRAM SUMMARY

<u>Site</u>	<u>Field Activities</u>	<u>Medium Sampled</u>	<u>Analyte:</u>
T-31 Storage Tank and D-1 Landfill (Sites 4 and 5)	Conduct geophysical survey.		
	Install three monitoring wells.		
	Sample ground water.	Ground water	Purgeable organics, gross alpha and beta and high resolution gamma radiation, hydrazine, pH, temperature, specific conductance, TDS, NDMA, metal scan, thorium, oil and grease, Kjeldahl nitrogen, nitrate, nitrite.
Systems and Components Test Facilities Storage Tanks (Site 7)	Collect sediment samples.	Sediment	Hydrazine, purgeable organics, phenols, hexavalent chromium, NDMA, Kjeldahl nitrogen, nitrate, nitrite.
Construction Materials Fill Area (Site 10)	Conduct geophysical survey.		
	Install one monitoring well.		
	Sample ground water.	Ground water	Hydrazine, phenols, purgeable organics, pH, specific conductance, temperature, TDS, NDMA, Kjeldahl nitrogen, nitrate, nitrite.
Brush Creek (Site 11)	Perform flow measurements.		
	Collect surface water and sediment samples (10 samples each).	Surface water	Hydrazine, phenols, hexavalent chromium, purgeable organics, NDMA, oil and grease, TDS, Kjeldahl nitrogen, nitrate, nitrite.
		Sediment	Hydrazine, phenols, hexavalent chromium, purgeable organics, NDMA, Kjeldahl nitrogen, nitrate, nitrite.

- 1/ MEK = methyl ethyl ketone
- 2/ TDS = total dissolved solids
- 3/ NDMA = Nitroso Dimethylamine

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downhill from the emergency spill pond. The original technical operations plan included drilling a well at the site of well GM-89; however, to prevent a duplication of effort, this well was relocated to Site 2.

Five soil borings (ES-3 through ES-7) were completed in the pond sediment fill area immediately west of pond T-8A. These borings were drilled to a depth of 20 feet. Water levels, if present, were recorded before the holes were grouted.

Pond T-8A water and sediment samples were collected from near the center of the pond. With the exception of pH, temperature, electrical conductivity, and total dissolved solids (TDS), which were not analyzed in sediments, the samples were analyzed for the same chemical parameters as the ground waters from wells MW-1 and MW-2.

3.2.4.2 EPL Test Cells, Valve Shop, Ready Storage Area and Soil Cone Areas (Site 2)

The field program at Site 2 consisted of drilling and sampling two monitoring wells and four soil borings (Figure 3.1). The monitoring wells, MW-3 and MW-7, were located directly downhill from the two soil cones. The four soil borings were drilled to depths of 15 feet. Boring ES-9 was located to test a reported spill area on the northeast side of building T-5A, where drums containing chemicals had been stored. Boring ES-11 was located 100 feet downhill from boring ES-9, in a drainage ditch adjacent to a parking lot. Boring ES-13 was located to test soils adjacent to the drainage flume and waste storage tanks south of buildings T-5A and T-5B. Boring ES-14 was positioned southwest of the eastern soil cone in an area that was reported to have been disturbed (LaBonte, 1985).

3.2.4.3 EPL Building T-6 and T-20 (Site 3)

Two soil borings were drilled and sampled at Site 3 (Figure 3.1). Both borings were drilled to a depth of 15 feet. Boring ES-15 was located immediately northwest of building T-20 in a reported solvent and diesel fuel spill area. Boring ES-16 was located at the southeast edge of the parking lot between buildings T-6 and T-20.

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3.2.4.4 T-31 Storage Tank and D-1 Landfill (Sites 4 and 5)

The field program at Sites 4 and 5 consisted of a geophysical survey and installation of three monitoring wells. The objectives of the geophysical survey were to (1) delineate the buried T-31 storage tank; (2) identify miscellaneous fill and suspected buried waste areas; (3) define the continuity of geologic conditions; and (4) locate saturated conditions. Magnetometer results were used to accomplish the first two objectives and electrical resistivity results were used to evaluate the latter two objectives. The results from both methods were used to site the monitoring wells.

The monitoring wells are located immediately downhill from tank T-31 and the D-1 landfill (Figure 3.1). Well MW-4 was located 100 feet downhill from tank T-31 (Figure 3.1). Well MW-5 was positioned approximately 150 feet downhill from the tank and landfill, and well MW-6 was located on the north side of the East Fork of Brush Creek about 50 feet downhill from the outlet of a culvert that extends beneath the D-1 landfill.

3.2.4.5 Components Test Facilities Storage Tanks (Site 7)

Nine sediment samples were collected from two ditches located downhill from the Site 7 storage tanks (Figure 3.1). Three samples (7-1, SD through 7-3, SD) were collected from the ditch below the upper tanks (T-6031 and T-6032), and six samples (7-4, SD through 7-9, SD) were collected from the ditch below the lower tanks (T-6033 and T-6034).

3.2.4.6 Construction Materials Fill Area (Site 10)

The field program at Site 10 included a geophysical survey and the installation of one monitoring well in a location determined by the survey results. The geophysical survey included magnetometry and electrical resistivity. The objective of the magnetometry survey was to locate buried magnetic objects such as rebar and other construction materials. The resistivity survey results helped to delineate the

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limits of the fill area and identify saturated areas. Monitoring well MW-8 was positioned downhill from most of the fill (Figure 3.1).

3.2.4.7 East Fork of Brush Creek (Site 11)

Ten sampling stations (11-1 through 11-10) were established along the East Fork of Brush Creek to collect stream water and sediment samples and to measure flow (Figure 3.1). In addition, station 11-0 was located upstream from the D-1 landfill to provide a background water quality reference. The station locations were selected to enable assessment of the effects on water quality and flow from specific facilities. For example, stations were located both upstream and downstream from pond T-8A, and station 11-1 was positioned to intercept discharge from the reported broken waterline.

3.2.5 Sample Preservation and Integrity

3.2.5.1 Sample Containers, Preservatives, and Holding Times

Sample bottle types, preservatives, and holding times required for the sampling program at AFP PJKS are summarized in Appendix H. These criteria comply with EPA recommended guidelines as specified in Methods for Chemical Analysis of Water and Wastes (1979b) and SW-846. A table documenting the time elapsed between sampling and analysis for each sample is also included in Appendix H. A chain-of-custody record documenting compliance with these criteria is provided in Appendix I.

3.2.5.2 Laboratories

Samples were shipped to various laboratories, depending on the analysis to be performed. Samples for hydrazine and NDMA were shipped to California Analytical Laboratory. EAL Corporation analyzed the samples for radiation. Purgeable organics in ground waters were analyzed by International Technology Corporation. The remaining samples were analyzed in the Engineering-Science laboratories in Georgia. In addition, complete sets of duplicate samples were forwarded to USAFOEHL, Brooks AFB, Texas.

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3.2.5.3 Sample Handling and Packaging

The procedures for handling samples of surface and ground waters, soils, and sediments are provided in Appendix H.

3.2.5.4 Chain-of-Custody Record

All samples were accompanied by a chain-of-custody record. When samples were transferred, the individuals relinquishing and receiving the samples signed, dated, and noted the time on the record. This record documented sample custody transfer from the sampler to the laboratory. Completed chain-of-custody records are provided in Appendix I.

3.2.6 Analytical Program

The analytical program involved analysis of the parameters listed in Table 3.2 using methodologies approved by the EPA, standard methods, or NIOSH. A summary of the methodologies applied to AFP PJKS water and soil samples is summarized in Table 3.3. A discussion of the laboratory quality assurance/quality control procedures is presented in Appendix J. A complete set of the results is presented in Appendix L.

3.2.6.1 Dual Column Analyses and Confirmation

As part of analytical methods EPA 601, 602, 8010 and 8020 (purgeable organic compounds) dual column analytical procedures are required. This process involves performance of a second column confirmation for those organic compounds which are detected in the first column. For soils, second column runs are required if organic concentrations exceed 10 milligrams per kilogram (mg/Kg), or a higher detection limit. For waters, second column confirmation is required when the following concentrations are exceeded:

Benzene	0.7 ug/L
Carbon tetrachloride	4.0 ug/L
1,2-Dichloroethane	0.1 ug/L
Methylene chloride	4.0 ug/L

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Tetrachloroethylene	4.0 ug/L
Trichloroethylene	1.0 ug/L
Vinyl chloride	1.0 ug/L
Dichlorobenzene isomers	sum greater than 10 ug/L
All other organics	Greater than 10 ug/L

The purpose for second column confirmation is to eliminate the co-elution of peaks, or the interference of unknowns. When a compound of interest is determined in column one and its identity is confirmed in column two, the quantity of the compound is taken to be equal to or less than the column one value. If, however, the two column values vary significantly (1 order of magnitude), the accepted quantity is taken to be the lesser value.

TABLE 3.3
ANALYTICAL METHODOLOGIES

<u>Parameter</u>	<u>Sample Media</u>	<u>Test Method Number</u>
pH	water	EPA 150.1
Temperature, in-situ	water	EPA 170.1
Specific conductance, in-situ	water	EPA 120.1
Total dissolved solids	water	EPA 160.1
Phenols	water	EPA 420.2
	soil	SW 3540 then 8040
MEK	water	EPA 8015
	soil	same
Hydrazine	water	modified ^{1/} NIOSH S237-1
	soil	same ^{2/}
NDMA	water	EPA 607 ^{3/}
	soil	Same
Total Kjeldahl nitrogen (TKN)	water	EPA 351.2
	soil	same
Nitrate	water	EPA 352.1
	soil	same
Nitrite	water	EPA 354.1
	soil	same
Oil and grease	water	EPA 413.2
Purgeable halocarbons	water	EPA 601
	soil	EPA 8010
Purgeable aromatics	water	EPA 602
	soil	EPA 8020
Base/neutral/acid	water	EPA 625
Extractable organics	soil	EPA 8250
Metals (primary)	water	SW 3020, then
Arsenic	water	EPA 206.2
Cadmium	water	EPA 213.2
Chromium (total)	water	EPA 218.2
Chromium (hexavalent)	water	SW 3060, then SM 312B
Lead	water	EPA 239.2
Mercury	water	EPA 245.1
Selenium	water	EPA 270.2

TABLE 3.3 (CONTINUED)
ANALYTICAL METHODOLOGIES

<u>Parameter</u>	<u>Sample Media</u>	<u>Test Method Number</u>
Metals (primary)	soil	SW 3020, then
Arsenic	soil	SW 7060
Cadmium	soil	SW 7131
Chromium (total)	soil	SW 7191
Chromium (hexavalent)	soil	SW 3060, then SM 312B
Lead	soil	SW 7421
Mercury	soil	SW 7471
Selenium	soil	SW 7740
Thorium	water	APHS
Gross alpha-beta and high resolution gamma radiation	water	EPA 600 4/80-032

- 1/ Water Samples. Sample aliquots (10 ml) were combined with 10 ml of 2.5% p-dimethylaminobenzaldehyde in a 25 ml volumetric flask. After 30 minutes the mixture was brought to 25 ml with glacial acetic acid. A 1:25 dilution in glacial acetic acid was then prepared and the absorbance at 480 nm read against a standard curve prepared using reference standards of hydrazine, treated in the same fashion. The method is based on NIOSH Method S237-1.
- 2/ Soil/Sediment Samples. Sub-samples (10g) were extracted with 20 ml of 0.1 N hydrochloric acid by shaking for one hour. A 10 ml aliquot (5g of soil) was removed to a 25 ml volumetric flask and made slightly alkaline (pH 8-9) using 1 M aqueous sodium hydroxide. This solution was then treated with p-dimethylaminobenzaldehyde and processed as described above. The absorbance readings were again compared to a standard curve and the results calculated back to the original 10g soil sub-sample.
- 3/ Final extracts were analyzed by GC-NPD.
- 4/ Alpha Pulse Height Spectroscopy (APHS) (EPA 600).

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SECTION 4.0

RESULTS AND SIGNIFICANCE OF FINDINGS

4.1 INTRODUCTION

Results of the field efforts described in Section 3.0 are summarized in this section under the categories of surface water hydrology, subsurface investigations, and field and laboratory analytical results. Findings from each of the eight study sites are presented, followed by discussions of their significance. Criteria used to determine significance include concentrations of contaminants detected relative to water quality standards or health risks documented in the literature, probable migration pathways, and locations of public receptors. The significance of contamination is evaluated for both onsite and offsite locations.

4.2 SURFACE WATER HYDROLOGY RESULTS

Surface water hydrologic investigations were conducted along the East Fork of Brush Creek (Site 11) and at the T-8A pond (Site 1). Sampling points and a summary of field measurements at these sites are presented in Figure 4.1.

4.2.1 Flow in the East Fork of Brush Creek

On 20 December 1985, 13 surface flow measurements were taken on the East Fork of Brush Creek and several of its tributaries between Site 4 and the eastern property line of AFP PJKS. As shown on Figure 4.1, the East Fork of Brush Creek emerges from a culvert on the eastern side of Site 4. Upstream from this culvert, water in the East Fork of Brush Creek was frozen.

The upstream-most flow measurement was taken at the outlet of the culvert which diverts the East Fork beneath the D-1 landfill. Flow at this location was 4 gallons per minute (gpm). Immediately downstream

FIGURE 4.1



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from the uppermost sampling point, a ditch draining an area northwest of tank T-31 contributed 2 gpm to the flow of the creek. Further downstream, at Station 11-1, a water line suspected to be leaking contributes water as a seep to the flow in the East Fork. No flow measurement was obtained for the seep. However, by subtracting the upstream flow (6 gpm) from the flow immediately downstream from the seeping water (19 gpm), it is estimated that the leaking water line contributes approximately 13 gpm to the flow of the East Fork.

The reach between stations 11-1 and 11-2 consists of a narrow restricted canyon in the Precambrian rocks which opens into a wider valley just upstream from station 11-2. The flow at station 11-2 was measured as 12 gpm. By subtracting the flow at station 11-2 from the flow immediately downstream from the seep (19 gpm), it was determined that this reach loses approximately 7 gpm to ground water.

All of the surface water sampling stations downstream from station 11-2 are located in a broad valley which contains alluvium estimated to be from 20 to 30 feet thick overlying the Fountain Formation (based on drilling results). Between stations 11-2 and 11-6, the East Fork of Brush Creek gains approximately 3 gpm, resulting in a flow of 15 gpm at station 11-6. Two water lines, conveying drinking and process waters, cross beneath the East Fork between stations 11-5 and 11-6. In addition, the cement flume draining the EPL test cells (Site 2) crosses over the East Fork immediately downstream from the water lines. It is not known whether the water lines or flumes are leaking. If either are leaking, each could be a source of the increased flow in the creek in this reach. Other sources could include natural discharges from ground water to the stream channel.

Between stations 11-6 and 11-7, flow increases to 27 gpm, a gain of approximately 12 gpm. An unlined ditch draining the area near the east soil cone enters the East Fork just upstream from the road. However, no flow was observed in this ditch. Immediately downstream

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from the road between stations 11-6 and 11-7, the East Fork flows through a weir which allows diversion of water to pond T-8A. The ditch which drains the Systems and Components Testing Facilities (Site 7) enters the East Fork at the weir. Flow from the ditch contributed approximately 1 gpm to the East Fork flow. According to LaBonte (1986), the ditch flow is generally 5 gpm, but during the field measurements, a heavy snow cover impeded flow. The large flow increase between stations 11-6 and 11-7 is a result of discharge from ground water to the stream channel. At the time of measurement, none of the flow in the East Fork of Brush Creek was diverted at the weir into pond T-8A.

The reach between stations 11-7 and 11-8 loses 8 gpm to ground water. From station 11-8 to the eastern property boundary (Station 11-10), flow remained constant at 19 gpm. Immediately upstream from station 11-9, an overflow spillway from pond T-8A discharges to the East Fork; no waters were observed in the spillway. Between stations 11-9 and 11-10, a small ditch draining Site 10 enters the East Fork of Brush Creek; this ditch was also dry.

4.2.2 Contributions to Pond T-8A

The only diversion structures currently connected to pond T-8A consist of the flumes associated with the test stands and the EPL test cells, and the flume originating at the weir in the East Fork of Brush Creek. According to LaBonte (1986), approximately 1,000 gallons of process waters per month are drained through the flume system to pond T-8A. During the December sampling of pond T-8A, no water was being channeled into the pond through any of these flumes. However, during February 1986 a small flow estimated to be a few gpm was observed from the flume draining the EPL test cells.

4.3 RESULTS OF SUBSURFACE INVESTIGATIONS

The geohydrologic conditions at AFP PJKS were investigated using surface geophysical methods and by drilling soil borings and constructing monitoring wells. Based on this information, cross sections have been prepared to illustrate subsurface conditions. Locations of the cross sections are shown on Figure 4.2. Geohydrologic conditions at each site are discussed below.

4.3.1 Site 1

The subsurface investigation of Site 1 involved the drilling of 5 soil borings and drilling and construction of 2 monitoring wells. Geohydrologic information was also obtained from Martin Marietta monitoring well GM-89, located downgradient from the overflow pond. Three geohydrologic cross sections (A-A', B-B', and C-C'), shown in Figure 4.3, were constructed through Site 1 and the surrounding area using information from these borings and wells.

The Quaternary alluvium, which is the Pleistocene Slocum Alluvium described in Section 2.4, is separated into two distinct units: an upper sand unit containing silt, gravel, and boulders, and a lower sand unit with a higher proportion of gravel, cobbles, and boulders. These two units are illustrated in all three cross sections. Thicknesses of the alluvium overlying the Fountain Formation range from 20 feet to 40 feet. Sediment from pond T-8A was placed in the area of soil borings ES-4 and ES-6 (cross section C-C'), but quantification of its thickness was difficult because of the sediment's similarity to the undisturbed alluvium.

Saturated thicknesses of the alluvium range from 5 to 30 feet. Considerable variability in the permeability of the alluvium is apparent based on the soil log from well MW-2 (cross section A-A'). During drilling of the boring, the water table was observed 21 feet below the ground surface. The static water level, however, stabilized 7 feet

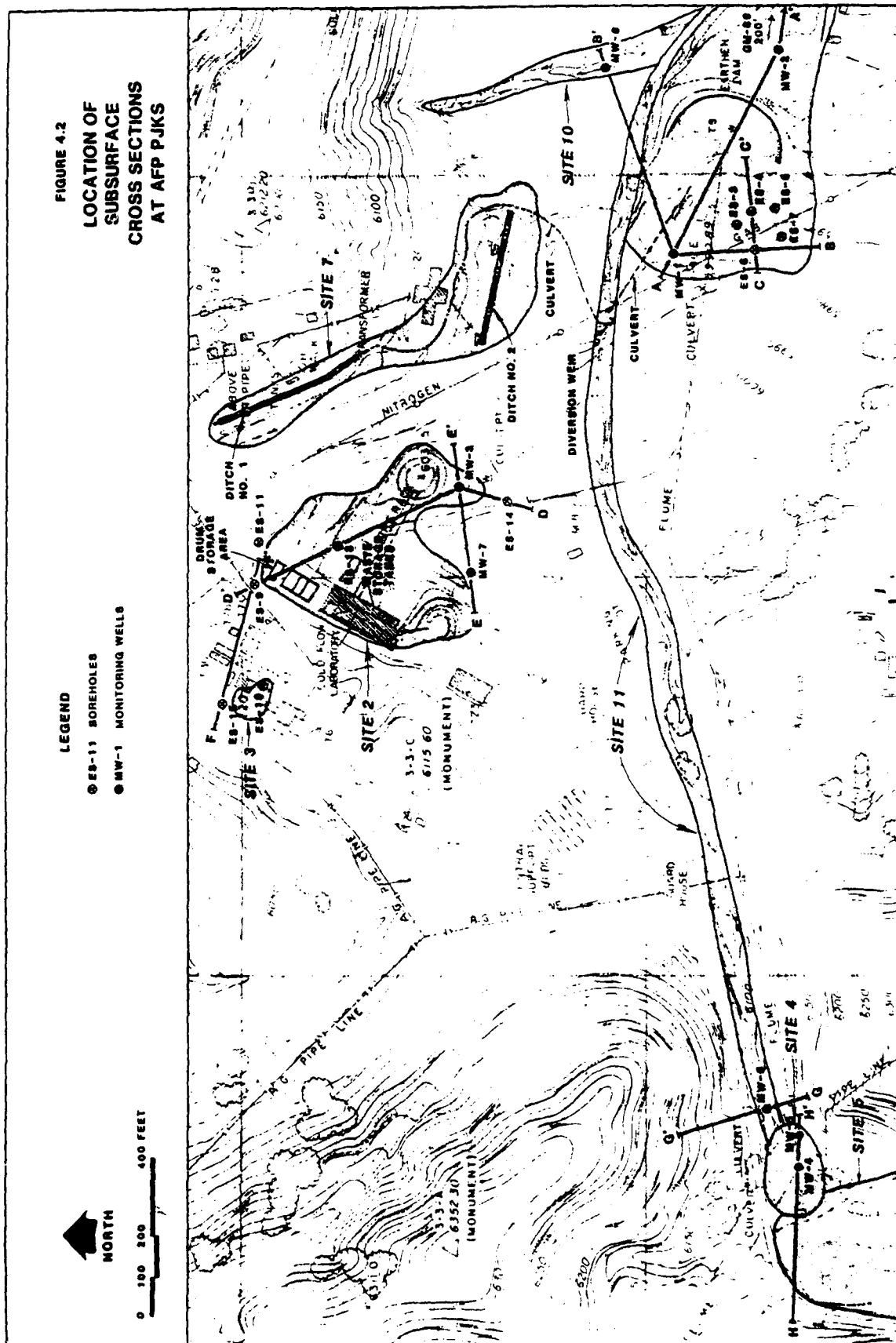
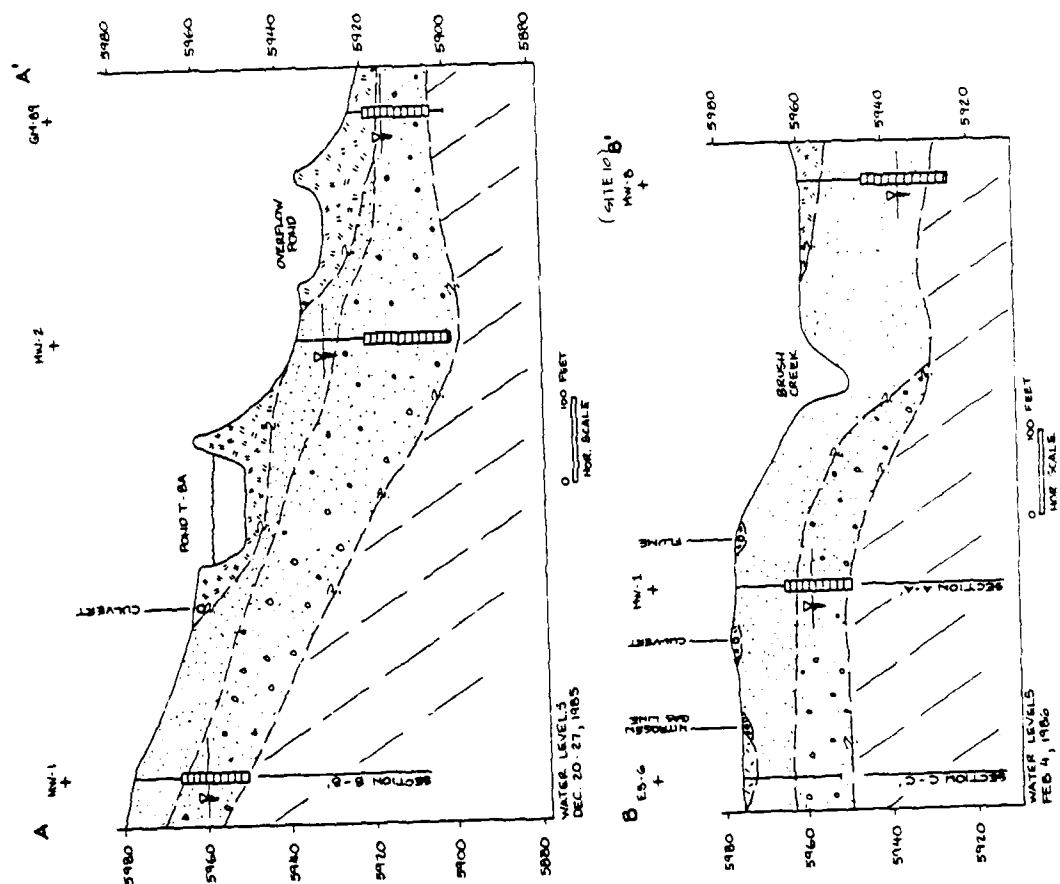


FIGURE 4.3
GEOHYDROLOGIC
CROSS SECTIONS AT SITE 1,
AFP PJKS
(SEE FIGURE 4.2 FOR LOCATIONS)



SOURCE: ENGINEERING-SCIENCE DATA

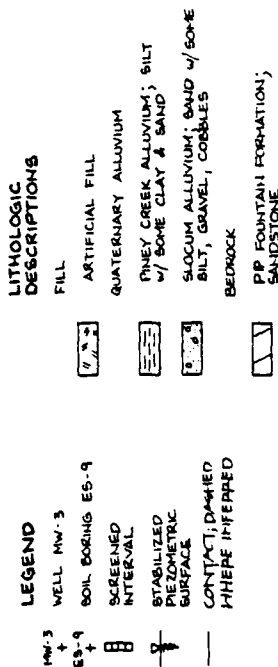
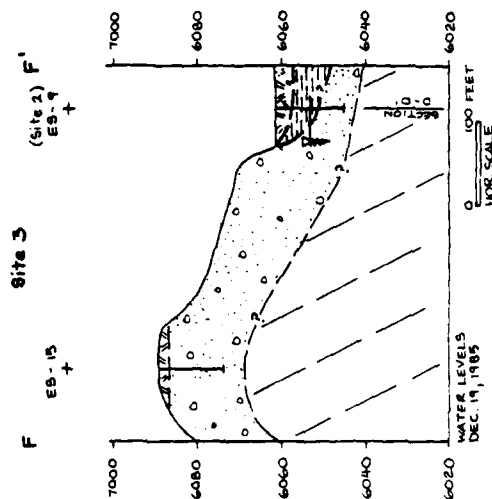
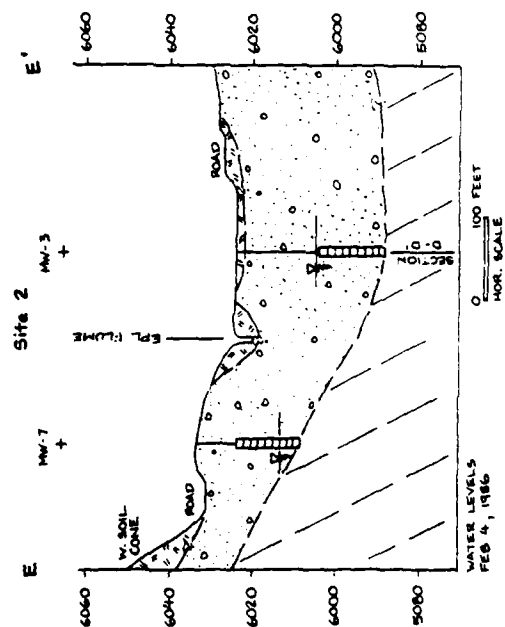
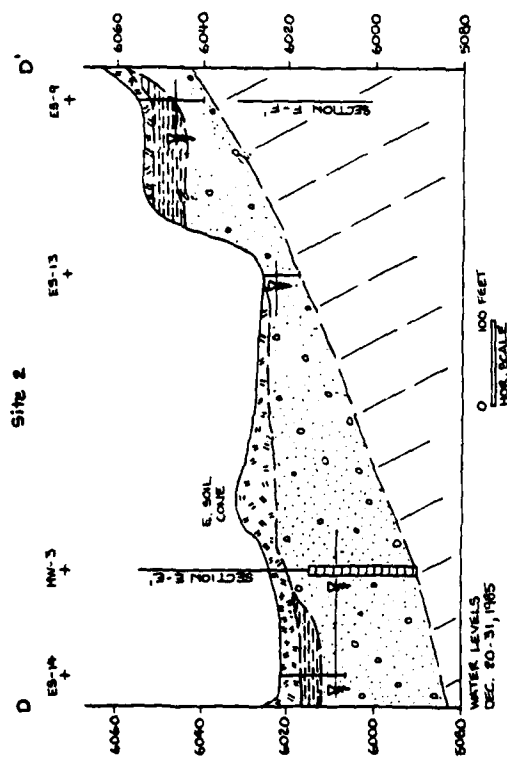
below the ground surface. A review of the MW-2 drilling log shows that the clay content decreases with depth, and, therefore, permeability increases with depth. Although the water table stabilized 7 feet below the ground surface, the more permeable portion of the saturated zone is deeper in the hole, starting at approximately 21 feet below the ground surface. Based on these observations, the majority of ground water movement is restricted to the deeper portion of the Slocum Alluvium (beneath 20 feet), and the alluvial aquifer is semi-confined.

4.3.2 Site 2

Two monitoring wells and four soil borings were drilled at Site 2. Cross sections D-D' and E-E', shown on Figure 4.4, were drawn through the site using information from these wells and borings. The alluvium, which correlates to the Pleistocene Slocum Alluvium, consists of fine to coarse sand with some silt, gravel, and cobbles. This alluvium is similar to the lower sand unit described at Site 1. In addition, beds (approximately 5 feet thick) of silt containing some clay and fine sand were encountered in borings ES-9 and ES-14, as illustrated on cross section D-D'. The silt beds are probably Piney Creek Alluvium. The total thickness of the Slocum and Piney Creek Alluvium layers ranges from 10 feet to almost 40 feet. The lower end of the range is probably the result of excavation for the EPL building site, as reflected in the stair-step configuration of the surface on cross-section D-D'.

Based on water level measurements observed while drilling and sampling, saturated thicknesses of the alluvium range from approximately 5 to 20 feet. An apparently perched water table was encountered during drilling of MW-7 at 8 feet below the ground surface (cross section E-E'). It is suspected that the perched water table is associated with a sewage leaching field located just south of well MW-7 (LaBonte, 1985). Following completion of the boring as a well, the

FIGURE 4.4
GEOHYDROLOGIC
CROSS SECTIONS
AT SITES 2 AND 3, AFP PJKS
(SEE FIGURE 4.2 FOR LOCATIONS)



SOURCE: ENGINEERING-SCIENCE DATA

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water table stabilized at 20 feet below the ground surface, or considerably lower than the perched ground water level. The alluvial aquifer is unconfined.

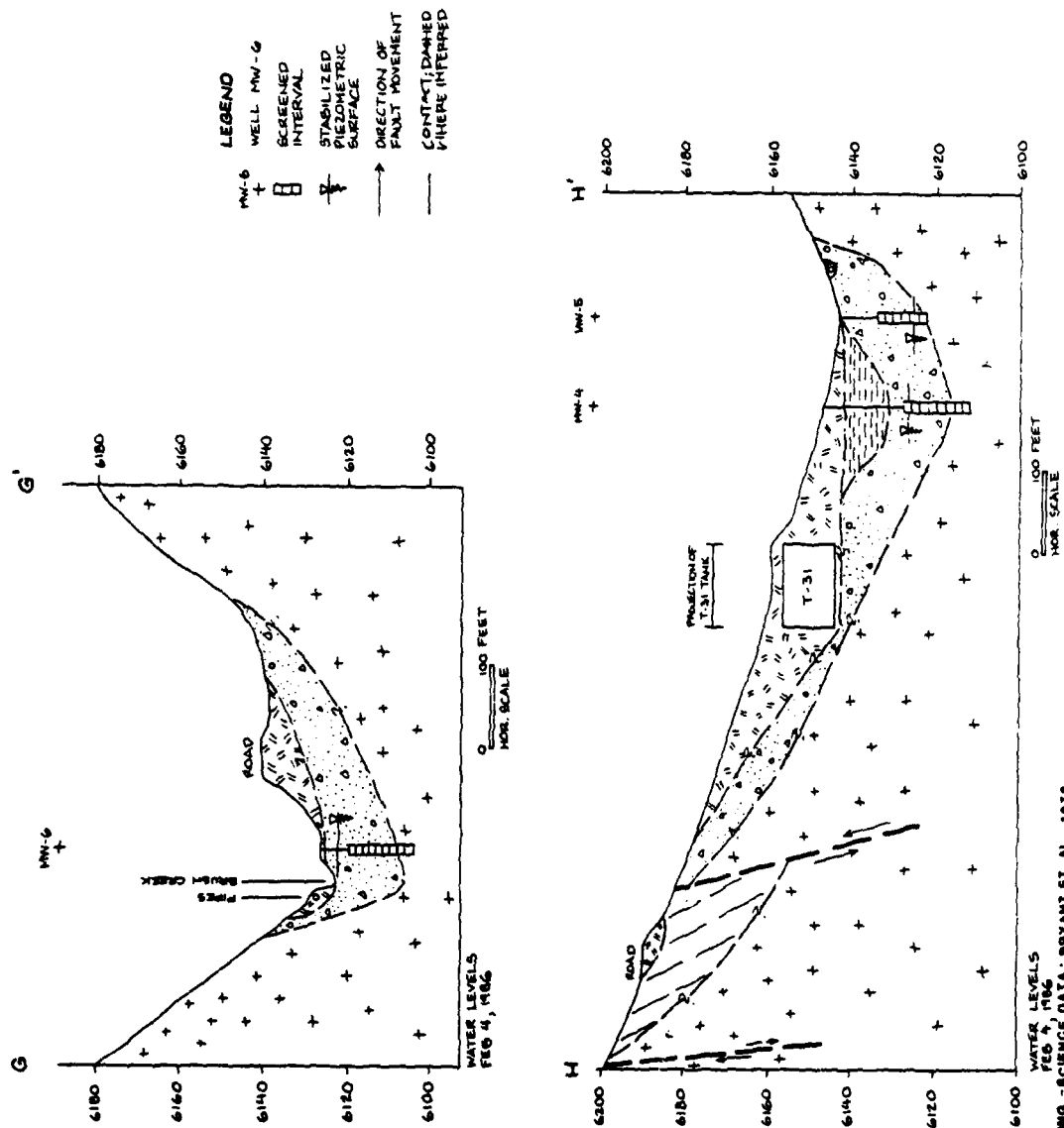
4.3.3 Site 3

Cross section F-F' (Figure 4.4) shows subsurface conditions beneath Site 3 eastward into Site 2 at the location of ES-9. The alluvium at Site 3, which correlates with the Pleistocene Slocum Alluvium, consists of fine to coarse sand with gravel and cobbles. The estimated thickness of the alluvium overlying the Fountain Formation is 20 feet. The water table was not intersected in either of the 15-foot-deep borings (ES-15 and ES-16) drilled at Site 3.

4.3.4 Sites 4 and 5

The field investigation of Sites 4 and 5 consisted of a geophysical survey (magnetic and resistivity methods) and installation of three monitoring wells. Cross sections G-G' and H-H' (Figure 4.5) illustrate the geohydrologic conditions beneath the area. Cross-section G-G' illustrates the approximate configuration of the Precambrian bedrock surface and Slocum Alluvium beneath the East Fork of Brush Creek, downstream from the T-31 tank. Cross-section H-H' illustrates structural displacement of the Precambrian gneiss and Fountain Formation, and the relative extent and depth of alluvial fill. The structural displacement of the Fountain Formation in cross section H-H' is based on the work of Bryant et al. (1973). The approximate position of the T-31 tank relative to wells MW-4 and MW-5 and bedrock is also depicted. In both cross sections, the alluvium (Slocum Alluvium) consists primarily of sand with gravel and cobbles. In cross section H-H', Slocum Alluvium underlies the Piney Creek Alluvium, which consists of beds of silt up to 10 feet thick containing some humic material and gravel. The thickness of the alluvium overlying the Precambrian gneiss near the East Fork of Brush Creek ranges up to 20 or 30 feet. The

FIGURE 4.8
GEOHYDROLOGIC
CROSS-SECTIONS
AT SITES 4 AND 5, AFP PKS
(SEE FIGURE 4.2 FOR LOCATIONS)



SOURCE: ENGINEERING - SCIENCE DATA; BRYANT ET. AL., 1973

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saturated thickness of the alluvium in the vicinities of Sites 4 and 5 ranged from 2 to 14 feet, and the water table generally follows bedrock topography. The aquifer is unconfined.

The magnetic and resistivity surveys provided additional information on the D-1 landfill area. The landfill was characterized by local magnetic variations shown in Figure 4.6. Storage tank T-31 generated a large magnetic high. Interpretation of the resistivity data in the landfill area indicated that the fill material ranged from 6 to 12 feet thick and the alluvium and weathered bedrock ranged from 13 to 20 feet thick.

4.3.5 Site 7

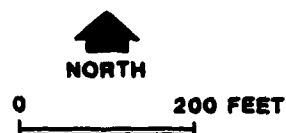
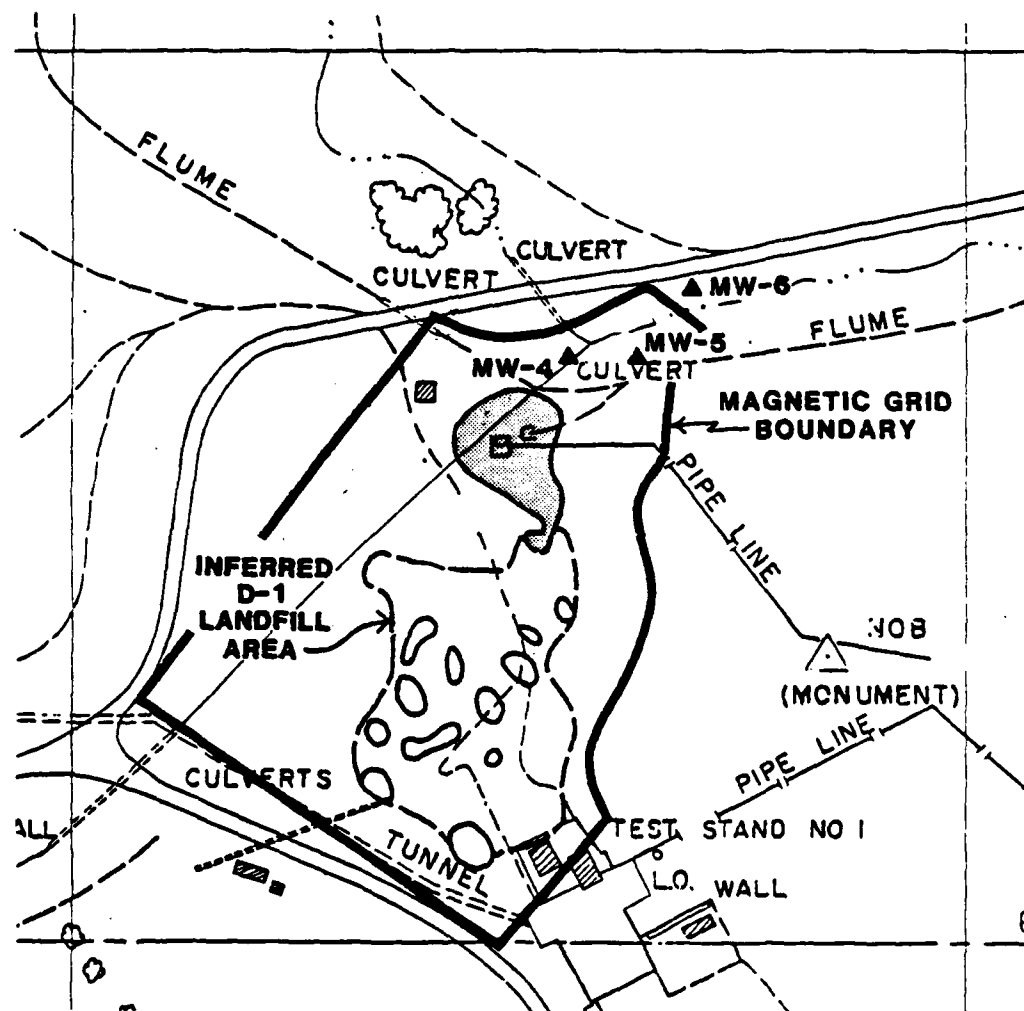
No subsurface investigations were conducted at Site 7.




4.3.6 Site 10

The field investigation of Site 10 included magnetic and resistivity surveys and the installation of one monitoring well, MW-8. The subsurface hydrogeologic conditions are illustrated in section B-B' on Figure 4.3. In the vicinity of well MW-8, the alluvium (Slocum Alluvium) is approximately 25 feet thick and consists of fine to coarse sand with some silt, gravel, and cobbles. During drilling, it was difficult to distinguish the fill material from the undisturbed alluvium. Based on the water level in well MW-8, the saturated thickness of the alluvium at Site 10 is approximately 7 feet, and the aquifer is unconfined.

The magnetic survey indicated several places in the fill area with high magnetic signatures (Figure 4.7). The depth to these anomalies is approximately 5 feet. The largest magnetic high was located approximately 50 feet north of well MW-8. The source of this magnetic high is unknown. Based on interpretations of the resistivity survey, the soil and fill material in the fill area are 6 to 11 feet thick. Depth

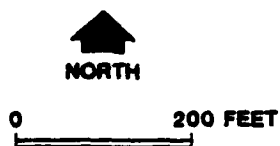
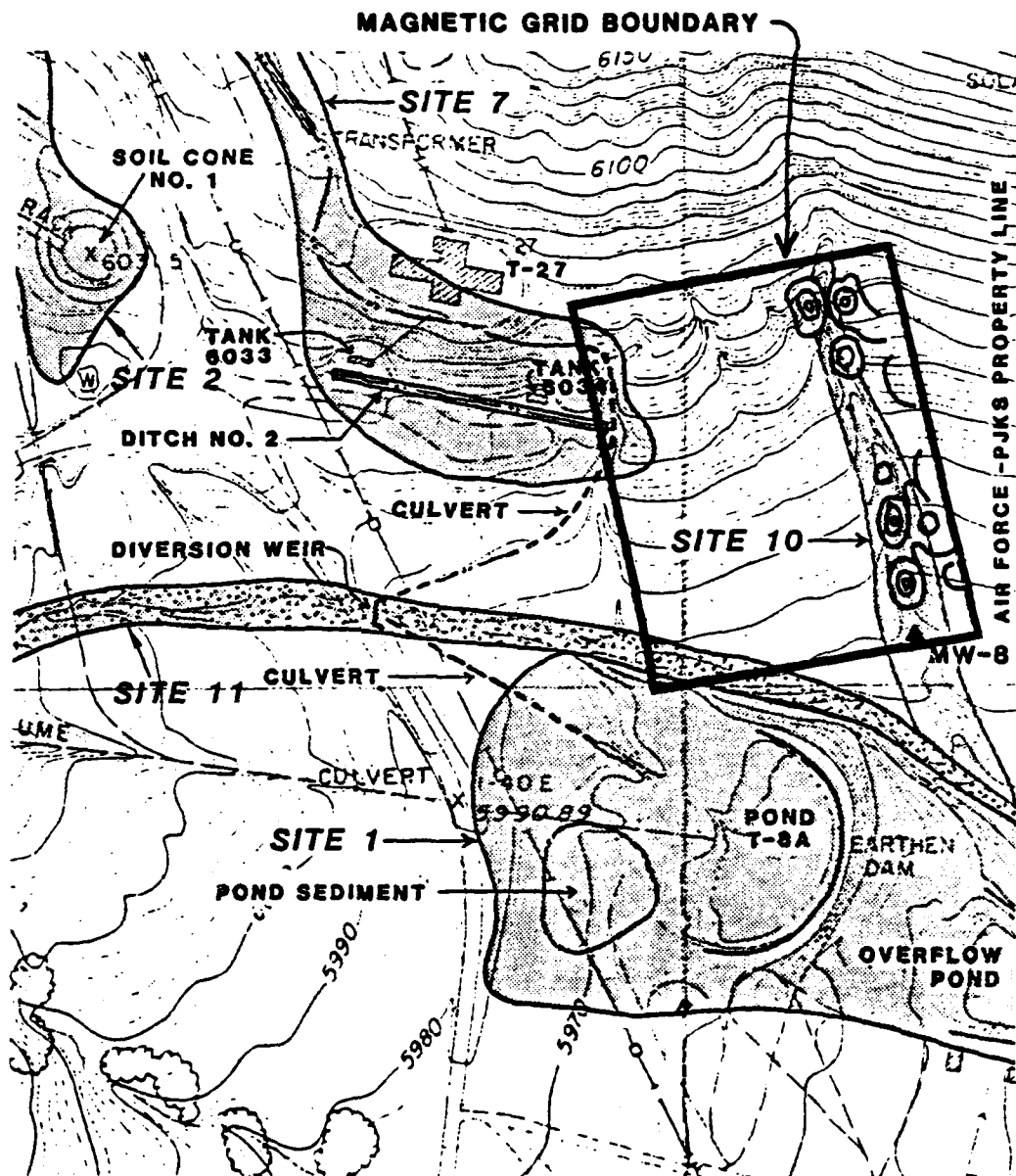
FIGURE 4.6
MAGNETIC SURVEY MAP OF SITES 4 AND 5,
AFP PJKS



- LEGEND**
-  LOCAL MAGNETIC ANOMALIES
 -  OUTLINE OF MAGNETIC HIGH NEAR TANK T-31
 -  MW-4 ▲ MONITORING WELL

SOURCE: ENGINEERING-SCIENCE DATA

FIGURE 4.7
MAGNETIC SURVEY MAP OF SITE 10,
AFP PJKS



- LEGEND**
-  LOCAL MAGNETIC ANOMALIES
 -  MONITORING WELL MW-8

SOURCE: ENGINEERING-SCIENCE DATA

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to the underlying alluvium is about 12 to 19 feet. Depth to the Fountain Formation was interpreted to be approximately 25 feet, which was the alluvial thickness found in well MW-8. The depth to ground water in the fill area could not be ascertained from the resistivity data.

4.3.7 Summary

A piezometric surface map for the PJKS study area is presented in Figure 4.8. Ground water in alluvial deposits generally flows towards the East Fork of Brush Creek. In the areas indicated as losing reaches, however, movement is away from Brush Creek.

Saturated thicknesses of the alluvium are also shown on Figure 4.8. A review of the water level data for soil borings (December data) and the information provided on Figure 4.8 shows that in the vicinity of the East Fork of Brush Creek there are greater saturated thicknesses of alluvium compared to areas of topographic highs.

Hydraulic conductivities for the Slocum Alluvium, which contains fine to coarse sand with varying amounts of silt and clay, are estimated to range from 0.07 to 13 feet per day. Piney Creek Alluvium, which consists primarily of silt with some clay and fine sand, has estimated hydraulic conductivities ranging between 0.03 and 3 feet per day. These estimates for hydraulic conductivities are typical ranges for unconsolidated sand and silt deposits based on Freeze and Cherry (1979). Considerable apparent variability in permeability existed in the alluvium at the sites investigated, but studies to quantify permeability ranges were not conducted in this investigation.

4.4 FIELD AND LABORATORY ANALYTICAL RESULTS

This section presents field and laboratory analytical results for surface and ground waters, soils, and sediments. Field measurements for surface waters are shown on Figure 4.1. Table 4.1 includes all compounds analyzed and their respective detection limits for the EPA

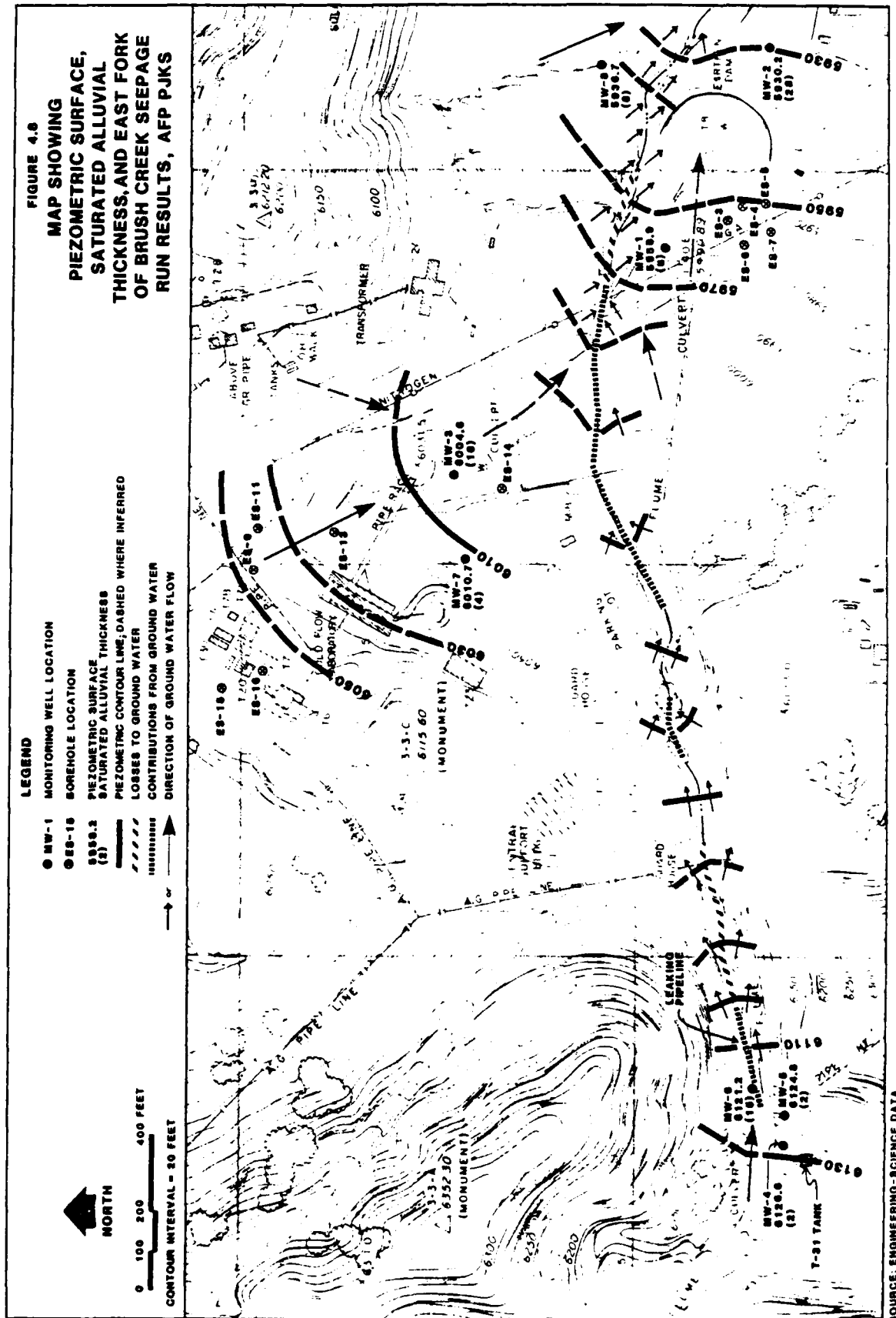


TABLE 4.1
PURGEABLE HALOCARBONS AND AROMATIC COMPOUNDS ANALYZED

EPA Method 601/8010 (Halocarbons)

Compound	601 ^{1/} ug/L Detection Limit	8010 ^{2/} ug/g Detection Limit
Benzyl chloride	1.0 ^{3/}	4
Bis(2-Chloroethoxy)methane	1.0 ^{3/}	12
Bis(2-chloroisopropyl)ether	1.0 ^{3/}	25
Bromobenzene	1.0 ^{3/}	8
Bromodichloromethane	1.0	2
Bromoform	1.0	4
Bromomethane	1.0(1.2) ^{2/}	24
Carbon tetrachloride	1.0 ^{3/}	3
Chloroacetaldehyde	1.0 ^{3/}	10
Chloral	1.0 ^{3/}	10
Chlorobenzene	1.0	5
Chloroethane	1.0	10
Chloroform	1.0 ^{3/}	1
1-Chlorohexane	1.0 ^{3/}	2
2-Chloroethyl vinyl ether	1.0	3
Chloromethane	1.0 ^{3/}	2
Chloromethyl methyl ether	1.0 ^{3/}	20
Chlorotoluene	1.0 ^{3/}	4
Dibromochloromethane	1.0 ^{3/}	2
Dibromomethane	1.0 ^{3/}	1
1,2-Dichlorobenzene	1.0	3
1,3-Dichlorobenzene	1.0	6
1,4-Dichlorobenzene	1.0	5
Dichlorodifluoromethane	1.0(1.2) ^{2/}	30
1,1-Dichloroethane	1.0	1
1,2-Dichloroethane	1.0	1
1,1-Dichloroethene	1.0	3
Trans-1,2-dichloroethene	1.0	2
Dichloromethane	1.0	5
1,2-Dichloropropane	1.0	1
1,3-Dichloropropylene	1.0 ^{4/}	6
Cis-1,3-Dichloropropylene	1.0 ^{4/}	
Trans-1,3-Dichloropropylene	1.0 ^{4/}	
1,1,2,2-Tetrachloroethane	1.0	7
1,1,1,2-Tetrachloroethane	1.0	7
Tetrachloroethene	1.0	1
1,1,1-Trichloroethane	1.0	1
1,1,2-Trichloroethane	1.0	1
Trichloroethene	1.0	2
Trichlorofluoromethane	1.0 ^{3/}	1
Trichloropropane	1.0	2
Vinyl chloride	1.0	4

TABLE 4.1 (CONTINUED)
PURGEABLE HALOCARBONS AND AROMATIC COMPOUNDS ANALYZED

EPA Method 602/8020

<u>Compound</u>	<u>602^{1/} ug/L Detection Limit</u>	<u>8020^{2/} ug/g Detection Limit</u>
Benzene	1.0	4
Chlorobenzene	1.0	4
1,2-Dichlorobenzene	1.0	8
1,3-Dichlorobenzene	1.0	8
1,4-Dichlorobenzene	1.0	6
Ethyl benzene	1.0	4
Toluene	1.0	4
Xylenes (Dimethyl benzene)	1.0	4

1/ Detection limits for IT and ES analyses.

2/ Detection limits for ES analyses are given in parentheses when different from IT detection limits.

3/ Additional compounds analyzed but not required in EPA 601 scan.

4/ Additional compounds analyzed by ES.

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methods 601 and 8010 (purgeable halocarbons for water and soil, respectively) and 602 and 8020 (purgeable aromatics for water and soil, respectively). Field measurements and analytical findings for ground waters, soils, surface waters, and sediments are summarized in site-specific tables and are discussed individually in subsequent paragraphs. Both the first and second column results for the organics detected are presented. The concentrations denoted with the asterisk are the values taken to be representative (see Section 3.2.6.1). Quality control documentation for the analytical laboratory work is provided in Appendix J and a complete set of data is presented in Appendix L.

4.4.1 Site 1

The investigation at Site 1 included sampling two monitoring wells, five soil borings, and pond T-8A water and sediment. As shown in Table 4.2, ground water at Site 1 was slightly acidic and had a moderate electrical conductivity (EC), but both the pH and EC are in the normal range for ground water in alluvium (White et al., 1963). Of the compounds listed on Table 4.1, only detectable amounts of TCE (130 ug/L) and possibly 1,1-dichloroethane and 1,1-dichloroethene were found in MW-1 waters. MW-2 contained detectable amounts of TCE (67 ug/L), and possibly 1,1-dichloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethene, and 1,1,1-trichloroethane. Base/neutral/acid extractable tests for compounds of method 625 (compounds are listed in Appendix H) on both well waters were below detection limits. In addition, waters from well MW-1 contained detectable amounts of NDMA (0.61 ug/L), MEK (105 ug/L), arsenic (0.011 mg/L), and selenium (0.002 mg/L). NDMA (0.23 ug/L) was also detected in waters from well MW-2. Most of the nitrogen in MW-1 and MW-2 waters was in the form of nitrate, at 2.8 and 4.7 mg/L, respectively.

Five soil borings drilled to 20-foot depths in the pond T-8A sediment disposal area showed limited contamination (Table 4.3).

TABLE 4.2
GROUND WATER QUALITY SUMMARY
AFP PJKS

Field Measurements	Detection Limit	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6 ^{7/}	MW-7	MW-8
Sampling Date	--	1/14/86	1/14/86	1/15/86	1/16/86	1/16/86	1/15/86	1/16/86	1/15/86
Temperature (°C)	--	12	10	15	12	10.5	10	13	13
Conductivity (umhos/cm)	--	825	519	930	732	834	987	312	878
pH	--	6.78	6.80	6.88	6.50	6.33	6.47	6.79	6.71
Chemical Parameters^{1/}									
TDS (mg/L) ^{2/}	10	490	340	540	550 ^{9/}	463 ^{9/}	370	--	410
NDMA (ug/L) ^{3/}	0.25	0.61	0.23 ^{4/}	0.28	ND	ND	ND	ND	5.2
Nitrite (mg/L)	0.011	0.019	0.036 ^{6/}	0.181	0.025 ^{10/}	0.46 ^{10/}	0.011	0.118	0.011
Nitrate (mg/L)	0.1	2.8	1.7 ^{10/}	4.0	0.38 ^{10/}	3.5	3.8	1.1	3.0
Total Kjeldahl Nitrogen (mg/L)	0.1	1.1	ND	1.84 ^{9/}	21.6	ND	ND	10.1	ND ^{9/}
Phenols (mg/L)	0.005	ND	ND	ND	ND	--	--	0.007	ND
Oil and Grease (mg/L)	1.0	ND	ND	ND	4070	ND	ND	ND	--
HEX - Column 1 (ug/L)	10	105*	ND	ND	--	--	--	ND	--
- Column 2 (ug/L)	--	133	--	--	--	--	--	--	--
Purgeable Halocarbons^{10/}									
Trans-1,2-dichloroethene	1.0	ND	ND	ND	36.2	2.3	290	11/	ND
- Column 1 (ug/L)	0.1	--	--	--	ND*	--	350	ND	--
- Column 2 (ug/L)	1.0	130*	67*	1110*	67*	ND	3.6*	11/	--
TCZE - Column 1 (ug/L)	0.12	125	80	841	80.5	--	178	ND	490*
- Column 2 (ug/L)	1.0	1.8 ^{9/}	2.0	12.7*	11.5*	ND	4.2	--	101
1,1 - dichloroethane	1.0	--	--	334	18.7	--	--	11/	ND
- Column 1 (ug/L)	1.0	1.2	ND	ND	ND	ND	ND	ND	--
- Column 2 (ug/L)	1.0	--	--	--	--	--	--	--	--
1,1,2,2 - tetrachloroethane	1.0	ND	1.2	ND	1.2*	ND	ND	11/	ND
- Column 1 (ug/L)	1.0	--	--	--	1.6	--	--	--	--
- Column 2 (ug/L)	1.0	ND	1.2	ND	1.2*	ND	ND	11/	ND
Tetrachloroethene	1.0	ND	1.2	ND	1.6	--	ND	--	--
- Column 1 (ug/L)	1.0	ND	--	--	--	--	ND	11/	ND
- Column 2 (ug/L)	1.0	ND	--	--	--	--	--	--	--
1,1,1 - trichloroethane	1.0	ND	9.0	ND	28.6*	ND	9.0	11/	18
- Column 1 (ug/L)	1.0	--	--	--	12.4	--	--	--	ND*
- Column 2 (ug/L)	1.0	--	--	--	--	--	--	--	--

(Continued)

TABLE 4.2 (CONTINUED)
GROUND WATER QUALITY SUMMARY
APF PJKS

Metals	Detection Limit	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6 ^{7/}	MW-7	MW-8
Dissolved Arsenic (mg/L)	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Cadmium (mg/L)	0.02	0.01	ND	ND	ND	ND	ND	0.01	ND
Dissolved Chromium (all species) (mg/L)	0.11	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Lead (mg/L)	0.12	0.13	ND	ND	ND	ND	ND	ND	ND
Dissolved Mercury (mg/L)	0.0005	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Selenium (mg/L)	0.002	0.002	ND	ND	ND	0.002	ND	ND	ND
Dissolved Thallium (mg/L)	0.23	ND	ND	ND	ND	ND	ND	ND	ND
Radiation									
Gross Alpha (pCi/L)	20	--	--	--	250	270	180	130	--
Gross Beta (pCi/L)	30	--	--	--	120	160	200	250	--
Gross Gamma (226 Radium) (pCi/L)	10	--	--	--	120	140	70	80	--
228Thorium (pCi/L)	0.1	--	--	--	8.2	4.1	1.13	0.65	--
230Thorium (pCi/L)	0.1	--	--	--	6.5	2.2	0.56	0.30	--
232Thorium (pCi/L)	0.1	--	--	--	5.8	2.8	0.8	0.48	--

ND - Not detected.

7/ Representative value.

8/ Samples were collected for Method 602 on three different occasions. Holding times were exceeded for some of the samples, however, no 602 compounds were detected in any of the samples (see Table 4.1 for compounds analyzed and detection limits). In addition, base/neutral/acid extractable tests were performed on MW-1, MW-2, MW-3, and MW-7, and were also below detection limits (<10 ug/L) (see Appendix H for compounds analyzed). Hydrazine in all samples was below the detection limit of 1 mg/L.

9/ Milligrams per liter (parts per million).

10/ Micrograms per liter (parts per billion).

11/ An NDMA value was reported at levels below detection limits.

12/ Average of duplicate samples for Method 601 only.

13/ PicoCuries per liter.

14/ Duplicate samples were collected from 4-MW-6.

15/ --- indicates not analyzed.

16/ From resampling on 4/11/86. Only first column analysis was performed because concentration did not exceed 10 mg/L procedural criteria. Consequently, this compound may or may not be present.

17/ From resampling on 4/23/86 or 4/24/86.

18/ From the original sampling on 1/16/86; the well was dry in subsequent samplings; detection limit from ES analysis was 10.

19/ Detection limit from analyses performed on 5/8/86.

TABLE 4.3
ANALYTICAL RESULTS FOR SITE 1 SOIL BORINGS
APP PJKS

Sample	Depth (feet)	Sampling Date	Nitrite ¹ / (ug/g)	Nitrate (ug/g)	Phenols (ug/g)	Total Kjeldahl Nitrogen (ug/g)	Hexavalent Chromium (ug/g)
Detection Limit			0.08	1.0	0.5	5	0.17
Boring ES-3/ ES-3, SS-1	0-1.5	12/13/85	0.13	5.0	0.6	919	ND
ES-3, SS-2	4.5-6.0	12/13/85	1.9	ND	0.7	180	ND
ES-3, SS-3	6.5-7.1	12/13/85	0.099	1.0	ND	110	ND
ES-3, SS-4	9.0-10.2	12/13/85	0.15	ND	ND	150	ND
ES-3, SS-5	12.5-14	12/13/85	0.12	5.0	ND	40	ND 3/
ES-3, SS-6	16.5-18	12/13/85	0.349	2.0	ND	50	--
ES-3, SS-7	19.5-20.5	12/13/85	0.088	ND	ND	54	ND
Boring ES-4/ ES-4, SS-1	0-2	12/13/85	0.415	5.5	ND	190	0.17
ES-4, SS-2	5-7	12/13/85	0.094	7.0	ND	604	0.19
ES-4, SS-3	8.5-10	12/13/85	0.15	6.0	ND	170	ND
ES-4, SS-4	11.5-13	12/13/85	0.13	8.0	ND	110	ND
ES-4, SS-5	14.5-16	12/13/85	0.17	ND	ND	67	ND
ES-4, SS-6	19-20.5	12/13/85	0.17	2.0	0.7	58	ND
Boring ES-5/ ES-5, SS-1	0-2	12/16/85	0.400	--	0.5	633	ND
ES-5, SS-2	2-4	12/16/85	0.14	ND	0.5	588	0.21
ES-5, SS-3	4-6	12/16/85	0.23	ND	ND	412	ND
ES-5, SS-4	9-11	12/16/85	0.25	3.5	ND	72	ND
ES-5, SS-5	14-16	12/16/85	0.10	ND	1.0	50	ND
ES-5, SS-6	19-20.5	12/16/85	0.096	ND	ND	28	ND
Boring ES-6/ ES-6, SS-1	0-2	12/17/85	0.16	ND	ND	810	ND
ES-6, SS-2	2-4	12/17/85	ND	ND	ND	300	ND
ES-6, SS-3	5-7	12/17/85	0.24	ND	0.7	520	ND
ES-6, SS-4	9-11	12/17/85	ND	ND	ND	30	ND
ES-6, SS-5	14-16	12/17/85	ND	1.0	ND	50	ND
ES-6, SS-6	19-21	12/17/85	ND	ND	ND	60	ND
Boring ES-7/ ES-7, SS-1	0-2	12/17/85	0.21	ND	ND	730	0.70
ES-7, SS-2	2-4	12/17/85	0.12	ND	ND	400	ND
ES-7, SS-3	5-7	12/17/85	ND	ND	ND	120	ND
ES-7, SS-4	9-11	12/17/85	ND	ND	ND	30	ND
ES-7, SS-5	14-16	12/17/85	ND	ND	ND	34	ND
ES-7, SS-6	19-21	12/17/85	ND	ND	ND	73	ND

Note: Hydrazine and NDMA analytical results were below detection limits of 6 ug/g and 0.250 ug/g, respectively. Analyses by methods 8010 and 8020 were all below respective detection limits (refer to Table 4.1 for compounds analyzed and detection limits).

ND - Not detected.

2/ micrograms per gram (parts per million)

3/ SS indicates soil sample.

-- indicates not analyzed.

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The compounds listed in Table 4.1 were not detected, nor were hydrazine or NDMA. Phenols were detected at various depths in borings ES-3, ES-4, ES-5, and ES-6. The range of phenols was 0.5 ug/g to 1.0 ug/g. Hexavalent chromium concentrations ranged from the detection limit of 0.17 ug/g to 0.70 ug/g, but most concentrations were at or near the detection limit. When detected, hexavalent chromium occurred in the shallower soils of the borings, between the surface and 4 feet. Total Kjeldahl Nitrogen (TKN) (the sum of ammonia and organic nitrogen) in the soil borings followed the normal distribution of nitrogen in soils, which decreases with depth below the soil surface. Nitrate was predominant over nitrite in the borings.

Field and laboratory analytical results for water and sediment samples collected from pond T-8A are presented in Table 4.4. The pond water had a basic pH and a conductivity in the same range as waters from the East Fork of Brush Creek. No contaminants except nitrate and nitrite were present at levels above the detection limits in pond T-8A water. The pond sediment was found to contain phenols (0.65 ug/g), oil and grease (584 ug/g), hexavalent chromium (0.74 ug/g), arsenic (3.1 ug/g), chromium (all species) (28 ug/g), and selenium (0.060 ug/g). Hydrazine, NDMA, and the compounds listed in Table 4.1 were not detected in the pond sediment. The compounds determined by base/neutral/acid extractable analyses (compounds listed in Appendix H) were also below detection limits. Most of the nitrogen in the pond water was in the nitrate form (4.8 mg/L); the pond sediment, however, contained most of its nitrogen as ammonia and/or organic forms (TKN at 780 ug/g).

4.4.2 Site 2

The investigation at Site 2 consisted of sampling two monitoring wells (MW-3 and MW-7) and four soil borings. As shown in Table 4.2, the ground water at Site 2 was slightly acidic but within the normal range for alluvial ground waters (White et al., 1963). The EC of well MW-3 was approximately three times higher than the EC of well MW-7, but

TABLE 4.4
ANALYTICAL RESULTS FOR POND T-8A WATER AND SEDIMENT^{1/}
APP PJKS

	Water		Sediment	
	Detection Limit	i-SW-1	Detection Limit	i-SD-1
Field Measurements				
Sampling Date	--	1/9/86	--	1/9/86
Temperature (°C)	--	8.5	--	--
Conductivity (umhos/cm)	--	434	--	--
pH	--	8.4	--	--
Chemical Parameters 2/				
Hydrazine	1	ND _{4/}	6	ND
NDMA	0.005	ND	0.25	ND
Nitrite	0.011	0.032	0.08	5.42
Nitrate	0.1	4.8	1.0	4.5
Phenols	0.005	ND	0.5	0.65
Total Kjeldahl Nitrogen	0.1	ND	5	780
Oil and Grease	5.0	ND	1	584
Hexavalent Chromium	0.02	ND _{5/}	0.17	0.74
MEK - Column 1	0.001	ND	10	39.7
MEK - Column 2	0.010	ND	10	ND
Total Arsenic	0.002	ND _{6/}	0.40	3.1
Total Cadmium	0.01	ND	0.40	ND
Total Chromium (all species)	0.11	ND _{6/}	2.1	28
Total Lead	0.13	ND	2.40	ND
Total Mercury	0.0002	ND	0.004	ND
Total Selenium	0.002	ND _{6/}	0.04	0.060
Total Thallium	0.23	ND	--	--

ND -Not detected.

- 1/ Units are milligrams per liter (parts per million) for water and micrograms per gram (parts per million) for sediment unless indicated.
- 2/ Analyses by methods 601 and 602 (water) (resampled on 4/24/86) and 8010 and 8020 (sediment) were below detection limits. Refer to Table 4.1 for compounds analyzed and detection limits for these methods. Base/neutral/acid extractable analyses were also below detection limits (see Appendix H for detection limits).
- 3/ "---" indicates not analyzed.
- 4/ At laboratory the extract final volume was mistakenly taken to 5.0 mL, which precluded the usual 0.25 ug/L detection limit.
- 5/ This data is from resampling on 4/11/86.
- 6/ This data is from resampling on 4/24/86.

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both are within the normal range for alluvial ground waters. Of the compounds listed on Table 4.1, the only compounds detected were TCE (1,110 ug/L) and 1,1-dichloroethane (12.7 ug/L) in well MW-3. No base/neutral/acid extractable compounds (listed in Appendix H) were detected in either well MW-3 or MW-7. However, well MW-3 water contained trace concentrations of NDMA (0.28 ug/L). Trace concentrations of phenols (0.007 mg/L) and selenium (0.004 mg/L) were detected in water from well MW-7. Nitrate was predominant over nitrite in MW-3 and MW-7. MW-7 showed 10.1 mg/L of TKN.

Analytical results for the four soil borings drilled to 15-foot depths at Site 2 are listed in Table 4.5. Phenols were not detected in any of the borings. The TKN contents of ES-13 and ES-14 follow the normal distribution of nitrogen in soils; that is, they decrease with depth below the soil surface. The TKN contents of ES-9 and ES-11, however, were highest at 5 to 7 feet, correlating with organic-rich clayey silt of the Piney Creek Alluvium.

4.4.3 Site 3

Table 4.5 contains the analytical data for the two soil borings at Site 3 (ES-15 and ES-16). The compounds listed in Table 4.1 were not detected in the soil boring samples. The only analyte detected in either soil boring was hexavalent chromium at 0.43 ug/g in boring ES-16. During drilling, however, the HNU monitor detected volatile organics in soil samples from ES-15 at levels of 30 to 50 ppm. These soils were sandy and the organics detected with the HNU meter may have volatilized or were not compounds that were analyzed by the 8010 and 8020 methods.

4.4.4 Sites 4 and 5

Three monitoring wells, MW-4, MW-5, and MW-6, were sampled at Sites 4 and 5. As shown in Table 4.2, ground water was slightly acidic and had an EC in the range of 732 to 987 umhos/cm. Both pH and EC were

TABLE 4.5
ANALYTICAL RESULTS FOR SITES 2 AND 3 SOIL BORINGS
APP PJKS

Sample	Depth (feet)	Sampling Date	Nitrite ¹ / (ug/g)	Nitrate (ug/g)	Phenols (ug/g)	Total Kjeldahl Nitrogen (ug/g)	Hexavalent Chromium (ug/g)
Detection Limit			0.08	1.0	0.5	5	0.17
Site 2 Soil Borings							
Boring ES-9/							
ES-9, SS-1	0-2	12/19/85	ND	ND	ND	290	--
ES-9, SS-2	2-4	12/19/85	ND	2.8	ND	240	--
ES-9, SS-3	5-7	12/19/85	ND	ND	ND	480	--
ES-9, SS-4	9-11	12/19/85	ND	ND	ND	140	--
ES-9, SS-5	14-16	12/19/85	ND	1.2	ND	100	--
Boring ES-11							
ES-11, SS-1	0-2	12/30/85	0.373	9	ND	200	--
ES-11, SS-2	2-4	12/30/85	0.343	ND	ND	210	--
ES-11, SS-3	5-7	12/30/85	1.01	5.7	ND	400	--
ES-11, SS-4	8-10	12/30/85	0.858	2.8	ND	320	--
ES-11, SS-5	13-15	12/30/85	0.27	4.7	ND	90	--
Boring ES-13							
ES-13, SS-1	0-2	12/31/85	0.19	7.0	ND	306	--
ES-13, SS-2	2-4	12/31/85	0.082	2.5	ND	150	--
ES-13, SS-3	5-7	12/31/85	0.13	2.2	ND	40	--
Boring ES-14							
ES-14, SS-1	0-2	12/31/85	0.45	ND	ND	596	--
ES-14, SS-2	2-4	12/31/85	1.01	1.6 ³ /	ND	336	--
ES-14, SS-3	5-7	12/31/85	0.096	3.1	ND	220	--
ES-14, SS-4	9-11	12/31/85	0.099	3.8	ND	71	--
ES-14, SS-5	13.5-14.8	12/31/85	0.499	2.1	ND	110	--
Site 3 Soil Borings							
Boring ES-15							
ES-15, SS-1	0-2	1/2/86	--	--	--	--	ND
ES-15, SS-2	2-4	1/2/86	--	--	--	--	ND
ES-15, SS-3	5-7	1/9/86	--	--	--	--	ND
ES-15, SS-4	8.2-10	1/9/86	--	--	--	--	ND
ES-15, SS-5	11.5-13	1/9/86	--	--	--	--	ND
ES-15, SS-6	13.4-15.4	1/9/86	--	--	--	--	ND
Boring ES-16							
ES-16, SS-1	0-2	1/2/86	--	--	--	--	ND
ES-16, SS-2	2-4	1/2/86	--	--	--	--	0.43
ES-16, SS-3	5-7	1/2/86	--	--	--	--	ND
ES-16, SS-4	8-9.5	1/2/86	--	--	--	--	ND
ES-16, SS-5	11-12	1/2/86	--	--	--	--	ND
ES-16, SS-6	14-15	1/2/86	--	--	--	--	ND

Note: Hydrazine and NMA analyses which were performed on all Site 2 samples were below detection limits of 6 ug/g and 0.250 ug/g, respectively. Analyses by methods 8010 and 8020 for all Site 2 and 3 samples were below respective detection limits (refer to Table 4.1 for compounds analyzed and detection limits).

ND - Not detected.

1/ micrograms per gram (parts per million).

2/ SS indicates soil sample.

3/ Estimated value.

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in the normal range for alluvial ground waters (White et al., 1963). TCE (67 ug/L), 1,1-dichloroethane (11.5 ug/L), 1,1,1-trichloroethane (28.6 ug/L), and possibly 1,1,2,2-tetrachloroethane and tetrachloroethene were compounds detected in waters from well MW-4. Well MW-5 may have contained a trace amount of trans-1,2-dichloroethene; however, a second column confirmation was not run to confirm the presence of this compound. Well MW-6 contained several compounds, including trans-1,2-dichloroethene (3.8 ug/L), TCE (190 ug/L), and possibly 1,1-dichloroethane, 1,1-dichloroethene, and 1,1,1-trichloroethane. The values indicated are the average of concentrations found in duplicate samples from well MW-6. In addition, well MW-5 water contained a substantial amount of oil and grease (4,070 mg/L), and a trace amount of selenium (0.002 mg/L). An oil sheen was observed on the water sampled from MW-5. Both nitrate and nitrite were low in the well waters. The TKN content of MW-4 (21.6 mg/L) was the highest of the eight monitoring wells and may be a result of an organic-rich zone penetrated from 10 to 12 feet in the well boring.

Radiation levels of ground waters from the three wells at Sites 4 and 5 were measured in December, 1985 by Engineering-Science. The highest levels of alpha and gamma radiation were found in waters from wells MW-4 and MW-5. The gross alpha activities of the three wells ranged from 130 to 270 pCi/L and gross gamma activities ranged from 70 to 140 pCi/L (as a measure of radium-226). Water from well MW-6 revealed the highest gross beta radiation. The range for gross beta activities for the three wells was from 120 to 250 pCi/L. Three isotopes of thorium, Th-228, Th-230, and Th-232, were also detected in these ground waters.

Waters from the three ground water wells were resampled in May, 1986 by USAFOEHL and analyzed for radiation. The analytical results are summarized in Table 4.6. Gross alpha activity ranged from less than 4.5 pCi/L in MW-6 to 53.5 pCi/L in MW-4. Gross beta activity ranged from 29.6 to 42.8 pCi/L. Of the thorium isotopes analyzed in

TABLE 4.6
RADIOLOGICAL DATA FOR SELECTED GROUND WATER MONITORING WELLS^{1/}
AND SURFACE WATER STATIONS ALONG THE EAST FORK OF BRUSH CREEK^{1/}
AFP PJKS

UNITS	11-0 ^{2/}	11-1 ^{3/}	11-9 ^{4/}	MW-4	MW-5	MW-6
Gross Alpha (Dissolved)						
Gross Beta (Dissolved)						
Gamma Nuclides						
Potassium (K-40)	<83	<92	<92	98	<99	<95
Chromium (Cr-51)	<96	<62	<89	<44	<39	<40
Cobalt (Co-60)	<11	<12	<11	<12	<11	<11
Zirconium (Zr-95)	<15	<16	<21	<11	<16	<7
Nobelium (Nb-95)	<8	<12	<10	<8	<9	<7
Molybdenum (Mo-99)	<450	<560	<500	<440	<520	<510
Ruthenium (Ru-103)	<9	<4	<8	<3	<8	<7
Ruthenium (Ru-106)	<47	<55	<46	<65	<12	<54
Iodine (I-131)	<30	<28	<20	<28	<27	<24
Cesium (Cs-134)	<9	<7	<8	<3	<8	<9
Cesium (Cs-137)	<7	<4	<5	<9	<6	<5
Barium (Ba-140)	<12	<47	<38	<29	<75	<66
Lanthanum (La-140)	20	<16	<17	<15	36	<16
Uranium (U-235)	<46	<43	<27	<60	<33	<26
Thorium Isotopes						
Thorium (Th-228)	0.12	0.07	0.08	0.31	0.38	0.21
Thorium (Th-232)	0.18	0.06	0.05	0.16	0.24	0.16

- 1/ Samples collected on May 21, 1986 and analyzed on June 10, 1986 by Brooks AFB.
- 2/ Station located above D-1 landfill near Test Stand D-2 (similar to ES Station 11-0).
- 3/ Station located below D-1 landfill (similar to ES Station 11-1).
- 4/ Station located below T-8A pond (similar to ES Station 11-9).

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the well waters, thorium-228 ranged from 0.21 to 0.38 pCi/L and thorium-232 ranged from 0.16 to 0.24 pCi/L. The only gamma nuclides detected were potassium-40 (98 pCi/L) in MW-4 and lanthanum-140 (36 pCi/L) in MW-5. All other gamma activity was below detection limits for the gamma nuclides analyzed.

4.4.5 Site 7

Nine samples of sediment from ditches draining the Systems and Components Test Facilities area were collected and analyzed. Analytical results are listed in Table 4.7 and sample locations are shown on Figure 3.1. The compounds listed in Table 4.1 were not detected in any of the sediment samples. In addition, hydrazine and NDMA were not detected. One sample (station 7-1) in the upper ditch contained hexavalent chromium (0.4 ug/g). This sample was located immediately downhill from tank T-6032. The lower ditch contained one contaminated sample at station 7-4. Station 7-4, located downhill from tank T-6031, contained phenols (0.5 ug/g) and hexavalent chromium (0.86 ug/g). Phenols were also detected at station 7-9 (1.3 ug/g). This station is located in the main drainage ditch about 200 feet upstream from its confluence with the East Fork of Brush Creek. Nitrate was predominant over nitrite in the ditch sediment samples. TKN in the sediments ranged from 140 to 650 ug/g.

4.4.6 Site 10

As listed in Table 4.2, the ground water sample collected from well MW-8 was slightly acidic and had a conductivity of 878 umhos/cm. These findings are in the normal range for ground waters (White et al., 1963). TCE (490 ug/L) was the only compound listed in Table 4.1 that was detected in MW-8 water. NDMA was detected at 5.2 ug/L; this was the highest concentration of this substance found on the PJKS property in all samples analyzed. Nitrate was predominant over nitrite in MW-8.

TABLE 4.7
ANALYTICAL RESULTS FOR DITCH SEDIMENT SAMPLES, SITE 7
APP PJKS

Sample Detection Limit	Date	Nitrite ¹ / (ug/g)	Nitrate (ug/g)	Phenols (ug/g)	Total Kjeldahl Nitrogen (ug/g)	Hexavalent Chromium (ug/g)
		0.08	1.0	0.5	5	0.17
<u>Upper Ditch</u>						
7-1, SD-1 ² / 12/19/85	12/19/85	0.08	7	ND	140	0.40
7-2, SD-1 12/19/85	12/19/85	0.08	2	ND	140	ND
7-3, SD-1 12/19/85	12/19/85	0.08	ND	ND	430	ND
<u>Lower Ditch</u>						
7-4, SD-1 12/19/85	12/19/85	0.08	3.0	0.5	570	0.86
7-5, SD-1 12/19/85	12/19/85	0.28	6.1	ND	650	ND
7-6, SD-1 12/19/85	12/19/85	0.08	5.3	ND	140	ND
7-7, SD-1 12/19/85	12/19/85	ND	5.6	ND	160	ND
7-8, SD-1 12/19/85	12/19/85	ND	5.3	ND	200	ND
<u>Ditch to East Fork</u>						
7-9, SD-1 12/19/85	12/19/85	0.31	1.0	1.3	230	ND

Note: Analyses by methods 8010 and 8020 were below detection limits (refer to Table 4.1 for compounds analyzed and detection limits). Hydrazine and NDMA analytical results were below detection limits of 6 ug/g and 0.250 ug/g, respectively.

ND - Not detected.

1/ micrograms per gram (parts per million).

2/ SD is sediment sample.

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4.4.7 Site 11

Samples of water and sediment were collected from 10 stations along the East Fork of Brush Creek. Field measurements for the surface water are presented in Table 4.8 and illustrated on Figure 4.1. Measurements of pH were neutral to slightly alkaline, with the exception of station 11-1, which was slightly acidic and in the same range as ground waters. Station 11-1 is located at the site where the underground water line is suspected to be leaking.

Of the compounds listed on Table 4.1, only small amounts of TCE, which occurred in half of the samples, were detected. TCE and NDMA concentrations detected in waters from the East Fork of Brush Creek are presented in Tables 4.8 and 4.9 and illustrated on Figure 4.9. The sample from Station 11-1 contained small amounts of TCE (2.0 ug/L). However, the TCE dissipated downstream and was not detected at Station 11-2. Samples from all stations between station 11-7 downstream to the eastern property boundary also contained small amounts of TCE (1.3 to 5.5 ug/L). Station 11-7 contained the highest amount of TCE (5.5 ug/L). NDMA occurred at stations 11-8, 11-9, and 11-10 at 0.34, 0.42, and 0.35 ug/L, respectively. Other contaminants detected were phenols (stations 11-5 and 11-7) and oil and grease (stations 11-2, 11-5, and 11-7). Concentrations of both of these substances were only slightly above their detection limits. No organics (halogenated or aromatic) were detected in a sample collected about 1,000 feet upstream from the D-1 landfill (station 11-0). NDMA, a decomposition product of unsymmetrical dimethyl hydrazine (UDMH), had a positive correlation downstream of station 11-7 with nitrate and TKN, as shown in Figure 4.10. However, nitrite concentrations did not correlate with concentrations of NDMA. Nitrate and nitrite are possible decomposition products of NDMA.

TABLE 4.8
ANALYTICAL RESULTS FOR THE EAST FORK OF BRUSH CREEK, SITE 11
APP PJKS

Water Sample Detection Limit	Date	NDA ₁ (ug/L)	Nitrite (ug/L)	Nitrate (mg/L)	Phenols (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Hexavalent Chromium (mg/L)	Oil/grease (mg/L)	Total Dissolved Solids (mg/L)	Temperature °C	Conductivity umhos/cm	pH
11-1, SW-2 ^{3/}	12/18/85	4/	0.032	--	ND	7/	ND	ND	--	10.5	466	6.4
11-2, SW-2	12/18/85	ND	0.018	ND	ND	ND	ND	2.07	320	7.5	448	7.55
11-3, SW-1	12/18/85	ND	0.012	ND	ND	ND	ND	ND	340	6.5	452	7.45
11-4, SW-1	12/18/85	ND	0.011	ND	ND	ND	ND	ND	260	6.5	466	7.4
11-5, SW-1	12/18/85	ND	0.011	ND	0.010	ND	ND	2.37	320	6.5	454	7.3
11-5, SW-2	12/18/85	ND	ND	ND	ND	ND	ND	ND	300	--	--	--
11-6, SW-1	12/18/85	ND	0.014	0.9	0.013	ND	ND	ND	320	5.5	456	8.2
11-7, SW-1	12/18/85	0.34	ND	0.9	ND	ND	ND	1.27	340	6.5	538	7.0
11-8, SW-1	12/18/85	0.42	0.014	0.9	ND	ND	ND	ND	340	6.5	507	7.1
11-9, SW-1	12/18/85	0.35	ND	0.9	ND	ND	ND	ND	340	6.0	545	7.3
11-10, SW-1	12/18/85	0.35	ND	0.9	ND	ND	ND	ND	340	6.5	534	7.3
Sediment Sample Detection Limit	Date	NDA ₁ (ug/g)	Nitrite (ug/g)	Nitrate (ug/g)	Phenols (ug/g)	Total Kjeldahl Nitrogen (ug/g)	Hexavalent Chromium (ug/g)					
11-1, SD-1 ^{6/}	12/18/85	ND	ND	ND	ND	280	ND					
11-2, SD-1	12/18/85	ND	ND	ND	ND	390	1.1					
11-3, SD-1	12/18/85	ND	ND	ND	ND	74	ND					
11-4, SD-1	12/18/85	ND	ND	ND	ND	71	ND					
11-5, SD-1	12/18/85	ND	ND	ND	ND	71	ND					
11-5, SD-2	12/18/85	ND	ND	ND	ND	110	ND					
11-5, SD-2	12/18/85	ND	0.20	ND	0.5	120	ND					
11-6, SD-1	12/18/85	ND	ND	ND	ND	110	ND					
11-7, SD-1	12/18/85	ND	ND	ND	ND	200	0.23					
11-8, SD-1	12/18/85	ND	ND	ND	ND	68	ND					
11-9, SD-1	12/18/85	ND	ND	3.9	ND	65	ND					
11-10, SD-1	12/18/85	ND	ND		ND		ND					

Note: Hydrazine analyses were below detection limits for water and sediment of 1 mg/l and 6 ug/g, respectively. Analyses by methods 8010 and 8020 for sediments were all below detection limits (see Appendix II for detection limits).

- ND - Not detected.
 1/ Microgram per liter (parts per billion).
 2/ Milligram per liter (parts per million).
 3/ SW indicates surface water sample; the succeeding number indicates whether a sample had been collected previously at that station.
 4/ "--" indicates not analyzed.
 5/ Microgram per gram (parts per million).
 6/ SD indicates sediment sample; the succeeding number indicates whether a sample had been collected at that station.
 7/ TKN data for all surface water samples is from resampling on 4/11/86.

TABLE 4.9
ORGANIC CONSTITUENTS IN EAST FORK OF BRUSH CREEK WATERS, SITE 11
AFP PJKS

Water Sample Detection Limit	Date	Trans - 1,2- Dichloroethene		TCE		Vinyl Chloride	
		ug/L		ug/L		ug/L	
		Column 1 10	Column 2 10	Column 1 1.0	Column 2 1.5	Column 1 10	Column 2 10
11-0, SW-1 ^{1/}	3/26/86	ND	-- ^{2/}	ND	--	ND	--
11-1, SW-3	3/26/86	33.6	ND*	2.0*	3.34	55.2	ND*
11-2, SW-3	3/26/86	ND	--	ND	--	ND	--
11-3, SW-2	3/26/86	ND	--	ND	--	ND	--
11-4, SW-2	3/26/86	ND	--	ND	--	ND	--
11-5, SW-3	3/26/86	ND	--	ND	--	ND	--
11-5, SW-4	3/26/86	ND	--	ND	--	ND	--
11-6, SW-2	3/26/86	ND	--	ND	--	ND	--
11-7, SW-2	3/26/86	ND	--	5.5*	3.2	ND	--
11-8, SW-2	3/26/86	ND	--	1.7*	4.1	ND	--
11-9, SW-2	3/26/86	ND	--	1.3*	3.4	ND	--
11-10, SW-2	3/26/86	ND	--	2.2*	6.6	ND	--

* Representative value.
ND - Not detected.

Note: Station 11-0 was located approximately 1,000 feet upstream from the D-1 landfill.

1/ SW indicates surface water sample; the succeeding number indicates whether a sample had been collected previously at that station.

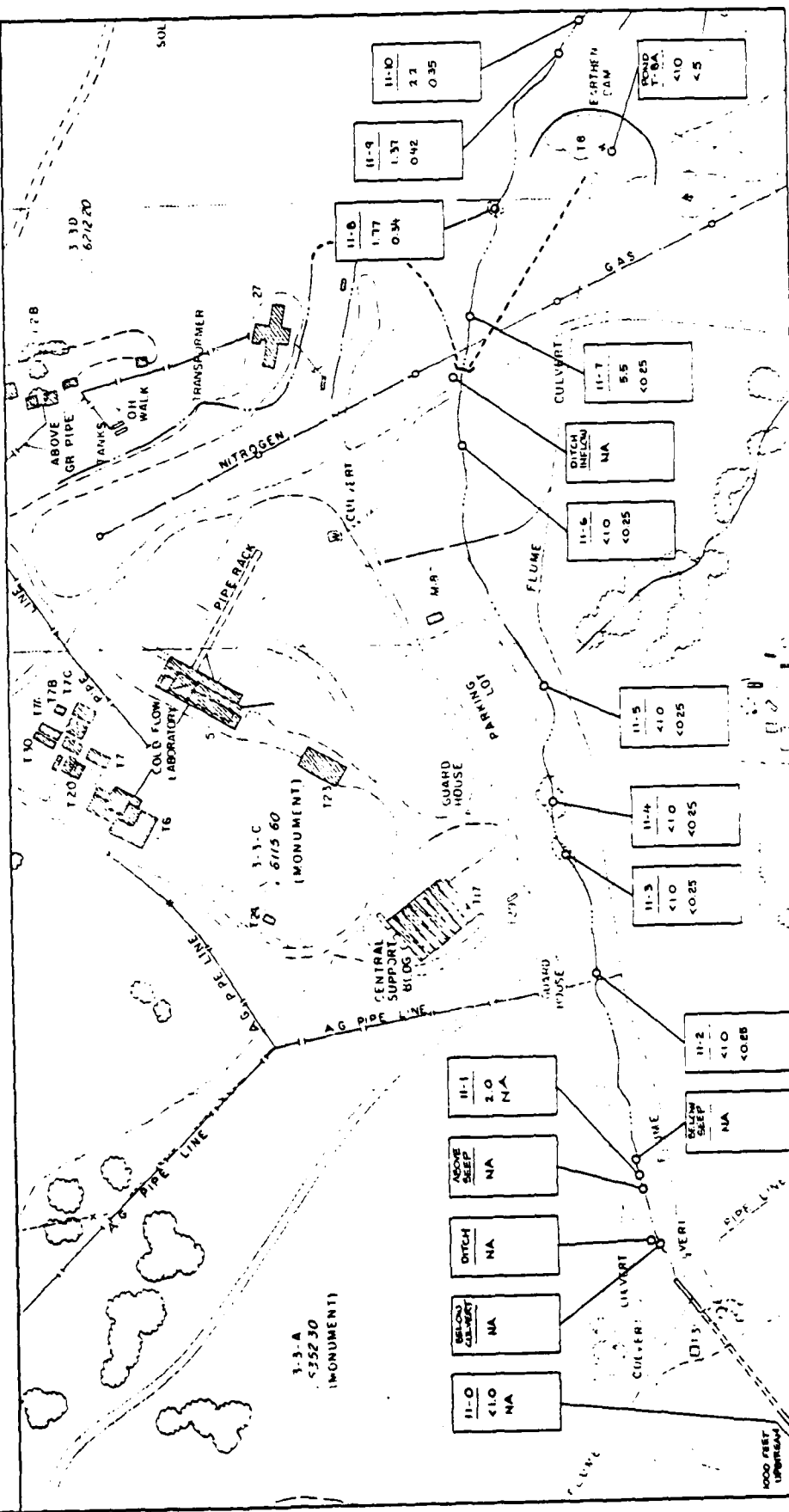
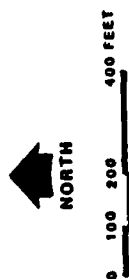
2/ "--" indicates not analyzed.

FIGURE 4.9
TCE AND NDMA
CONCENTRATIONS
IN EAST FORK OF
BRUSH CREEK
AT AFP PJKS

LEGEND

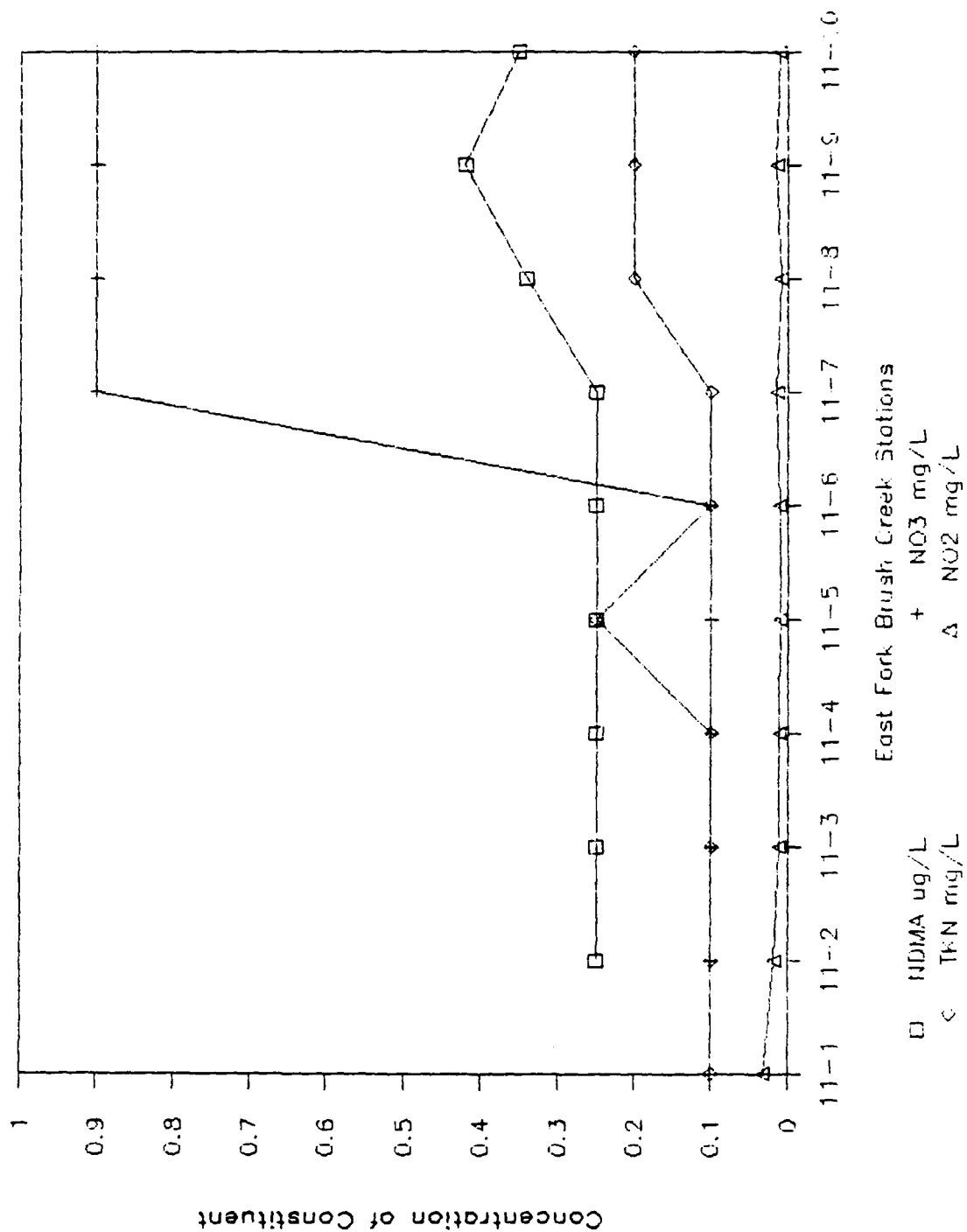
11-2	STATION
<1.0	TCE (ug/L) (SAMPLED 3/28/88)
<0.25	NDMA (ug/L) (SAMPLED 12/18/88)
NA	NOT ANALYZED

O	SAMPLE LOCATION
—	WIER
---	STREAMBED
---	CULVERT



SOURCE: ENGINEERING-SCIENCE DATA

FIGURE 4.10
NITROGEN/NDMA CORRELATION - EAST FORK OF BRUSH CREEK, AFP PJKS



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Three surface water samples were collected and analyzed for radiation levels by USAFOEHL in May, 1986. As listed in Table 4.6, the sample collection points were positioned along Brush Creek upstream from the D-1 landfill (Station 11-0), immediately downstream from the landfill (Station 11-1) and immediately downstream from the T-8A pond (Station 11-9). The gross alpha activity of all three samples was below the method detection limit. Gross beta activity ranged from 10.4 to 41.9 pCi/L, with the highest activity occurring upstream from the landfill. Gamma activity was below detection limits for all nuclides analyzed except lanthanum-140 which measured 20 pCi/L at station 11-0. Thorium-228 ranged from 0.07 to 0.12 pCi/L and thorium-232 ranged from 0.05 to 0.18 pCi/L. The highest thorium activities occurred at station 11-0.

East Fork of Brush Creek sediment analytical data are presented in Table 4.8. None of the compounds listed in Table 4.1 were detected, nor were hydrazine or NDMA. The only parameters detected were phenols (Station 11-6) and hexavalent chromium (Stations 11-2 and 11-8). Both nitrite and nitrate were generally low in the sediment. TKN ranged from 65 to 390 ug/g.

4.5 SIGNIFICANCE OF FINDINGS

The significance of the contaminants found at AFP PJKS was determined by evaluating (1) the analytical results from the testing of surface water, ground water, soils, and sediments with respect to human health risks reported in the literature; (2) the existence of a pathway for contaminant migration; and (3) the presence of human receptors. If all three of these conditions were met at a particular site, then the significance was rated high; if two conditions were met, then the significance was moderate; and if only one condition was met, the significance was low.

Before the analytical results can be interpreted, a preliminary screening of results must be performed to ascertain the type and concentration of contaminant detected. Analytical results that are at or near the detection limit of the analytical procedure used may be the result of interference introduced by the operator, the instrumentation, or the testing procedure. For this reason, the analytical results presented in the previous section were screened for practical quantification levels (PQL) before they were evaluated for significance. The PQL is taken to be three times the detection limit. Thus, if a reported concentration is less than the PQL for that parameter, the reported value is considered suspect and its significance, relative to a health risk standard or guideline, is qualified.

Health risks associated with the contaminants detected were evaluated with respect to regulatory standards and/or guidelines as presented in Table 4.10. The standards and guidelines were used to evaluate the relative threat to human health at the point of sample collection. The only enforceable standard in Table 4.10 is the maximum contaminant level (MCL). An MCL is the maximum permissible level of a contaminant in water which is delivered to the user of a public water system (40 CFR, Part 141). If an MCL is not available for a particular compound, then a proposed MCL is used. A proposed MCL is an MCL recommended by the U.S. Environmental Protection Agency that has not undergone the public review and comment period.

If neither an MCL nor a proposed MCL is available, lifetime cancer risk guidelines were used. The U.S. EPA uses cancer risk data to place plausible upper bounds on risk, but not to establish actual risks (i.e., the risks are not likely to be higher but could be lower). Cancer risk estimates are expressed as a probability of contracting cancer after a 70-year lifetime consumption by a 70-kg human of 2 liters of water per day containing a certain concentration of a compound. Using tetrachloroethene as an example, the lifetime cancer risk

TABLE 4.10
PUBLIC HEALTH REGULATIONS OR HEALTH GUIDELINES FOR SELECTED DRINKING WATER CONTAMINANTS

Contaminant	MCL ^{1/}	Proposed MCL ^{2/}	Lifetime Cancer Risk ^{3/}	Maximum Metals Accumulation/ Guidelines for Soils ^{4/}	Other Criteria
MEK					
Trans-1,2-dichloroethene					
NDMA					860 ug/L ^{5/} 70 ug/L ^{6/}
TCE		5 ug/L	0.014 ug/L 1×10^{-5}		810 ug/L ^{8/}
1,1-dichloroethene					
1,1,2-dichloroethene		7 ug/L	1.7 ug/L 1×10^{-5}		
1,1,2,2-tetrachloroethane					
1,1,1-trichloroethane		200 ug/L	7 ug/L 1×10^{-5}		
Tetrachloroethene					
Arsenic ^{11/}	0.05 mg/L				
Chromium ^{11/}	0.05 mg/L			300 ug/g 1000 ug/g	
Nitrate (as N)	10 mg/L				
Nitrite (as N)	0.01 mg/L ^{12/}				1 mg/L ^{12/}
Selenium	15 pCi/L ^{13/}			5 ug/g	
Gross alpha particle activity	50 pCi/L				
Gross beta emission					
Gross alpha emission					
Thorium ^{14/}					
^{1/} Maximum contaminant level (MCL).					
^{2/} Proposed MCL's are MCL's recommended by the EPA, but which have not undergone the public review and comment period.					
^{3/} Lifetime cancer risk information is expressed as the concentration of the carcinogen and corresponding probability of 70-year lifetime cancer risk. In the example of tetrachloroethene, the 70-year lifetime cancer risk for a 70-kg human consuming 2 liters a day of water containing 7 ug/L of tetrachloroethene is 1×10^{-5} .					
^{4/} EPA, 1983. Guidelines based on microbial and plant toxicity limits, animal health considerations, and soil chemistry which reflects the ability of soil to immobilize the metal elements.					
^{5/} The lifetime health advisory for MEK is based on a 70-kg adult consuming 2 liters of water per day (EPA, 1985).					
^{6/} The criteria for trans-1,2-dichloroethene is the proposed recommended maximum contaminant level, which are unenforceable goals proposed by the EPA for drinking water at levels that present no risk to public health (40 CFR Part 141).					
^{7/} U.S. Environmental Protection Agency, 1980a.					
^{8/} Based on the EPA's acceptable intake for chronic oral exposure of 8.1 mg/L (U.S. Environmental Protection Agency, 1984). Using EPA's Office of Drinking Water approach, that 2 liters/day of water are consumed and 70 percent of exposure is from drinking water and 80 percent is from other sources, then 810 ug/L in drinking water is a reasonable limit for 1,1-dichloroethene.					
^{9/} U.S. Environmental Protection Agency, 1980b.					
^{10/} U.S. Environmental Protection Agency, 1985.					
^{11/} Includes all species of chromium; hexavalent chromium, however, is more toxic than the trivalent species (Sax, 1984). Hexavalent chromium is not a carcinogen by ingestion (Dr. Chen, personal communication, 1986).					
^{12/} The criteria for nitrite is the proposed recommended maximum contaminant level (MCL) (See Footnote 6 for explanation of MCL).					
^{13/} This activity value includes Ra^{226} , but excludes radon and uranium.					
^{14/} Available data do not provide evidence of risk from thorium in drinking water; however, there have been numerous reports of clinical carcinogenicity of thorium compounds in humans (National Academy of Sciences, 1980).					

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for daily consumption of 2 liters of water containing 7 ug/L of tetrachloroethene is 1 in 100,000 (1×10^{-5}). The risk relationship is linear, so that if only 0.7 ug/L of tetrachloroethene is consumed over a 70-year lifetime, the cancer risk is reduced to 1 in 1,000,000 (1×10^{-6}). For purposes of continuity, all applicable cancer risk guidelines used to evaluate AFP PJKS data are reported as 1 in 100,000.

If neither MCL nor cancer risk guidelines were available for a detected compound, other criteria as indicated in Table 4.10 were used to evaluate health risks.

Possible pathways or routes for contaminant migration include ground water and surface water. The location of human reception points such as wells, surface water diversions, or recreational areas were considered to assess the presence of human receptors.

The significance of contamination was assessed for locations both on-plant and offsite. Section 4.5.1 contains a discussion regarding on-plant significance and Section 4.5.2 contains an offsite significance discussion.

4.5.1 Significance of Contamination on AFP PJKS Property

The relative significance of contamination at individual PJKS sites is presented in the following sections.

4.5.1.1 Site 1 - Ground Waters

As shown in Table 4.2, ground waters from wells MW-1 and MW-2 contain several organic compounds. Of the compounds having proposed MCL standards, only TCE (130 ug/L and 67 ug/L in wells MW-1 and MW-2, respectively) exceeds its proposed MCL of 5 ug/L. If tetrachloroethene is present in MW-2, its concentration at 1.2 ug/L does not exceed the 7 ug/L lifetime cancer risk (10^{-5}) guideline, nor the 3 ug/L PQL. Wells MW-1 and MW-2 may both contain 1,1-dichloroethane (1.8 ug/L and 2.0 ug/L, respectively). If present, these concentrations are below both the 810 ug/L guideline for this compound and the PQL of 3 ug/L. Well

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MW-2 may contain 1,1,2,2-tetrachloroethane (1.2 ug/L) which is less than the 1.7 ug/L cancer risk criterion and the 3 ug/L PQL. Well MW-2 may also contain 1,1,1-trichloroethane (9.0 ug/L) which is below the proposed MCL of 200 ug/L. NDMA contents in both of the wells (0.61 and 0.23 ug/L for MW-1 and MW-2, respectively) exceed the concentration which is calculated to increase the lifetime cancer risk by 1 in 100,000 (0.014 ug/L). However, the PQL for NDMA is 0.75 ug/L, which is greater than both values reported for the wells. The MEK concentration of 105 ug/L in well MW-1 is below the 860 ug/L lifetime health advisory. In addition, MEK is easily biodegradable (40 CFR Part 300, App. A). Nitrate and nitrite contents of MW-1 and MW-2 did not exceed the EPA MCL standard or recommended maximum contaminant level (RMCL) guidelines, respectively. Detectable concentrations of arsenic (0.011 mg/L) and selenium (0.002 mg/L) in MW-1 also were below the MCL standards.

Organic contamination was detected in waters from well GM-89, located immediately east of Site 1 on Martin Marietta property, and to a lesser degree, in well GM-15, located 500 feet downgradient from well GM-89. GM-89 contained trans-1,2-dichloroethene (25 ug/L), 1,1,1-trichloroethane (5.8 ug/L), and TCE (46 ug/L) and GM-15 contained TCE (13 ug/L) (Martin Marietta Environmental Systems, 1986). The presence of organic contaminants in these wells suggests that migration of contaminants from Site 1 onto Martin Marietta property may have occurred. A possible source of contamination is pond T-8A and its associated flumes, even though pond waters sampled during this field program showed no organic contamination. As discussed in Section 1.0, process wastewaters routed to pond T-8A in the past may have contained contaminants at higher concentrations than those currently found in waters discharged to the pond. Between 1957 and approximately 1974, the pond was unlined and contaminants may have infiltrated into alluvial ground waters. Other possible sources of contamination include leakage from

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Site 7 ditches during past operations, and unreported releases of solvents to the north and/or northwest of pond T-8A.

Alluvial ground waters beneath Site 1 generally flow toward the East Fork of Brush Creek, as shown on Figure 4.8. As depicted on cross sections A-A', B-B', and C-C' (Figure 4.3), the alluvial aquifer consists of the Slocum Alluvium, which is comprised primarily of moderately permeable sands. It is highly probable, therefore, that contaminated ground waters discharge to the East Fork of Brush Creek adjacent to the T-8A pond and/or downstream from the property boundary. As discussed in Section 2.3.2, Surface Water Quality, organic contaminants were detected at the Martin Marietta surface water sampling site near the property boundary. However, the levels of organic compounds dissipated to below detection levels within the relatively short distance of 1,500 feet downstream (Table 2.1 and Figure 2.4). Alluvial ground waters may also discharge to the bedrock ground water system, but this interrelationship was not evaluated in this investigation. Because the contaminants TCE and, possibly, NDMA exceed health criteria, and because contaminant migration pathways exist, contamination of ground water at Site 1 is of concern. However, because there are no public receptors on AFP PJKS property, the relative significance of ground water contamination at Site 1 is rated as moderate.

4.5.1.2 Site 1 - Soils and Sediments

Pond T-8A sediments, consisting of a 6-inch-deep layer of sand and silt, contained phenols (0.65 ug/g), oil and grease (584 ug/g), arsenic (3.1 ug/g), chromium (all species) (28 ug/g), hexavalent chromium (0.74 ug/g), and selenium (0.060 ug/g) (Table 4.4). Concentrations of arsenic, total chromium, and selenium did not exceed the EPA guidelines for maximum accumulations of these metals in soils (300, 1,000, and 5 ug/g, respectively) (U.S. Environmental Protection Agency, 1983). These guidelines are based on microbial and plant toxicity limits, animal health considerations, and soil chemistry, which reflect the ability of

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soil to immobilize the metal elements. Phenols were detected in sediments, but not in pond waters. Similarly, relatively high concentrations of oil and grease were detected in the pond sediments, but not in pond waters. Both phenols and oil and grease appear to be bound into the soil matrix, as evidenced by the absence of these parameters in pond waters.

The only migration pathway of leachate from the sediments into the environment would be through cracks in the concrete pond liner. However, based on field observations, the concrete pond liner appears to be in good condition. Consequently, the potential for movement of contaminants in pond sediments to the environment is very low. Because of the relatively low concentrations of contaminants in pond sediments, the relative unavailability of the pollutants (since they are bound to the sediment) and the lack of migration pathways or receptors, the significance of contaminated pond sediments as a threat to human health at AFP PJKS is judged to be low.

Hexavalent chromium (0.17 to 0.7 ug/g) and phenols (0.5 to 1.0 ug/g) were the only constituents detected in the five soil borings drilled through the pond sediment disposal area (Table 4.3). The hexavalent chromium concentration is below the guidelines for chromium accumulation for soils of 1000 ug/g (U.S. Environmental Protection Agency, 1983). Since phenols occur naturally in soils, it is difficult to determine the significance of the levels of phenols found in the borings without comparison to background data.

Because hydrazine fuels may degrade to various forms of nitrogen, the soil borings were sampled for nitrite, nitrate, and TKN contents. The levels of hydrazine and NDMA were below detection limits and, therefore, could not be correlated with nitrite, nitrate, or TKN. There does not appear to be an excessive loading of nitrate which, if leached from soils, could adversely affect ground waters.

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Possible impacts to ground and surface waters are rated as low because of the low levels of pollutants detected, the absence of these constituents in monitor well MW-1 waters, and the relatively small surficial area of the disposal area through which percolation could occur.

4.5.1.3 Site 1 - Surface Water

Base/neutral/acid extractable (BNA) analyses including specific phenolic compounds were all below detection limits in pond T-8A waters. The phenols found in the pond sediment may be attributed to phenolic compounds not quantified by the BNA analyses which may include naturally occurring organic material.

No contaminants were detected in pond T-8A waters (Table 4.4). Therefore, there is no concern about toxic substances in surface waters at this site.

4.5.1.4 Site 2 - Ground Waters

Well MW-3 contains TCE (1,110 ug/L) at levels considerably above the proposed MCL of 5 ug/L. The compound 1,1-dichloroethane (12.7 ug/L) was also detected but it does not exceed the 810 ug/L guideline. Well MW-3 also contains NDMA (0.28 ug/L) at a level which exceeds the lifetime cancer risk (1 in 100,000) guideline of 0.014 ug/L but below its PQL of 0.75 ug/L. Trace contamination by phenols (0.007 mg/L) was detected in well MW-7 water, but data from the BNA analysis showed that specific phenolic compounds were all below the detection limits. The selenium content of well MW-7 (0.004 mg/L) did not exceed the MCL of 0.01 mg/L. The nitrate and nitrite contents of wells MW-3 and MW-7 did not exceed either the respective EPA MCL standard or RMCL guideline.

A probable source of the ground water contamination at wells MW-3 and MW-7 is spent solvents used in equipment cleaning that were reportedly spilled onto the ground or leaked from drums at Sites 2 and 3. However, the soil borings drilled in the reported spill areas contained

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only near-surface scattered contamination by hexavalent chromium (Site 3). NDMA contamination in well MW-3 is suspected to have come from tank overflows or leaks at Site 7 which may have migrated into the alluvial ground water system.

The direction of contaminant migration in the alluvial aquifer at Site 2 is southeastward toward the East Fork of Brush Creek (Figure 4.8). The aquifer consists of the moderately permeable sands of the Slocum Alluvium. In the vicinity of borings ES-9 and ES-14, there is a near-surface silt layer of Piney Creek Alluvium which may have locally impeded surface contamination from infiltrating into the ground water system.

The contaminated ground waters at Site 2 may discharge to the East Fork of Brush Creek. Contributions by ground water to the East Fork were found in the reach near Site 2. However, as discussed in Section 2.3.2, organic contamination dissipates within 1,500 feet downstream of the PJKS-Martin Marietta property boundary. In addition, contaminated alluvial ground water may recharge the bedrock aquifer.

The relative significance of the ground water problem at Site 2 is rated as moderate because contamination in ground water at this site meet two of the three criteria for concern. TCE and, possibly, NDMA exceed health criteria or standards, and pathways for contaminant migration exist, but there are no public receptors on AFP PJKS property.

4.5.1.5 Site 2 - Soils

Hydrazine, NDMA, and phenols were not detected in the four soil borings drilled at Site 2 (Table 4.5). The soil borings did not show elevated levels of nitrite, nitrate, or TKN, which may be degradation products of hydrazine fuels. There is no excessive loading of nitrate which, if leached from soils, could adversely affect ground waters. Since no contaminants were detected in soils from Site 2, there is no concern about toxic substances in soils at this site.

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4.5.1.6 Site 3 - Soils

The only contaminant detected in either of the Site 3 soil borings was hexavalent chromium (0.43 ug/g) in boring ES-16 (Table 4.5). This soil sample was extracted from between 2 and 4 feet below the ground surface. The hexavalent chromium concentration falls below the EPA guidelines for maximum chromium accumulation for soils of 1000 ug/g (U.S. Environmental Protection Agency, 1983). During drilling, however, the HNU monitor indicated volatile organics in soil samples from ES-15 at levels of 30 to 50 ppm. The organics detected may have volatilized or they were not compounds analyzed by the 8010 and 8020 methods.

Soils beneath the site are primarily Slocum Alluvium, consisting of relatively low permeability sands and silt. The depth to ground water exceeds 15 feet in this area. The significance of soil contamination at Site 3 is low based on the limited extent and concentration of contamination, the low probability that metals are migrating into ground waters, and the absence of public receptors.

4.5.1.7 Sites 4 and 5 - Ground Water

The three ground water monitoring wells constructed at Sites 4 and 5 (MW-4, MW-5, and MW-6) are located downgradient from the D-1 landfill and the T-31 storage tank. Of the several organic contaminants detected in MW-4 waters (Table 4.2), only TCE occurs at a level which exceeds the proposed standard or guideline presented in Table 4.10. MW-4 waters contain 67 ug/L of TCE, which exceeds the proposed MCL of 5 ug/L. Dichloroethene occurred at 11.5 ug/L, which is below the 810 ug/L guideline discussed earlier. The compounds 1,1,2,2-tetrachloroethane, tetrachloroethene, and 1,1,1-trichloroethane were all detected in well MW-4 at 1.2 ug/L, 1.2 ug/L, and 28.6 ug/L, respectively. All concentrations were below each compound's respective lifetime cancer risk criteria or proposed MCL standards of 1.7 ug/L, 7 ug/L, and 200

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ug/L. In addition, the first two compounds were below their respective PQL's of 3 ug/L.

Well MW-5 waters may contain trans-1,2-dichloroethene (2.3 ug/L), but this compound occurs at levels below the proposed RMCL (70 ug/L). Waters from MW-5 also contained a high concentration of oil and grease (4,070 mg/L) and trace amount of selenium (0.002 mg/L). No standards or health risk data are available for oil and grease, but the selenium content is below the MCL of 0.010 mg/L.

Well MW-6 waters contained several organic contaminants as shown in Table 4.2. The TCE content of well MW-6 (190 ug/L) exceeds the 5 ug/L proposed MCL. Well MW-6 waters may contain 4.1 ug/L (average of duplicate samples) of 1,1-dichloroethane which does not exceed the 810 ug/L guideline. The nitrate and nitrite contents of MW-4, MW-5, and MW-6 are low and do not exceed their respective MCL standard or RMCL guideline.

Relatively high radioactivity levels were observed in all three wells at Sites 4 and 5 from the December, 1985 sampling. Since natural uranium mineralization occurs within the area (Nelson-Moore et al., 1978), natural radioactivity cannot be distinguished from radioactivity produced by the low-level waste (magnesium thorium alloy) buried in the D-1 landfill until background radiation levels are established. The claimblock investigated by uranium exploration companies extended northward to the upper portions of the East Fork of Brush Creek (upstream from the D-1 landfill) and southward approximately 2 miles to the South Platte River. Samples from some adits and pits near the South Platte River (SE 1/4 Sec 33, T.6S., R. 69W) contained from 0.16 to 11.2 percent U_3O_8 (Nelson-Moore et al., 1978). All of the gross alpha radiation levels (130 to 270 pCi/L) found at Sites 4 and 5 in December exceeded the EPA MCL for drinking water (15 pCi/L) by factors ranging between 8.7 and 18. MW-4 was the only well which exceeded the EPA MCL for drinking water for gross alpha radiation from the May, 1986

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sampling. Gross beta radiation levels (120 to 250 pCi/L) also exceeded the MCL (50 pCi/L) by factors from 2.4 to 5 for the December, 1985 sampling. The results from the May, 1986 sampling for gross beta were below the 50 pCi/L MCL. The difference in radiation activity levels for gross alpha and gross beta for the two sampling periods can possibly be explained by the seasonal variation of flow in the East Fork of Brush Creek. The December, 1985 sampling occurred during a relatively low flow period while the May, 1986 sampling represented a higher flow period causing a dilution effect on the radiation levels. As discussed previously, the surface water flow and ground water flow are interrelated. The background levels of radiation must be quantified for this area before the significance of the radiation data can be determined.

Thorium isotopes 228, 230, and 232, were detected in the three wells. The thorium isotopes analyzed in the May sampling were considerably lower than the December sampling. There are no standards or guidelines for these substances. However, thorium compounds have been reported to be carcinogenic to humans (National Academy of Sciences, 1980). Background levels of thorium must also be quantified before the significance of the thorium data can be determined.

The sources of the various detected solvents and oil and grease contamination are believed to be the D-1 landfill and the T-31 tank. Solvents may have been disposed in the landfill and are apparently migrating in the alluvial ground water system toward the East Fork of Brush Creek. It is not known whether ground water contamination exists upgradient from the D-1 landfill because these areas were not investigated.

Based on stream flow measurements and water level data collected from the monitoring wells, contaminated ground water emanating from the D-1 landfill discharges to the East Fork of Brush Creek. East Fork of Brush Creek waters may contain TCE (2.0 ug/L vs. PQL of 3 ug/L) at station 11-1 located downstream of the landfill (Figure 4.9) which has

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dissipated to below detection levels at station 11-2. In addition, contaminated ground waters may recharge underlying bedrock aquifers comprised of fractured and faulted Precambrian gneiss and Fountain Formation sandstone.

The relative significance of ground water contamination at Sites 4 and 5 is moderate because of the contamination of ground water by TCE (MW-4 and MW-6); the potential for migration of ground water into East Fork surface waters and into bedrock systems; and the absence of public receptors onsite. Relatively high levels of gross alpha, beta, and gamma radioactivity were detected in the wells. Because natural uranium mineralization exists in the area, the background levels of radiation must first be quantified before the effects of the disposal of low level radioactive wastes can be determined.

4.5.1.8 Site 7 - Sediments

Hexavalent chromium contamination ranging up to 0.86 ug/g was detected in sediments collected from the Site 7 ditches (Table 4.7). The hexavalent chromium content did not exceed the EPA guideline for maximum chromium accumulation for soils. The contamination was restricted to areas immediately downstream from tanks T-6032 and T-6033. The sediment sample from the main drainage ditch located 200 feet from the confluence with the East Fork of Brush Creek (station 7-9) contained phenols. The sediment at station 11-7 immediately downstream on the East Fork also contained phenols. Since phenols occur naturally in soils or sediments, it is not possible to determine the significance of these levels without comparison to background data. There was no excessive loading of nitrate which, if leached from soils, could adversely affect ground water quality. Consequently, the relative significance of the sediment contamination at Site 7 is rated as low based on the limited amount of contamination found.

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4.5.1.9 Site 10 - Ground Water

Ground water collected from well MW-8 contained several organic compounds, including NDMA and TCE. The NDMA concentration (5.2 ug/L) found in well MW-8 is considerably greater than the 0.014 ug/L concentration for lifetime cancer risk criterion of 1×10^{-5} determined by the U.S. Environmental Protection Agency (1980a) and the 0.75 ug/L PQL. Well MW-8 waters contain TCE (490 ug/L) at levels above the proposed MCL of 5 ug/L. The nitrate content of MW-8 does not exceed the EPA MCL standard.

Monitor well MW-8 lies directly downhill from the Construction Material Fill Area. Possible sources of the contaminants include hydrazine/NDMA and solvent wastes that may have been disposed in the Site 10 fill area or nearby fill areas, or past leakage of hydrazine/solvent-laden wastewaters from Site 7 conveyance ditches. Such seepage may have entered alluvial ground waters and migrated toward the Construction Material Fill Area. Ground water testing was not conducted at Site 7 and the origin of the NDMA and TCE in well MW-8 cannot be confirmed with the available data.

Local directions of alluvial ground water movement at Site 10 are south and southeastward toward the East Fork of Brush Creek. Contaminated ground water may discharge to the East Fork, contributing NDMA loading to the creek. In addition, contaminated ground waters may recharge the Fountain Formation bedrock aquifer. Because 1) the contaminants TCE and NDMA exceed proposed regulatory standards or health risk guidelines, 2) there is the possibility that contaminants are moving into surface water and bedrock ground waters, and 3) no public receptors are located on AFP PJKS property, the significance of the ground water contamination at Site 10 is rated as moderate.

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4.5.1.10 Site 11 - Surface Water

Concentrations of TCE (1.3 to 5.5 ug/L) and NDMA (0.34 to 0.42 ug/L) have been detected along the East Fork of Brush Creek between Site 5 and the eastern property boundary (Figure 4.9 and Tables 4.8 and 4.9). A possible source of the TCE contamination found at the upstream station 11-1 (2.0 ug/L) is the D-1 landfill. This TCE concentration is below the proposed MCL of 5 ug/L and below the PQL of 3 ug/L. If TCE is present at this station, it probably originated from the D-1 landfill and migrated into the alluvial ground water system. A large portion of the flow in the upper East Fork of Brush Creek is probably contributed by the discharge of shallow ground water. Another possible source of TCE contamination is the flow from the suspected broken water line.

In stream reaches where there is a loss of surface water to ground water, contaminants from surface water may be contributed to the alluvial ground water system. Conversely, in gaining reaches, contaminated ground waters may be discharging to surface waters. Based on the flow measurements of the East Fork of Brush Creek, the TCE at station 11-7 (5.5 ug/L) is probably contributed from ground water. The TCE at station 11-7 (5.5 ug/L) just exceeds the proposed MCL of 5 ug/L. TCE contamination (130 ug/L) was found at the nearest monitoring well, MW-1, located 150 feet downgradient of station 11-7. From station 11-7, TCE concentrations generally decreased in the downstream direction toward the eastern property boundary. As discussed previously (Section 2.3.2 Surface Water Quality) organic contaminants were detected at the Martin Marietta surface water station near the property boundary. No contaminants were detected, however, at the next station located 1,500 feet further downstream (Table 2.1 and Figure 2.4).

Phenols were detected at stations 11-5 (0.010 mg/L) and 11-7 (0.013 mg/L). The significance of these levels can not be determined without comparison to background values.

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NDMA, detected at stations 11-8, 11-9, and 11-10, probably originates from the discharge of contaminated alluvial ground water from Sites 1 and 10 to Brush Creek. NDMA concentrations ranging from 0.34 to 0.42 ug/L exceed the lifetime cancer risk criterion of 0.014 ug/L but are below the PQL of 0.75 ug/L. Research has shown that NDMA undergoes photolysis with exposure to sunlight and degrades (U.S. Environmental Protection Agency, 1979a). This process may be important in reducing levels of NDMA downstream.

Radiation levels for the three surface water samples collected in May, 1986 along the East Fork of Brush Creek (stations 11-0, 11-1, and 11-9) were below the MCL's for both gross alpha and gross beta activities (Table 4.6). The highest gross beta activity was at Station 11-0 upstream from the D-1 landfill. The only gamma nuclide detected in the three samples was lanthanum-140 (20 pCi/L) at station 11-0. Thorium-228 and thorium-232 contents were highest in the sample at Station 11-0. These data indicate that natural radiation exists in the East Fork of Brush Creek above the D-1 landfill and dissipates downstream.

The significance of the surface water contamination at AFP PJKS is moderate because 1) the contaminants, TCE (station 11-7) and, possibly, NDMA (stations 11-8, 11-9 and 11-10) exceed proposed regulatory standards or health risk guidelines, 2) there is a potential for contaminant migration to the ground water system, and 3) no public receptors are located on AFP PJKS property.

4.5.1.11 Site 11 - Sediment

Sediment contamination with hexavalent chromium in the East Fork of Brush Creek was detected at two stations: 11-2 (1.1 ug/g) and 11-8 (0.23 ug/g). The chromium contents did not exceed the EPA guidelines for maximum contaminant levels in soils. Phenols at 0.5 ug/g were detected in sediments at station 11-6. Background data are needed for comparison, since phenols occur naturally in soils or sediment. No

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excessive loading of nitrate was detected. Thus, the overall significance of contamination in stream sediments from the parameters analyzed is low.

4.5.1.2 Summary

Figures 4.9 and 4.11 show the concentrations of the major contaminants TCE and NDMA in surface and ground waters, respectively. As shown in the figures, surface and ground water contamination problems occur in two general areas on AFP PJKS property. They include 1) the area containing the T-8A pond site (Site 1), EPL test cells (Site 2), the Construction Material Fill Area (Site 10), and the lower portion of the East Fork of Brush Creek (Site 11); and 2) the area comprised of the T-31 tank area (Site 4), the D-1 landfill (Site 5), and the upper portion of the East Fork of Brush Creek (Site 11). The significance of contamination in these areas is moderate because, while the contaminants detected (predominantly TCE and NDMA) exceed proposed regulatory standards or health risk guidelines and the potential for contaminant migration to surface and ground waters exists, no public receptors are located on AFP PJKS property. An important aspect of the contaminant problems at AFP PJKS is the interrelationship between surface and ground waters and the movement of contaminants between them. Only limited contamination was detected in AFP PJKS soils and sediments, and contamination of these resources is believed to be of low significance.

4.5.2 Evaluation of Contaminant Migration Offsite

Possible pathways for contaminant migration from AFP PJKS are via the East Fork of Brush Creek and through the alluvial and bedrock ground water systems. Downstream from AFP PJKS, the East Fork flows through the Martin Marietta property for about 2 miles and then converges with the West Fork of Brush Creek (refer to Figure 2.3). Brush Creek is tributary to the South Platte River. South Platte River waters downstream from its confluence with Brush Creek are used for domestic, agricultural, commercial, and recreational purposes.

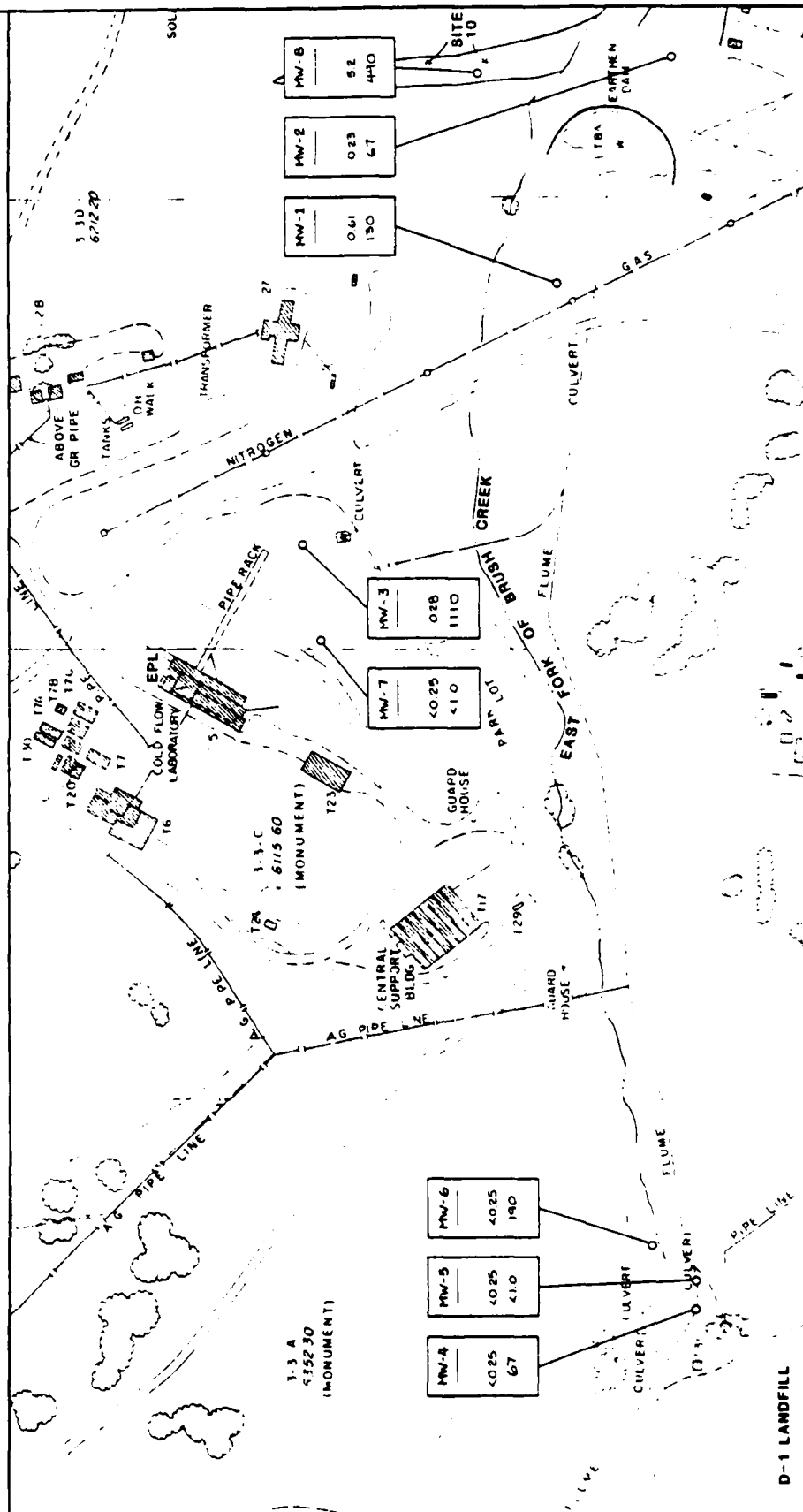
FIGURE 4.11
TCE AND NDMA
CONCENTRATIONS IN
GROUND WATERS
AT AFP PJKS

LEGEND

WELL	NDMA (ug/L) (SAMPLED 1/88)	TCE (ug/L) (SAMPLED 4/88)
MW-1	0.61	130



0 100 200 400 FEET



D-1 LANDFILL

SOURCE: ENGINEERING SCIENCE DATA

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Surface water in the East Fork at the station immediately downstream from the AFP PJKS property boundary contains trace to elevated concentrations of organic compounds, including 1,1,1-trichloroethane, TCE, and cis-1,2-dichloroethylene (Chapter 2, Table 2.1). These concentrations dissipate to below detection levels within a relatively short distance downstream (1,500 feet). Various other sources which contribute to organic contamination in the East and West Forks of Brush Creek are currently being investigated by Martin Marietta (Kisling, 1986).

Ground waters in Martin Marietta well GM-89, located immediately downgradient from Site 1, contained trans-1,2-dichloroethene, 1,1,1-trichloroethane, and TCE. Small amounts of TCE were detected in GM-15, located 500 feet downgradient from GM-89. The presence of the contaminants in these wells suggests that some migration of contaminants in the alluvial ground water system has already occurred.

The significance of contaminant migration offsite is low based on the dissipation and dispersion of contaminants in surface and ground waters as discussed above and the large distance (several miles) between potential receptors and AFP PJKS. The South Platte River and Kassler Water Treatment Plant lie approximately 2 miles southeast of AFP PJKS; the main intake for Kassler Water Treatment Plant is located upstream from the Brush Creek confluence. Chatfield Reservoir, an important recreation facility for the Denver metropolitan area, is located about 4 miles downstream from AFP PJKS. The nearest wells are approximately 1.5 miles to the north of AFP PJKS (refer to Section 2.5.3). Despite these relatively long distances to human receptors, pathways for the offsite migration of the contaminants present at AFP PJKS do exist and should be further investigated. Recommendations to address these concerns include drilling wells, sampling waters, and determining geohydrologic characteristics of the bedrock aquifer in areas at AFP PJKS where the alluvial aquifer is most contaminated. More detail on these actions is provided in Chapters 5 and 6.

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SECTION 5.0
ALTERNATIVE MEASURES

Alternative measures applicable to the eight sites investigated include no action, alteration of disposal or operating practices, and additional investigative work. Site-specific issues pertaining to these alternatives are presented below.

5.1 SITE 1

Ground waters beneath the T-8A pond site were found to contained TCE (67 to 130 ug/l) and possibly NDMA (0.23 to 0.61 ug/L) at levels which exceed proposed standards or health guidelines. The significance of the contamination was considered moderate.

The no action alternative is acceptable for pond waters and sediments. It is not a feasible option for the ground waters because the potential for offsite migration via discharge to surface water and deeper ground waters exists.

Alteration of disposal or operating practices is not applicable to this site because past operating practices were responsible for present contamination problems. Present operating practices do not appear to contribute to or aggravate the ground water contamination problem.

Additional investigative efforts to further characterize the source(s) of ground water contamination, the extent of contamination, and the direction and rate of contaminant migration are warranted. Such work would consist of additional ground water monitoring, detailed structural mapping, and construction and sampling of additional monitoring wells. A recommended field program designed to address these issues is presented in Section 6.0 of this report.

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5.2 SITES 2 and 3

Ground waters downgradient from Sites 2, 3, and 7 contained TCE (up to 1,110 ug/L) and, possibly, NDMA (up to 0.28 mg/L) at levels which exceed proposed standards or health guidelines. The relative significance of these contaminants was considered moderate. Consequently TCE and NDMA contamination are the subjects for further consideration. No contamination of significance was detected in soils of Sites 2 and 3.

Similarly to Site 1, the no action alternative is applicable to soils at Sites 2 and 3. However, it is not an acceptable option for ground waters because of the potential for ground waters to discharge to the East Fork of Brush Creek or to deeper bedrock aquifers. Alteration of disposal or operating practices is not applicable to either site because current practices of waste disposal and handling do not contribute to or aggravate the ground water problem. Further investigations to identify and quantify the source(s) of ground water contamination, the extent of contamination, and the direction and rate of contaminant migration are warranted. These include detailed structural mapping at Sites 2 and 7, and installation and sampling of additional monitoring wells within Site 2 and between Sites 2 and 7. Details pertaining to the locations of these wells and the investigative approach are provided in Section 6.0 of this report.

5.3 SITES 4 AND 5

Ground waters collected from wells positioned immediately downgradient from the T-31 storage tank and the D-1 landfill contained oil and grease (4,070 mg/L) and TCE (67 to 190 ug/L). TCE occurred at levels which exceed the proposed MCL standard. The relative significance of the organic contamination is moderate. The well waters also contained relatively high levels of gross alpha, beta, and gamma radioactivity during December, 1985 but substantially lower values were detected during May, 1986. The primary concerns are 1) to determine

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the significance of radiation measured in the well waters since uranium mineralization exists in the area and 2) to investigate the organic contamination.

Of the three alternative measures identified, the only feasible alternative consists of further investigative efforts. Background radiation levels of ground waters should be quantified before the possible effects of the disposal of low-level radioactive wastes in the D-1 landfill can be determined. This data could be obtained by the installation and sampling of a monitoring well upgradient from the D-1 landfill. Further investigation to identify and quantify the extent of organic contamination and the direction and rate of organic contaminant migration are warranted. A recommended field program which would include detailed structural mapping and installation and sampling of an additional monitoring well within Sites 4 and 5 is described in detail in Section 6.0.

5.4 SITE 7

The significance of the trace amounts of hexavalent chromium detected in sediments from ditches draining Site 7 was considered to be low. Of greater importance is the presence of NDMA contamination detected in ground waters downgradient from Site 7 at Sites 10 and possibly Site 2, and in surface waters in the East Fork of Brush Creek.

The no action alternative is feasible for ditch sediments, but may not be acceptable for operating practices of the ditch system which may be linked to ground water recharge. Past operations of the ditches may have been the source of NDMA ground water contamination via seepage through unlined portions of the ditches. Continued seepage of clean waters during present operations may accelerate the migration of pollutants toward discharge areas, including the East Fork of Brush Creek and bedrock aquifers. By lining the unlined segments of the ditches and/or discontinuing use of the ditches entirely, a possible driving head for pollutant migration may be reduced.

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Further investigative efforts aimed toward characterizing the source area(s) of contamination and defining the extent, direction, and rate of contaminant migration are warranted. Such efforts would involve detailed structural mapping, and construction and sampling of ground water monitoring wells immediately down-gradient from the ditch system, focusing primarily on the unlined ditch segments. Details of the recommended field investigation are provided in Section 6.0.

5.5 SITE 10

Ground water collected from Site 10 contained NDMA (5.2 ug/L) and TCE (490 ug/L) at levels which exceed proposed MCL standards or health guidelines. The significance of the contamination was considered moderate.

Of the three alternative measures considered, the best option is additional investigative efforts, primarily to determine the source(s) of contamination. TCE, NDMA, and, possibly, hydrazine wastes may have been co-disposed within the Construction Materials Fill Area or in its general vicinity. Alternatively, the source(s) of NDMA and, possibly, hydrazine wastes may be associated with leakage from Site 7 ditches. Past operations at Sites 2 and 3 may have contributed to TCE contamination at Site 10. In all cases, construction and sampling of additional monitoring wells in the suspect areas are needed to better define the sources of contamination. Structural mapping of the site is also recommended to determine possible hydrogeologic controls. Data gathered from the wells would also enable quantification of contamination extent and direction and rate of migration. Recommended well sites and pertinent details for such an investigative program are described in Section 6.0.

5.6 SITE 11

Surface water sampled from the East Fork of Brush Creek contained trace amounts of TCE and NDMA, which at several stations may have exceeded proposed standards or health risk guidelines. The sources of these contaminants are suspected to be Sites 2, 3, 4, 5, and 10 (TCE)

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and Sites 7 and 10 (NDMA). The contaminant migration pathway is most likely ground water. If the investigative efforts proposed for the suspected source sites are undertaken, the no action alternative for the East Fork of Brush Creek is temporarily acceptable.

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SECTION 6.0
RECOMMENDATIONS

6.1 INTRODUCTION

The eight AFP PJKS sites investigated can be divided into two categories: Category 1 - sites requiring no further action and Category 2 - sites requiring additional Phase II effort. Category 1 includes sites where there is sufficient supporting data to rule out significant public health or environmental hazards. The soil contamination and/or sediment contamination at Sites 1, 2, 3, and 7 are included in Category 1. Ground water contamination at Sites 1, 2, 4, 5, 7, and 10 and surface water contamination at Site 11 are included in Category 2 and will require additional effort to determine the magnitude and extent of detected contaminants and the direction and rate of movement. There are no sites requiring Category 3 - immediate remedial actions (Phase IV), based on this investigation. Supporting data, including field data and environmental or regulatory criteria for each site, are summarized in Table 6.1.

6.2 CATEGORY 1 - SITES REQUIRING NO FURTHER ACTION

The significance of soil and/or sediment contamination at Sites 1, 2, 3, and 7 was determined to be low based on the limited extent of contamination (Table 6.1), the low probability that pollutants are migrating offsite via either ground or surface waters, and the absence of human receptors. Therefore, no further action is recommended for the soils or sediments at these sites.

6.3 CATEGORY 2 - SITES REQUIRING ADDITIONAL PHASE II EFFORT

6.3.1 General Recommendations

Future investigations for sites requiring additional Phase II efforts are discussed below. Possible sources of contamination are

TABLE 6.1
CONCENTRATIONS OF CONTAMINANTS EXCEEDING REGULATORY STANDARDS OR HEALTH GUIDELINES^{1/}
APP PJKS

	NDMA	TCE	Oil and Grease	Gross Alpha	Gross Beta	Gross Gamma	Thorium
Standard/Criteria							
Water	0.014 ug/L ^{2/}	5 ug/L ^{3/}	None	15 pCi/L ^{4/}	50 pCi/L ^{5/}	None	None
Soil or sediment	None	None	None	None	None	None	None
Site 1							
Pond water	ND ^{6/} 7/	ND	ND ^{8/}	---	---	---	---
Pond sediment	ND	ND	584 mg/L	---	---	---	---
Soils	ND	ND	---	---	---	---	---
Ground water	0.23-0.61 ug/L	67-130 ug/L	ND	---	---	---	---
Site 2							
Soils	ND	ND	ND	---	---	---	---
Ground water	0.28 ug/L	<1.0-1110 ug/L	ND	---	---	---	---
Site 3							
Soils	ND	ND	---	---	---	---	---
Sites 4 & 5							
Ground water	ND	67-190 ug/L	<1.0-4,070 mg/L	130-270 pCi/L ^{9/}	120-250 pCi/L ^{9/}	70-140 pCi/L ^{10/}	0.3-8.2 pCi/L ^{9/14/}
				<4.5-53.5 pCi/L ^{10/}	29.6-42.8 pCi/L ^{10/}	---	0.16-0.38 pCi/L ^{10/15/}
Site 7							
Sediment	ND	ND	---	---	---	---	---
Site 10							
Ground water	5.2 ug/L	490 ug/L	---	---	---	---	---
Site 11							
Surface water	0.34-0.42 ug/L	1.3-5.5 ug/L	1.3-2.4 mg/L	<1.8-1.9 pCi/L ^{12/}	10.4-41.9 pCi/L ^{12/}	20 pCi/L ^{12/13/}	0.05-0.18 pCi/L ^{12/15/}
Sediment	ND	ND	---	---	---	---	---

1/ Except as indicated, detection limits are as follows:

NDMA	Water	Solids
TCE	0.25 ug/L	0.230 ug/g
Oil and Grease	1 ug/L	10 ug/g
	1 mg/L	1 ug/g

2/ Lifetime cancer risk of 10⁻⁵ for a concentration of 0.014 ug/L (U.S. Environmental Protection Agency, 1980a).

3/ Proposed maximum contaminant level (MCL) of EPA (40 CFR Part 141).

4/ EPA MCL including Radium-226, but excluding radon and uranium.

5/ EPA MCL as strontium.

6/ ND = none detected; --- indicates analyses were not conducted for this substance at this site.

7/ Detection limit of 5 ug/L.

8/ Detection limit of 5 mg/L.

9/ Natural uranium mineralization is known to exist in the area (Nelson-Moore et al., 1978) and may explain, at least partially, these high levels.

10/ Radiation ranges for December, 1985 sampling.

11/ Radiation ranges for May 1986 sampling.

12/ Gross gamma not analyzed for May 1986 sampling.

13/ Data from limited sampling in May, 1986.

14/ Gross gamma not analyzed; however, the gamma nuclide lanthanum-140 was detected at 20 pCi/L. All others below detection limit.

15/ Data range for thorium-228, thorium-230, and thorium-232.

16/ Data range for thorium-228 and thorium-232 only.

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identified. The first recommended action for all sites where contamination was detected is resampling and analyzing for those contaminants detected. In the case of surface water, additional sampling and analyses for radioactive contaminants should be conducted. Additional investigations at sites where ground water problems are confirmed will consist of mapping detailed geologic structure and drilling and sampling of monitoring wells to quantify the sources of contamination. Mapping geologic structure will help locate potential conduits or barriers that may affect ground water flow. Identification of source areas will enable evaluation of remedial measures designed to ameliorate and possibly eliminate contaminant loading to surface and ground waters.

6.3.2 Methodology

Structural mapping will consist of both aerial photo interpretation and field checking. Field checking will involve geologic mapping and verification of faults which were shown as linears on photos. Field work will also involve further study of faults that have been mapped previously to determine their extent and possible geohydrologic significance.

All alluvial ground water monitoring wells proposed for future studies would be screened in the saturated alluvium immediately overlying bedrock to assess the lateral extent of contaminant migration in the deeper portions of the alluvium. This screening interval assumes that the underlying bedrock is less permeable than the alluvium (Slocum) and, consequently, acts as a confining layer. In addition, potentiometric data from each well would be utilized to better quantify localized directions of ground water movement.

Two bedrock wells would be drilled and constructed in the vicinity of Sites 1, 2, 7, and 10 and one bedrock well would be installed at Site 4 or 5 in areas where alluvial ground water contamination is

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determined to be the greatest. The completed intervals of the wells would begin a minimum of 20 feet beneath the surface of bedrock to ensure adequate communication with bedrock ground waters and to reduce the potential for leakage of contaminated alluvial waters via shallow bedrock fractures. The wells would be screened for approximately 20 feet. Potentiometric data from the wells would enable quantification of vertical hydraulic gradients to assess directions of vertical movement and to evaluate the degree of hydraulic connection between bedrock and alluvial aquifers. Ground waters from these wells would be analyzed for hydrazine, NDMA, halocarbons, and radiation (Sites 4 and 5 only), to determine if contamination is migrating vertically downward into the bedrock aquifer.

Aquifer tests consisting of slug and/or constant yield drawdown tests would be conducted in both alluvial and bedrock wells for determination of in situ hydraulic conductivities. These values, in conjunction with piezometric data and assumed aquifer porosities, would provide the information necessary to allow computation of the direction and rates of ground water movement and, in turn, contaminant migration.

6.3.3 Site 1

Based on the analytical results from monitoring wells MW-1 and MW-2, ground waters at Site 1 contain TCE and, possibly, NDMA at levels which exceed proposed standards or health guidelines. As illustrated on Figure 6.1, a possible source for this contamination is the area west-northwest of the T-8A pond site between the East Fork of Brush Creek and the buried concrete flume which once conveyed deluge waters.

The recommended action for Site 1 is to first confirm the presence of NDMA and halocarbons in wells MW-1 and MW-2 by resampling and analyzing the ground water. Hydrazine should also be analyzed if a method with lower detection limit is available. Following confirmation of pollutants and detailed structural mapping of the site, proposed well MW-9, located on Figure 6.1, should be drilled, constructed, and

FIGURE 8.1



▲ MW-3
 ○ MW-9
 ⊗ 11-3

 EXISTING WELL MW-3
 PROPOSED WELL MW-9
 SURFACE WATER SAMPLING
 STATION 11-1
 UNLINED DITCH
 INFERRED DIRECTION OF
 GROUND WATER MOVEMENT



0 100 200 400 FEET

SOURCE: MOONFRO FROM MARTIN MARIETTA BASE MAP

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sampled. Ground waters from this well would be analyzed for hydrazine, NDMA, and halocarbons.

6.3.4 Sites 2 and 7

Sites 2 and 7 are discussed together because of their adjacent location and because they comprise a potential single source area for contamination. Ground water from well MW-3 at Site 2 contains TCE and, possibly, NDMA at levels which exceed proposed standards or health guidelines (Table 6.1). The ground water at Site 7 has not been investigated. Possible migration pathways for contamination from Sites 2 and 7 are along the flow lines shown on Figure 6.1 and through the unlined ditches at Site 7.

The recommended action for Sites 2 and 7 includes resampling monitoring wells MW-3 and MW-7 to confirm the presence of the contaminants (NDMA and halocarbons) and to test for hydrazine if a method with a lower detection limit is available. If the presence of contaminants is confirmed, detailed structural mapping of the site should be completed and then proposed wells MW-16, MW-17, and MW-20 should be constructed and sampled. Waters from these wells would be analyzed for hydrazine, NDMA, and halocarbons.

6.3.5 Sites 7 and 10

Sites 7 and 10 lie adjacent to the East Fork of Brush Creek and will be discussed together. The compounds NDMA and TCE were found in the ground water at levels which exceed proposed standards or health guidelines at Site 10 (Table 6.1). Site 7 ground water was not investigated in this study. The possible source areas for ground water contamination at these sites are the unlined ditches at Site 7, the area north of the East Fork of Brush Creek between the culvert draining ditch No. 2 and Site 10, and the Construction Materials Fill Area (Site 10).

It is recommended that ground water from well MW-8 be resampled and analyzed to confirm the presence of contamination. The well water

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should be analyzed for hydrazine, NDMA, and halocarbons. Following confirmation of contamination and detailed structural mapping of the site, proposed wells MW-10, MW-11, MW-12, MW-13, MW-14, and MW-15, located on Figure 6.1, should be drilled, constructed, and sampled. Ground waters from these wells should be analyzed for hydrazine, NDMA, and halocarbons.

6.3.6 Sites 4 and 5

As shown in Table 6.1, ground water at Sites 4 and 5 contains TCE at levels which exceed the proposed MCL standard. Tank T-31, which was the probable source of high levels of oil and grease contamination in well MW-5, has been steam cleaned and is no longer used. The ground water contained relatively high levels of gross alpha, beta, and gamma radioactivity. The background levels of radiation need to be confirmed before the significance of the measured radiation can be determined, since natural uranium mineralization occurs within the area (Nelson-Moore et al., 1978).

The objectives of further studies at Sites 4 and 5 are 1) to determine the significance of radiation measured in the well waters and 2) to investigate the organic contamination. Ground waters from wells MW-4, MW-5, and MW-6 should be resampled and analyzed for gross alpha, total uranium, and gamma spectroscopy (EPA Method 600). In addition, proposed well MW-18 located upstream from the D-1 landfill (Figure 6.1) should be drilled, constructed, and sampled for gross alpha, total uranium, and gamma spectroscopy. This well would be completed in alluvium. The sampling and analytical program will aid in the differentiation and quantification of natural and artificially-induced radiation sources.

Ground waters from wells MW-4, MW-5, and MW-6 should also be analyzed for halocarbons and oil and grease. Following confirmation of contamination and the completion of detailed structural mapping of the site, proposed well MW-19 would be drilled and constructed in the

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faulted and fractured bedrock downgradient of the most highly contaminated well completed in the alluvium. MW-19 would be sampled for halocarbons, oil and grease, gross alpha, total uranium, and gamma spectroscopy.

6.3.7 Site 11

The East Fork of Brush Creek surface waters contain trace levels of TCE and, possibly, NDMA, as shown in Table 6.1. Potential sources of contamination to the lower portion of the East Fork include Sites 1, 2, and 7; the area between Sites 7 and 10; and Site 10. The possible source of contamination to the upper portion of the East Fork is the D-1 landfill (Site 5).

The recommended action for Site 11 is to resample and analyze surface waters for NDMA, hydrazine (if a method with a lower detection limit can be used), and halocarbons at stations 11-6 through 11-10, in order to confirm the presence of the contaminants. If the radiation measured in ground waters at sites 4 and 5 is significantly higher than background levels, then it is also recommended that surface waters from stations 11-0 (upstream from the D-1 landfill), 11-A (outlet of D-1 landfill culvert), and 11-1 through 11-10 (Figure 6.1) be analyzed for gross alpha, total uranium, and gamma spectroscopy (EPA Method 600). This sampling and analytical program will aid in determination of quantities and mobilities of radioactive daughter products in the East Fork of Brush Creek. Sampling should be performed quarterly for radiation to assess the seasonal variation of radioactivity relative to surface flow.

APPENDIX A
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REFERENCES

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APPENDIX B
DEFINITIONS, NOMENCLATURE, AND UNITS OF MEASURE

APPENDIX B
DEFINITIONS, NOMENCLATURE, AND UNITS OF MEASURE

DEFINITIONS AND NOMENCLATURE

Alconox - Brand name of a detergent specially formulated for washing field and laboratory equipment.

Alluvial - Referring to alluvium (see).

Alluvium - Unconsolidated terrestrial sediment composed of sorted or unsorted sand, gravel, and clay that had been deposited by water.

Analyte - The substance for which an analysis is conducted.

Anticlinal arch - A fold in the geologic strata that is convex upward.

Aquifer - A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

Arkosic - Pertaining to a variety of sandstone (arkose) containing abundant feldspar and quartz, usually derived from silicic igneous rocks.

Arroyo - A steep-sided, flat-bottomed gully in an arid region that is occupied by a stream only intermittently after rains or during snowmelt.

Attitude - General term describing the relation of a directional feature in a rock to a horizontal plane.

Base/neutral/acid extractable organics - Designation for EPA method 625, which detects phthalate esters, phenols, benzidines, nitrosamines, organochlorine pesticides, polychlorinated biphenyls, polynuclear aromatics, and haloethers.

Bentonite - A sedimentary rock derived from volcanic ash. Because of its ability to absorb water and swell, it is commonly used for sealing around wells.

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Primary federal legislation governing remedial action at past hazardous waste disposal sites.

CMP - Corrugated metal pipe.

Coelution - The washing out of two or more substances from a sample.

Deluge water - Waters used to regulate test stand temperatures during rocket testing.

Displacement - General term applied to the relative movement of the two sides of a fault in any direction.

Ephemeral stream - A stream that flows for only a short period of time during the year, usually after heavy precipitation or during snowmelt runoff.

EPL - Engineering Propulsion Laboratory.

Electrical resistivity survey - A surface survey that indicates the electrical resistance of the earth to conductance of an induced electrical current. Results can be used to assess subsurface features such as the continuity of geologic conditions and the depth and extent of subsurface saturation.

Fault - A fracture or fracture zone in the earth's crust along which there has been relative displacement.

Fault strike - The direction of the intersection of the fault surface, or the shear zone, with a horizontal plane.

Fault trend - The direction of the intersection of a fault with the surface of the ground.

GC-NPD - Gas chromatography with a nitrogen-phosphorus detector; is specific for nitrogen-phosphorus compounds such as hydrazine.

Ground water region - Geologic province which contains one or more subsurface water system. Depending on numerous geologic and hydrologic factors, the subsurface water systems may or may not be aquifers.

HNU meter - An instrument that detects and quantifies organic vapor.

Hydraulic conductivity - Ratio of flow velocity to driving force for viscous flow of water under saturated conditions in soil or rock.

Hydraulic gradient - Rate of change of pressure head per unit of distance of flow at a given point and in a given direction.

Igneous rock - A rock formed by solidification of molten material.

Infiltration gallery - A system of buried pipelines in the alluvial material used to convey waters to a central pump.

IRP - Installation Restoration Program. Program instituted by Department of Defense to assure compliance with hazardous waste regulations.

Laramide event - Geologic occurrence approximately 63 million years ago that formed the Rocky Mountains.

Lithology - The physical characteristics of a rock.

M - Molarity of a solution expressed as moles of solute per liter of solution.

Magnetometer survey - A surface survey that indicates the total magnetic field intensity of the earth from a given site. Results can be used to locate subsurface features such as buried metallic objects and buried waste areas.

MEK - Methyl ethyl ketone

Metamorphic rock - A rock whose original mineralogy, texture, or composition has been changed by pressure, temperature, or the gain or loss of chemical components.

Mesozoic - A geologic era ranging from 230 million to 63 million years ago.

Micron - One-millionth of a meter.

Millipore water - Water purified by filtering through a Millipore brand filter.

MSL - Mean sea level.

OEHL - Air Force Office of Environmental Health Labs.

N - Normality of a solution expressed as number of equivalent weights of solute per liter of solution.

NDMA - Nitroso dimethylamine.

NIOSH - National Institute for Occupational Safety and Health.

Paleozoic - A geologic era ranging from 600 million to 230 million years ago.

PCB - Polychlorinated biphenyl.

Pediment - A planar, sloping rock surface forming a ramp up to the front of a mountain range in an arid region.

Pennsylvanian - A geologic period ranging from 310 to 280 million years ago.

Perched water table - An isolated body of ground water that occurs above and is separated from underlying unsaturated rocks or the main water table by an impermeable stratum.

Piezometric surface - The static level of the water in an aquifer; the surface to which water in an aquifer will rise under its full head.

Pleistocene - A geologic epoch ranging from 1 million to 10,000 years ago.

Pliocene - A geologic epoch ranging from 13 million to 1 million years ago.

Porosity - The percentage of the total volume of a rock that is pore space (not occupied by mineral).

Precambrian - Geologic time ranging from 3 billion to 600 million years ago.

Priority pollutants - Sixty-five pollutants or families of pollutants (total of 129 individual substances) listed as toxic under the Clean Water Act. Water quality criteria have been developed by the U.S. Environmental Protection Agency for these substances.

Purgeable organics - Designation for EPA methods 601 and 602 which includes chlorinated and aromatic organic compounds that are volatile and will be purged by a carrier gas bubbled through the test solution. Detection is by gas chromatograph with photo-ionization detectors and coulometric detectors or electrolyte conductivity detectors.

PVC - Polyvinyl chloride.

QA/QC - Quality assurance/quality control.

Quaternary - A geologic period ranging from 1 million years ago to the present.

RCRA - Resource Conservation and Recovery Act of 1976. Primary federal legislation governing disposal of hazardous waste.

Recent - A geologic epoch ranging from 10,000 years ago to the present.

Regolith - A layer of loose, incoherent rock material of various origins.

Strike - The angle between true north and the horizontal line contained in any planar feature (inclined bed, dike, fault plane, etc.); also, the geographic direction of this horizontal line.

Strike valley - A valley which trends in the strike (see strike definition above) direction of its underlying bedrock.

TCE - Trichloroethylene. Synonymous with trichloroethene.

TDS - Total dissolved solids.

Test cell - A facility used for fuel testing.

Test stand - A concrete and steel structure that was used in firing tests of the Titan rockets.

TKN - Total Kjeldahl nitrogen (see).

Total Kjeldahl nitrogen - A test that detects nitrogen in organic form and as ammonia, but not in nitrite or nitrate form.

Transmissivity - The intrinsic property of an aquifer represented by the product of hydraulic conductivity (permeability) and saturated thickness.

Tremie pipe - A small-diameter pipe inserted into the well annulus, through which well construction materials are introduced.

Umhos (micromhos) - Used to measure conductance. Mhos are the reverse of ohms, which measure resistance.

Unconfined aquifer - An aquifer in which the water table forms the upper boundary.

Unconformable - Refers to layers of strata that are not in immediate order of age and in parallel position. This occurred when deposition stopped, erosion removed some sediments and rock, and then deposition resumed.

USCS - Unified Soil Classification system.

Volatile organic carbon - Designation for EPA method 625 which includes chlorinated and aromatic organic compounds that are volatile and will be purged by a carrier gas bubbled through the test solution. Detection is by gas chromatography/mass spectography.

UNITS OF MEASURE

cfs - cubic feet per second
feet MSL - feet above mean sea level
g - grams
gpm - gallons per minute
mg/l - milligrams per liter
ml - milliliters
pCi/l - pico Curie per liter
nm - nanometer
ppm - parts per million
ug/g - micrograms per gram
ug/l - micrograms per liter
umhos/cm - micromhos per centimeter
mg/Kg - milligrams per kilogram
ug/Kg - micrograms per kilogram

APPENDIX C

DELIVERY ORDER

ORDER FOR SUPPLIES OR SERVICES										PAGE 1 OF 24	
2. PROC INSTRUMENT ID NO. (PIIN)		3. CALL/ORDER NO.		4. DATE OF ORDER*		5. REQUISITION/PURCHASE REQUEST PROJECT NO.		6. CERTIFIED FOR NATIONAL DEFENSE UNDER			
F33615-84-D-4403		0012		85SEP30		FY7624-85-01859		DO-S1			
7. ISSUED BY						8. ADMINISTERED BY		9. CODE			
DEPARTMENT OF THE AIR FORCE AIR FORCE SYSTEMS COMMAND AERONAUTICAL SYSTEMS DIV/PMRSC WRIGHT-PATTERSON AFB, OH 45433-6503 NEGOTIATOR: JANA L. GORDIN PHONE: (513) 255-5616						DCASMA ATLANTA 805 WALKER ST MARIETTA GA 30060-2789		S1103A			
9. CONTRACTOR NAME AND ADDRESS						FACILITY CODE		10. MAIL INVOICES TO			
ENGINEERING-SCIENCE 57 EXECUTIVE PARK SOUTH, N.E. SUITE 590 ATLANTA GA 30329 (COUNTY: DE KALB) PHONE: (404) 325-0770						MAILING DATE SEP 30 1985		11. DISCOUNT FOR PROMPT PAYMENT			
12A. PURCHASE OFFICE POINT OF CONTACT						13. PAYMENT WILL BE MADE BY		14. IF "9" FOR "G" SEE SECT "G"			
LQF/L58/LQF						DCASR ATLANTA 805 WALKER ST MARIETTA GA 30060-2789		S1102A IF "9" SEE SECT "G"			
12B. RESERVED FOR SERVICE/AGENCY USE											
14. TYPE CONTRACTOR		15. SECURITY A. CLASS		B. DATE OF DD 284		17. (RESERVED)		18. SVC/AGENCY USE		19. SURV CRIT	
A		U								20. TOTAL AMOUNT	
CONTRACT ADMINISTRATION DATA										C 231,006.39	
A. FAST PAY (1) KIND (2) TYPE						C. ABSTRACT RECIP ADP POINT		D. SPL CONT PROVISIONS		E. CONT ADMIN FUNC LMT	
O Y											
21. APPROPRIATION AND ACCOUNTING DATA						22. SUPPLEMENTAL ACCOUNTING CLASSIFICATION					
A. ACTY CLASS						B. LIMIT SUBHEAD					
U AA 9750810 0200						E75 4308 P82000 000000 00000 000000 503701					
F. CPN RECIPIENT DODAAO						G. OBLIGATION AMOUNT					
F03701						231,006.39					
23. NON-DOO CONTRACT NO.						FY7624-85-01859 **					
DELIVER/X						This delivery order is subject to instructions contained on this side of form only and is issued in accordance with and subject to terms and conditions of above numbered contract, or Non-DOO Contract No.					
PURCHASE						CONTRACT CATEGORY CODE: FAZ					
15. CHECKED, AND NO 15 IS THIS 153						16. CHECKED, special provisions					
or as specified in the schedule if within the U.S., its possessions or Puerto Rico; 18 otherwise, under 2304(a)(6).						17. If checked, Additional General Provisions apply. Supplier shall sign Acceptance on DD form 1155 and return.					
*All quantity accepted by the Government is same as quantity ordered, indicated by check mark. If different under actual quantity accepted below quantity ordered and encircle.						23. UNITED STATES OF AMERICA CHRISTOPHER D. MILLER BY: NAME OF CONTRACTING/ORDERING OFFICER AND DATE					
25. QUANTITY ORDERED HAS BEEN						26. SHIP NO.		27. D.O. VOUCHER NO.		28. TOTAL	
INSPECTED RECEIVED ACCEPTED, AND CONFORMS TO THE CONTRACT EXCEPT AS STATED										29. DIFFERENCES	
SIGNATURE OF AUTHORIZED GOVERNMENT REPRESENTATIVE						30. PAYMENT		31. PAID BY		32. Amount Verified Correct For	
35. CERTIFY THIS AMOUNT IS CORRECT AND PROPER FOR PAYMENT						COMPLETE PARTIAL FINAL				33. CHECK NUMBER	
SIGNATURE AND TITLE OF CERTIFYING OFFICER										34. BILL OF LADING NO.	
CEIVED AT 37. RECEIVED BY						38. DATE RECEIVED		39. TOTAL CONTAINERS		40. S/R ACCOUNT NUMBER	
										41. S/R VOUCHER NO.	

AFSC FORM 700

1947 HSG/FMCF, Pentagon, Washington DC 20330-6010
AF Form 402, E7-OA85-3, CH3, 26 Jun 85

C-1

PREVIOUS EDITION IS OBSOLETE.

705

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PART I SECTION B OF THE SCHEDULE SUPPLIES LINE ITEM DATA				1. PROC INSTRUMENT ID NO. (PIIN) F33615-84-D-4403		2. SPIIN 0012		3. PAGE 2 OF 24	
4. ITEM NO. 0001		5. QUANTITY* 1		6. PURCH UNIT LO		7. UNIT PRICE \$ N		8. TOTAL ITEM AMOUNT* \$ N	
9. SCTY/10. ACRN U AA N		11. NSM		12. FSCM AND PART NUMBER		13. CIRR			
14. SITE CODES A. POA B. ACP C. POS D D D		15. NOUN SAMPLING, ANALYSIS, AND DATA		16. SVC/AGENCY USE					
17. PR/MIPR DATA FY7624-85-01859-0001		18. AUTHORIZED RATE A. PROGRESS PAY B. RECoup		19. CONTRACT PERCENT FEE		20. SVC ID NO.		21. ITEM/PROJ MGR FY7624	
22. 1ST DISCOUNT A. B. DAYS		23. 2ND DISCOUNT A. B. DAYS		24. 3RD DISCOUNT A. B. DAYS		25. NET A. OVER B. UNDER		26. QUANTITY VARIANCE A. OVER B. UNDER	
27. TYPE CONTRACT		28. OPR							
29. DESCRIPTIVE DATA CONDUCT WORK IN ACCORDANCE WITH THE TASK DESCRIPTION (PAGES 4 THRU 23 HEREOF) AND SECTION C, DESCRIPTION/SPECIFICATIONS OF THE BASIC CONTRACT. SUBMIT DATA IN ACCORDANCE WITH ATTACHMENT #1, THE CONTRACT DATA REQUIRE- MENTS LIST OF THE BASIC CONTRACT, AS IMPLEMENTED BY PARAGRAPH VI OF THE TASK DESCRIPTION.									

4. ITEM NO. 0002		5. QUANTITY* 1		6. PURCH UNIT LO		7. UNIT PRICE \$ N		8. TOTAL ITEM AMOUNT* \$ N	
9. SCTY/10. ACRN U AA N		11. NSM		12. FSCM AND PART NUMBER		13. CIRR			
14. SITE CODES A. POA B. ACP C. POS D D D		15. NOUN SUPPORT		16. SVC/AGENCY USE					
17. PR/MIPR DATA FY7624-85-01859-0002		18. AUTHORIZED RATE A. PROGRESS PAY B. RECoup		19. CONTRACT PERCENT FEE		20. SVC ID NO.		21. ITEM/PROJ MGR FY7624	
22. 1ST DISCOUNT A. B. DAYS		23. 2ND DISCOUNT A. B. DAYS		24. 3RD DISCOUNT A. B. DAYS		25. NET A. OVER B. UNDER		26. QUANTITY VARIANCE A. OVER B. UNDER	
27. TYPE CONTRACT		28. OPR							
29. DESCRIPTIVE DATA SUPPORT FOR ITEM 0001									

*REPRESENTS NET AMOUNT OF INCREASE/DECREASE WHEN MODIFYING EXISTING ITEM NO.

N = NOT APPLICABLE

U = UNDEFINIZED

NSP = NOT SEPARATELY PRICED

E = ESTIMATED

- (IN QTY AND \$) = DECREASE

+ OR - (IN ITEM NO.) = ADDITION OR DELETION

CIRR: CONTROLLED ITEM RPT RQMT

SITE
CODES:

S = SOURCE

D = DESTINATION

O = INTERMEDIATE

PART I SECTION B OF THE SCHEDULE SUPPLIES LINE ITEM DATA				1. PROC INSTRUMENT ID NO. (PIIN) F33615-84-D-4403	2. SPIIN 0012	3. PAGE 3 OF 24
4. ITEM NO. 0004	5. QUANTITY 1	6. PURCH UNIT LO	7. UNIT PRICE \$ N	8. TOTAL ITEM AMOUNT \$ N		13. CIR
9. SCTY(10. ACRN CLAS J AA N	11. NSM	12. FSCM AND PART NUMBER		16. SVC/AGENCY USE		13. CIR
15. NOUN D D D CHEMICAL ANALYSIS AND DATA						
17. PR/MIPR DATA FY7624-85-01859-0004		18. AUTHORIZED RATE A. PROGRESS PAY B. RECoup		19. CONTRACT PERCENT FEE	20. SVC ID NO.	21. ITEM/PROJ MGR FY7624
22. 1ST DISCOUNT A. %	23. 2ND DISCOUNT A. %	24. 3RD DISCOUNT A. %	25. NET DAYS	26. QUANTITY VARIANCE A. OVER B. UNDER	27. TYPE CONTRACT	28. OPR
29. DESCRIPTIVE DATA PERFORM CHEMICAL TESTS IN ACCORDANCE WITH THE TASK DESCRIPTION (PAGES 4 THRU 23 HEREOF) AND SECTION C, DESCRIPTION/SPECIFICATIONS OF THE BASIC CONTRACT. SUBMIT DATA IN ACCORDANCE WITH ATTACHMENT #1, THE CONTRACT DATA REQUIREMENTS LIST OF THE BASIC CONTRACT, AS IMPLEMENTED BY PARAGRAPH VI OF THE TASK DESCRIPTION.						

PRESENTS NET AMOUNT OF INCREASE/DECREASE WHEN MODIFYING EXISTING ITEM NO.

N = NOT APPLICABLE
U = UNDERPRICED
NSP = NOT SEPARATELY PRICED

E = ESTIMATED
- (IN QTY AND S) = DECREASE
+ OR - (IN ITEM NO.) = ADDITION OR DELETION
CIRR: CONTROLLED ITEM RPT RQMT

SITE CODES:
S = SOURCE
D = DESTINATION
O = INTERMEDIATE

TASK DESCRIPTION

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION (STAGE 1)
USAF Plant PJKS, Waterton, Colorado

I. DESCRIPTION OF WORK

The overall objective of the Phase II investigation is to define the magnitude, extent, direction and rate of movement of identified contaminants. A series of staged field investigations may be required to meet this objective. The contractor shall recommend any additional investigations required beyond this stage (Stage 1), including an estimate of costs.

The purpose of this task is to undertake a field investigation at Plant PJKS, CO : (1) to determine the presence or absence of contamination within the specified areas of investigation; (2) if possible, to determine the magnitude of contamination and the potential for migration of those contaminants in the various environmental media; and (3) to identify significant public health and environmental hazards of migrating pollutants based on State or Federal standards for those contaminants.

The Phase I IRP Report (mailed under separate cover) incorporates the background and description of the sites/zones for this task. To accomplish this survey effort, the contractor shall take the following actions:

A. General

1. The contractor shall monitor all exploratory well drilling and borehole operations with a photoionization meter or equivalent organic vapor analyzer to identify potential generation of hazardous and/or toxic materials. In addition, the contractor shall monitor drill cuttings for discoloration and odor. During drilling operations, if soil cuttings are suspected to be hazardous, the contractor shall containerize them in new, unused drums and test them for EP Toxicity. The results of these tests shall be included in boring logs. A maximum of 5 samples shall be collected for EP Toxicity and solvents. In addition, the contractor shall comply with all applicable EPA, AFOSH, OSHA, State and any other regulatory agencies' regulations/procedures concerning safety during drilling, sampling, and analysis procedures. If required, a safety plan shall be filed directly with the regulatory agencies.

2. All water samples collected shall be analyzed on site by the contractor for pH, temperature, and specific conductance. Sampling, maximum holding time, and preservation of samples shall strictly comply with the following references: Standard Methods for the Examination of Water and Wastewater, 15th ed. (1980), pp. 35-42; ASTM, Section 11, Water and Environmental Technology; Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA-600/4-82-057; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix.

(1983). All chemical analyses (water and soil) shall meet the required limits of detection for the applicable EPA method identified in Attachment 1.

3. Locations where surface or sediment samples are taken or where soil exploratory borings are drilled shall be marked with a permanent marker; and the location shown on a project map of the site.

4. Field data collected for each site shall be plotted and mapped. The nature, magnitude, and potential for contaminant flow within each zone to receiving streams and groundwaters shall be estimated. Upon completion of the sampling and analysis, the data shall be tabulated in the next R & D Status Report as specified in Item VI below. All raw data shall be maintained in the contractor's laboratory for one year, and will be provided to the USAF upon request.

5. Determine the areal extent of the sites by reviewing available aerial photos of the plant, both historical and the most recent panchromatic and infrared. If available, remote sensing photos may be acquired from the plant; USDA Agricultural Stabilization and Conservation Service's Aerial Photography Division at 2505 Parleys's Way, Salt Lake City, UT 84109; EROS Data Center, Sioux Falls, SD 57198; or USGS National Cartographic Information Center, Mail Stop 507, National Center, Reston, VA 22092.

6. Split all water, sediment and soil samples as part of the contractor's specific Quality Assurance/Quality Control (QA/QC) protocols and procedures. One set of samples shall be analyzed by the contractor. The other set of samples shall be forwarded for analysis through overnight delivery to the laboratory listed below. At the time of collection, samples may also be split with the EPA or State of Colorado regulatory agencies. The agencies will provide their own sample containers.

USAF OEHL/SA
Bldg. 140
Brooks AFB, TX 78235-5501

The samples sent to the USAF OEHL/SA shall be accompanied by the following information:

- (a) Purpose of sample (analyte)
- (b) Installation name (base)
- (c) Sample number (on container)
- (d) Source/location of sample
- (e) Contract task numbers and title of project
- (f) Method of collection (bailer, suction pump, air-lift pump, etc.)
- (g) Volumes removed before sample taken
- (h) Special conditions (use of surrogate standard, special nonstandard preservations, etc.)
- (i) Preservatives used
- (j) Date and time of sampling
- (k) Sampler's name

Forward this information with each sample by properly completing an AF Form 2752 (copy of form and instruction on proper completion mailed under separate cover). In addition, copies of field logs documenting sample collection should accompany the samples.

Maintain chain-of-custody records for all samples, field blanks, and quality control samples.

7. Analyze an additional 10% of all samples, for each parameter, for quality control purpose, as indicated in Attachment 1. Include all quality control procedures and data in draft and final reports.

8. For groundwater monitoring wells, comply with the USEPA Publication 330/9-S1-002, NEIC Manual for Ground Water/Subsurface Investigators at Hazardous Waste Sites for monitoring well installation. Use only screw-type joints; no solvent glue can be used.

9. Wells shall be of sufficient depth to collect samples representative of aquifer quality and to intercept contaminants if they are present.

10. Survey elevations of all newly installed monitoring wells and soil borings with respect to a USGS bench mark on or near the plant to an accuracy of 0.01 feet. Horizontally locate the new wells to an accuracy of 1 foot and record on site maps.

11. Measure water levels at all monitoring wells as feet below the ground surface or below the top of casing elevation to the nearest 0.01 feet. Report measurements in terms of feet above mean sea level (msl). Measure static water level in wells prior to sampling and at time of well development.

12. The exact location and number of monitoring wells, borings, and augerings for each site shall be determined in the field by the contractor in consultation with the OEHL project manager. The approximate locations, and recommended number and depth of wells (including screening lengths), borings and augerings for sites under investigation are given in the site specific section of the task. Monitoring wells and borings at all landfill sites shall be drilled around the perimeter and outside of the landfill areas unless the geophysical survey indicates that there are no safety problems or buried drums.

13. Drill all monitoring wells using the following specifications:

a. Drill all wells that are less than 100 feet deep using hollow-stem auger. With the hollow-stem auger, a center stem, plug, and bit attached to the center stem may be inserted into the auger for use while drilling. This will prevent material from entering into the hollow-stem of the auger. Drill all wells that are equal to or more than 100 feet deep using mud/air rotary techniques. Where loose gravel (unconsolidated alluvial

and colluvial) is expected, the contractor shall use cable tool, air rotary with casing drive, or other pertinent drilling methods to install soil borings.

If drilling fluid additives such as bentonite or polymers are used, ensure their components will not interfere with the chemical analyses to be performed on samples. If an additive is used, a sample of the additive shall be split. One of the samples shall be analyzed by the contractor and the other sent to OEHL/SA for analysis.

Take soil samples for stratigraphic control purposes at the surface and at 2.5 foot intervals to a depth of 15 feet. From 15 feet to 100 feet, collect samples at 5 foot intervals. The contractor shall follow ASTM D1452-65, Soil Investigation and Sampling by Auger Boring; ASTM D1586-67, Penetration Test and Split-Barrel Sampling of Soils; ASTM D2487-83, Unified Soil Classification System; and ASTM D2488-69, Rec. Practices for Visual-Manual Description of Soils. Besides the Unified Soil Classification, the contractor shall also correlate the strata with local geological formations. Any visual observation of discoloration, petroleum odor, and anomalies shall be recorded on the soil boring logs. Record and store these soil samples for 0.5 year. Include pilot boring log and well completion summaries in the Final Report (as specified in Item VI below).

b. Total footage of all borings and wells in this task shall not exceed 520 linear feet. Drill a maximum of eight (8) wells. Maximum depth of each well shall not exceed 40 linear feet. Construct each well with two-inch, Schedule 40 PVC casing using threaded, non-glued fittings. Borehole of these two-inch ID (inside diameter) monitoring wells shall be six (6) inches diameter. Screen the entire saturated zone of the surficial deposits, or below the top of a confined aquifer, as it is encountered during drilling. Total screen for all wells in this task shall not exceed 160 linear feet. The screen shall consist of two-inch diameter PVC. Cap the screen at the bottom. All connections shall be flush-joint threaded. Casing and screen shall be washed in lab-grade detergent and clean potable water before installation. Prior to well completion, flush all boreholes constructed with mud rotary technique by using clean water. The screen shall be mill slotted; the practice of sawing slots in the pipe (e.g., home-made screen) is forbidden.

Gravel-pack each well with washed and bagged rounded sand or gravel with a grain size distribution compatible with the screen and formation. For monitoring well, the screen slot opening shall be 0.020 inches. Place the pack from the bottom of the borehole to two (2) feet above the top of the screen. Granulated or pelletized bentonite shall be tremied above the sand/gravel pack to a minimum thickness of five (5) feet. Place Type I Portland cement and bentonite grout from above the top of the bentonite seal to the land surface using tremie pipe with pressure grouting. The suggested proportions are 3 to 5 lb of bentonite per 94 lb sack of cement mixed with 6.5 gal of water.

Complete each well with the installation of a locking cap and clearly number the well with exterior paint. Locks shall be provided by the contractor for each well and their master key shall be delivered to the Air Force POC. Protective guard posts may be required for wells in areas where moving equipment such as a tractor and riding lawn mower is operated. If well stick-up is of concern in an area (e.g., golf course, runway, taxi-way, access roads, etc.) complete the well flush with the land surface. The contractor shall take measures to prevent surface runoff from entering into this ground-flush well.

14. Develop each well with a submersible pump, bailer, high velocity jet, surge block, and/or airlift method until the water is clear of suspended solids. If mud is used during drilling, polyphosphate dispersing agents may be used to help with mud removal. Besides the observation of suspended solids, consecutive measurement of pH, temperature, and specific conductance shall be taken during well development (stabilization test).

15. Purge wells prior to sampling. Purging will be complete when three wellbore volumes of water have been displaced or until the pH, temperature, specific conductance, color, and odor of the discharge is stabilized. Conduct purging operations using a pump or bailer. Conduct all sampling using a Teflon bailer. If water level is above the screen, the contractor shall make sure this portion of water i.e., water above the screen, has been evacuated before water sampling. This can be done by setting the pump intake above the screen first to draw off the stagnant well bore water and then lower the pump intake to the screened section to continue the purging process.

16. Decontamination Procedures

a. All sampling equipment, including components of sampling interface, shall be decontaminated prior to use between samples, and between sampling locations to avoid cross-contamination. Sampling equipment and interface shall be thoroughly washed with a laboratory-grade detergent followed by clean water, solvent (methanol), and distilled water rinses. Sufficient time shall be allowed for the solvent to evaporate and for the equipment to dry completely. The monofilament line or steel wire used to lower bailers into the well shall be dedicated to each well or discarded after each use. The calibrated water level indicator for measuring well volume and product elevation must be decontaminated before use in each well. Water sampling shall be conducted from the background monitoring wells to the "least" contaminated and finally the "most" contaminated wells, if possible.

b. The drilling rig and tools shall receive thorough initial cleaning and be decontaminated after each borehole. As a minimum, drilling bits shall be steam cleaned after each borehole is installed. Drilling shall proceed from the "least" to the "most" contaminated areas, if possible.

17. Second-column confirmation shall be required when detection limits exceed values identified in Attachment 1 for EPA Methods 8010, 8020, 608, 601 and 602 and for Standard Methods 509A and 509B. Conduct second-column confirmation on a maximum of 50% of the samples collected for these analyses. Total number of samples for Methods 8010, 8020, 608, 509A, 509B, 601, and 602 in Attachment 1 include these confirmation analyses. Report all procedures and conditions used. Second column results and parameters shall be reported with the other analysis results.

18. The maximum depth of soil borings, excluding shallow soil augering, shall be 40 feet. Perform a minimum of 19 borings. Collect soil samples for chemical analysis at site specific intervals (see Section IB later) from the ground surface, and at depths suspected of containing waste materials, and at any major soil interface, but not to exceed five (5) samples per boring (maximum of 35 boring samples for chemical analysis). Obtain stainless steel split-spoon samples, using ASTM Method D-1536.

19. Upon completion of operations at each boring, grout the borehole from the bottom of the hole to the land surface in order to prevent cross-aquifer contamination. The grout mixture shall be the same as discussed in Section IA13b.

20. Whenever possible, measure water levels in all boreholes after the water level has stabilized.

21. Conduct a literature search to complement the Phase I Report (mailed under separate cover) for local hydrogeologic conditions. Data generated in this literature search shall complement Phase I Report data such that the following list will be complete. This list of data shall be utilized by the contractor to pinpoint well locations, sampling points, etc. In addition, these data shall be included in Appendix D of the Final Report of this effort.

a. Topographic data

b. Geologic data

(1) Structure

(2) Stratigraphy

(3) Lithology

c. Hydrologic data

(1) Location of existing wells, observation holes and springs within a one-mile radius of sites to be investigated

(2) Groundwater table and potentiometric contours

(3) Depth to water

(4) Quality of water

(5) Recharge, discharge, and contributing areas

d. Data on existing wells, observation holes, and springs within a 1-mile radius of sites to be investigated and the Kassefer water treatment plant

- (1) Location, depth, diameter, type of wells, and logs
- (2) Static and pumping water level, hydrographs, yield, specific capacity, quality of water
- (3) Present and projected groundwater development and use
- (4) Corrosion, incrustation, well interference, and similar operation and maintenance problems
- (5) Location, type, geologic setting, and hydrographs of springs
- (6) Observation well networks
- (7) Existing water sampling sites

e. Aquifer data

- (1) Type, such as unconfined, artesian, or perched
- (2) Thickness, depths, and formational designation
- (3) Boundaries
- (4) Transmissivity, storativity, and permeability
- (5) Specific retention
- (6) Discharge and recharge
- (7) Ground and surface water relationship
- (8) Aquifer models

f. Climatic data

- (1) Precipitation
- (2) Evapotranspiration

22. All well drilling, development, purging, and sampling methods must conform to State and other applicable regulatory agencies' requirements. Include in the Appendix the names of all approving regulatory personnel and dates that they accepted drilling techniques, well development, purging, and sampling methods.

23. Summarize sampling methods used, detection levels, and holding times in a table included in the Appendix. The sample holding times shall not be exceeded. The contractor shall coordinate with his(her) laboratory before executing field sampling to assure the holding time will not be exceeded.

24. Include second column confirmation results in the report. These shall include what columns were used, conditions, and the two different retention times for major components.

25. Internal quality control procedures and data (lab blanks, lab spikes, and lab duplicates) as well as field quality control measures shall be included in the draft finals and final reports.

2b. Determine available techniques for well abandonment. Consider that these wells will be abandoned at some future date after the study objectives have been met and there is no longer a need for the wells. Recommend a candidate method(s) or technique to apply, including costs for well abandonment. The actual process of well abandonment is not a part of this study at this time.

3. Site Specific

In addition to items delineated in Section A above, conduct the following specific actions at following sites:

1. T-8A Containment Pond (Site 1)

a. Install alluvial monitoring wells. A total of three, 40-foot alluvial monitoring wells shall be constructed at this site. One monitoring well shall be installed directly upgradient of Pond T-8A; another shall be installed directly downgradient of Pond T-8A, between the containment and the spill ponds, and the third well shall be located southeast of Pond T-8A. The wells will be drilled to bedrock which is approximately 40 feet below ground surface. The wells shall be completed using PVC threaded joint casing and well screen.

b. Collect groundwater samples. Groundwater samples shall be collected from the installed wells.

c. Analyze the three groundwater samples for hydrazine, phenols, purgeable organics, base/neutral/acid extractable organics, MEK, oil and grease, pH, temperature, specific conductance, total dissolved solids (TDS), Nitroso Dimethyl amine (NDMA), Monomethyl hydrazine (MMH), Unsymmetrical dimethyl hydrazine (UDMH), metal scan (lead, cadmium, thallium, arsenic, selenium, mercury, total chromium and hexavalent chromium), Kjeldahl nitrogen, nitrate, and nitrite.

d. Conduct soil sampling. Soil borings shall be conducted at five (5) locations in a reported spoil bank immediately west of Pond T-8A. These borings shall be conducted by the split-spoon/hollow/stem auger method or other applicable methods. Soil samples shall be collected at 1, 3, 6, and 10 feet depths. Soil samples shall be selected for chemical analysis based on QVA readings and field observations of signs of contamination. Average depth of these boreholes is 20 ft. Record the depth to water of each borehole.

e. Analyze soil samples. The contractor shall analyze the 20 soil samples for hydrazine, phenols, purgeable organics, hexavalent chromium, NDMA, Kjeldahl nitrogen, nitrate, and nitrite.

f. Characterize Pond T-8A water and sediment. Collect one water sample 2 feet below water surface from Pond T-8A and analyze for the parameters listed in IB1c and base/neutral/acid extractable organics.

Collect one pond sediment near the pond center and analyze for hydrazine, phenols, purgeable organics, base/neutral/acid extractable organics, MEK, oil and grease, NDMA, MHH, UDMH, metal scan of IBIC, Kjeldahl nitrogen, nitrate, and nitrite.

2. T-5A, T-5B EPL Test Cell, Valve Shop, Ready Storage Area
(Site 2)

a. Put down four soil borings. Four soil borings shall be conducted to the depth of 15 feet or to the groundwater table, whichever is higher. One boring shall be placed near the western corner of Building T-5A, one shall be placed along the eastern corner of Building T-5B, one shall be placed along the ditch just east of Building T-5B, and one shall be placed adjacent to the drainage flume south of Buildings T-5A and T-5B. An organic vapor analyzer (OVA) or similar equipment will be used to monitor the sealed container head space of all samples, the air space above each boring and the breathing zone around each boring. Samples shall be taken at the surface and at 3-foot intervals or at depths that have high OVA readings. A maximum of 12 samples shall be selected for chemical analyses based on OVA readings and field observations of signs of contamination.

b. Analyze soil samples. The twelve soil samples shall be analyzed for NDMA, purgeable organics, hydrazine, Kjeldahl nitrogen, nitrate, and nitrite.

3. EPL Building T-6 and T-20 (Site 3)

a. Conduct two soil borings. Two soil borings shall be put down to depths of 15 feet or the groundwater table, whichever is higher. One boring shall be located behind building T-20 where TCE has apparently been dumped on the ground; the other boring shall be located between buildings T-6 and T-20. Samples shall be taken at the surface and at 3-foot intervals or at depths of high OVA readings. Based on OVA readings and field observations of contamination signs, six (6) samples shall be chosen for analysis.

b. Analyze soil samples. All samples shall be analyzed for purgeable organics and hexavalent chromium.

4. T-31 Storage Tank (Site 4) and D-1 Landfill (Site 5)

a. Perform a surface geophysical survey using electrical resistivity and magnetometer to delineate the buried trenches, to prove the existence/absence of buried drums, and to trace a plume with high electrical conductivity.

b. Put down two (2) soil borings on the land-fill at locations where surface geophysical survey confirms the absence of subsurface drilling hazard. The estimated total linear footage is 60 feet.

Put down approximately two (2) borings with a maximum of 80 linear feet downgradient of the landfill and T-31 storage tank adjacent to Brush Creek. One boring shall be placed near a culvert where it surfaces northeast of the landfill and the other shall be installed across Brush Creek from the first boring. Convert these borings into two-inch ID monitoring wells.

c. Collect one groundwater sample from each of these four monitoring wells. Analyze each sample for purgeable organics, gross alpha and beta and high resolution gamma ray, hydrazine, pH, temperature, specific conductance, TDS, NDMA, lead, selenium, arsenic, thorium, cadmium, mercury, oil and grease, Kjeldahl nitrogen, nitrate, and nitrite.

5. Systems and Components Test Facilities Storage Tanks (Site 7)

a. Collect sediment samples from ditches downgradient of the tanks. Six samples shall be taken from ditches below the lower tank (T-6034), and three samples shall be taken from the ditch along the road below the upper tank (T-6032). Special attention shall be paid to these hydrazine and hydrazine waste tanks in relation to sampling locations.

b. Analyze these nine samples for hydrazine, purgeable organics, phenols, and hexavalent chromium, NDMA, Kjeldahl nitrogen, nitrate, and nitrite.

6. Suspect Landfill (Site 10), North of Pond T-8A and Brush Creek

a. Perform a surface geophysical survey consisting of the magnetometer and electrical resistivity techniques.

b. Install a monitoring well using the results of the surface geophysical survey. The monitoring well shall be installed downgradient of the landfill between the landfill and Brush Creek. The well shall be installed and completed using procedures described for Site 1.

c. Collect one groundwater sample from this monitoring well and analyze for hydrazine, phenols, purgeable organics, pH, specific conductance, temperature, TDS, Kjeldahl nitrogen, nitrate, and nitrite.

7. Brush Creek (Site 11)

a. Perform a seepage run along Brush Creek from the headwaters near Plant PJKS fenceline to the point below the discharge point of Pond T-8A. Flow measurements shall be taken using a portable flume or a current meter to determine which reaches of the creek are gaining or losing water to the groundwater. Ten surface water stations shall be established. Special attention shall be given to the locations where hardrock changes to sedimentary rock, where the tributaries of Brush Creek contribute flows, and where Pond T-8A meets the creek. The stations shall be marked and located on a map. In conjunction with flow measurements, the contractor shall

measure pH, specific conductance and temperature at the same time. For discharge measurement, the contractor shall refer to the USGS Techniques of Water Resources Investigation, Discharge Measurement At Gaging Stations, Book 3, Chapter A8, 1969. For seepage run, refer to pp. 11-13 of the Low-Flow Investigations, Techniques of Water-Resources Investigations of the USGS, Book 4, Chapter B1, 1972, and the Texas Board of Water Engineers Bulletin 580/D, Channel Gain and Loss Investigations, 1960.

Prepare a map illustrating the relationship among the selected sampling locations and all flumes, ditches, surface and underground pipes, channels and streams which carried or may have been used to carry wastewater on and off Plant PJKS property.

b. Collect ten surface water samples and ten sediment samples along the main channel of the creek. It shall be noted that one of the stations has to be below the T-3A pond discharge point and one station above the pond discharge point, in the vicinity of Site 10.

c. Analyze these samples (water and sediment) for hydrazine, phenols, hexavalent chromium, purgeable organics, NDMA, oil and grease (water only), TDS (water only), Kjeldahl nitrogen, nitrate, and nitrite.

C. Well and Borehole Cleanup

Remove all well and boring area drill cuttings and clear the general area following the completion of each well and boring. Only those drill cuttings suspected as being a hazardous waste (based on discoloration, odor, or organic vapor detection instrument) shall be properly containerized and moved to locations within the installation (according to PJKS commander designation) by the contractor for eventual government disposal. The suspected hazardous waste shall be tested by the contractor for EP Toxicity and if liquid waste, ignitibility. The contractor is not responsible for the ultimate disposal of the hazardous drill cuttings. Disposal shall be accomplished by plant personnel.

D. Health and Safety

Comply with USAF, OSHA, EPA, State and local health and safety regulations regarding the proposed work effort. Use EPA guidelines for designating the appropriate levels of protection at the study sites. Prepare a written Health and Safety Plan for the proposed work and coordinate it directly with applicable regulatory agencies. Provide an information copy of the Health and Safety Plan to the USAF OEHL prior to commencing field operations (i.e., drilling and sampling).

E. Data Review

1. Tabulate field and analytical laboratory results, including field and laboratory parameters and QA/QC data, and incorporate them into the monthly R&D Status Reports. Forward them to the USAF OEHL for review as

soon as they become available as specified in Item VI below. Field and laboratory parameters shall include time and dates for sample collection, extraction, and analysis.

2. Upon completion of all analyses, tabulate and incorporate all results into an Informal Technical Information Report (Attn 1, Seq 2, as specified in Item VI below) and forward the report to USAF OEHL for review.

3. Data/results, generated through this undertaking, indicating a possibility of health risk (e.g., contaminated drinking water aquifer) shall be reported immediately via telephone to the USAF OEHL Program Manager.

F. REPORTING

1. A draft report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL (as specified in Item VI below) for Air Force review and comment. This report shall include a discussion of the regional/site-specific hydrogeology, well and boring logs, data from water level surveys, groundwater surface and gradient maps, water quality and soil analysis results, available hydrogeologic cross-sections, and laboratory and field quality assurance/quality control information. The contractor shall assess the impacts to the Kasseler water treatment plant and the South Platte River. The report shall follow the USAF OEHL format (mailed under separate cover). The format is an integral part of this delivery order.

2. The results section of the report shall include water and soil analysis results, field quality control sample data, internal laboratory control data (lab blanks, spikes, and duplicates), and laboratory quality assurance procedures. Provide second column confirmation results and include which columns were used, the conditions, and retention times. Summarize the specific collection techniques, analytical method, holding time, and limit of detection for each analyte (Standard Methods, EPA, etc.). The contractor shall correlate Kjeldahl nitrogen, nitrate, and nitrite with hydrazine, NDMA, NMH, and JDMH.

3. The recommendation section shall address each site and list them by categories. Category I shall consist of sites where no further action (including remedial action) is required. Data for these sites are considered sufficient to rule out significant public health or environmental hazards. Category II sites are those requiring additional monitoring or work to quantify or further assess the extent of current or future contamination. Category III sites are sites that will require remedial actions (ready for IRP Phase IV actions). Recommendations for Category III sites shall include any possible influence on sites in Category I and/or II due to their connection to the same hydrologic system. Any dependency between sites in different categories shall be clearly stated.

The contractor shall include a list of candidate remedial action alternatives including Long-Term Monitoring (LTM) as remedial action and

corresponding rationale, that, as a minimum, should be considered in selecting the remedial action for a given site. The list shall encompass alternatives that could potentially attain applicable environmental standards. For contaminants that do not have standards, the contractor may use EPA recommended safe levels for non-carcinogens (Health Advisory of Suggested-No-Adverse-Response Level*) and target levels for carcinogens (one millionth cancer risk level).

If not specifically requested, comprehensive cost or technical analyses of alternatives shall not be included. However, in those situations where field survey data indicate immediate corrective action is necessary, the contractor shall present specific, detailed recommendations. For each category above, the contractor shall summarize the results of field data, environmental or regulatory criteria, or other pertinent information supporting conclusions and recommendations.

4. For those sites in need of additional Phase II effort, identify specific requirements, if any, for future monitoring needed to determine the magnitude, extent, and direction of movement of detected contaminants. Identify potential environmental consequences of discovered contamination, where known. Provide estimates of costs by line items for additional investigations beyond this stage along with estimates of time required to accomplish the investigation. Furnish the cost data in a separately bound appendix to the final report.

5. Include in an appendix to the report the approved well drilling techniques, materials, well development, purging, and sampling methods. All well drilling, development, purging, and sampling must conform to State and/or other regulatory agencies requirements.

6. A Field Technical Operation Plan (FTOP) shall be prepared (site specific) based on the technical requirements specified in this task description. This plan will be explicit with regards to field procedures. It will include, but not limited to, field decontamination operations, sampling protocol, QA/QC field procedures, updated field schedule, etc.

7. The contractor shall prepare a briefing package for presentation. Presentation shall be site by site and include the following:

- a. a brief description of each site with overheads or slides included;
- b. a summary of the investigation of each site, i.e., work done, parameters examined, and methods used;
- c. the findings of each site;
- d. the recommendations for each site; and
- e. an overview of all sites.

Upon completion of Phase II work (second draft report), an out briefing will be presented by the contractor as directed by the OEHL. Presentation materials shall be given to the government for future use as a part of the Phase II data requirement.

G. MEETINGS

The contractor's project leader shall attend four (4) meetings to take place at times to be specified by the USAF OEHL. The meetings shall take place at Plant PJKS for a duration of one day each.

II. SITE LOCATION AND DATES:

- o Plant PJKS, Waterton (near Denver), Colorado
- o Date to be established

III. BASE SUPPORT:

A. Obtain approval to place monitor well for site 1 (T-3A pond) on Martin Marietta property.

B. Plant personnel shall assign the disposal points within the installation of all hazardous drill cuttings.

IV. GOVERNMENT FURNISHED PROPERTY: None

V. GOVERNMENT POINTS OF CONTACTS:

A. OEHL Monitor

Dr. John K. Yu
USAF OEHL/TSS
Brooks AFB, TX 78235-5501
(512) 536-2158
AV 240-2158

B. Plant Monitor

Mr. Andrew Serino
AFPRO/DET 10
Martin Marietta Denver
Aerospace
P.O. Box 179
Denver, CO 80201-0179
(303) 977-6397

C. MAJCOM Monitor

Haj. Gary A. Fishburn
USAF Hosp. Edwards/SGPB
Edwards AFB, CA 93523-5000
(805) 277-3272
AV 350-3272

D. MAJCOM

Col. M.J. Humerickhouse
HQ AFSC/SGPB
Andrews AFB, DC 20334-5000
(301) 981-5235
AV 358-5235

VI. CONTRACT DATA ITEM DESCRIPTIONS (DID)

In addition to sequence numbers 1, 5, and 11 in Attachment 1 to the contract, which are applicable to all orders, the sequence numbers listed below are applicable to this order. Also shown are data applicable to this order.

<u>Seq.No.</u>	<u>Block 10</u>	<u>Block 11</u>	<u>Block 12</u>	<u>Block 13</u>	<u>Block 14</u>
3	O/TIME	*	*	-	5
4	ONE/R	36 MAR 3	86 APR 07	87 JAN 30	**
9	ONE/R	***	***		1

* Upon completion of analytical effort before submission of 1st draft report.

** Two draft reports (25 copies each) will be required. After incorporating Air Force comments concerning the first draft report, the contractor shall supply the USAF OEHL with one copy of the second draft report. Upon acceptance of the second draft, the USAF OEHL will furnish a distribution list for the remaining 24 copies of the second draft. The contractor shall supply 50 copies plus the original camera ready copy of the final report.

*** The briefing package shall be ready one week after the submission of the second draft/final report for presentation at Plant PJKS. The USAF OEHL will inform the date of presentation later.

Attachment 1

Plant PJKS Phase II Stage 1
Analytical Methods, Detection Limits, and Number of Samples

PARAMETER	METHOD	DETECTION LIMIT	NO. OF SAMPLES	QA	TOTAL SAMPLES
Purgeable Organic Compounds	EPA 8010 & 8020 EPA 601 & 602	a b	58 soil 19 wat.	6 soil 2 wat.	93 soil ^h 30 wat. ⁱ
Base/neutral/ acid extractable organic compounds	EPA 625 EPA 8250	c	4 wat. 1 soil	1 wat. 1 soil	5 wat. 2 soil
Oil & Grease	EPA 413.2 EPA 3550, 413.2	100 ug/g	18 wat. 1 soil	2 wat.	20 wat. 1 soil
Total Dissolved solids (TDS)	EPA 160.1	1 mg/l	19 wat.	2 wat.	21 wat.
Metals, primary (1 pond water)	EPA 200 series	d	4 wat. 1 soil	1 wat.	5 wat. 1 soil
Arsenic	EPA 206.2	0.01 mg/l	4 wat.	1 wat.	5 wat.
Cadmium	EPA 213.2	0.01 mg/l	4 wat.	1 wat.	5 wat.
Chromium, 6+	SM 312B	0.05 mg/l	10 wat. 45 soil	1 wat. 5 soil	11 wat. 50 soil
Lead	EPA 239.2	0.02 mg/l	4 wat.	1 wat.	5 wat.
Mercury	EPA 245.1	0.007 mg/l	4 wat.	1 wat.	5 wat.
Selenium	EPA 270.2	0.01 mg/l	4 wat.	1 wat.	5 wat.
Thorium	SM 303C	1000 ug/l	4 wat.	1 wat.	5 wat.
Gross alpha- beta and high resolution gamma ray	spectroscopy	—	4 wat.	1 wat.	5 wat.
pH, in-situ	EPA 150.1		19 wat.	2 wat.	21 wat.
Temperature, in-situ	—		19 wat.	2 wat.	21 wat.

Specific cond. in-situ	—		19 wat.	2 wat.	21 wat.
Phenols	EPA 420.2		15 wat. 40 soil	2 wat. 4 soil	17 wat. 44 soil
MEK, 1 pond + 3 wells	EPA 8015		4 wat. 1 soil	1 wat. 1 soil	7 wat. ^j 2 soil
Hydrazine	e		19 wat. 52 soil	2 wat. 5 soil	21 wat. 57 soil
NDMA	EPA 607 ^e		17 wat. 52 soil	2 wat. 5 soil	27 wat. ^k 83 soil
MMH	e		4 wat. 1 soil	1 wat. —	5 wat. 1 soil
UDMH	e		4 wat. 1 soil	1 wat. —	5 wat. 1 soil
Kjeldahl Nitrogen	EPA 351.2		19 wate.	2 wat.	21 wat.
Nitrate	EPA 352.1		52 soil	5 soil	57 soil
Nitrite	EPA 354.1				
EP Toxicity	40 CFR 261.24	f	10 soil	1 soil	11 soil
Ignitibility	40 CFR 261.24	g	—	—	—
Solvents	40 CFR 261.24		10 soil	1 soil	16 soil ^L

a. Detection limits for halogenated & aromatic volatile organics shall be as specified for compounds by EPA Methods 8010/8020. If analytes analyses exceed 10 ug/g in soil, second column confirmation is required.

b. Detection limits for Purgeable Halocarbons & Aromatics shall be as specified for the compounds by EPA Methods 601/602. Methods 601 and 602 for volatile organics require positive confirmation by a second gas chromatographic column. This must be done before reporting positive values. Methods 601 & 602 specify the two columns to use. Second column confirmation is required when values exceed:

Benzene	0.7 ug/l
Carbon Tetrachloride	4.0 ug/l
1,2 Dichloroethane	0.1 ug/l
Methylene Chloride	4.0 ug/l
Tetrachloroethylene	4.0 ug/l
Trichloroethylene	1.0 ug/l
Vinyl Chloride	1.0 ug/l
Dichlorobenzene isomers	sum greater than 10 ug/l
Any other organics	greater than 10 ug/l

Retention times on both columns must match before reporting positive value. If no match, it will be considered as interference.

If questions are encountered about certain contaminants, the contractor may be asked to show both chromatograms used to rule out possible interference.

c. Use detection limits specified by the EPA for Method 625.

d.	Element	Estimated Detection Limit, ug/l
	Aluminum	45
	Arsenic	10
	Antimony	32
	Barium	2
	Beryllium	.3
	Boron	5
	Cadmium	4
	Calcium	10
	Chromium	7
	Cobalt	6
	Copper	5
	Iron	7
	Lead	20
	Magnesium	30
	Manganese	2
	Molybdenum	3
	Nickel	15
	Potassium	—
	Selenium	10
	Silica (SiO ₂)	53
	Silver	7
	Sodium	29
	Thallium	40
	Vanadium	3
	Zinc	2

e. USAF SAM Report, TR-82-29. For method other than USAFSAM, see ASTM D1335 (1982) for hydrazine and EPA 607 for nitroamines.

f.	Metal	ug/l of leaching solution
	As	10
	Ba	200
	Cd	10
	Cr	50
	Pb	20
	Hg	1
	Se	10
	Ag	10

- g. Test for ignitability at 140°F
- h. Total of 93 includes second column confirmation for 50% of the samples (29 duplicates).
- i. Total of 30 includes second column confirmation for 50% of the samples (9 duplicates).
- j. Total of 7 includes second column confirmation for 50% of the samples (2 duplicates).
- k. Total of 27 includes second column confirmation for 50% of water samples (8 duplicates). Total of 83 includes second column confirmation for 50% of the sediment samples (26 duplicates).
- l. Total of 16 includes second column confirmation for 50% of water samples (1 duplicate).

AMENDMENT TO DELIVERY ORDER

ES ENGINEERING-SCIENCE

1100 STOUT STREET, SUITE 1100 • DENVER, COLORADO 80204 • 303/825-8100

December 20, 1985

TELEX 450192

Dr. John K. Yu
U.S.A.F. OEHL/TS
Brooks AFB, Texas 78235-5000

Re: Relocation of PJKS monitor wells

Dear John:

Pursuant to our discussions concerning the relocation of two PJKS monitoring wells, I would like to confirm the new well locations. Referring to the attached figure, monitor well ES-3 has been moved to immediately southeast of the soil cone designated as SC-1. This position is established in a down-strike direction from the soil cone to intercept possible groundwater contaminants migrating from the cone. Monitor well ES-7 has been relocated to immediately southeast of soil cone SC-2 for the same reason. The approximate completion depth for the two wells is forty feet which corresponds with the depths of the originally proposed well locations.

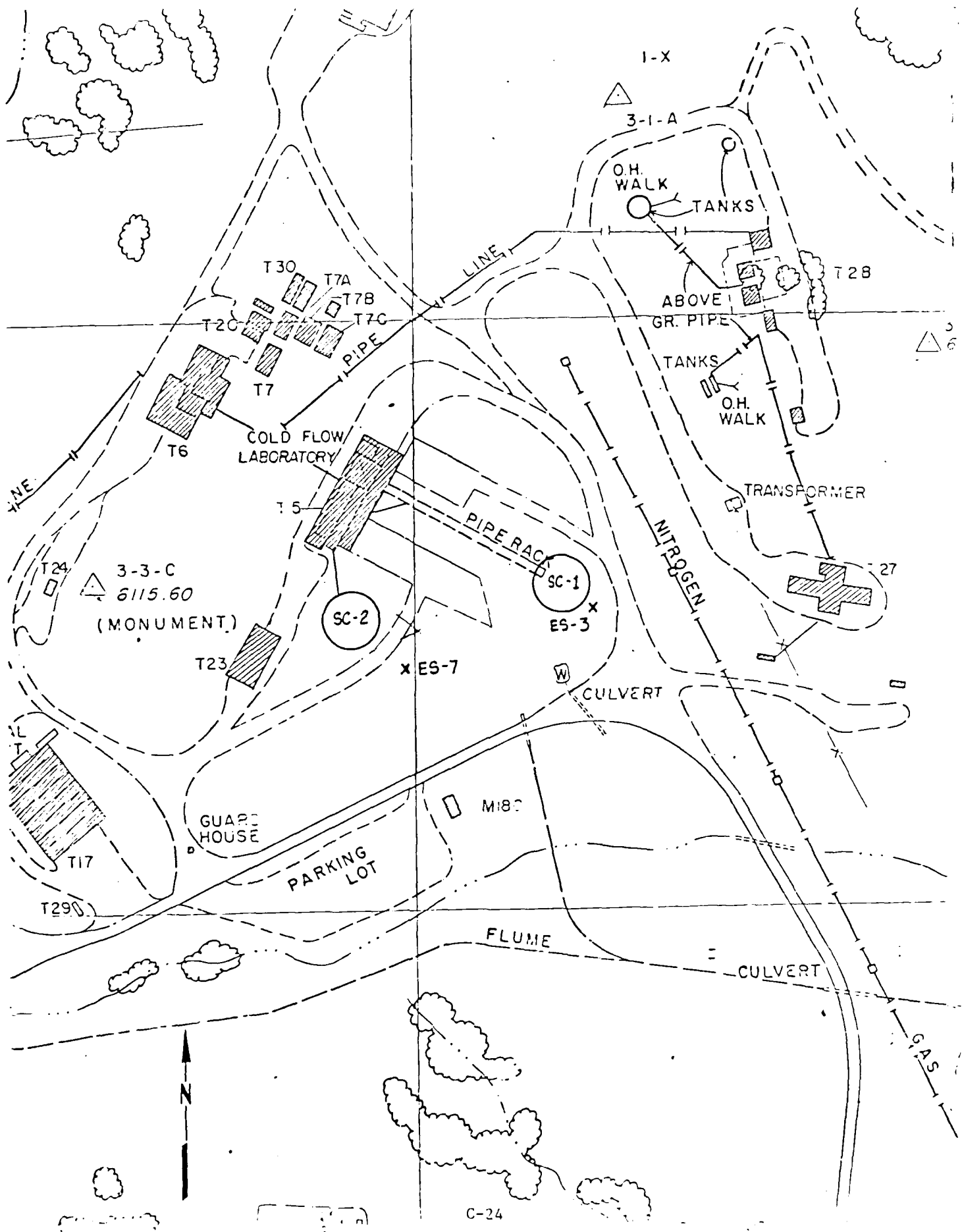
Please call me if these locations are not acceptable to you.

Sincerely,



Timothy C. Shangraw
Project Manager

cc: Ernie Schroeder



MEMO FOR RECORD

DATE: 27 December 1985

SUBJECT: Relocation of Two Proposed Monitoring Wells to Areas Below Sites 2 and 3 but Above Brush Creek, IRP II-1 Study, AFP PJKS, Waterton, Colorado

1. SUMMARY: In order to maximize information, we propose relocating the third monitoring well planned for T-8A Pond to a new site down slope from a "volcano" pile southeast of Building T5 and the fourth monitoring well planned for Sites 4 and 5 landfill to another "volcano" south of Building T23 (see attached figure). Both US EPA and Colorado Department of Health have agreed upon this modification. This modification will not incur additional cost for the AF contract with Engineering-Science.

2. INTRODUCTION: After the Air Force IRP II-1 (Installation Restoration Program, Phase II, Stage 1) contract award, Martin-Marietta collected new information concerning two potential pollution sites which were not addressed in the IRP Phase I Report. These two sites, so called "volcanoes", were used to burn waste solvents and fuels. It is desirable to collect soil and groundwater samples at these new sites in Stage 1.

3. PROPOSAL: The third monitoring well allocated to Site T-8A Pond can be relocated to the "volcano" site. Originally, the third monitoring well was proposed either below the spill retaining pond below T-8A Pond or southeast of T-8A Pond. However, Martin-Marietta has already installed a monitoring well below the spill retaining pond, and the Air Force installed a monitoring well immediately below T-8A Pond. Thus any groundwater pollution from the pond will be detected by these two downgradient wells. Although we can still install the third well southeast of T-8A Pond to define the groundwater flow direction, we feel relocating this third well to the "volcano" will gain much more needed information.

At Sites 2 and 3 the IRP II-1 Statement of Work proposes four monitoring wells; two downgradient wells and two in the landfill. After considering the new "Volcano" site, we believe it is more prudent to relocate the second landfill well to the "volcano" site.

4. REGULATORY AGENCIES' AGREEMENT: On 17 December 1985, I visited Messrs. David A. Schaller and Eric W. Johnson of the US EPA Region VIII to update them the status of IRP II-1 at AFP PJKS and the proposed relocation of monitoring wells to the new "volcano" sites. Neither of them has any objection. They indicated that they may collect split samples with us.

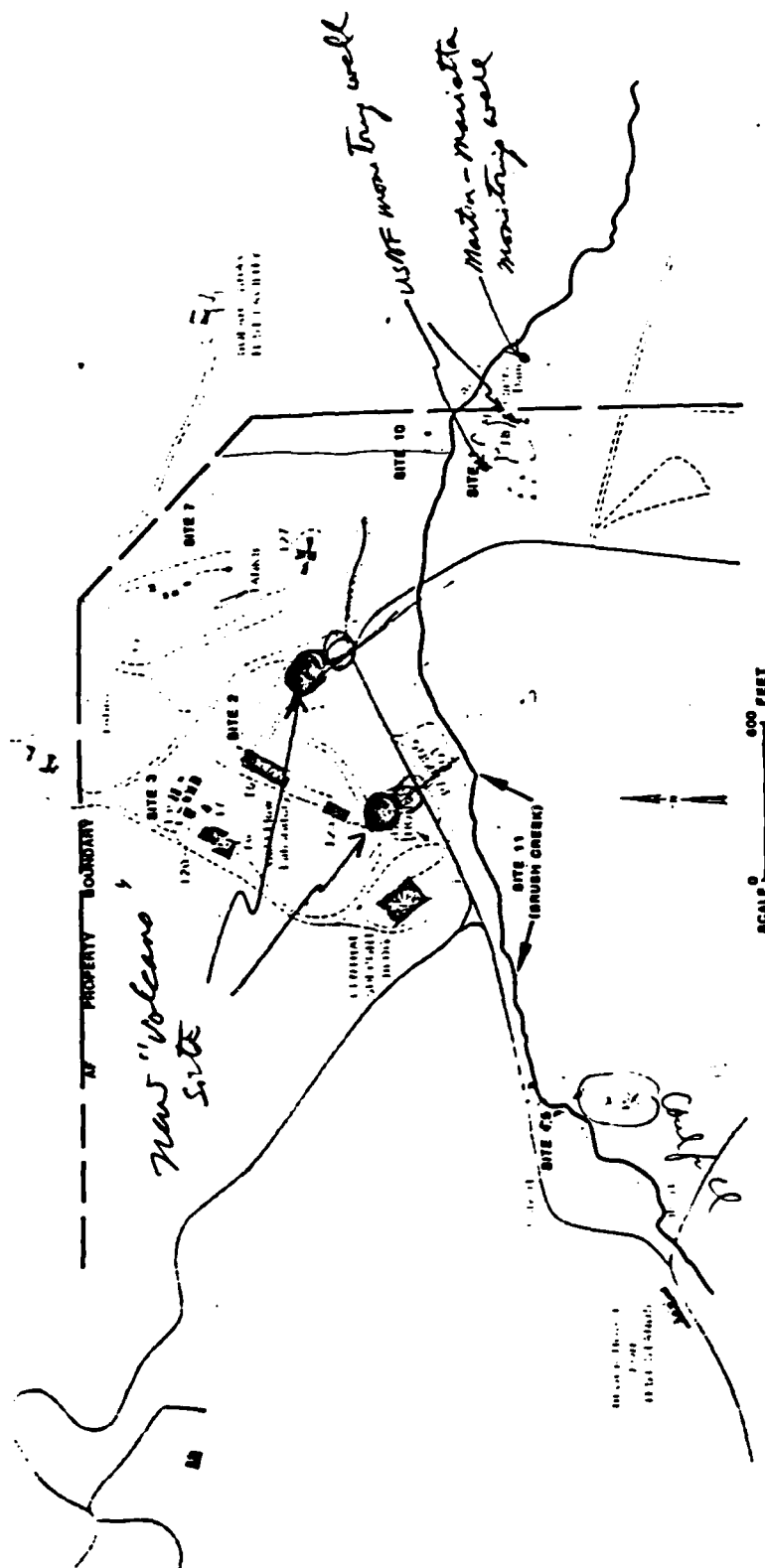
On 18 December 1985, I visited Mr. Randy Jones, Permit Section Chief, Waste Management Division of the Colorado Department of Health (The DOH project manager for AFP PJKS, Mr. Greg Starkebaum, was not available). Mr. Jones had no objection to this modification and indicated that DOH will not collect split samples with the Air Force.

5. ACTIONS: After returning to my office on 19 December, I communicated to Mr. Tim Shangraw of Engineering-Science the plan to relocate the monitoring wells to the new "volcano" sites.

John K. Yu, Ph.D.
Technical Program Manager

cc.
file (AFP PJKS, IRP II-1)
David Schaller (US EPA)
Greg Starkebaum (DOH)
• Tim Shangraw (E-S)
Lee McKittrick (AFPRO)
Col. Humerickhouse (HQ AFSC/SGPB)
Lt. Reynolds (ASD/PMDA)

AF PLANT PJKS Waterton, Colorado FIELD INVESTIGATION SITES



APPENDIX D
RESUMES OF PROJECT PERSONNEL

Biographical Data

OLA A. AWOSIKA

Engineering Geophysicist/Hydrogeologist

PII Redacted

EDUCATION

B.S. Geological Engineering, 1980 University of Mississippi,
University, Mississippi

M.A. Geology (Geophysics), 1983 State University of New York
at Buffalo, New York

PROFESSIONAL AFFILIATIONS

Member: National Society of Professional Engineers

Member: Society of Exploration Geophysicists

EXPERIENCE RECORD

1983-1985 Recra Research Inc., 4248 Ridge Lea Rd., Amherst, NY
14226.

Well installation, drilling, statistical analyses and
quality control of geotechnical and hydrogeological
data, development of computer programs for reducing,
analyzing and formatting data bases for geological,
geotechnical hydrogeological and geophysical data,
geophysical investigation of hazardous and toxic
waste sites, technical report preparation on geolo-
gical and geophysical investigations, cost estimate
of geophysical projects. Supervision of supporting
staff.

1980-1983 S.U.N.Y. at Buffalo, NY 14226.

Acquisition of geophysical data: Seismic, magnetic,
gravity and resistivity. Reduction, analyses and
interpretation of acquired data. Computer applica-
tion to geological and geophysical analyses (model-
ling, graphing, mapping, programming).

1976-1980 University of Mississippi, MS 38677

Field surveys, mapping, laboratory exercises.
Engineering application to geological processes.

PUBLICATIONS

Masters Thesis: Geophysical Interpretation of Magnetic Data from the Northeastern United States and Adjoining Parts of Canada.

PAPERS AND PRESENTATIONS

- (1984) 1) Pine Avenue Waste Disposal Site Expansion Program - Geophysical Surveys.
- (1984) 2) Statistical Analyses on Hydrogeological, Geochemical and Geological Data to Evaluate Parameters of Significant Interest in Establishing Background Levels for Groundwater Monitoring Programs.
- (1985) 3) Statistical and Quality Control Analyses of Geotechnical and Hydrogeological Data - Indian Creek, Huntsville Spring Branch, Huntsville, Ala.
- 4) Technical Reports on Geophysical Investigations at; Gowanda, Markhams and Rochester, New York, (State Superfund Projects).

Biographical Data

ERNEST L. DALY, JR.

Chemist

PII Redacted

Education

B.S., Chemistry and Biology, University of Miami, 1978
M.S., Biology, University of Miami, 1978

Professional Affiliations

American Chemical Society
Wastewater Treatment Plant Operator, Massachusetts

Experience Record

1973-1975	Cat Cove Marine Laboratory, Salem MA. Chief Laboratory Technician.
1978-1981	University of Miami, Coral Gables, FL. Research Associate. Environmental Chemist for the interdisciplinary research team charged with characterizing and performing an environmental assessment of the United States Department of Energy's garbage-to-gas proof of concept facility at Pompano Beach, Florida. As Co-investigator conducting Bacterial and Trace Organic analyses, developed the sampling and analysis protocol for total coliform, fecal streptococci, <u>Salmonella</u> spp., <u>Shigella</u> spp., and <u>Vibrio</u> spp. estimations in solid and liquid process streams and present as airborne contaminants at the site. Also developed and conducted analyses, including necessary clean-up, for chlorinated pesticides in the solid and liquid process and effluent streams. Responsibilities have included coordination of sampling for all sub-groups, maintenance of the analytical laboratories and laboratory instruments (including gas chromatographs, atomic absorption spectrometer, UV/Visible spectrophotometers, incubators, distillation equipment, refrigerators and freezers), supervision of all biological and chemical analytical work especially of liquid and solid samples, technical advisor to the Leaching/Modeling and Air Quality sub-groups, coordinator of purchasing for the team, and designer of the new Resource Recovery Laboratory of the Department of Mechanical Engineering.

Ernest L. Daly, Jr.
(Continued)

ES ENGINEERING-SCIENCE

- 1981-1983 Cornell Associates, Inc., Coral Gables, FL. Senior Environmental Chemist. Wrote proposal/contract letters for potential clients, including cost analysis. Conducted sampling and analysis of environmental samples for nutrients, bacteria (total and fecal coliforms, fecal strep, and sterility testing), trace metals, and other environmentally important anions and cations, and gross chemical and physical characteristics such as BOD, moisture, solids, fractional distillations, and oil and grease; in seawater, surface and ground waters, muds, wastewaters, and hazardous wastes. Arranged for subcontractors to analyze for parameters which could not be done in-house, such as pesticides, trihalomethanes, and other analyses by gas chromatography. Maintained analytical instruments including atomic absorption spectrometer with both furnace and flame capability, Auto-analyzer, furnace spectrophotometers, and field instruments such as oxygen and salinity/conductivity meters, and composite samplers.
- 1983-1984 Florida International University, Miami, FL. Research Assistant Professor. Analytical quality control officer for a multidisciplinary team conducting research into the degradation of ethylene dibromide, trichloroethylene and other hazardous chlorinated and brominated compounds, in groundwater environments. Supervised a group of analysts responsible for nutrient, trace metal, gas and volatile organic analyses. In addition, advised the bacteriological analyst on techniques for identification and quantitation of environmentally important bacteria.
- 1984-1985 Chem-Technics, Inc., Atlanta, GA. Senior Research Scientist and Manager, Product Development Laboratory and Biological Laboratory. Initiated and conducted investigations into detoxification techniques for organic compounds present in industrial waste streams. Established and supervised a biological testing laboratory for conducting bioassays on fish, bacteria, and algae.
- 1985-Present Engineering-Science, Inc., Atlanta, GA. Project Scientist responsible for many activities within the Technology Development Department. Lead responsibility for investigations into fixation of arsenic sludge produced in the manufacture of food grade phosphoric acid. Also, as Assistant to the Quality Assurance officer, responsible for preparation of Q.A. samples and routine review of Quality Control data.

Publications/Presentations

- E. L. Daly, Jr., S. Farooq, (A. Dasgupta, S. Sengupta, K. V. Wong and H. P. Gerrish). 1982. Reliability of analytical methods for anaerobic municipal solid waste samples. JWPCF 54, pp. 187-192.
- E. L. Daly, Jr., and J. S. Prince. 1981. The ecology of Sargassum pteropleuron Grunow (Phaeophyceae, Fucales) in the waters off South Florida. III. Seasonal variation in alginic acid concentration. Phycologia 20, pp. 352-357.
- J. S. Prince and E. L. Daly, Jr. 1981. The ecology of Sargassum pteropleuron Grunow (Phaeophyceae, Fucales) in the waters off South Florida. IV. Seasonal variation in mannitol, protein, ash, and laminaran. Phycologia 20, pp. 232-241.
- S. Sengupta, D. Dasgupta, K. V. Wong, E. L. Daly, Jr., S. Farooq, and H. P. Gerrish. 1981. Numerical simulation of chemically reacting flows through soils: a parametric study. International Journal Simulation 1, pp. 21-23.
- A. Dasgupta, N. L. Nemerow, S. Farooq, E. L. Daly, Jr., S. Sengupta, H. P. Gerrish, and K. V. Wong. 1981. Anaerobic digestion of municipal solid waste. Biocycle, March-April, 1981, pp. 34-38.
- K. V. Wong, S. Sengupta, D. Dasgupta, E. L. Daly, Jr., N. L. Nemerow, H. P. Gerrish. 1981. Transport of heavy metal pollutants in saturated porous media. Biocycle, Sept.-Oct., 1981.
- E. L. Daly, Jr., S. A. Voorhees, R. Narasimhan, H. P. Gerrish, S. Sengupta, N. L. Nemerow, and K. V. Wong. 1983. Airborne coliforms at a municipal solid waste processing facility. Second Conference on Municipal, Hazardous, and Coal Wastes Management, Miami Beach, Florida.
- S. A. Voorhees, E. L. Daly, Jr., S. Sengupta, K. V. Wong, H. P. Gerrish, and N. L. Nemerow. 1982. Bacterial levels as a function of operating temperatures at a municipal solid waste anaerobic digester. IN: S. Sengupta and K. V. Wong (eds.). Resource Recovery from Solid Wastes (New York: Pergamon Press), pp. 125-133.
- M. M. Streitfeld, F. J. Roth, Jr., B. Chester, S. A. Voorhees, E. L. Daly, Jr., J. Samowitz, R. Narasimhan, S. Sengupta, K. V. Wong, H. P. Gerrish and N. L. Nemerow. 1982. Microbiologic content of aerosols generated in the classification shed of a municipal solid waste processing facility. IN: S. Sengupta and K. V. Wong (eds.). Resource Recovery from Solid Wastes (New York: Pergamon Press), pp. 96-108.

- R. Narasimhan, H. P. Gerrish, S. Sengupta, E. L. Daly, Jr., N. L. Nemerow, K. V. Wong, and S. A. Voorhees. 1982. Composition of gas produced by large scale anaerobic digestion of municipal solid waste. IN: S. Sengupta and K. V. Wong (eds.). Resource Recovery from Solid Wastes (New York: Pergamon Press), pp. 171-176.
- K. V. Wong, S. Sengupta, D. Dasgupta, E. L. Daly, Jr., H. P. Gerrish. 1981. Modelling and experimental study of heavy metal migrations in soil-leachate systems. Symposium on Resource Recovery and Environmental Issues of Industrial Solid Wastes, Gatlinburg, Tennessee.
- A. Dasgupta, N. L. Nemerow, S. Farooq, E. L. Daly, Jr., S. Sengupta, and H. P. Gerrish. 1981. Anaerobic digestion of municipal solid waste. Proceedings of the Second Seminar on Biomass Energy for City, Farm, and Industry, Chicago, Illinois.
- S. Farooq, A. Dasgupta, E. L. Daly, Jr., H. P. Gerrish, S. Sengupta, and K. V. Wong. 1980. Prototype demonstration studies of production of methane from municipal solid waste at Pompano Beach, Florida. Third Miami International Conference on Alternative Energy Sources, Miami Beach, Florida.
- H. P. Gerrish, J. F. Lascarro, S. Sengupta, E. L. Daly, Jr., S. Farooq, and K. V. Wong. Characterization of gas produced by the anaerobic digestion of municipal solid waste. Third Miami International Conference on Alternative Energy Sources, Miami Beach, Florida.
- S. Sengupta, K. V. Wong, S. Farooq, E. L. Daly, Jr., and H. P. Gerrish. 1980. Environmental studies on methane production by anaerobic digestion of municipal wastes. Third Miami International Conference on Alternative Energy Sources, Miami Beach, Florida.
- K. V. Wong, S. Sengupta, D. Dasgupta, E. L. Daly, Jr., S. Farooq, and H. P. Gerrish. 1980. Transport of heavy metal pollutants in saturated porous media. AAWA/FPCA/FW&PCOA Annual State Technical Conference, Orlando, Florida.

Biographical Data

LISA A. KORNER

Geochemist

PII Redacted

Education

B.S. in Geology, 1975, Rensselaer Polytechnic Institute,
Troy, New York
M.S. in Geochemistry and Mineralogy, 1977, Pennsylvania State
University, State College, Pennsylvania

Special Training

Additional coursework in computer programming, 1983, Arapahoe
Community College, Littleton, Colorado
American Red Cross CPR and First Aid Certifications, 1980

Professional Affiliations

Colorado Ground-water Association - Newsletter Editor
Computer Oriented Geological Society
Association of Exploration Geochemists
Society of Economic Geology

Honorary Affiliations

Graduated from Rensselaer Polytechnic Institute cum laude

Experience Record

1985 - Date Engineer'ng-Science, Inc. Geochemist and Computer
Specialist. Responsible for investigating the dis-
persion of pollutants in acid mine drainage, providing
geochemical characterization of tailings containing
hazardous substances, and evaluating water quality data
using statistical techniques at two Superfund mining
sites in the Colorado mountains. Conducted field
investigations to detect and characterize subsurface
migration of contaminants at Air Force Plant PJKS in
Colorado for the U.S. Air Force Installation Restoration
Program.

Lisa A. Korner (Continued)

- 1983 - 1985 Cygnus Geoscience Consultants, Inc. Vice President and Senior Geochemist/Geologist. Developed own successful consulting business. Prepared waste discharge permits and state operating permits for large cyanide heap leach mining operations. Performed technical writing and editing of numerous reports for engineering firms. Researched geology and geochemistry of western Montana, conducted field trips, and presented results in oral and written reports. Developed geochemical programs for microcomputers including data base and statistics.
- 1977 - 1983 Exxon Minerals Company. Exploration Geochemist. Developed and conducted geochemical exploration programs for base metals ore deposits. Evaluated geochemical data using statistical techniques. Planned and managed a substantial exploration budget for geological, geochemical, land, and drilling expenses. Responsible for training field personnel, supervising drilling operators, and coordinating company support groups.
- 1975 - 1977 Pennsylvania State University. Research Assistant. Researched the geochemistry of radon, radium, and uranium in ground and surface waters near uranium deposits. Operated prototype radon detection instrument in both field and laboratory settings. Developed uranium dispersion models for ground water.

Publications

- "Radon in Natural Waters as a Guide to Uranium Deposits in Pennsylvania," in Geochemical Exploration 1978, Watterson, J.R., and P.K. Theobald, eds., Proc. of the 7th International Geochemical Exploration Symposium, Assoc. of Explor. Geochem., 1979 (Coauthor A.W. Rose).
- "Radon in Streams and Ground Waters of Pennsylvania as a Guide to Uranium Deposits," Open File Report GJBX-60(77), U.S. ERDA, Grand Junction, Colorado, (Coauthor A.W. Rose).

Biographical Data

TIMOTHY S. MUSTARD

Health and Safety Officer

PII Redacted

Education

B.S. in Botany, 1976, Michigan State University, East Lansing
M.S. in Plant Systematics, 1979, Michigan State University, East Lansing

Special Training

MSA Air Mask Maintenance Certification (1985)
Red Cross CPR and First Aid Certifications (1985)
EPA Response Decision-Making Workshop (1985)
Basic Principals of Hazardous Waste Site Investigation (1984)

Professional Affiliations

American Society of Plant Taxonomists
International Association for Plant Taxonomy
Michigan Botanical Club
Professional Association of Diving Instructors

Experience Record

1985-Date Engineering-Science, Inc. Health and Safety Officer.
Developed and implemented site health and safety plans and conducted health and safety field audits; prepared written procedural documents for respiratory protection of personnel and conducted several workshops on health and safety and respiratory protection. Served as quality assurance manager for hazardous waste site investigations. Projects included asbestos investigations at the U.S. Air Force Academy in Colorado Springs, characterization and cleanup of the Micronutrients CERCLA site in Utah, site characterization and damage assessments at

Timothy S. Mustard (Continued)

two CERCLA mining sites in the Colorado mountains, and hazardous waste investigations at a former pesticide formulating plant in Arizona.

1981-1985

Camp Dresser & McKee, Inc. Plant Ecologist and Hazardous Waste Site Technician. Served as field investigator, site health and safety officer, and decontamination supervisor for hazardous waste site investigations in Washington and Oregon. Received certification to conduct "Superfund" hazardous waste site activities. Assisted in the preparation of three RCRA Part B applications as well as several hazardous waste site work plans, project operation plans, and health and safety plans. Served as project manager of a reclamation project for 760 abandoned mines in Wyoming; conducted endangered species surveys; and conducted numerous permitting and environmental resources inventory studies for coal and synfuel mines and electric utility sites nationwide.

1979-1980

Camp Dresser & McKee, Inc. Plant Ecologist. Chief field botanist for site selection surveys for electric utilities in Michigan and Wisconsin, and environmental resources inventories of underground coal mine sites in Indiana. Other responsibilities included report and proposal writing, and assisting in bird, mammal, herpetofaunal, and benthic macroinvertebrate field and laboratory studies.

1979

Private consultant for Michigan Department of Natural Resources, Lansing, Michigan. Conducted studies of distribution, abundance, habitat requirements, and management considerations of a threatened plant species occurring at a burial site for livestock contaminated with polybrominated biphenyl (PBB).

Publications and Presentations

Mustard, T.S. 1983. The vegetation of the Manistee National Forest, Oceana and Mason Counties, Michigan. II. Checklist of vascular plants. Michigan Botanist 22:151-161.

Mustard, T.S. 1983. The vegetation of the Manistee National Forest, Oceana and Mason Counties, Michigan. I. Physical, historical and ecological aspects. Michigan Botanist 22:111-122.

Mustard, T.S. 1982. The distribution and autecology of pale agoseris, Agoseris glauca in Michigan. Michigan Botanist 21:205-211.

Timothy S. Mustard (Continued)

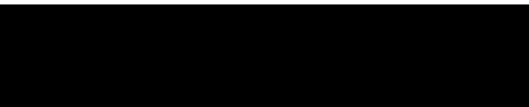
Mustard, T.S., M.W. Davis and H.D. Bredwell. 1978. The Nature of Grand Ledge. Published by the Grand Ledge, Michigan Bicentennial Commission. 68 pp.

Biographical Data

FRANK N. REPPLIER

Geologist

PII Redacted



Education

B.S. in Geological Sciences, 1978. Pennsylvania State University.

Preliminary Graduate Course work, spring 1984- spring 1985, University of Colorado at Denver.

Professional Affiliations

Colorado Groundwater Association
Governmental Refuse Collection and Disposal Association
Resource Recovery Committee of the Waste Management Advisory Council

Experience Record

1978-1979	The Analysts Inc., A division of Schlumberger. Well-logging on- and off-shore Texas and Louisiana.
1979-1981	Department of Natural Resources - Colorado Geological Survey, Groundwater Division. Helped compile all existing ground water quality data in the state, mapped all alluvial and bedrock aquifers and established a computer-based data bank with this information. Responsible for several geothermal resource publications.
1982	Hydroelectric Development Inc., Denver, Colorado. Technical expert for siting potential hydro sites and prefeasibility studies.
1982-1983	Colorado Department of Health, Waste Management Division. Responsible for review of Engineering Design and Operations Reports for new solid and liquid waste facilities in the state; inspection of current facilities; hazardous waste and RCRA inspections, and incident response (spills).
1984-Date	Engineering-Science, Inc. Geologist.

FRANK N. REPPLIER (Continued)

Publications

Repplier, F.N., 1981. Geothermal Gradient Map of Colorado: Colorado Geological Survey Map Series 20.

Repplier, F.N., M. Relf, K. Columbia, 1981. Groundwater Temperature Map of Colorado: CGS Map Series 21.

Repplier, F.N., P.C. Healy, 1981. Atlas of Ground Water Quality in Colorado: CGS Map Series 16.

Repplier, F.N., T.G. Zacharakis, C. Ringrose. Geothermal Resources of Idaho Springs: CGS Resource Series 16.

Biographical Data

ERNEST J. SCHROEDER

Environmental Engineer
Manager, Solid and Hazardous Waste Dept.

PII Redacted

Education

B.S. in Civil Engineering, 1966, University of Arkansas,
Fayetteville, Arkansas
M.S. in Sanitary Engineering, 1967, University of Arkansas,
Fayetteville, Arkansas

Professional Affiliations

Registered Professional Engineer (Arkansas No. 3259, Georgia
No. 10618, Texas No. 33556, and Louisiana No. 21685)
Water Pollution Control Federation
American Academy of Environmental Engineers

Experience Record

1967-1976 Union Carbide Technical Center, Engineering Department,
South Charleston, West Virginia (1967-1968). Project
Engineer. Responsible for environmental protection
engineering projects for various organic chemicals and
plastics plants. Conducted industrial waste surveys,
landfill design, and planning for plant environmental
protection programs; evaluated air pollution discharges
from new sources; reviewed a wastewater treatment plant
design; and participated on a project team to design a
new chemical unit.

Union Carbide Corporation, Environmental Protection
Department, Texas City, Texas (1969-1975). Project
Engineer and Engineering Supervisor. Responsible for
various aspects of plant pollution abatement programs,
including preparation of state and federal permits for
wastewater treatment activities.

Operations Representative on \$8 million regional waste-
water treatment project and member of design team which
made the initial site selection and process evaluation
and recommendation. Participated in contract negotiations,
process and detailed engineering design, construction of

Ernest J. Schroeder

Page 2

the facilities, preparation of start-up manuals, operator training, and the start-up activities. Designated as Project Engineer after start-up on expansion to original waste treatment unit.

Engineering Supervisor responsible for operation of wastewater treatment facilities including collection system, sampling and monitoring programs, spill control and clean-up, primary waste treatment, wastewater transfer system, biological waste treatment, and waste treatment pilot plants. Developed odor control program which successfully reduced odor emissions and represented Union Carbide at a public hearing on community odor problems.

Led special projects such as an excess loss control program to reduce water pollution losses; sewer segregation program involving coordination and reporting of 38 projects for the separation of contaminated and non-contaminated water; and sludge disposal program to develop long-term sludge disposal alternatives and recover land in present sludge landfill area. Developed improved methods of sampling and continuous monitoring of wastewater.

Union Carbide Corporation, Environmental Protection Project Engineer, Toronto, Ontario, Canada (1975-1976). Responsible for the environmental permitting and engineering design of waste treatment systems associated with a new refinery.

1976-Date

Engineering-Science, Inc., Project Manager (1976-1978). Responsible for several industrial wastewater projects including the following: wastewater investigation to characterize sources of waste streams in a chemical plant and to develop methods to reduce the wastes, sludge settling studies to evaluate settling characteristics of activated sludge at a chemical plant, development of a process document for the design and operation of a wastewater treatment facility at a petrochemical complex, wastewater treatment evaluation which included characterization of wastewater, unit process evaluation, inhibition studies, design review, operations review, preparation of operations manual, operator training and providing operating assistance for waste treatment facilities, various biological treatability studies and bench-scale and pilot-scale evaluation of advanced waste treatment technologies such as granular carbon adsorption, multimedia filtration, powdered activated carbon treatment, ion exchange and ozonation.

Project Manager for hazardous waste disposal projects involving waste characterization, development of criteria for disposal of hazardous waste, site

Ernest J. Schroeder
Page 3

investigation, preparation of permits, detailed design, construction of facilities and spill clean-up activities.

Deputy Project Manager for industry-wide pilot plant study of advanced waste treatment in the textile industry. Technologies evaluated included coagulation/clarification, multi-media filtration, granular carbon adsorption, powdered activated carbon treatment, ozonation and dissolved air flotation.

Engineering-Science, Inc., Manager of the Industrial Waste Group in the Atlanta, Georgia office (1978-1980). Responsible for the supervision of industrial waste project managers and project engineers and the management of industrial waste studies conducted in the office. Also directly involved in project management, consulting with clients on environmental studies and environment assessment projects, e.g., project manager for several spill control and wastewater treatability projects and for a third-party EIS for a new phosphate mine in Florida.

Engineering-Science, Inc., Manager of Solid and Hazardous Waste Group in the Atlanta, Georgia office (1980-date). Responsible for the supervision of solid and hazardous waste project managers and project engineers and the management of solid and hazardous waste projects in the office. Project activities have included permit and regulatory assistance, environmental audits, waste management program development, delisting partitions, ground-water monitoring, landfill evaluations, landfill closure design, hazardous waste management, waste inventory, waste recovery/recycle evaluation, waste disposal alternative evaluation, transportation evaluation, and spill control and countermeasure planning, HRS evaluations, preparation of remedial investigations and feasibility studies, and design and construction supervision for hazardous waste site cleanup.

Project Manager for fourteen Phase I Installation Restoration Program projects for the U.S. Air Force. The objective of this program is to audit past hazardous waste disposal practices that could result in migration of contaminants and recommend priority sites requiring further investigation.

Conducted environmental audits (air, water and solid waste) at ten industrial facilities. Project manager for contamination assessments and hazardous waste site cleanups conducted for industrial clients as part of consent decree or administrative agreements. Project manager for site

Ernest J. Schroeder

Page 4

investigation and contamination assessment projects at multiple hazardous waste sites throughout the United States. Project manager for preparation of four Remedial Investigation/Feasibility Studies in Illinois, New York, North Carolina and Mississippi.

Technical Director for Eastern Group Hazardous Waste Projects (1985 - Date). Responsible for technical review and direction of hazardous waste projects conducted by Engineering-Science Eastern Group.

Publications and Presentations

Schroeder, E. J., "Filamentous Activated Sludge Treatment of Nitrogen Deficient Waste," research paper submitted in partial fulfillment of the requirements for MSCE degree, 1967.

Schroeder, E. J. and Loven, A. W., "Activated Carbon Adsorption for Textile Wastewater Pollution Control," Symposium Proceedings: Textile Industry Technology, December 1978, Williamsburg, VA.

Schroeder, E. J., "Summary Report of the BATEA Guidelines (1974) Study for the Textile Industry," North Carolina Section of AWWA/WPCA, Pinehurst, North Carolina, November 1979.

Mayfield, R. E., Sargent, T. N. and Schroeder, E. J., "Evaluation of BATEA Guidelines (1974) Textiles," U.S. EPA Report, Grant No. R-804329, February 1980.

Storey, W. A. and Schroeder, E. J., "Pilot Plant Evaluation of the 1974 BATEA Guidelines for the Textile Industry," Proceedings of the 35th Industrial Waste Conference, Purdue University, May 1980.

Pope, R. L., and Schroeder, E. J., "Treatment of Textile Wastewaters Using Activated Sludge With Powdered Activated Carbon," U.S. EPA Report, Grant No. R-804329, December 1980.

Schroeder, E. J., "Industrial Solid Waste Management Program to Comply with RCRA," Engineering Short Course Instructor, Auburn University, October 1980.

Schroeder, E. J., "Technical and Economic Impact of RCRA on Industrial Solid Waste Management, Florida Section, American Chemical Society, May 1981.

Schroeder, E. J. and Sargent, T. N., "Hazardous Waste Site Rating Systems," Textile Wastewater Treatment and Air Pollution Control Conference, January 1983.

Biographical Data

TIMOTHY C. SHANGRAW

Water Resource Engineer

PII Redacted

Education

B.S.C.E., 1977, Southeastern Massachusetts University, North
Dartmouth, Massachusetts

M.S.C.E., 1979, University of Colorado, Boulder, Colorado

Special Training

Geophysics Workshop, 1985, Colorado Ground Water Association.

Microcomputer Workshop for Ground Water Modeling, 1984, Colorado
Ground Water Association

Continuing Education in Computer Science, 1983, University of
Colorado, Denver, Colorado

Professional Affiliations

Registered Professional Engineer in Colorado (No. 19853)

National Water Well Association

Colorado Ground Water Association

Colorado Association of Commerce and Industry

Colorado Hazardous Waste Management Society

International Mine Water Association

Honorary Affiliations

Graduated S.M.U. with Distinction

Experience Record

1984 - Date	Engineering-Science, Inc. <u>Project Manager</u> . Responsible for hydrogeologic, hydrologic, and hazardous waste studies. Managed comprehensive ground water and contamination assessments for hazardous waste facilities in Wyoming, Utah and Arizona. Studies consisted of Part B permitting, aquifer restoration, site closures, and risk assessments, and involved field drilling and sampling programs, preparation of assessment reports, ground water modeling, evaluation of corrective action alternatives, and design and implementation of ground water monitoring
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TIMOTHY C. SHANGRAW (Continued)

programs. Client and regulatory liaison were integral to these investigations.

Evaluated potential impacts to subalpine watersheds from acid rain in Colorado's Mt. Zirkel Wilderness Area. Study focused on relationships between acid rain, surficial buffering capacities, and mineral dissolution. Outflow hydrographs were used to quantify magnitudes of potential damage.

Investigated treatment and disposal alternatives for the disposition of residential wastewaters at a proposed mountain development in Utah. Onsite treatment and/or disposal options were compared against centralized treatment options. The feasibility and economics of each option were evaluated.

1983-1984

Law Engineering Testing Company, Englewood, Colorado. Project Engineer. Performed RCRA compliance studies at wood preserving sites in the midwest, southeast and northwest U.S. Conducted hydrogeologic field investigations, reduced and interpreted field data and prepared reports describing site geohydrology. Performed a baseline hydrologic and geotechnical investigation for a landfill siting study in Oregon.

Performed flood plain analyses on a major river in Colorado. Encroachment into the 100-year flood plain was evaluated for its effect on a five-mile-long stretch of the river's flood plain. Limits of encroachment were determined based on an acceptable maximum rise in flood plain elevation. The HEC-2 computer model was utilized in the analyses.

Prepared drainage reports for land development projects in Colorado. 100-year flood flows were computed for both onsite and offsite drainage basins. Where necessary, detention facilities were sized and placed onsite to assure release of design storm historic flows. Provisions for routing the 100-year flood flows through the study sites were also evaluated. Report preparation necessitated analyses of street carrying capacities, sizing of storm sewers, design and placement of street inlets, inlet and outlet control structures and drainage conveyance channels.

1980-1983

D'Appolonia Consulting Engineers, Englewood, Colorado. Staff Engineer. Performed hydrologic baseline studies for the mining industry, layout and

TIMOTHY C. SHANGRAW (Continued)

design of surface drainage facilities and evaluations of mine water inflows and dewatering requirements for surface and underground mines. Potable water treatment facilities and associated distribution lines were also designed. Conducted geotechnical and hydrogeologic investigations for an earth-filled water supply impoundment and for surface facilities associated with an underground coal mine. Performed onsite assessments of reclamation potential for abandoned mine sites in Wyoming.

Supervised field activities at a hazardous waste cleanup project in Philadelphia, Pennsylvania. Managed transfer and repackaging of organic/inorganic compounds, pesticides and laboratory chemicals. Drum staging, manifesting and shipping were supervised to ensure compliance with RCRA guidelines. Concurrently enforced OSHA health and safety regulations.

1979-1980

Cyprus Mines Corporation - Hansen Project, Canon City, Colorado. Staff Engineer/Hydrologist. Responsible for the design and implementation of aquifer test programs, reduction and interpretation of test results and supervision of a computer modeling study for mine dewatering. Implemented surface and ground water monitoring programs, trained field technicians, provided treatment concepts for mine water treatment facilities and managed subcontractor activities.

Biographical Data

PHILIP C. SIRLES

Geologist

PII Redacted

Education

B.S. Geology, 1980 Fort Lewis College, Durango, Colorado
M.S. Geophysics, 1986 University of Nevada at Reno, Nevada

Professional Affiliations

Association of Engineering Geologists
Society of Exploration Geophysicists
American Geophysical Union

Honorary Affiliations

Sigma Xi Honorary Scientific Society

Experience Record

- 1985-1986 Engineering-Science, Inc. Geologist. Responsible for supervision of drilling projects. Performed geologic logging, and installed and developed monitoring wells. Assisted in interpretation and reduction of field and laboratory data.
- 1983-1985 Nevada Bureau of Mines and Geology. Graduate Research Assistant. Installed and maintained short-period analog and broad-band digital seismic stations for the statewide seismic network. Performed data reduction and interpretation for local epicentral determinations using computers. Assisted in public information and publication offices.
- 1980-1982 Law Engineering Testing Company. Geologist. Responsible for field investigative portion of projects completed by Denver office. Project responsibilities included supervision of shallow-soil and deep-rock drilling, inspection of shallow test pits and trenches, detailed geologic reconnaissance and mapping, assistance with geophysical surveys, installation of shallow-alluvial piezometer and deep-aquifer test wells to conduct in-situ hydrologic testing. Project

PHILIP C. SIRLES (Continued)

experience and technical training conducted in Colorado, New Mexico, Arizona, Nevada, Utah, Wyoming, Montana, Washington, California, and Missouri.

Publications

"Attenuation of Shear Waves Through Liquefiable Soils in the South Truckee Meadows, Washoe County, Nevada," M.S. Thesis, University of Nevada, Reno, Nevada, 1986.

APPENDIX E
NEARBY WATER WELL DATA

Wells Within 1 Mile Radius of PJKS Boundary

Map 1/ Symbol	Owner	Location	Completion Date	Depth (Feet from GS)	Yield (GPM)	(Static) Water Level	Use
8-1	Kayser, H.L.	T6S R69W Sec 8 NWSE	4-12-65	990	5.0	250	Domestic
8-2	Kayser, H.L.	T6S R69W Sec 8 SWSE	8-28-67	420	1.0	256	Domestic
8-3	Hoaler, C.K.	T6S R69W Sec 8 NWSW	5-20-68	336	0.5	90	Domestic
8-4	Boast, W.	T6S R69W Sec 8 NESW	10-11-68	247	0.0	136	Domestic
8-5	Anthony, W.B.	T6S R69W Sec 8 NESE	1-16-70	410	0.0	59	Domestic
8-6	Blyzes, A.	T6S R69W Sec 8 NWSW	5-25-70	200	2.0	50	Domestic
8-7	Blyzes, B.	T6S R69W Sec 8 SWSW	10-20-70	236	1.0	50	Domestic
8-8	Smith, J.N.	T6S R69W Sec 8 NWSW	1-16-74	420	15.0	--	In House Use Only
8-9	Gordon, A.	T6S R69W Sec 8 NWSW	10-10-75	247	6.0	--	In House Use Only
8-10	Near, R.W.	T6S R69W Sec 8 SUNE	3-29-77	770	3.0	400	In House Use Only
8-11	Barrett, G.G.	T6S R69W Sec 8 NWSW	9-29-72	198	3.0	80	Domestic
9-1	Erickson, R.	T6S R69W Sec 9 SUNW	4-2-77	460	7.0	30	In House Use Only
17-1	Sobey, R.L.	T6S R69W Sec 17 NENW	9-28-72	495	1.0	80	In House Use Only
17-2	Robley, B.	T6S R69W Sec 17 NUNW	0-0-61	35	5.0	--	In House Use Only
18-1	Workman, G.E.	T6S R69W Sec 18 SWSW	10-11-65	200	4525.9	Unknown	Domestic
18-2	Workman, G.E.	T6S R69W Sec 18 SWSW	11-18-66	600	4525.9	Unknown	Domestic
18-3	Baca, J.M.	T6S R69W Sec 18 NWSW	7-20-67	300	1.0	150	Domestic
18-4	Ebers, J.	T6S R69W Sec 18 SWSW	6-15-71	No State Record			Domestic
19-1	Wallace, A.	T6S R69W Sec 19 NUNW	9-1-66	380	2.0	65	Domestic
19-2	Hahn, P.S.	T6S R69W Sec 19 NENW	9-6-66	420	1.0	135	Domestic
22-1 ^{2/}	Peters, D.M.	T6S R69W Sec 22 NWSE	6-13-69	150	10.0	94	Domestic
23-1	Denver Water Board	T6S R69W Sec 23 NWSE	11-19-54	31	745.0	7	Municipal
23-2	Denver Water Board	T6S R69W Sec 23 NWSE	12-03-54	34	924.0	7	Municipal
23-3	Denver Water Board	T6S R69W Sec 23 NWSE	6-30-55	32	750.0	8	Municipal
23-4	Denver Water Board	T6S R69W Sec 23 NWSE	6-29-55	33	750.0	9	Municipal
26-1	McRae, R.B.	T6S R69W Sec 26 NWSW	5-0-36	25	800.0	15	Municipal
26-2	Lamb, C.	T6S R69W Sec 26 SUNE	3-25-53	47	785.0	4	Commercial/Stock
30-1	Vandenburgh, A.	T6S R69W Sec 30 NWSW	6-26-69	223	--	60	Domestic
34-1	Assoc. Realty	T6S R69W Sec 34 SENE	12-23-58	31	325.0	--	Municipal
34-2	Denver Water Board	T6S R69W Sec 34 NWSE	7-0-10	23	40.0	13	Domestic
24-1	Ambrosio, K.S.	T6S R70W Sec 24 NENE	7-21-67	260	1.0	60	Domestic
24-2	LeMatle, C.W.	T6S R70W Sec 24 SESW	6-23-72	200	1.0	80	In House Use Only
24-3	Copenhaver, E.P.	T6S R70W Sec 24 NENE	7-1-74	478	1.0	110	In House Use Only
24-4	Bishop, N.U.	T6S R70W Sec 24 NESW	5-12-19	--	2.0	--	Domestic
24-5	Bishop, N.U.	T6S R70W Sec 24 NESW	5-12-19	--	2.0	--	Domestic
24-6	Bottinelli, C.A.	T6S R70W Sec 24 SENE	9-13-76	75	2.0	15	In House Use Only

Wells Within 1 Mile Radius of PKS Boundary (Continued)

Map Symbol	Owner	Location	Completion Date	(Feet from GS) Depth	(GPM) Yield	(Static) Water Level	Use
25-1	Olsen, M.	T6S R70W Sec 25 NENW	9-28-59	91	3.0	--	Domestic
25-2	Holm, D.	T6S R70W Sec 25 NENW	2-8-68	248	2.0	50	Domestic
25-3	Hamm, D.	T6S R70W Sec 25 SENE	6-2-71	285	4.0	150	Domestic
25-4	Norman, H.C.	T6S R70W Sec 25 NWSE	11-3-71	500	8.0	500	Domestic
25-5	Maxwell, J.	T6S R70W Sec 25 NENW	8-7-75	680	0.8	60	Domestic
25-6	McCrinmon, D.E.	T6S R70W Sec 25 SENW	7-23-73	40	5.0	--	In House Use Only
25-7	Hoerner, J.	T6S R70W Sec 25 NESW	2-14-81	505	3.0	40	In House Use Only
25-8	McCrinmon, D.E.	T6S R70W Sec 25 NESW	2-26-81	505	8.0	40	In House Use Only

1/ The wells are located on Figure 2.9.

2/ This well is not located correctly and probably should be located one township and range to the east (Fuscher, L., 1986).

APPENDIX F

**SOIL BORING LOGS
WELL CONSTRUCTION DETAILS
WELL AND SOIL BORING SURVEY DATA**

GEOLOGIC BORING LOG

Sheet 1 of 2

JOB NUMBER 56423.04
 BORING NUMBER MW-1 (ES-1)
 MACHINE TYPE Cyclone 750
 TEMPERATURE 45 °F

CLIENT PJRS Air Force
 BORING DIAMETER 6"
 CONTRACTOR Arrow Drilling
 WEATHER Sunny
 DRILLING MEDIUM USED Air

DATE 12/4/95
 ELEVATION 5977.24
 DATUM Ground Surface
 ENGINEER LAK, FNR

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		SW- dk brn med to co SAND w/sm fi sand, roots, stiff, moist					
2		lt brn med SAND w/sm co sand, tr med gravel, stiff, moist	SS-1	0'-2'	X	1200	HNu = 2 ppm (background)
4		SAND w/tr silt and gravel	SS-2	2'-4'	X	1200	HNu = 2ppm
6		SP gray-brn, med to co SAND, dry					HNu = 2ppm
8		GP red-brn, BOULDERS, GRAVEL SAND, very stiff, dry	SS-3	4.5'-6'	X	2000	HNu = 2ppm
10		SAA					-Tricone bit used from 8' down
12		SP red-brn med to fi SAND very stiff, dry	SS-4	7.5'-10'	X		-split spoon attempted at each sampling point
14		GP red, brn BOULDERS, COBBLES, GRAVEL, SAND tr clay, very stiff, moist	SS-5	10.0 12.0			ES-1A
16			SS-6	12.0 15.0		2000	ES-1
18							HNu = 2
20		SAA	SS-7	18.0 20.0			HNu = 2
22							HNu = 2
24		SW red-brn med to fi SAND med stiff, moist	SS-8	24.0 25.0	X	1000	HNu = 2

MODIFIERS:
 fi fine
 med medium
 co coarse
 sm some

tr trace
 sl slightly

X SPLIT SPOON SAMPLE
 ▨ GRAB SAMPLE
 ▩ UNDISTURBED SAMPLE
 ▴ WATER TABLE 24 HR
 ▾ WATER TABLE TIME OF BORING

ENGINEERING-SCIENCE

F-1

Sheet 2 of 2

DATE 12/4/85

ELEVATION 5997.04

DATUM Ground Surface

ENGINEER LAK, FNR

DRILLING MEDIUM USED Air

ENGINEERING-SCIENCE

GEOLOGIC BORING LOG

Sheet 1 of 2

JOB NUMBER 56423.04
 BORING NUMBER MW-2 (ES-2)
 MACHINE TYPE IR Cyclone 750
 TEMPERATURE 45 °F

CLIENT PJKS Air Force
 BORING DIAMETER 6"
 CONTRACTOR Arrow Drilling
 WEATHER breezy, partly cloudy
 DRILLING MEDIUM USED air

DATE 12/6/85
 ELEVATION 5937.16
 DATUM Ground Surface
 ENGINEER FNR

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		SC dk brn med SAND w/clay, roots		0			top soil - 1 foot
1		soft, tr moist	SS-1	1.0		1000	HNu = 2 (background)
2		SP grn brn, med SAND w/pebbles tr		2.0			
		clay, med stiff.	SS-2	2.5			
4		2.5' - dk red med SAND tr clay		4.0			
		sm gravel (1/2" - 3"), stiff	SS-3	5.0		1500	HNu = 2
6							
8			SS-4	6.0 7.5			
10		SAA, but moist	SS-5	9.0 10.0			HNu = 2
12							
			SS-6	11.0 12.5			
14							
		GP red med GRAVEL (1/4" - 1") w/	SS-7	14.0 15.0			
16		sand, moist					
18							
			SS-8	19.0 20.0			HNu = 2
20		SAA - but gravel increasing in					
		size to 2", very moist					
22							
24							
26							

MODIFIERS:
 fl fine
 med medium
 co coarse
 sm some

tr trace
 sl slightly

SPLIT SPOON SAMPLE
 GRAB SAMPLE
 UNDISTURBED SAMPLE
 WATER TABLE 24 HR
 WATER TABLE TIME OF BORING

ENGINEERING-SCIENCE

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Sheet 2 of 2

CLIENT PJKS - Air Force
BORING DIAMETER 6"
CONTRACTOR Arrow Drilling
WEATHER Snowing and overcast
DRILLING MEDIUM USED Air

DATE 12/6/85
ELEVATION 5937.16
DATUM Ground Surface
ENGINEER ENR

ENGINEERING-SCIENCE
F-4

JOB NUMBER 56423.04
BORING NUMBER YW-3 (ES-10)
MACHINE TYPE Cyclone 750
TEMPERATURE 30 °F

CLIENT PJKS Air Force
BORING DIAMETER 6 1/8"
CONTRACTOR Arrow Drilling Co.
WEATHER Clear, Sunny
DRILLING MEDIUM USED Air

DATE 12/20/86
ELEVATION 6023.91
DATUM Ground Surface
ENGINEER P. Stiles

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS	
			NO.	DEPTH (FT.)				
2		SM dk brn fi-co SAND sm silt loose, moist	SS-1	0 2.0		800	- melting snow HNU = 1.0-1.2 ppm	
4		SAA, loose-firm, dry	SS-2	2.0 4.0				1000
5		soil break						
9			SP brick red fi to co SAND sm silt tr fi gvl, firm-dense, dry	SS-3	7.0 9.0		1100 1200	HNU = 1.2
10	SAA							
12			SAA - increasing moisture					HNU = 1.2-1.4
14				SS-4	12.0 14.2		1054	
16		SAA - moist to v moist						
18								Driller drops bushing in hole - hole abandoned and grouted to surface (12/23/85)

GEOLOGIC BORING LOG

Sheet 2 of 2

JOB NUMBER <u>56423.04</u>	CLIENT <u>PJRS Air Force</u>	DATE <u>12/20/85</u>
BORING NUMBER <u>MW-3 (ES-10)</u>	BORING DIAMETER <u>6 1/8"</u>	ELEVATION <u>6023.91</u>
MACHINE TYPE <u>Cyclone 750</u>	CONTRACTOR <u>Arrow Drilling</u>	DATUM <u>Ground Surface</u>
TEMPERATURE <u>45°F</u>	WEATHER <u>calm, clear</u>	ENGINEER <u>P. Sirles</u>
DRILLING MEDIUM USED <u>air</u>		

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
15	0	See pg. 1 for 1st 17' of log					15'
16	0						
17	0						HNU = 0.8
18	0	SP brick red fi to co SAND sm	SS-5	17.0	X	900	
19	0	silt, tr fi gvl, loose-firm wet		19.0			
20	0						
22	0						
24	0	SAA v. soft to loose	SS-6	22.0	X	800-900	
24	0	saturated		24.0			
26	0						
28	0						Borehole collapse
29	0						change to auger
30	0	SAA	SS-7	29.0	X	900	HNU = 2.8
31	0			31.0			
32	0						No recovery
34	0						Bedrock TD = 34'
36	0						
38	0						

MODIFIERS:

fi fine	tr trace
med medium	sl slightly
co coarse	
sm some	

X	SPLIT SPOON SAMPLE
▬	GRAB SAMPLE
■	UNDISTURBED SAMPLE
~	WATER TABLE 24 HR
~	WATER TABLE TIME OF BORING

GEOLOGIC BORING LOG

Sheet 1 of 2

JOB NUMBER 56423.04
 BORING NUMBER MW-4 (ES-18)
 MACHINE TYPE Cyclone 750
 TEMPERATURE 25 °F

CLIENT PJKS Air Force
 BORING DIAMETER 6-5/8"
 CONTRACTOR Arrow Drilling
 WEATHER clear, cool

DATE 1/7/86
 ELEVATION 6146.28
 DATUM Ground Surface
 ENGINEER P. Sirles

DRILLING MEDIUM USED _____

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		br - brick red sl silty fi - co					HNu background = 2.0 ppm
		SAND w GRAVEL					Cobbles and Boulders on
2	SW	COBBLES, moist stiff	SS-1	0 2.0	X	1200 1400	ground surface
							HNu = 1.8 - 2.0
							Air - rotary drilling
		dk br sl clayey fi - co	SS-2	4.0 6.5		850	HNu = 3.5
5	ML SM	sand SILT w GRAVEL v moist soft			X		HNu = 3.0
9							Easy drilling
10		SAA - Lots of organics					
12		v moist, soft	SS-3	10.0 12.5	X	800 900	HNu = 2.5
14	ML SM						Material possibly fill from
16		SAA - tr more sand less clay	SS-4	14.3 16.5	X	800	construction of D-1 tank
18						800 900	HNu = 2.0
20		SAA	SS-5	19.5 20.5	X	800 2300	(no water)
		6" Brick red to br silty					Problems keeping hole open
22	SM GM	SAND GRAVEL with					HNu = 2.0
		COBBLE in shoe					HNu = 3.0 (in-hole)
24		too rocky to "push sample"					water on tape 21.0
							Washout in borehole
26	GP	SAA GRAVEL, COBBLES BOULDERS	SS-6	25.0 27.0	X		cuttings
							HNu = 2.0

MODIFIERS:
 fi fine
 med medium
 co coarse
 sm some

tr trace
 sl slightly

X SPLIT SPOON SAMPLE
 GRAB SAMPLE
 UNDISTURBED SAMPLE
 WATER TABLE 24 HR
 WATER TABLE TIME OF BORING

Sheet 2 of 2

CLIENT PJRS Air Force
BORING DIAMETER 6-5/8"
CONTRACTOR Arrow Drilling
WEATHER clear, cool
DRILLING MEDIUM USED NA

DATE 1/7/86
ELEVATION 6146.28
DATUM Ground Surface
ENGINEER P. Sirles

ENGINEERING-SCIENCE
F-8

GEOLOGIC BORING LOG

Sheet 1 of 1

JOB NUMBER 56423.04
 BORING NUMBER MW-5 (ES-19)
 MACHINE TYPE Cyclone 750
 TEMPERATURE 40°F

CLIENT PJMS Air Force
 BORING DIAMETER 7-7/8"
 CONTRACTOR Arrow Drilling
 WEATHER Clear, warm, breezy
 DRILLING MEDIUM USED NA

DATE 1/9/36
 ELEVATION 6142.35
 DATUM Ground Surface
 ENGINEER P. Sirles

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0	SP	dk br very sl silty					H ₂ O background = 1.2 ppm
	GP	fi - co SAND & GRAVEL					
2		tr cobbles, moist, soft	SS-1	0 2.0		850	H ₂ O = 1.4
4		SAA	SS-2	2.0 4.0		1000	H ₂ O = 1.4
6		Br - brick red silty fi - co SAND, GRAVEL, COBBLES	SS-3	4.0 6.0		1300	
8		moist, stiff					
10		SAA	SS-4	6.0 8.0		1400	H ₂ O = 1.2
12	GP	SAA - br color v. stiff	SS-5	9.0 10.0		1800	change to air-rotary H ₂ O = 1.2
14	SP	only 11" recovery, COBBLES GRAVEL and SAND	SS-6	11.5 13.0		2300	
16			SS-7	14.0 14.5		2300	
18							H ₂ O = 1.8
20		SAA					No water in hole Too hard to push sample
22							18' Blackwater H ₂ O = 1.4 Background H ₂ O = 5-8 downhole
24		V. hard, possible bedrock GRANITE/GNEISS					TD - 19.7'

MODIFIERS:
 fi fine
 med medium
 co coarse
 sm some

tr trace
 sl slightly



SPLIT SPOON SAMPLE
 GRAB SAMPLE
 UNDISTURBED SAMPLE
 WATER TABLE 24 HR
 WATER TABLE TIME OF BORING

GEOLOGIC BORING LOG

Sheet 1 of 1

JOB NUMBER <u>56423.04</u>	CLIENT <u>PJKS Air Force</u>	DATE <u>1/2/86</u>
BORING NUMBER <u>MW-6 (ES-17)</u>	BORING DIAMETER <u>6-1/8"</u>	ELEVATION <u>6125.44</u>
MACHINE TYPE <u>Cyclone 750</u>	CONTRACTOR <u>Arrow Drilling</u>	DATUM <u>Ground Surface</u>
TEMPERATURE <u>40 °F</u>	WEATHER <u>clear, warm</u>	ENGINEER <u>P. Siries</u>
DRILLING MEDIUM USED <u>NA</u>		

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		dk br sl silty fi - co					HNu background = 0.2 ppm
1	SM	SAND w GRAVEL, COBBLES		0			site graded by cat lots of boulders on ground surface
2	GM	wet at surface very stiff	SS-1	2.0		1400	HNu = 0.2
3		moist		2.0			
4		SAA tr clay	SS-2	4.0		1500	HNu = 0.4
5		SAA (sl wet)					4.8 1/6/36
6		BOULDER					5.5 boulder
7	OL	dr br - blk humus, organic matter, silty and sandy w	SS-3	7.0			
8				9.0			HNu = 0.8 - 1.0
10	GP	GRAVEL/COBBLES soft					HNu = 35 - 40
12							8.0 black water of SS but rose to 5.5 in borehole
14		SAND, GRAVEL, COBBLES					Drill/Drive casing method (1/6/86)
16							
18		Possibly Bedrock, weathered igneous rock, GRANITE					
20		GNEISS	SS-4				cuttings
22		Bedrock GRANITE/GNEISS, hard					very hard drilling
							Powdered chips
							ID = 22.0

MODIFIERS:
fi fine
med medium
co coarse
sm some

tr trace
sl slightly



SPLIT SPOON SAMPLE
GRAB SAMPLE
UNDISTURBED SAMPLE
WATER TABLE 24 HR
WATER TABLE TIME OF BORING

GEOLOGIC BORING LOG

Sheet 1 of 1

JOB NUMBER 56423.04
 BORING NUMBER MW-7 (ES-12)
 MACHINE TYPE Cyclone 750
 TEMPERATURE 25 °F

CLIENT PJKS Air Force
 BORING DIAMETER 10" H.S. Auger
 CONTRACTOR Arrow Drilling
 WEATHER Cold, cloudy, snowy
 DRILLING MEDIUM USED NA

DATE 12/23/85
 ELEVATION 6032.63
 DATUM Ground Surface
 ENGINEER P. Sirles

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		ML dk br-br SILT fi to co SAND	SS-1	0		800	HNU = 0.6-0.8
		SP w GRAVEL, frozen 6", moist		2.0			
2			SS-2	2.0		950	
		CL br w rust limonite stain		4.0			
4		ML clayey SILT w tr fi-med					
		SM sand, soft					
6							
		COBBLES					
8			SS-3	9.0		2300	
		SP br silt fi to co SAND w		9.8			HNU = 0.6
10		GP GRAVEL, COBBLES, wet					
		very stiff					
12						2350	
		SAA					
14		cobbles					
		(very rocky)					
16							Change to air rotary
							and advance augers
18							
20		SP br silt fi to co SAND	SS-4	19.5			HNU = 0.8
		GP w GRAVEL, COBBLES		20.5			
22							
		SAA					
24		SW wh/maroon SANDSTONE	SS-4	24.0		800	HNU = 0.6
		weathered very stiff		24.5		2300	TD-25'
26							

MODIFIERS:

fi fine

med medium

co coarse

sm some

tr trace

sl slightly

SPLIT SPOON SAMPLE

GRAB SAMPLE

UNDISTURBED SAMPLE

WATER TABLE 24 HR

WATER TABLE TIME OF BORING

GEOLOGIC BORING LOG

Sheet 1 of 2

JOB NUMBER <u>56423.04</u>	CLIENT <u>PJKS Air Force</u>	DATE <u>12/18/85</u>
BORING NUMBER <u>MW-8 (ES-8)</u>	BORING DIAMETER <u>6-1/8"</u>	ELEVATION <u>5690.30</u>
MACHINE TYPE <u>Cyclone 750</u>	CONTRACTOR <u>Arrow Drilling Co.</u>	DATUM <u>Ground Surface</u>
TEMPERATURE <u>25-30 °F</u>	WEATHER <u>Cloudy, cold</u>	ENGINEER <u>P. Sirles</u>
DRILLING MEDIUM USED <u>sir</u>		

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		dk brn fi SAND (Frozen) w/roots					
2	SC	brn-dk brn fi-med SAND w/silt. med stiff, moist	SS-1	0 2.0		450	HNU = 0.8 ppm
4	SW	brn-brick red, fi to co SAND some silt, tr fi gvl, stiff, moist	SS-2	2.0 4.0		1100	HNU = 0.8 ppm
6							
8		SAA, moist to dry	SS-3	7.0 9.0		950	HNU = 0.6 - 0.8 ppm
10							- easy drilling
12		SAA; w/granite cobbles	SS-4	11.0 13.0		1100	HNU = 1.0 - 1.2 ppm
14		(cuttings contain gray-dk gray chips)					
16							
18	SP	brn-brick red fi to co SAND w/ sm silt, gvl and cobbles, sl moist	SS-5	16.0 18.0		2300	HNU = 0.8 - 1.0 ppm
20		SAA - w/cly sand and gvl					
22		SAA - moist-loose to firm	SS-6	21.0 23.0		1100	HNU = 1.0 ppm
24							
26		SAA - v moist to wet					

MODIFIERS:
fi fine
med medium
co coarse
sm some

tr trace
sl slightly

SPLIT SPOON SAMPLE
 GRAB SAMPLE
 UNDISTURBED SAMPLE
 WATER TABLE 24 HR
 WATER TABLE TIME OF BORING

Sheet 2 of 2

DATE 12/18/85

ELEVATION 5960.30

DATUM Ground Surface

ENGINEER

SHEET 2 of 2

ENGINEERING-SCIENCE
F-13

GEOLOGIC BORING LOG

Sheet 1 of 1

JOB NUMBER 56423.04
 BORING NUMBER ES-3
 MACHINE TYPE Cyclone 750
 TEMPERATURE 10 °F

CLIENT PKS Air Force
 BORING DIAMETER 6"
 CONTRACTOR Arrow Drilling Co.
 WEATHER very cold, clear, sunny

DATE 12/13/85
 ELEVATION 5971.73
 DATUM Ground Surface
 ENGINEER P. Sirles

DRILLING MEDIUM USED Air

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		ML dk brn - red SILT, w/clay and fi -		0			
		CL med sand, organics med stiff, moist	SS-1	1.5		1000	H _{Nu} = 1-1.5 (background)
		SAA w/tr gravel and 2" cobbles				1400	
		SP lt brn fi - med SAND sm silt tr		4.5			
6		gravel and cobbles very stiff, dry	SS-2	6.0		2500	H _{Nu} = 0.3 ppm
		GP br-red GRAVEL w/fi-co sand matrix	SS-3	6.5			change to air rotary
		material stiff, dry		7.1			
3		SP dk brn-blk fi SAND w/cobbles,				2500	H _{Nu} = 1.0 ppm
		(weathered gneiss) dry	SS-4	9.0			
10				10.2		2500	-two pushes w/spl. sp. to
							collect sample
12		SP lt brn-brick red fi-co SAND and		12.5			H _{Nu} < 1.0 ppm
		GP GRAVELS, w/cobbles, dry	SS-5	14.0		2500	-spl. sp. part of sample
14							cuttings for the rest
16							
18		SAA	SS-6	16.5			H _{Nu} < 1.0
				18.0			-very rocky
20		SP brick red fi-co SAND w/gravel and	SS-7	19.5			TD-20.5'
		tr cobbles, very moist to wet		20.5			-no water in the hole
22							an hour after drilling
24							
26							

MODIFIERS:
 fi fine
 med medium
 co coarse
 sm some

tr trace
 sl slightly

SPLIT SPOON SAMPLE
 GRAB SAMPLE
 UNDISTURBED SAMPLE
 WATER TABLE 24 HR
 WATER TABLE TIME OF BORING

ENGINEERING-SCIENCE

F-14

Sheet 1 of 1

CLIENT PJKS Air Force
BORING DIAMETER 6-1/8"
CONTRACTOR Arrow Drilling
WEATHER Sunny, clear - cold
DRILLING MEDIUM USED Air

DATE 12/13/95
ELEVATION 5969.87
DATUM Ground Surface
ENGINEER P. Sirles

ENGINEERING-SCIENCE
F-15

Sheet 1 of 1

DATE 12/16/85

ELEVATION 5969.22

DATUM Ground Surface

ENGINEER P. Sirles

DRILLING MEDIUM USED air

F-16

Sheet 1 of 1 ES-6

CLIENT PJKS Air Force
BORING DIAMETER 6-1/8"
CONTRACTOR Arrow Drilling
WEATHER Clear, cool
DRILLING MEDIUM USED air

DATE 12/17/85
ELEVATION 5973.36
DATUM Ground Surface
ENGINEER P. Sires

ENGINEERING-SCIENCE
E-17

GEOLOGIC BORING LOG

Sheet 1 of 1

JOB NUMBER 56-23.04
 BORING NUMBER ES-7
 MACHINE TYPE Cyclone 750
 TEMPERATURE 40 °F

CLIENT PJKS Air Force
 BORING DIAMETER 6-1/8"
 CONTRACTOR Arrow Drilling Co.
 WEATHER Prtly cloudy

DATE 12/17/95
 ELEVATION 5972.54
 DATUM Ground Surface
 ENGINEER P. Sires

DRILLING MEDIUM USED air

DEPTH (FT.)	PROFILE	GEOLOGIC DESCRIPTION	SAMPLES		SAMPLE TYPE	DRILL PRESS.	REMARKS
			NO.	DEPTH (FT.)			
0		lk brn fi SAND w/tr co sand					HNU = 0.8
	SM	stiff, moist		0			
2		brn-brick red fi-med SAND w/	SS-1	2.0		1100	
	SP	silt tr fi gravel, firm, dry		2.0			
4		SAA w/fi to co SAND	SS-2	4.0		1200	HNU = 0.8
						1600	
6		brn-brick red fi to co SAND		5.0			
	GP	and GRAVEL w/cbbs, dense, drv	SS-3	7.0		2300	HNU = 0.6
8							
10							
	SP	brick red fi to med SAND w/	SS-4	9.0		1100	
12		tr clay, co sand and gravel, loose		11.0			
		to firm, moist to v moist					HNU = 1.0 ppm
14							Hard drilling
		SAA but dense and increasing		14.0			
16		2 of cobbles	SS-5	16.0			
18							
							HNU = 1.0 ppm
20		SAA		19.0			
			SS-6	21.0		2300	TD = 21.0'
22							(3" of water in the hole 15 min. after drilling)

MODIFIERS:

fi fine tr trace
 med medium sl slightly
 co coarse
 sm some



SPLIT SPOON SAMPLE
 GRAB SAMPLE
 UNDISTURBED SAMPLE
 WATER TABLE 24 HR
 WATER TABLE TIME OF BORING

ENGINEERING-SCIENCE

F-18

Sheet 1 of 1

CLIENT PJKS Air Force
BORING DIAMETER 6-1/8"
CONTRACTOR Arrow Drilling Co.
WEATHER Clear-calm
DRILLING MEDIUM USED air

DATE 12/19/85
ELEVATION 6054.02
DATUM Ground Surface
ENGINEER P. Sirles

ENGINEERING-SCIENCE
F-19

ES-11
Sheet 1 of 1

CLIENT PJKS Air Force
BORING DIAMETER 3"
CONTRACTOR Arrow Drilling
WEATHER Clear, warm
DRILLING MEDIUM USED NA (Push sample)

DATE 12/30/85
ELEVATION 6051.35
DATUM Ground Surface
ENGINEER P. Sirles

ENGINEERING-SCIENCE
F-20

Sheet 2 of 2

CLIENT PJKS - Air Force
BORING DIAMETER 3" (push sampler)
CONTRACTOR Arrow Drilling
WEATHER clear, cool, calm
DRILLING MEDIUM USED NA

DATE 12/31/85
ELEVATION 6025.39
DATUM Ground Surface
ENGINEER P. Sirls

ENGINEERING-SCIENCE
F-21

Sheet 1 of 1

CLIENT PJKS - Air Force

DATE 12/31/85

BORING DIAMETER 6-1/8"

ELEVATION 6020.98

CONTRACTOR Arrow Drilling

DATUM Ground Surface

WEATHER sunny, warm

ENGINEER P. Sirles

DRILLING MEDIUM USED NA

ENGINEERING-SCIENCE

Sheet 1 of 2

DATE 1/2/86
ELEVATION 6089.60
DATUM Ground Surface
ENGINEER P. Sirles

F-23

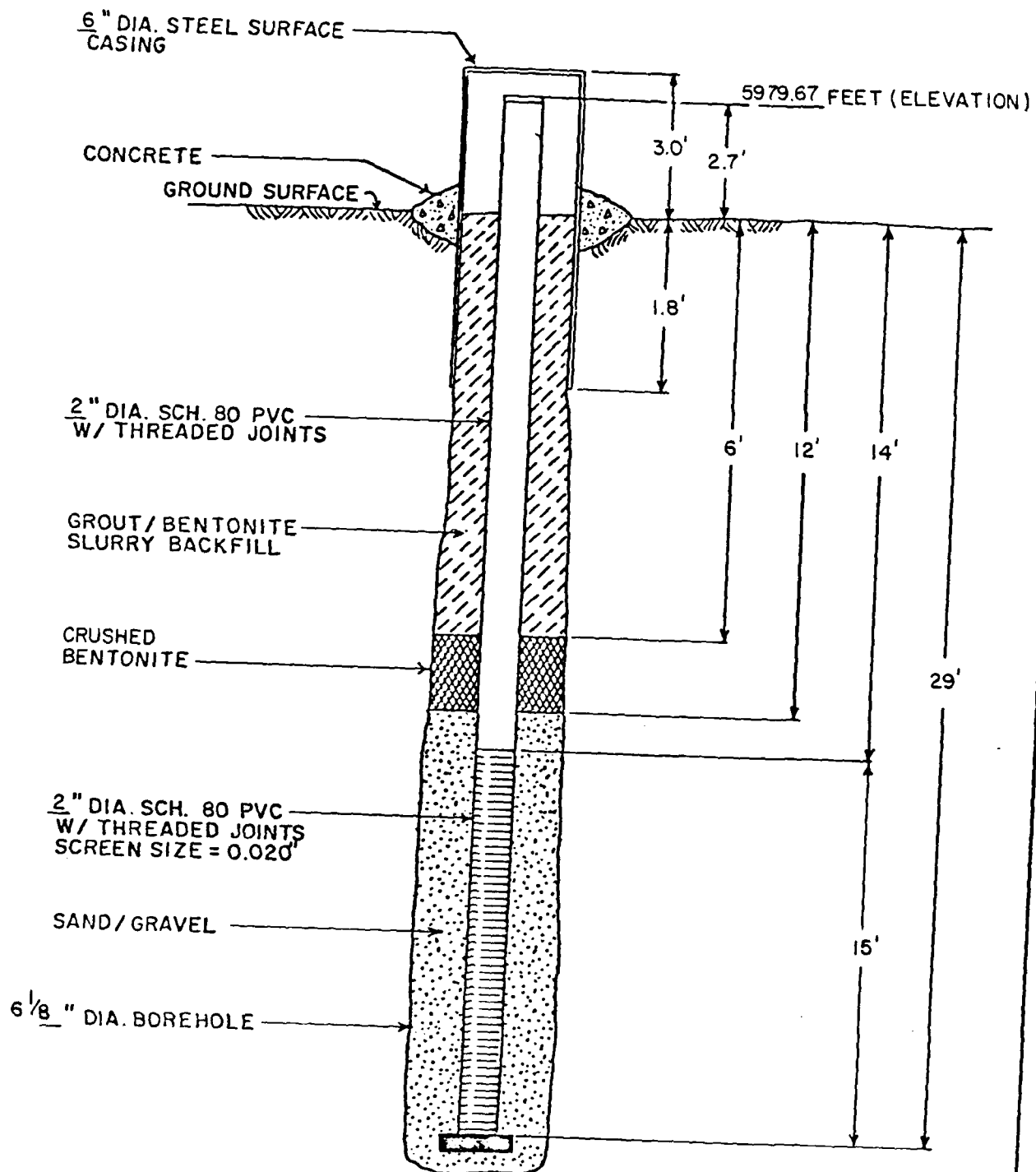
Sheet 2 of 2

CLIENT PJKS Air Force
BORING DIAMETER 6-3/8"
CONTRACTOR Arrow Drilling
WEATHER clear, cool
DRILLING MEDIUM USED Na

DATE 1/9/86
ELEVATION 6039.60
DATUM Ground Surface
ENGINEER PCS

ENGINEERING-SCIENCE

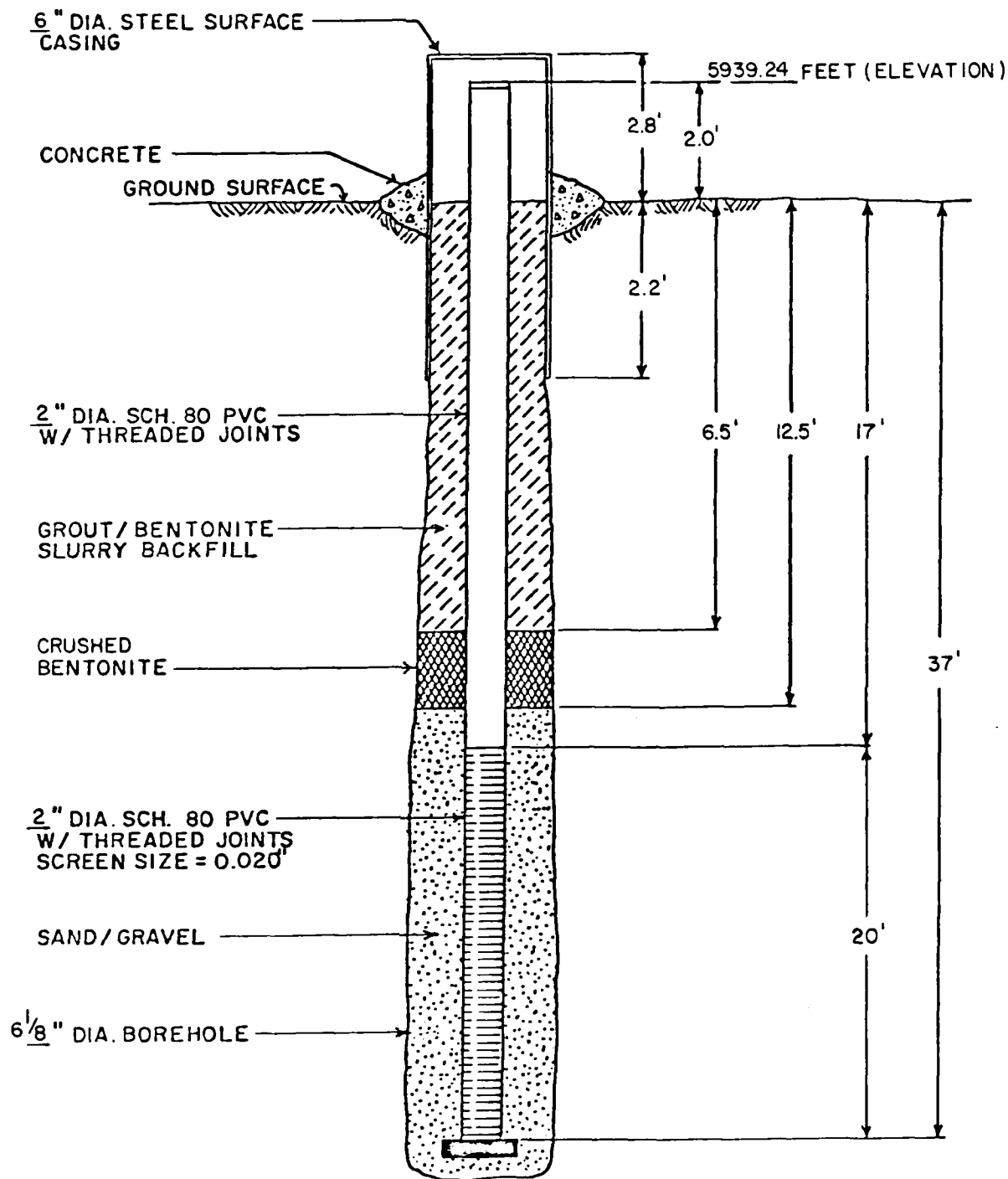
WELL CONSTRUCTION DETAILS



MW- 1
WELL DESIGN DETAIL

Completion Date : 12-6-85
 Engineer : L. Korner

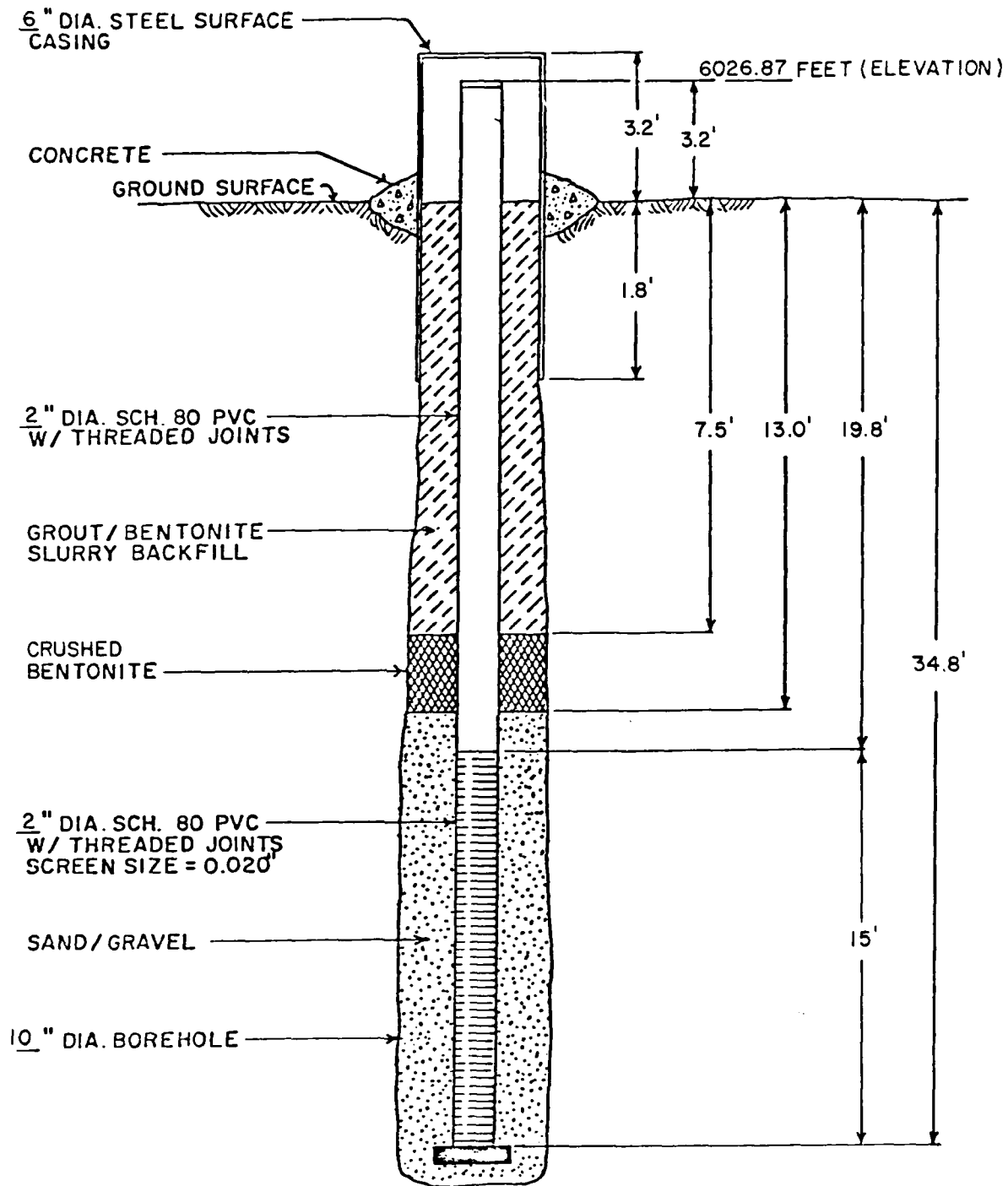
Boring No. : ES-1



MW- 2
WELL DESIGN DETAIL

Completion Date : 12-9-85
 Engineer : P. Sirles

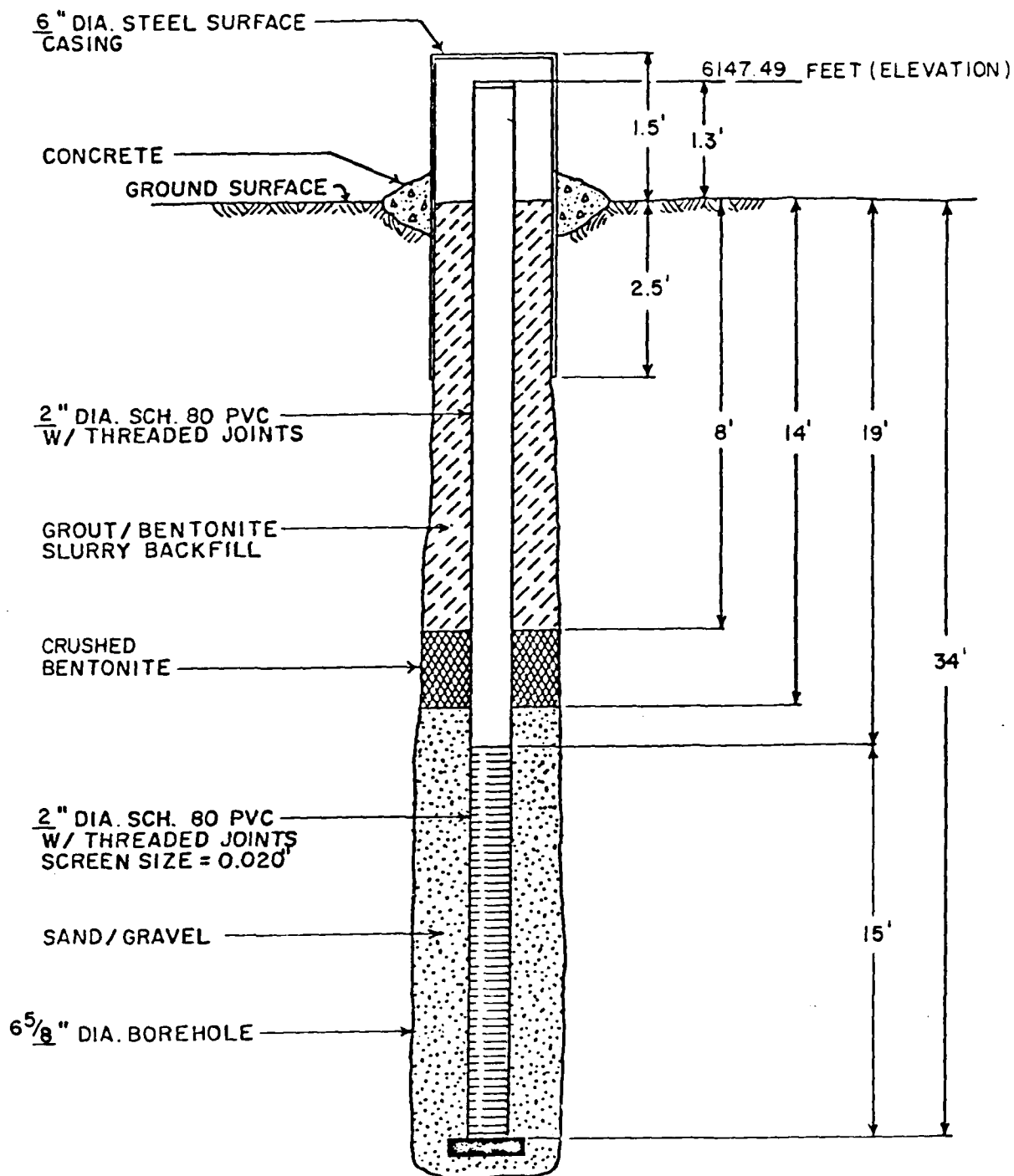
Boring No. : ES-2



MW- 3
WELL DESIGN DETAIL

Completion Date : 12 - 23 - 85
 Engineer : P. Sirles

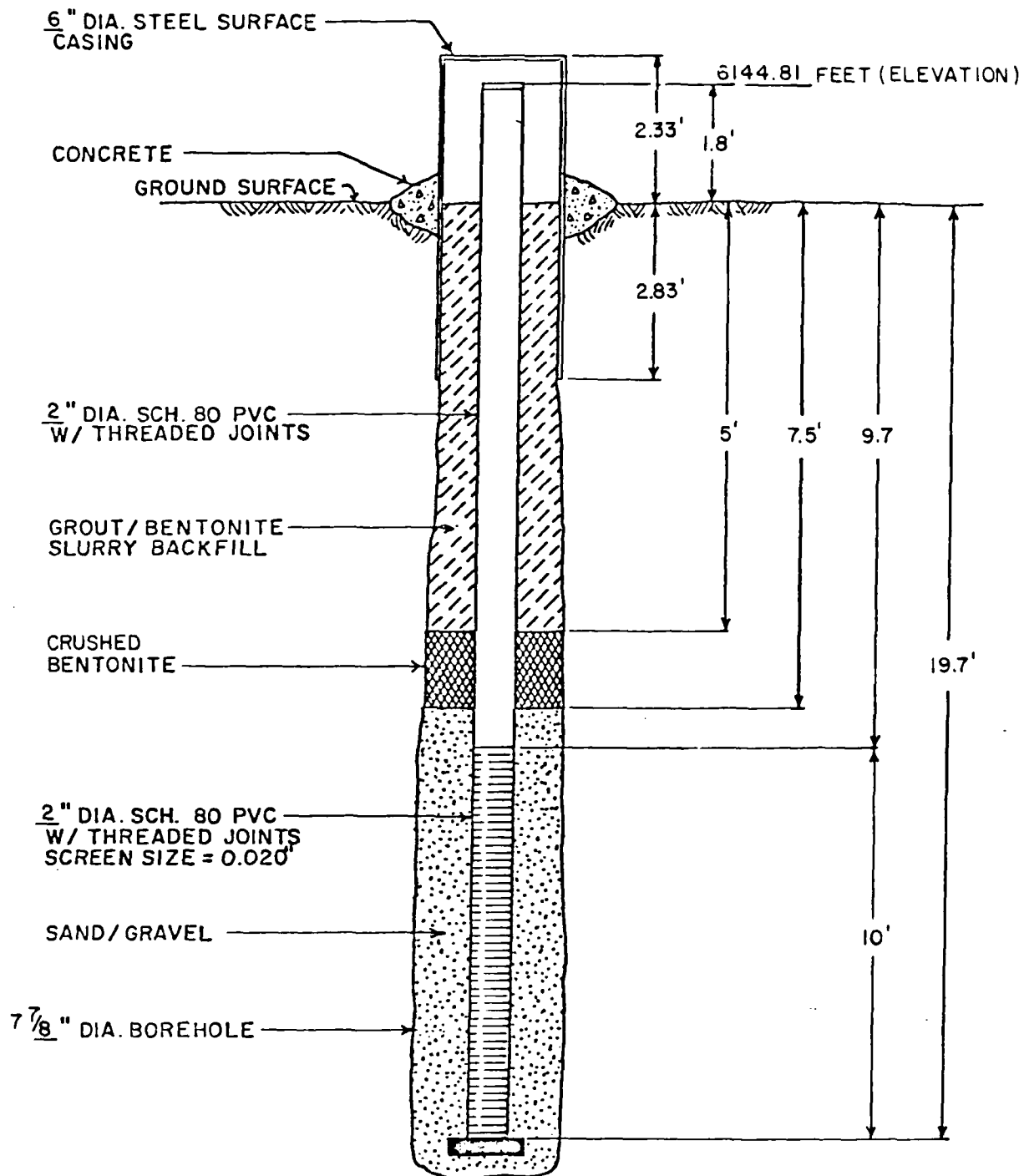
Boring No. : ES - 10



MW- 4
WELL DESIGN DETAIL

Completion Date : 1-8-86
 Engineer : P. Sirles

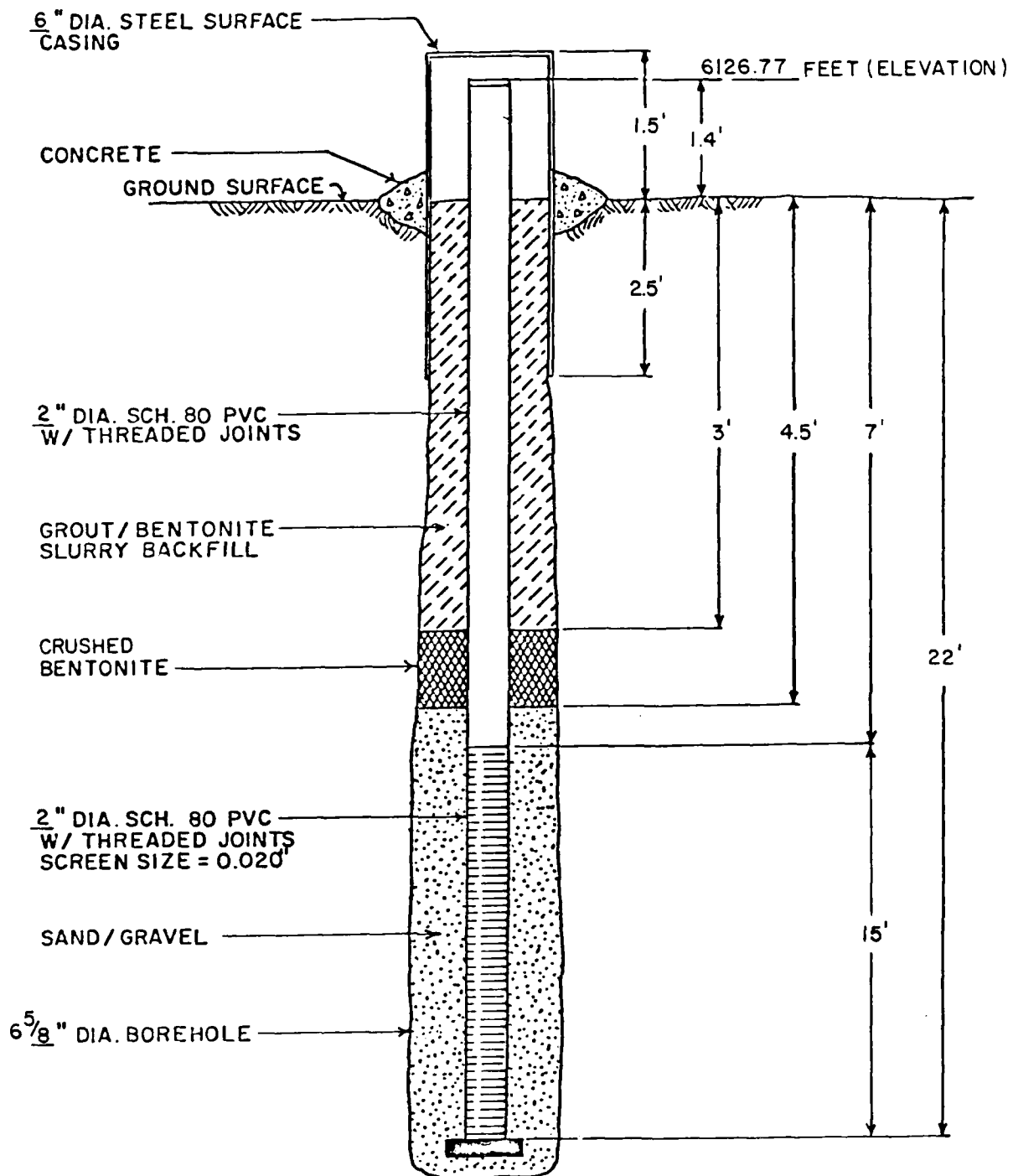
Boring No. : ES-18



MW- 5
WELL DESIGN DETAIL

Completion Date : 1-9-86
 Engineer : P. Sirles

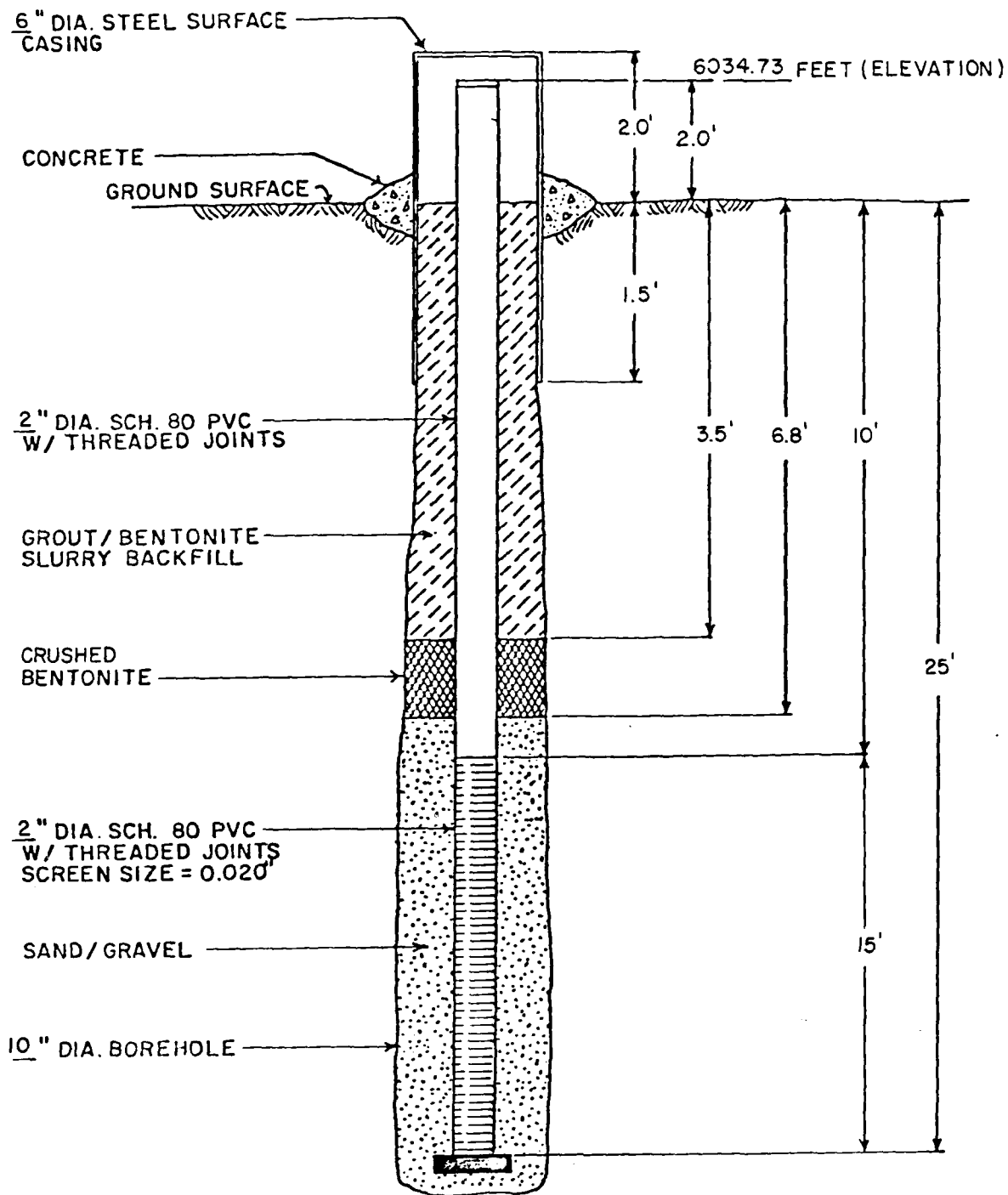
Boring No. : ES-19



MW- 6
WELL DESIGN DETAIL

Completion Date : 1-6-86
 Engineer : P. Sirles

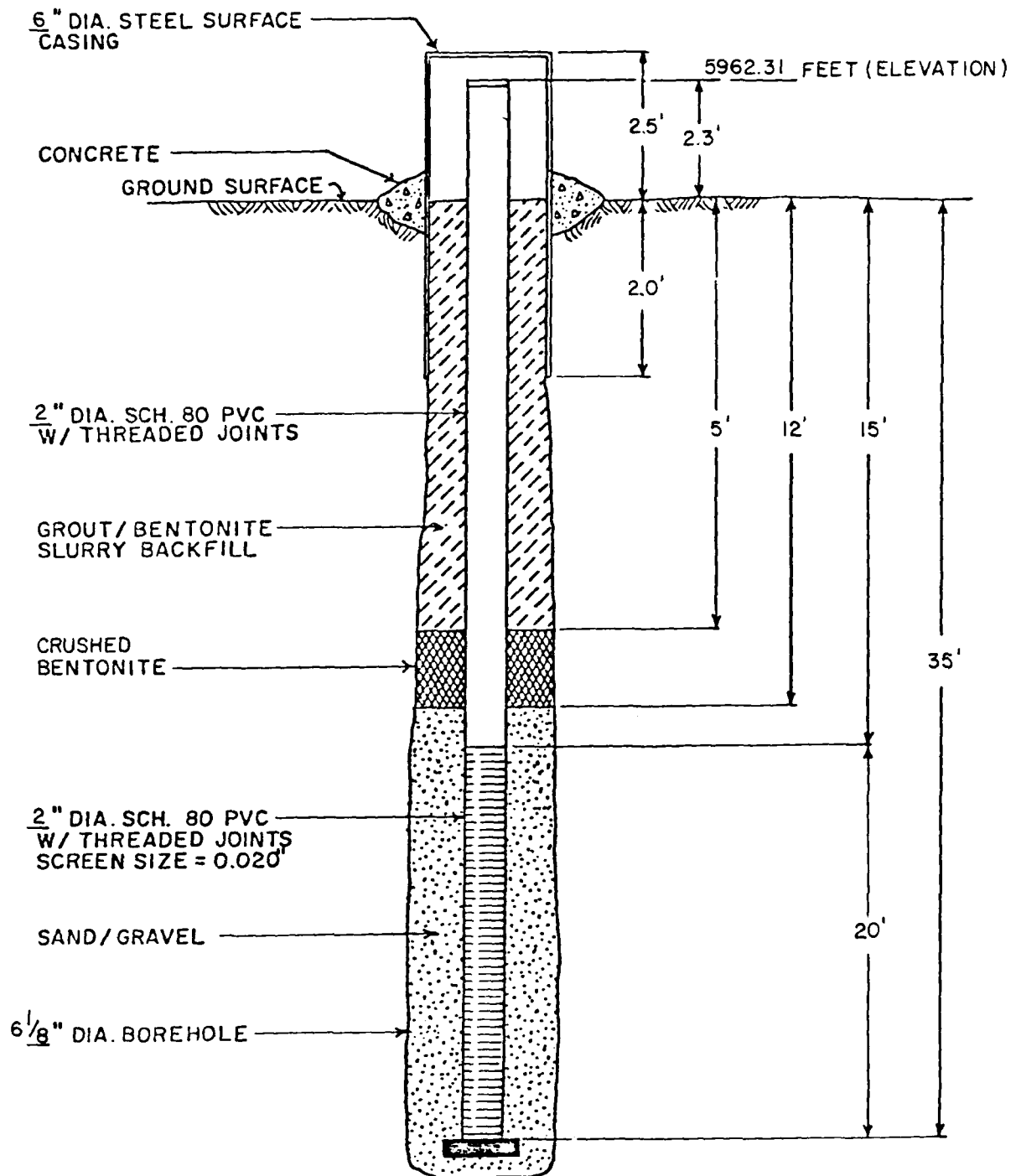
Boring No. : ES-17



MW- 7 **WELL DESIGN DETAIL**

Completion Date : 12-27-85
 Engineer: P. Sirles

Boring No.: ES-12



MW- 8
WELL DESIGN DETAIL

Completion Date : 12-18-85
 Engineer : P. Sirles

Boring No. : ES-8

WELL AND SOIL BORING SURVEY DATA

	<u>NORTHING</u>	<u>EASTING</u>	<u>Top PVC</u>	<u>GROUND</u>
MW-1	610,914.36	2,107,826.91	5979.67	5977.04
MW-2	610,668.85	2,108,284.63	5939.24	5937.16
MW-3	611,465.78	2,107,246.69	6026.87	6023.91
MW-4	610,629.79	2,105,525.82	*6147.49	6146.28
MW-5	610,616.76	2,105,580.11	6144.81	6142.95
MW-6	610,694.42	2,105,639.32	6126.77	6125.44
MW-7	611,454.15	2,107,028.19	**6032.73 ¹	6032.63
MW-8	611,073.20	2,108,268.04	5962.31	5960.30

*Top of PVC Cap (could not get cap off)

**Too far down to mark elevation to rim of casing 6034.59

1 2.0 ft riser added. Top PVC is now 6034.73 *see above*

<u>SOIL BORING #</u>	<u>ELEVATION</u>
ES-3	5971.73
ES-4	5969.87
ES-5	5969.22
* ES-6	5973.36
* ES-7	5972.64
ES-9	6054.02
ES-11	6051.85
ES-13	6025.39
ES-14	6020.98
ES-15	6089.60
ES-16	6091.00

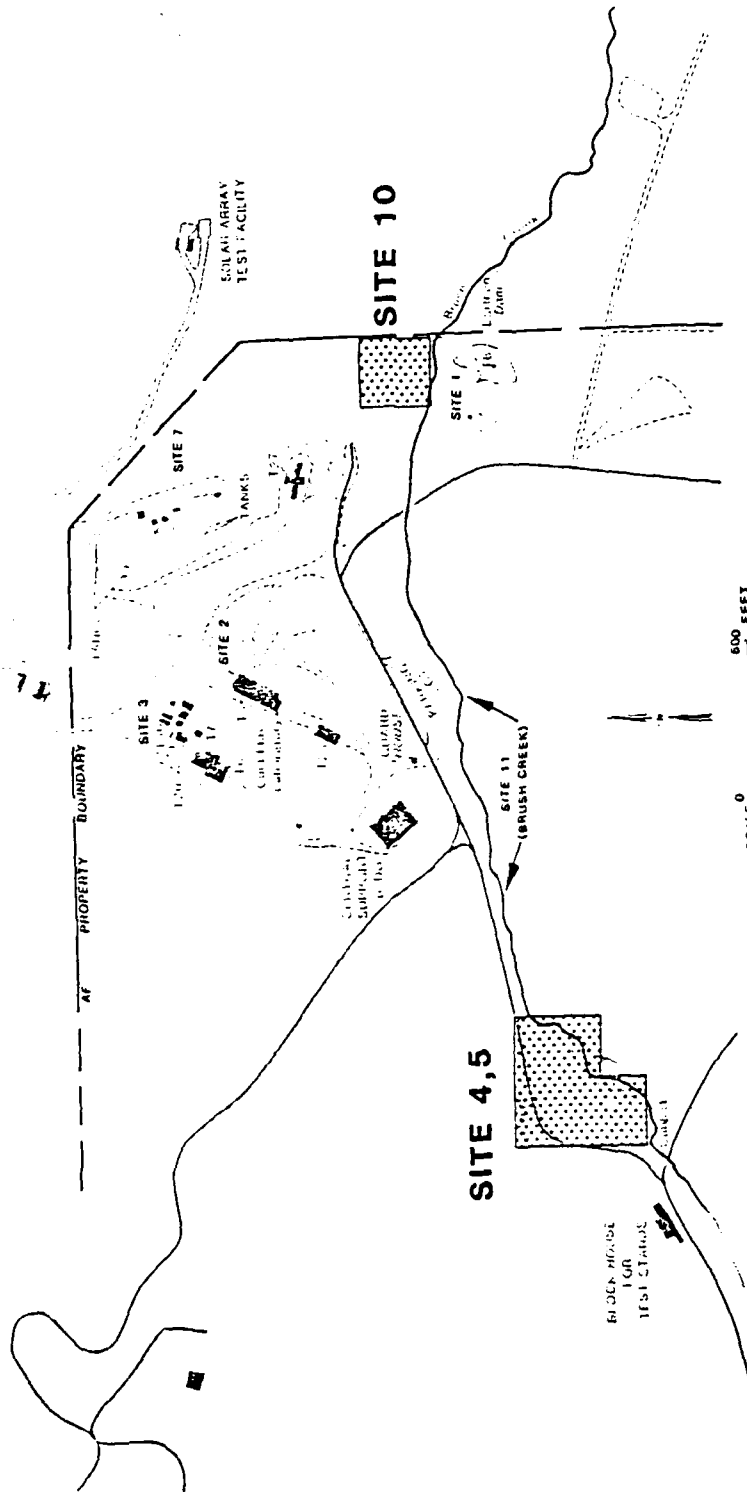
- * Numbers are as marked on stakes
 - ES-6 and ES-7 are switched on map
 - No mark on ES-5

The locations as marked on
the stakes are correct.

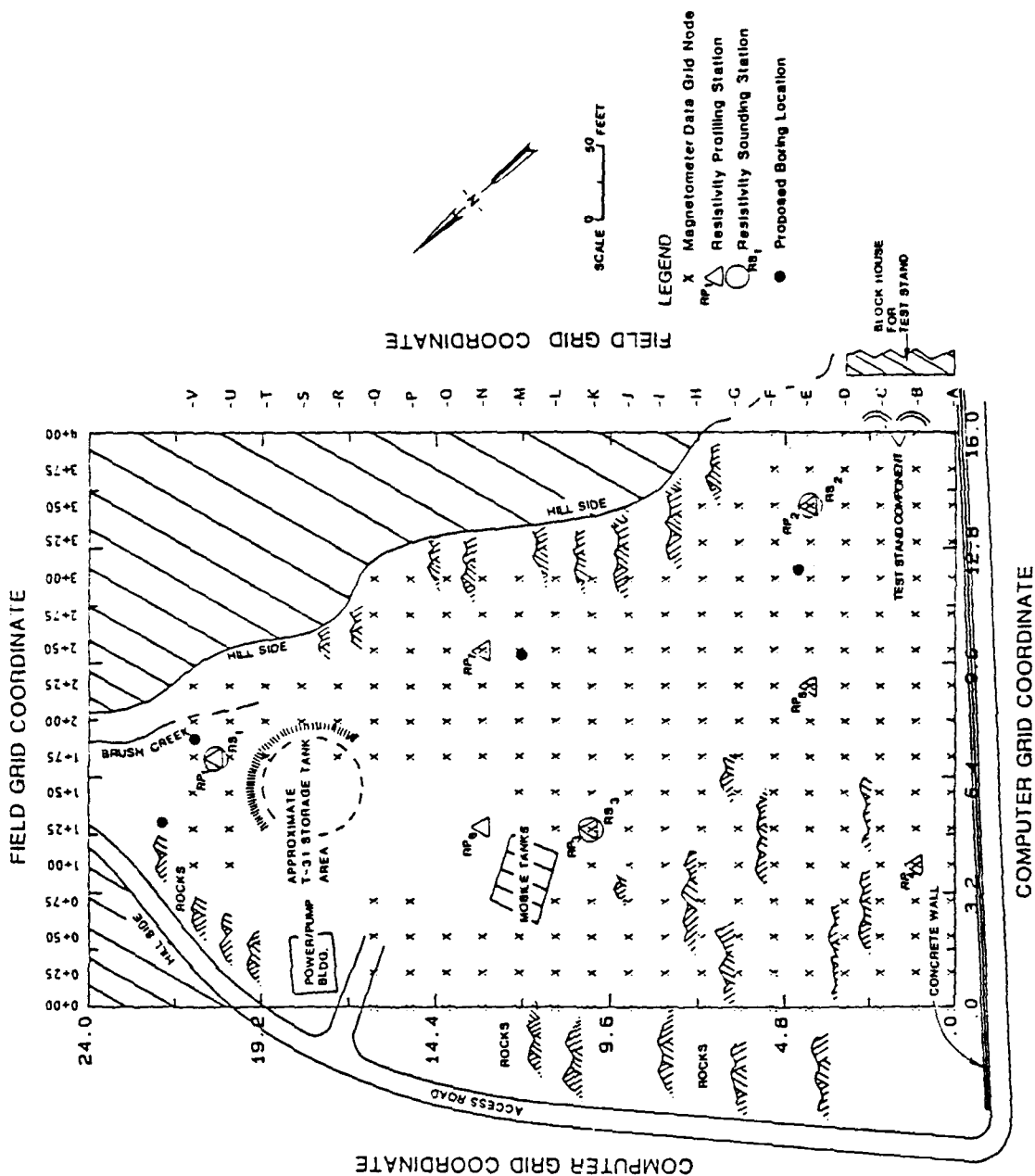
Lisa A. Korman

APPENDIX G
GEOPHYSICAL SURVEY DATA

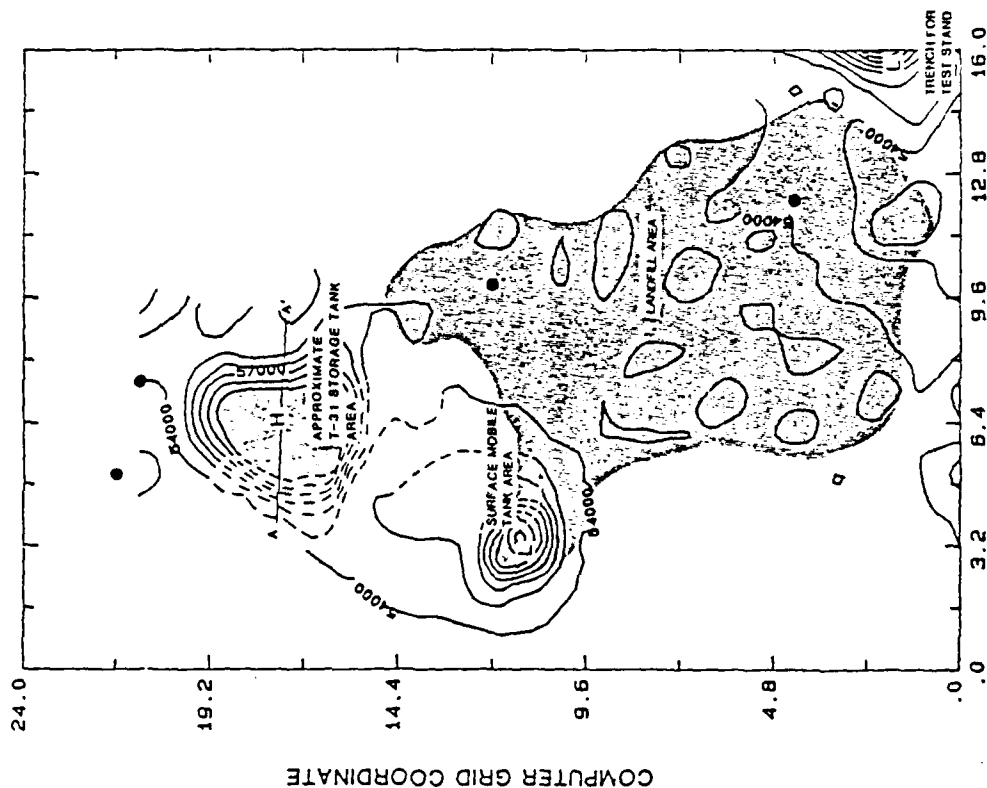
AF PLANT PJKS Waterton, Colorado GEOPHYSICAL FIELD INVESTIGATION SITES



DATA GRID SYSTEM LAYOUT - SITE 4 & 5 PLANT PJKS



MAGNETOMETER SURVEY SITE 4 & 5 PLANT PJKS



LEGEND
 H High Anomalous Area ● Proposed Boring Location
 L Low Anomalous Area A-A' Depth Estimate Model Profile

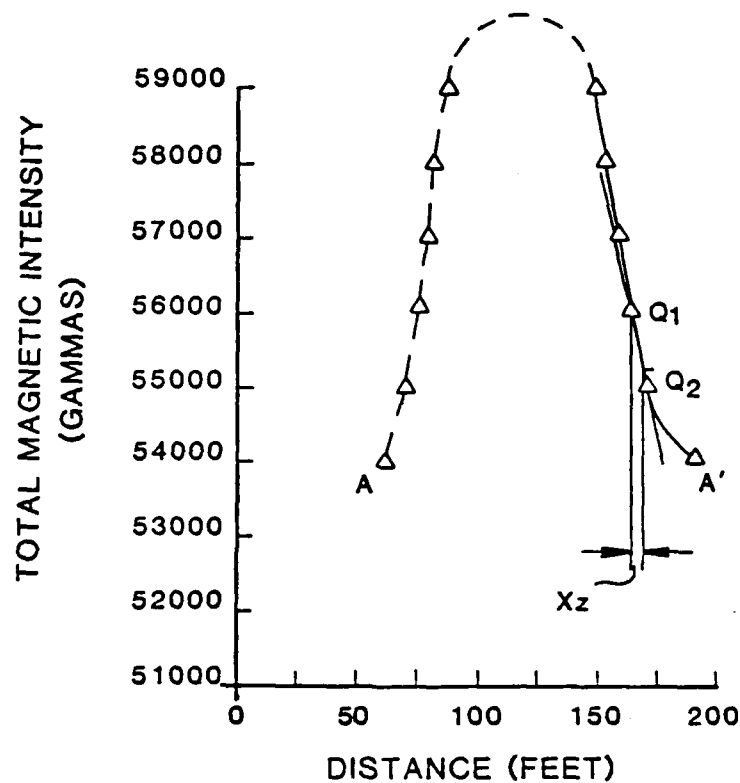
Note: Dashed contours occur over inaccessible area subjected to other ongoing site activity during geophysical investigation.

SCALE 0 50 FEET

COMPUTER GRID COORDINATE

CONTOUR FROM 42000.00 TO 56000.00 CONTOUR INTERVAL - 1000.00 GAUSS

DEPTH ESTIMATE MODEL AT SITES 4&5 (PROFILE A-A')



DEPTH ESTIMATE CALCULATION

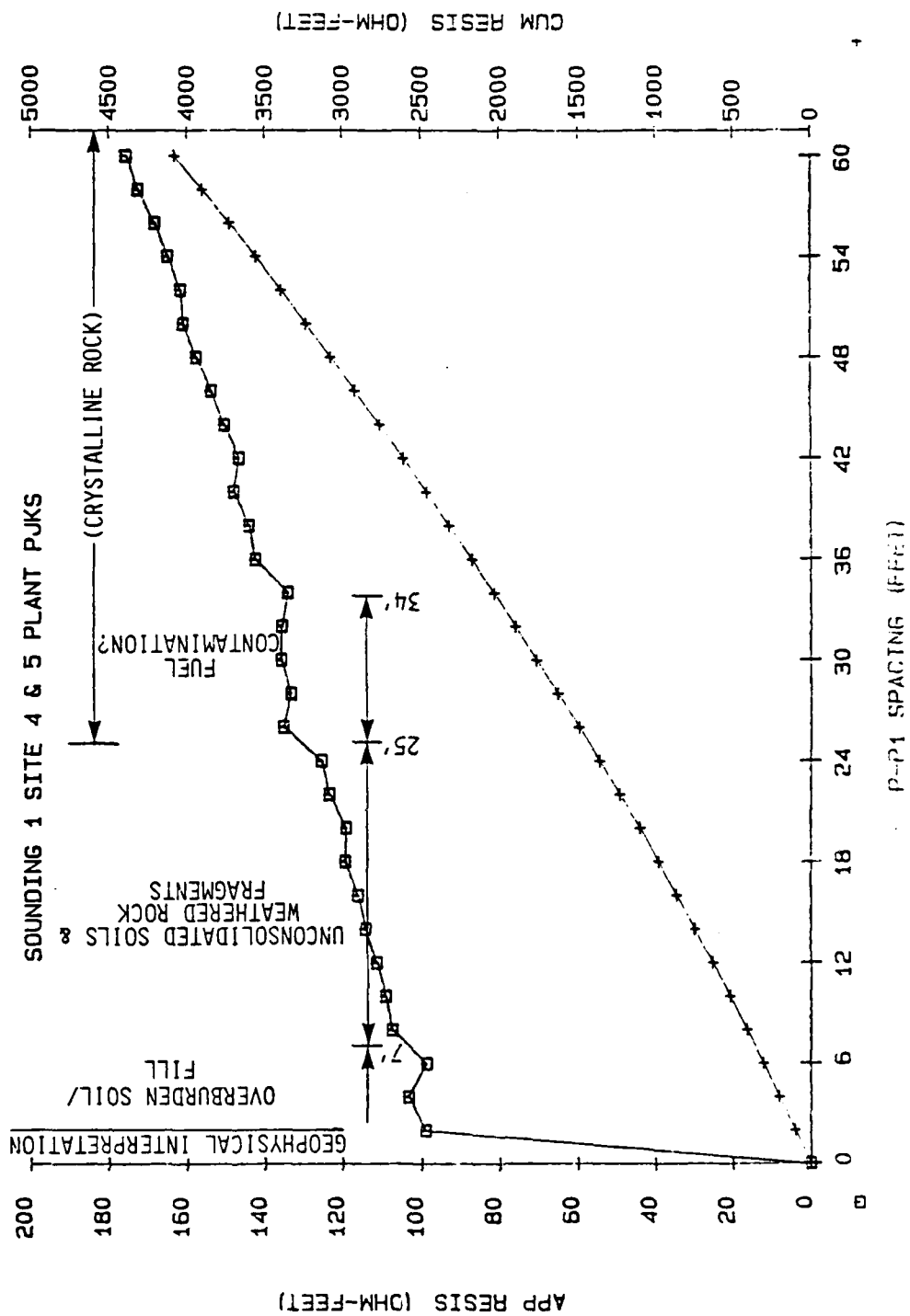
$$Z = KX_z \approx 1(3.5 \text{ FEET}) = 3.5 \text{ FEET}$$

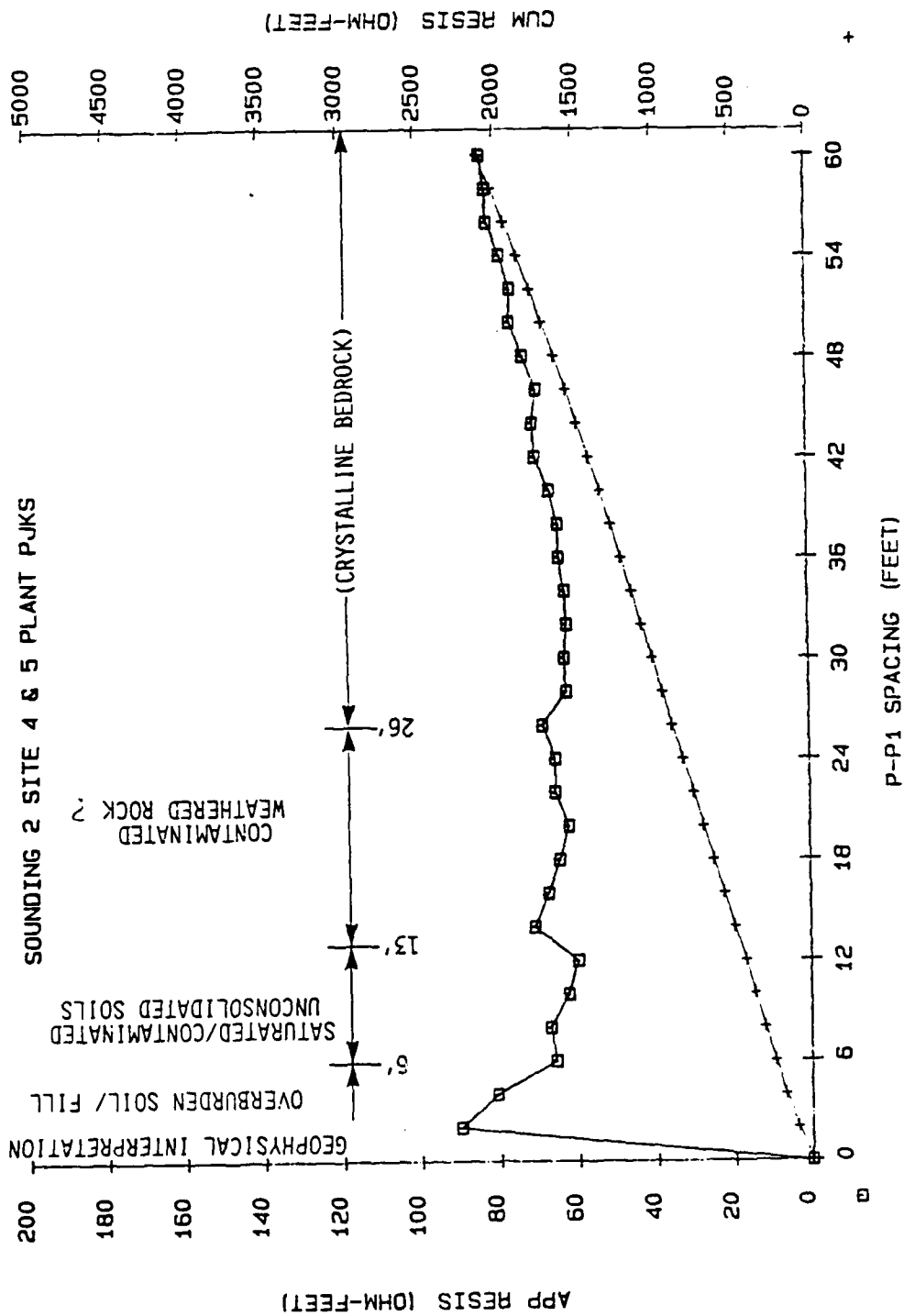
Z = APPROXIMATE DEPTH TO
CAUSATIVE BODY

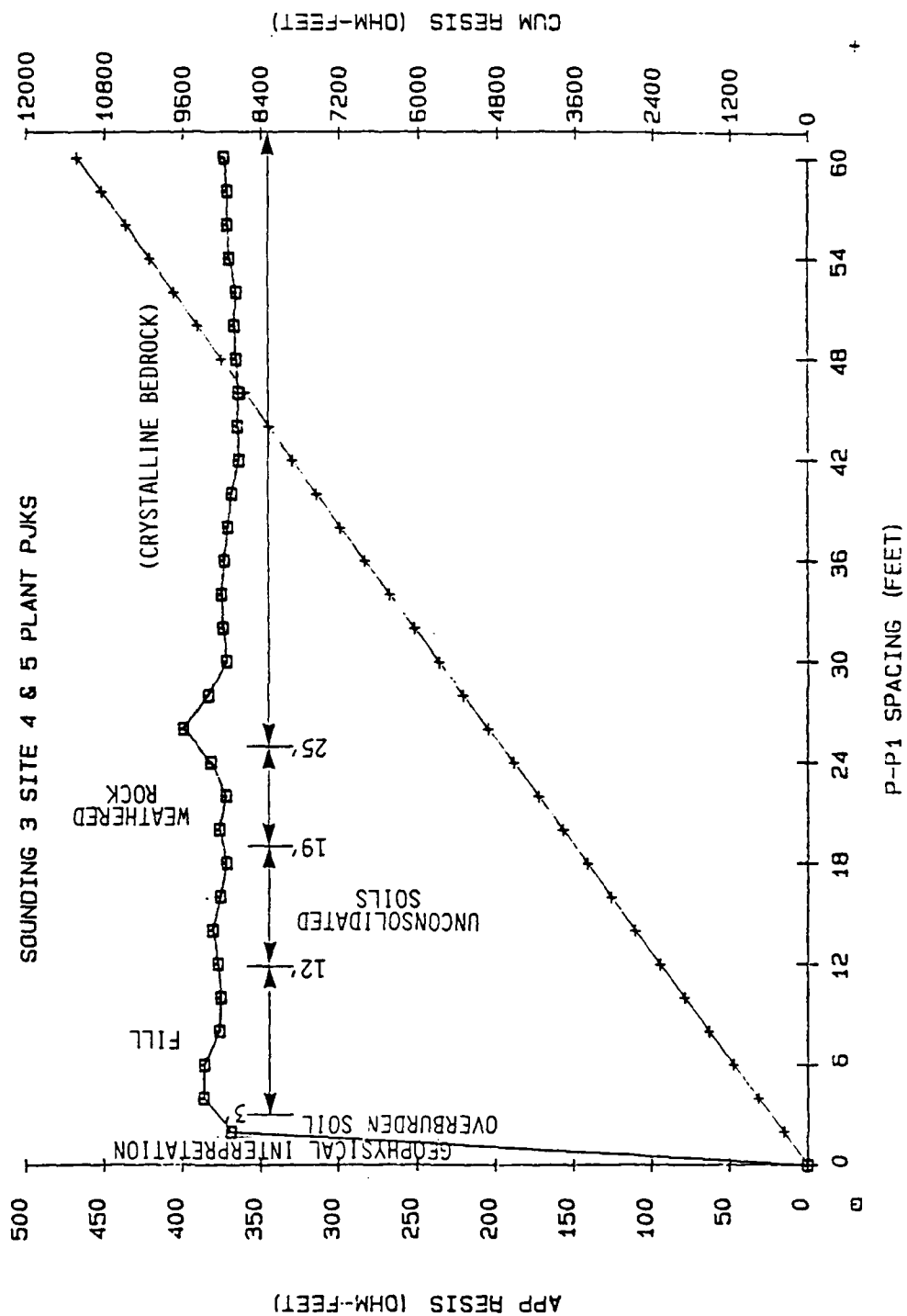
K = EMPIRICALLY DERIVED
CONSTANT

X_z = HORIZONTAL COMPONENT OF THE
MAXIMUM SLOPE LINE OF CURVE
(ANOMALY)

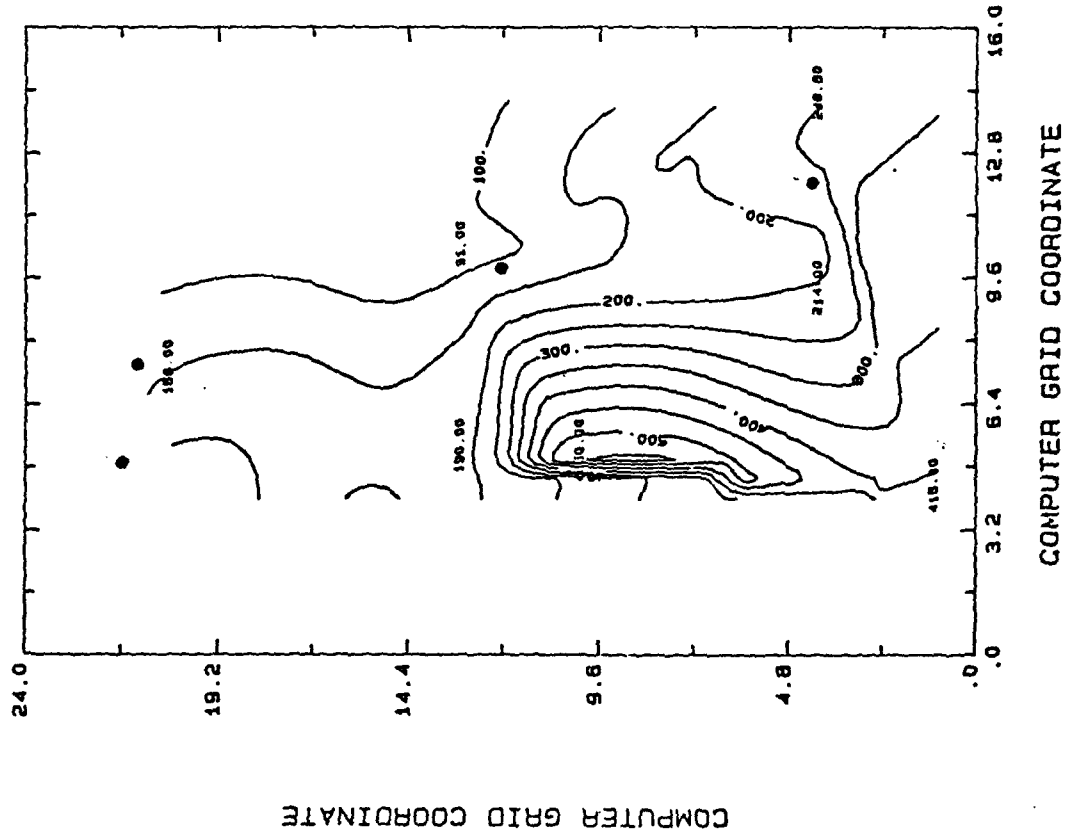
$$\begin{aligned} X_z &= Q_2 - Q_1 \\ &= 162.0 - 165.5 = 3.5 \text{ FEET} \end{aligned}$$



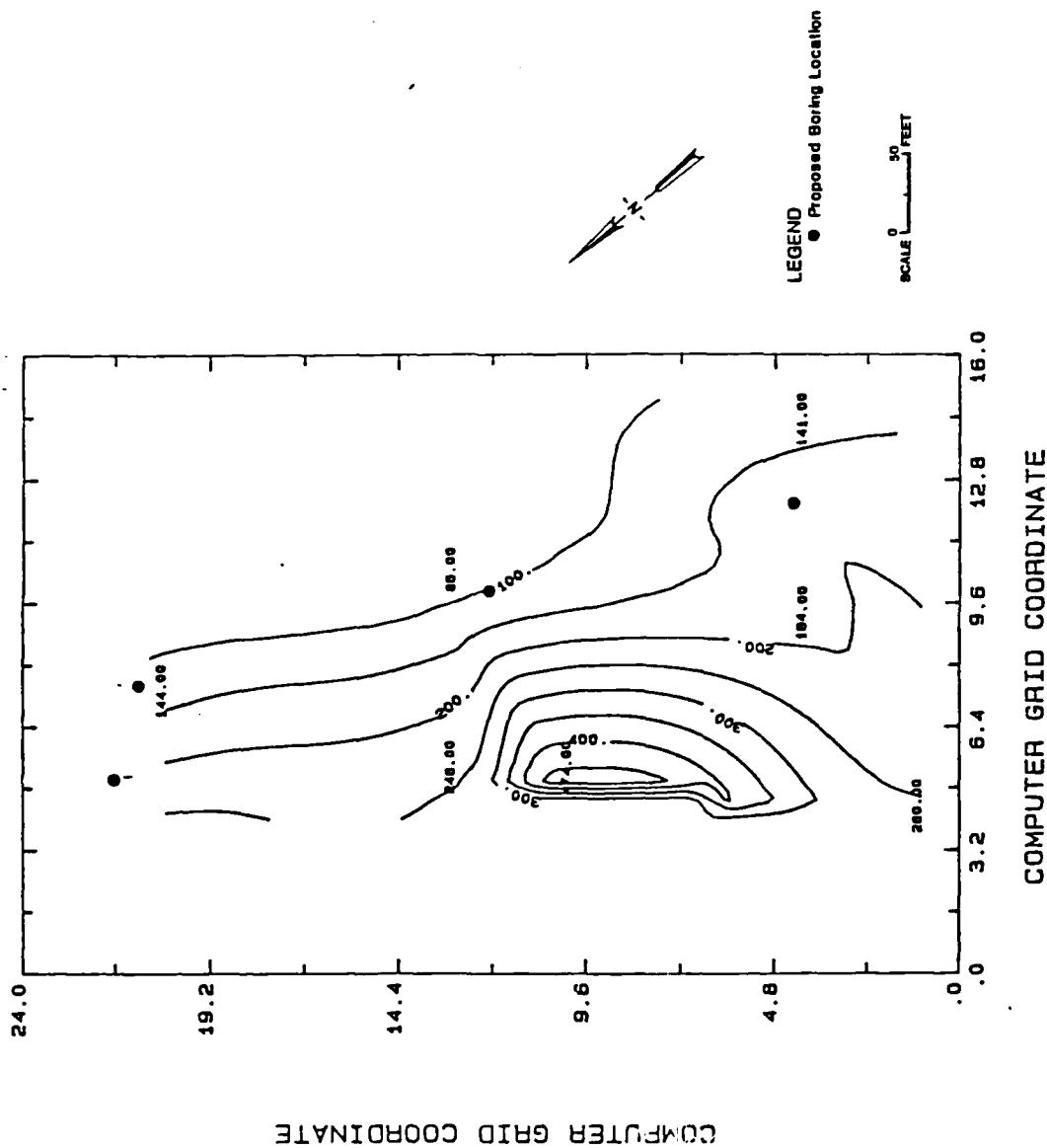




RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 5 FEET)

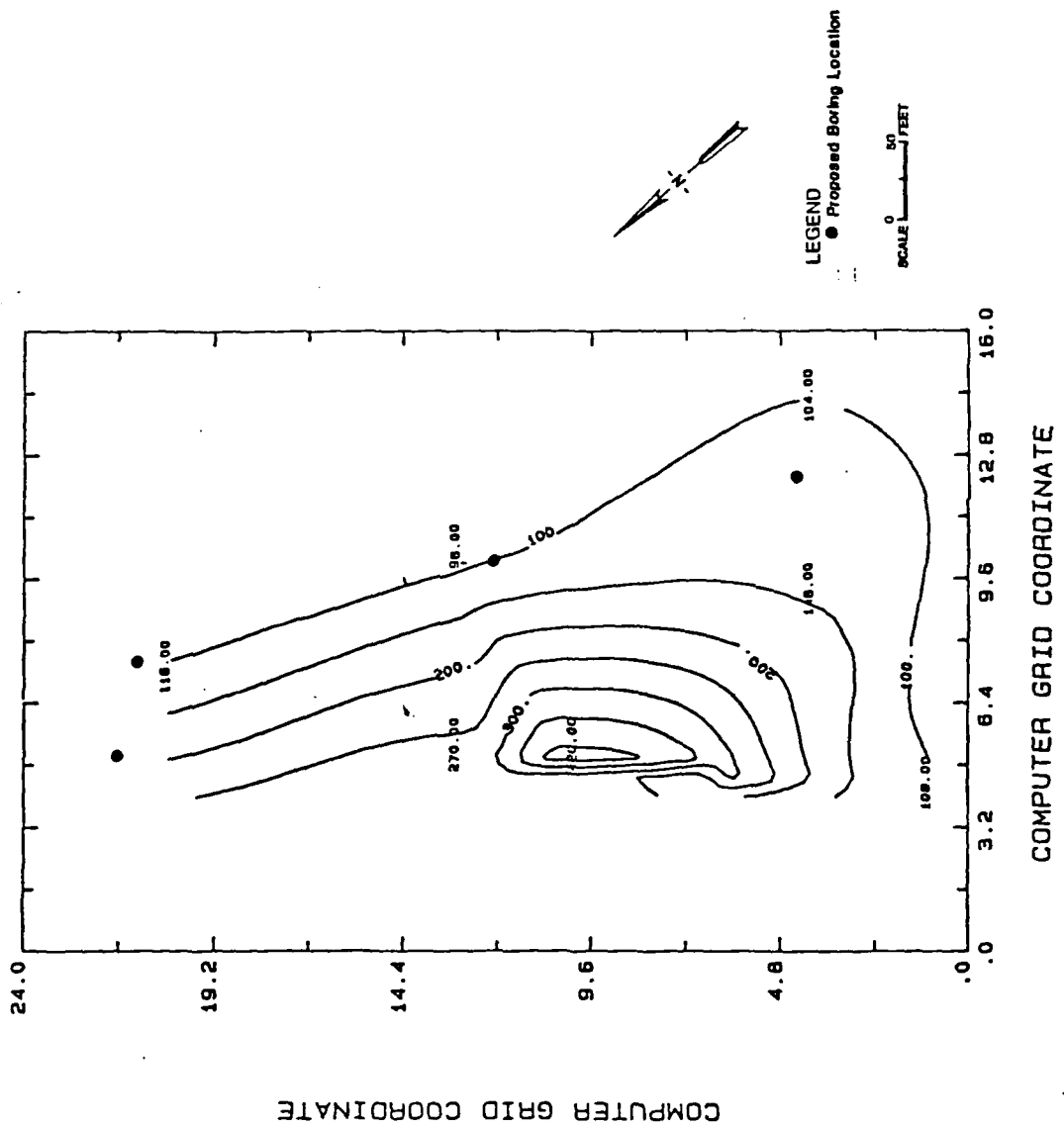


RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 10 FEET)



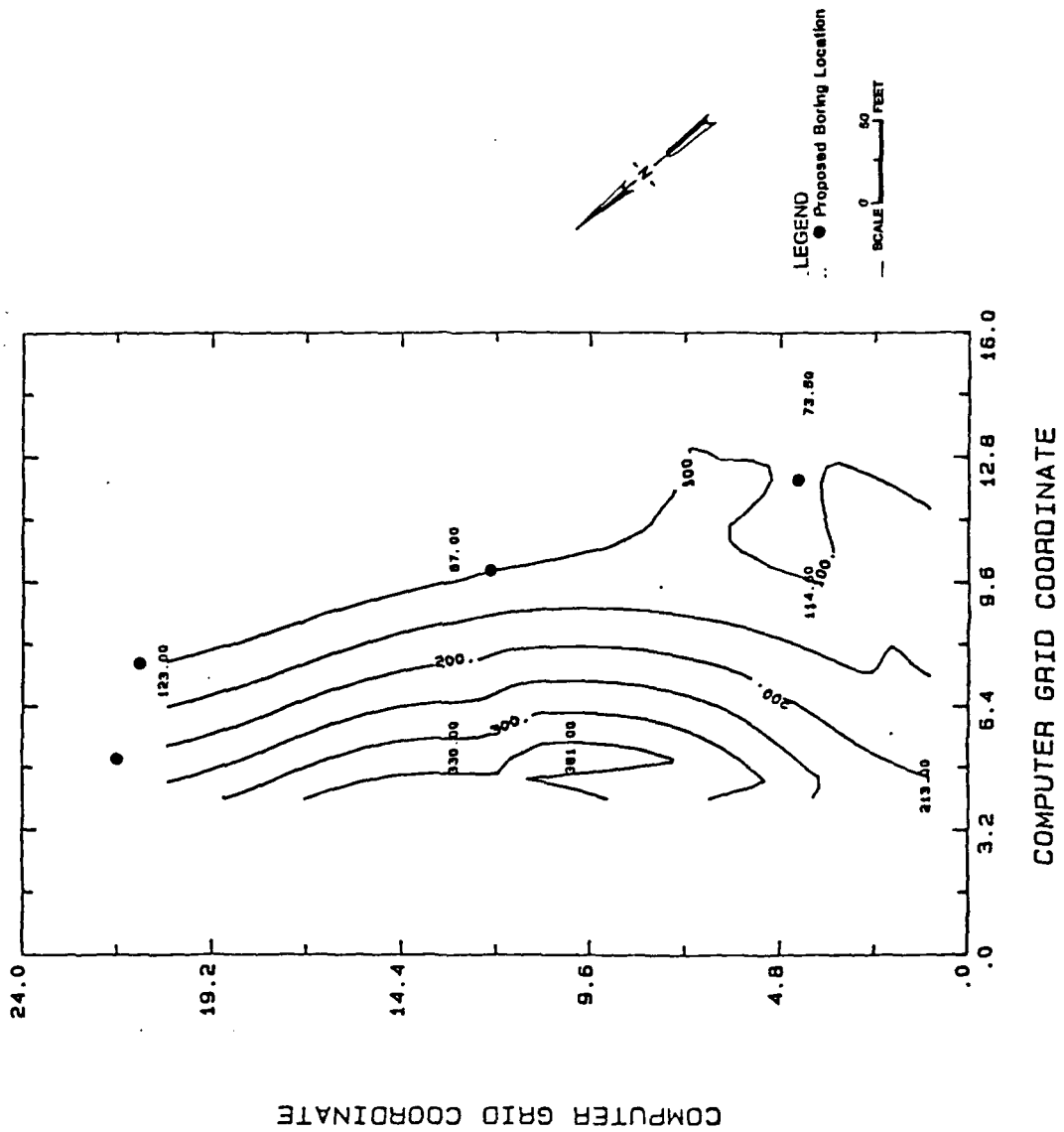
CONTOUR FROM 100.00 TO 400.00 CONTOUR INTERVAL - 80.00 OHM-Feet

RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 20 FEET)

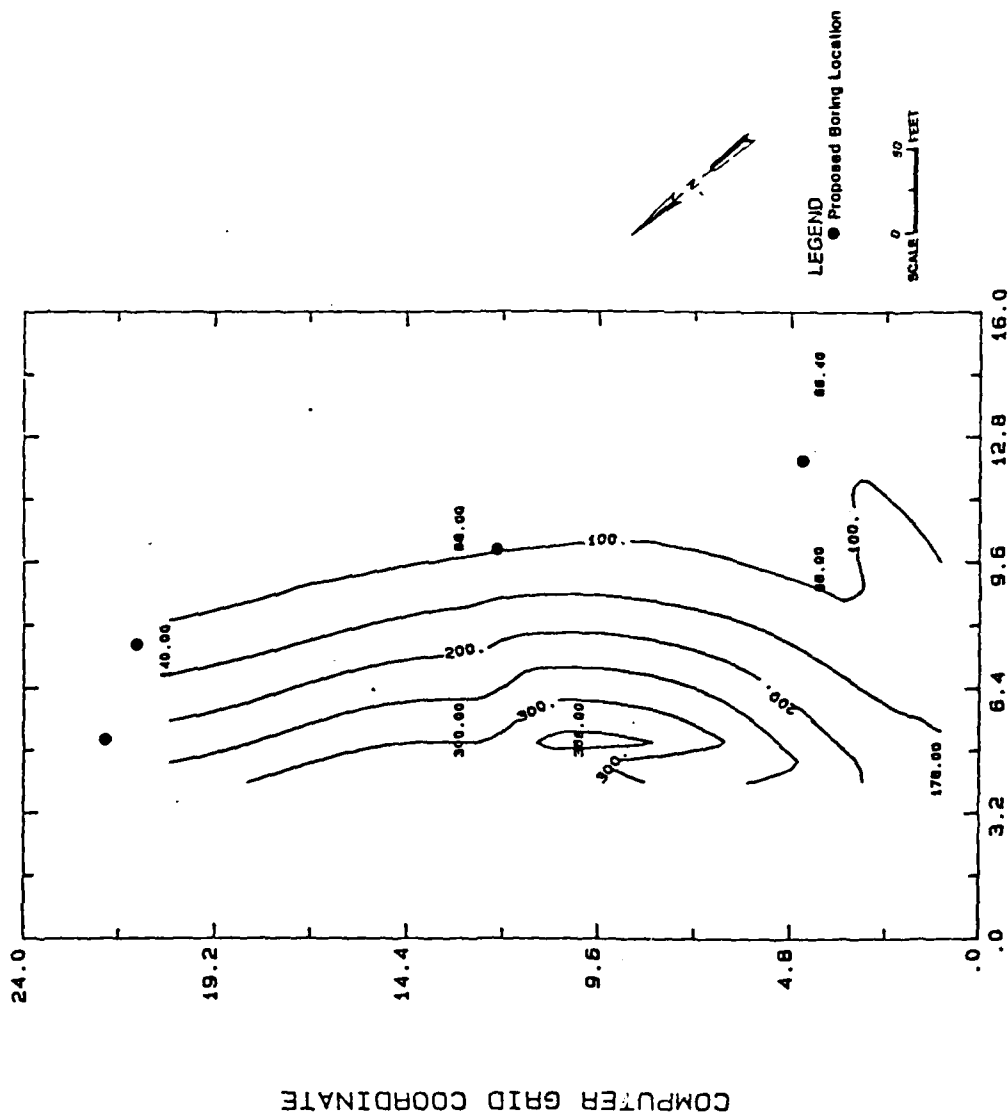


CONTOUR FROM 100.00 TO 400.00 CONTOUR INTERVAL 100.00

RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 30 FEET)



RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 40 FEET)



COMPUTER GRID COORDINATE

CONTOUR FROM 100.00 TO 300.00 CONTOUR INTERVAL - 50.00 OHM-Feet

SOUNDING 1 PJKS PLANT, COLORADO
SITE 4 & 5

p-p1 spacing (feet)	dial reading (ohms)	scale multiplier	corrected reading (ohms)	*k (feet)	apparent resistivity (ohm-ft)	cumulative resistivity (ohm-ft)
2.00	11.00	0.010	0.1100	899.80	98.98	98.98
4.00	23.00	0.010	0.2300	449.50	103.39	202.36
6.00	33.00	0.010	0.3300	299.30	98.77	301.13
8.00	48.00	0.010	0.4800	224.00	107.52	408.65
10.00	61.00	0.010	0.6100	178.80	109.07	517.72
12.00	75.00	0.010	0.7500	148.50	111.38	629.10
14.00	90.00	0.010	0.9000	126.80	114.12	743.22
16.00	105.00	0.010	1.0500	110.50	116.03	859.24
18.00	122.00	0.010	1.2200	97.80	119.32	978.56
20.00	136.00	0.010	1.3600	87.50	119.00	1097.56
22.00	156.00	0.010	1.5600	79.10	123.40	1220.95
24.00	174.00	0.010	1.7400	72.00	125.28	1346.23
26.00	192.00	0.010	1.9200	70.00	135.10	1481.33
28.00	212.00	0.010	2.1200	60.80	133.15	1614.48
30.00	241.00	0.010	2.4100	56.30	135.68	1750.17
32.00	259.00	0.010	2.5900	52.30	135.46	1885.62
34.00	275.00	0.010	2.7500	48.70	133.93	2019.55
36.00	312.00	0.010	3.1200	45.50	142.42	2161.96
38.00	338.00	0.010	3.3800	42.60	143.99	2305.95
40.00	37.00	0.100	3.7000	40.00	148.00	2453.95
42.00	39.00	0.100	3.9000	37.60	146.64	2600.59
44.00	42.50	0.100	4.2500	35.40	150.45	2751.04
46.00	46.00	0.100	4.6000	33.40	153.64	2904.68
48.00	50.00	0.100	5.0000	31.50	157.50	3062.18
50.00	54.00	0.100	5.4000	29.80	160.92	3223.10
52.00	57.50	0.100	5.7500	28.10	161.59	3384.68
54.00	62.00	0.100	6.2000	26.60	164.92	3549.60
56.00	67.00	0.100	6.7000	25.10	168.17	3717.77
58.00	72.50	0.100	7.2500	23.80	172.55	3890.32
60.00	78.00	0.100	7.8000	22.50	175.50	4065.82

*APPARENT RESISTIVITY = $(2:1R) [1/1/r1 - 1/r2 + 1/r3 + 1/r4]$ where K=[1]

SOUNDING 2 PJKS PLANT, COLORADO
SITE 4 & 5

p-pl spacing (feet)	dial reading (ohms)	scale multiplier	corrected reading (ohms)	*k (feet)	apparent resistivity (ohm-ft)	cumulative resistivity (ohm-ft)
2.00	10.00	0.010	0.1000	899.80	89.98	89.98
4.00	18.00	0.010	0.1800	449.50	80.91	170.89
6.00	22.00	0.010	0.2200	299.30	65.85	236.74
8.00	30.00	0.010	0.3000	234.00	67.20	303.94
10.00	35.00	0.010	0.3500	178.80	62.58	366.52
12.00	40.50	0.010	0.4050	148.50	60.14	426.66
14.00	56.00	0.010	0.5600	126.80	71.01	497.67
15.00	61.00	0.010	0.6100	110.50	67.41	565.07
18.00	66.00	0.010	0.6600	97.80	64.55	629.62
20.00	71.00	0.010	0.7100	87.50	62.13	691.74
22.00	83.00	0.010	0.8300	79.10	63.65	757.40
24.00	91.00	0.010	0.9100	72.00	63.62	822.02
26.00	98.00	0.010	0.9800	70.00	63.60	891.62
28.00	103.00	0.010	1.0300	60.80	63.62	954.14
30.00	112.00	0.010	1.1200	56.30	63.66	1017.20
32.00	119.00	0.010	1.1900	52.30	62.24	1079.43
34.00	129.00	0.010	1.2900	48.70	62.82	1142.26
36.00	141.00	0.010	1.4100	45.50	64.16	1206.41
38.00	151.00	0.010	1.5100	42.60	64.63	1270.74
40.00	166.00	0.010	1.6600	40.00	66.40	1337.14
42.00	185.00	0.010	1.8500	37.60	63.34	1407.07
44.00	199.00	0.010	1.9900	35.40	70.45	1477.52
46.00	208.00	0.010	2.0800	33.40	63.47	1546.93
48.00	231.00	0.010	2.3100	31.50	73.77	1619.76
50.00	25.50	0.100	2.5500	29.80	75.99	1695.75
52.00	27.00	0.100	2.7000	28.10	76.87	1771.62
54.00	29.50	0.100	2.9500	26.60	78.47	1850.09
56.00	32.50	0.100	3.2500	25.10	81.58	1931.66
58.00	34.50	0.100	3.4500	23.80	82.11	2013.77
60.00	37.00	0.100	3.7000	22.50	83.25	2097.02

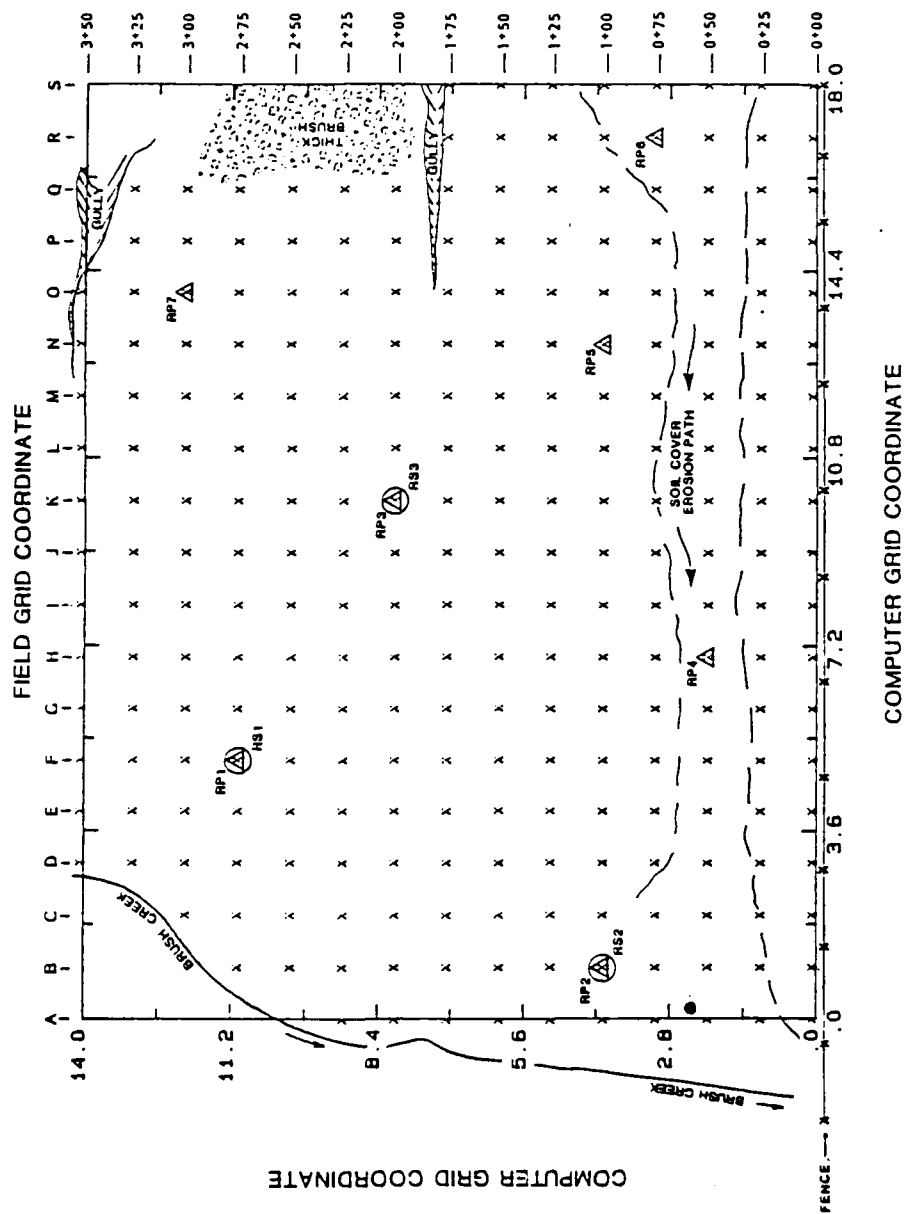
*APPARENT RESISTIVITY = $(2\pi iR) [1/1/r_1 - 1/r_2 \ 1/r_3 + 1/r_4]$ where $K=[]$

SOUNDING 3 PJKS PLANT, COLORADO
SITE 4 & 5

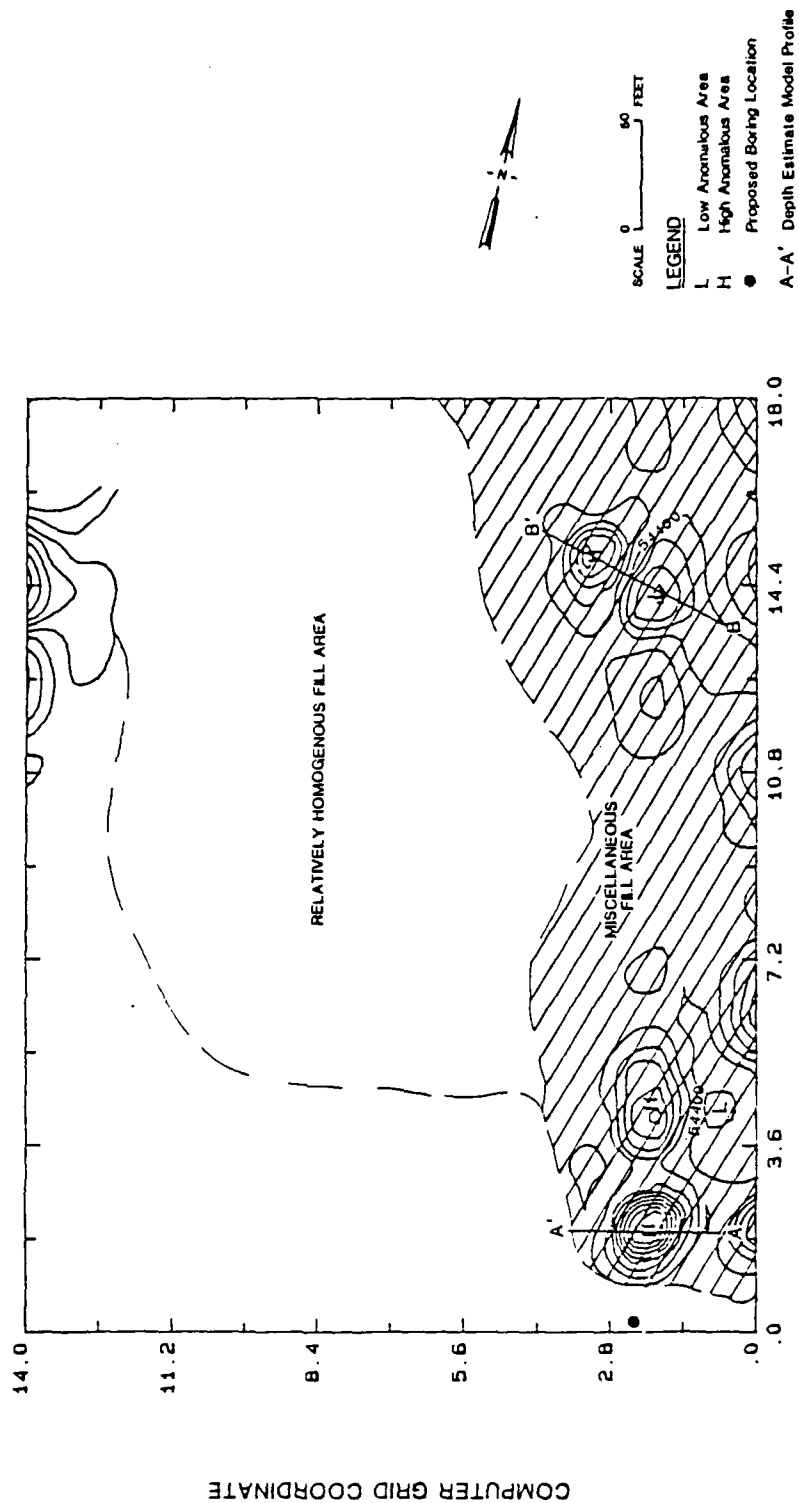
p-pl spacing (feet)	dial reading (ohms)	scale multiplier	corrected reading (ohms)	*k (feet)	apparent resistivity (ohm-ft)	cumulative resistivity (ohm-ft)
2.00	41.00	0.010	0.4100	899.80	368.92	368.92
4.00	86.00	0.010	0.8600	449.50	386.57	755.49
6.00	139.00	0.010	1.3900	299.30	386.10	1141.59
8.00	168.00	0.010	1.6800	224.20	376.32	1517.91
10.00	210.00	0.010	2.1000	178.80	375.48	1893.39
12.00	254.00	0.010	2.5400	148.50	377.19	2270.58
14.00	30.00	0.100	3.0000	126.90	380.40	2650.98
16.00	34.00	0.100	3.4000	110.50	375.70	3026.68
18.00	38.00	0.100	3.8000	97.80	371.64	3398.32
20.00	43.00	0.100	4.3000	87.50	376.25	3774.57
22.00	47.00	0.100	4.7000	79.10	371.77	4146.34
24.00	53.00	0.100	5.3000	72.00	381.60	4527.94
26.00	57.00	0.100	5.7000	70.00	389.00	4916.94
28.00	63.00	0.100	6.3000	60.00	389.04	5305.98
30.00	66.00	0.100	6.6000	56.00	371.68	5677.66
32.00	71.50	0.100	7.1500	50.00	373.90	6051.56
34.00	77.00	0.100	7.7000	48.70	374.90	6426.46
36.00	83.00	0.100	8.3000	43.00	373.10	6800.56
38.00	87.00	0.100	8.7000	40.00	370.00	7170.56
40.00	92.00	0.100	9.2000	38.00	368.20	7538.76
42.00	98.00	0.100	9.8000	33.00	368.48	7907.24
44.00	103.00	0.100	10.3000	30.00	368.40	8275.64
46.00	109.00	0.100	10.9000	28.00	368.40	8644.04
48.00	116.00	0.100	11.6000	21.00	368.40	9012.44
50.00	123.00	0.100	12.3000	20.00	368.40	9380.84
52.00	130.00	0.100	13.0000	18.00	368.40	9749.24
54.00	139.00	0.100	13.9000	16.00	368.40	10117.64
56.00	148.00	0.100	14.8000	14.00	368.40	10486.04
58.00	158.00	0.100	15.8000	12.00	368.40	10854.44
60.00	168.00	0.100	16.8000	10.00	368.40	11222.84

*APPARENT RESISTIVITY = $(2\pi i k) [1/r_1 - 1/r_2 + 1/r_3 - 1/r_4]$ where $K=0$

DATA GRID SYSTEM LAYOUT - SITE 10 PLANT PJKS



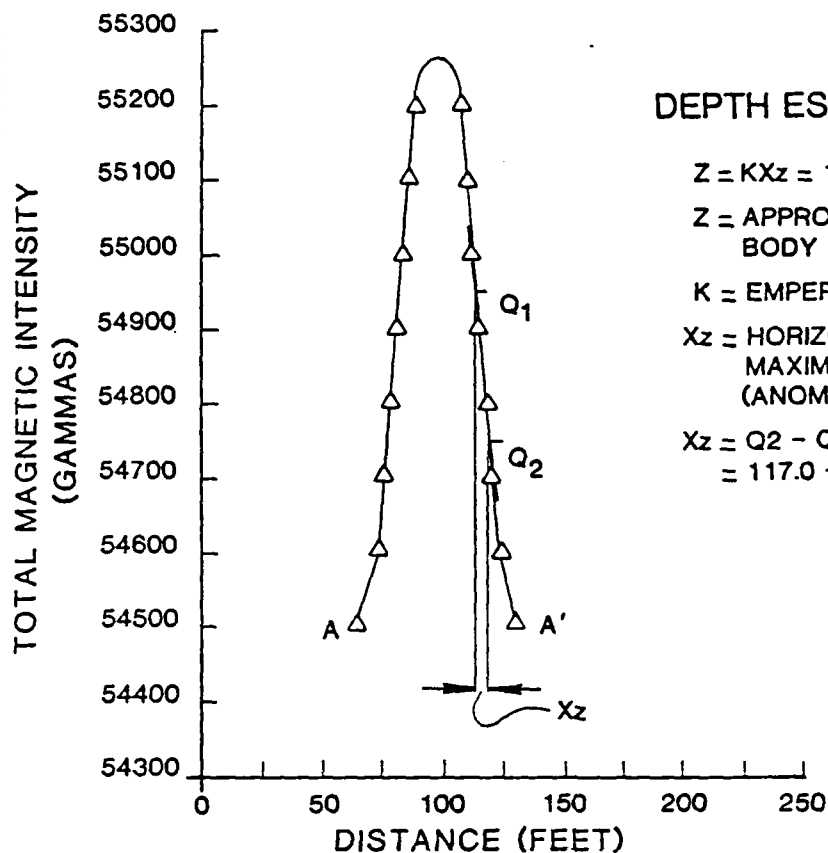
MAGNETOMETER SURVEY SITE 10 PLANT PJKS



COMPUTER GRID COORDINATE

CONTOUR FROM 84000.00 TO 88300.00 CONTOUR INTERVAL = 100.00 GAUSS

DEPTH ESTIMATE MODEL AT SITE 10 PROFILE A-A'



DEPTH ESTIMATE CALCULATION

$$Z = KXz = 1(4.5 \text{ FEET}) = 4.5 \text{ FEET}$$

Z = APPROXIMATE DEPTH TO CAUSATIVE BODY

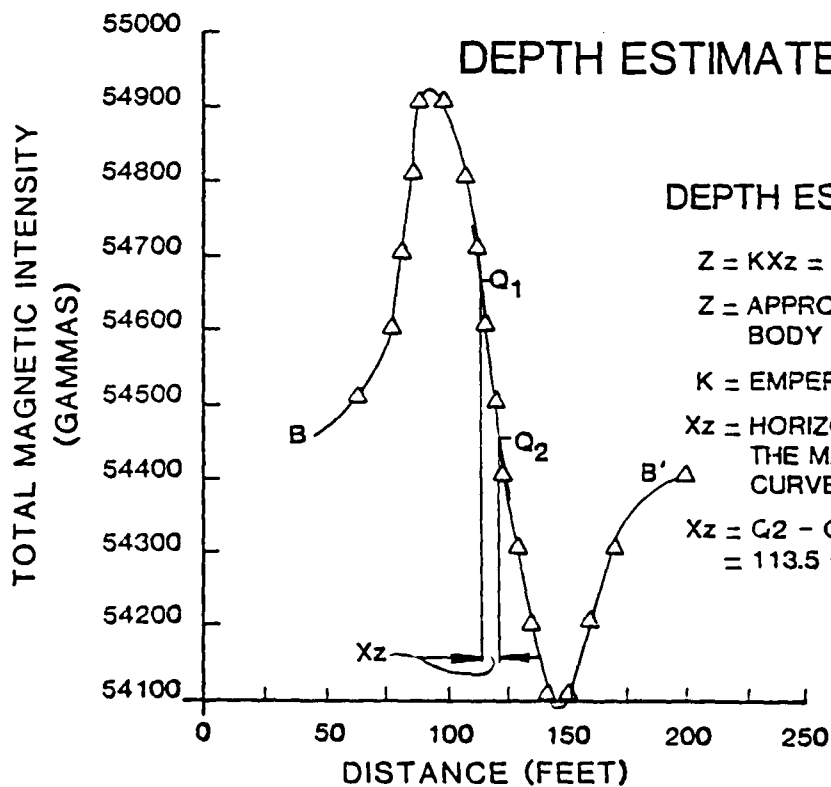
K = EMPIRICALLY DERIVED CONSTANT

Xz = HORIZONTAL COMPONENT OF THE MAXIMUM SLOPE LINE OF CURVE (ANOMALY)

$$Xz = Q2 - Q1 \\ = 117.0 - 112.5 = 4.5 \text{ FEET}$$

FIGURE 6B

DEPTH ESTIMATE MODEL AT SITE 10 PROFILE B-B'



DEPTH ESTIMATE CALCULATION

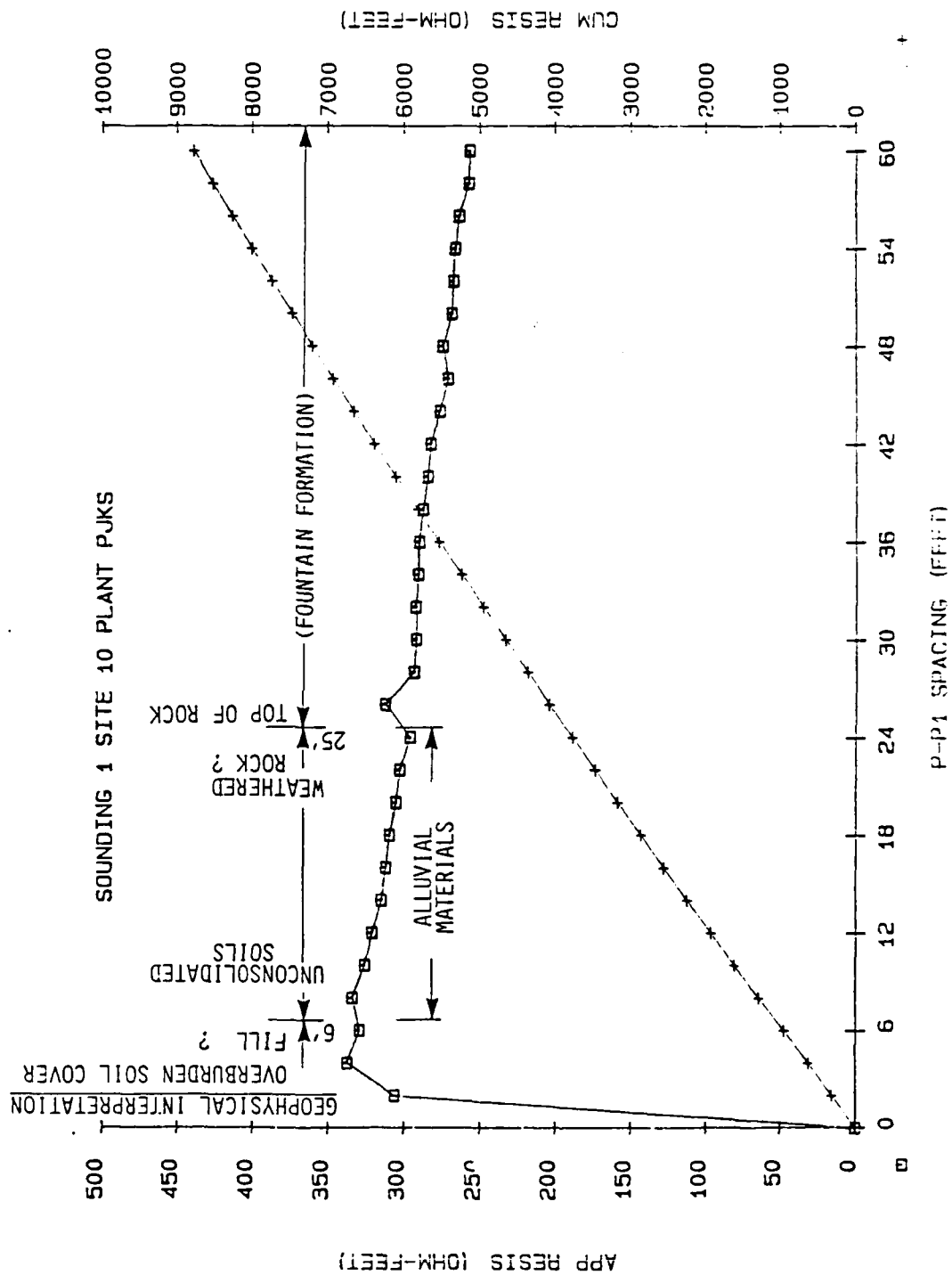
$$Z = KXz = 1(6.0 \text{ FEET}) = 6.0 \text{ FEET}$$

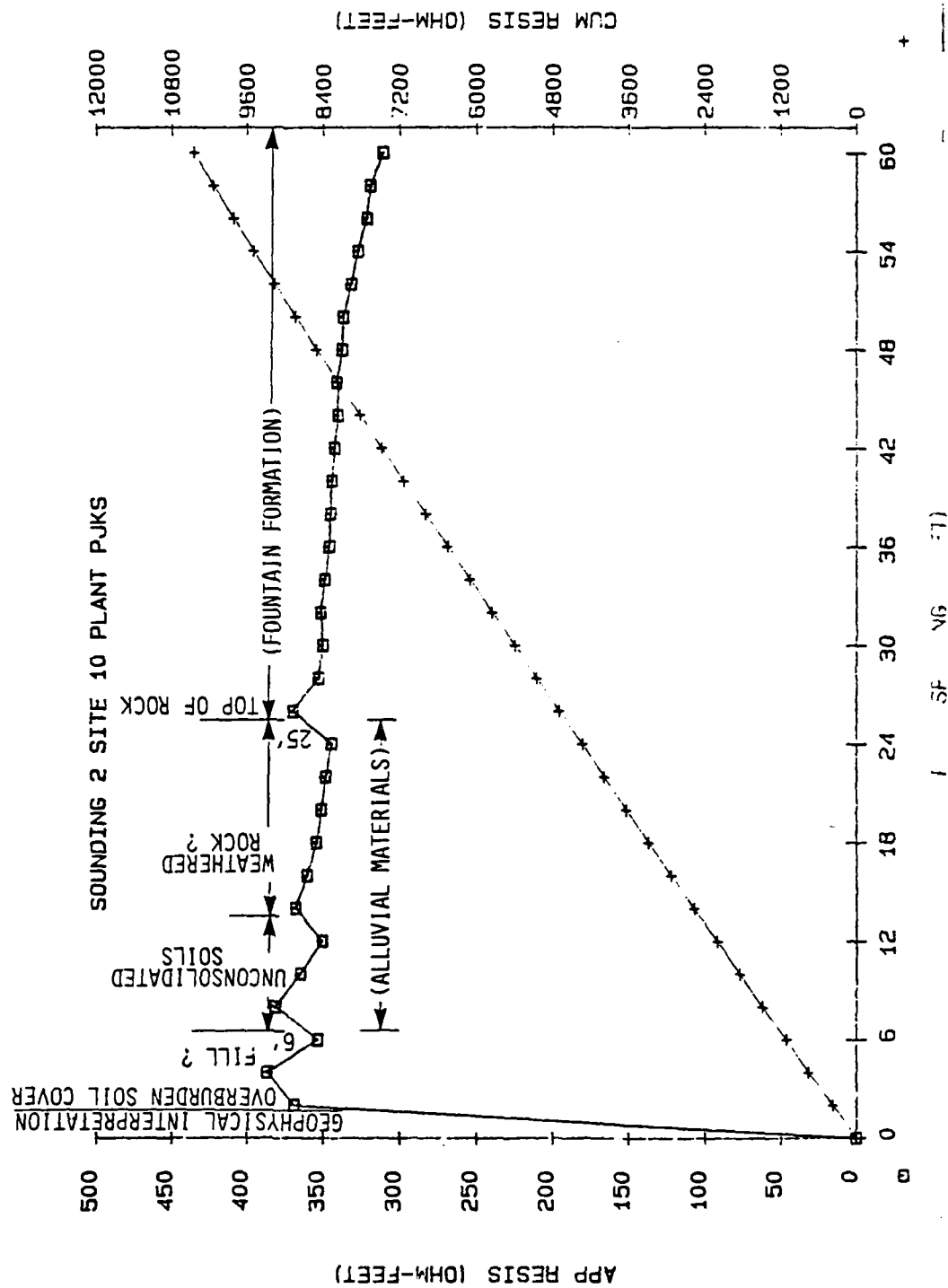
Z = APPROXIMATE DEPTH TO CAUSATIVE BODY

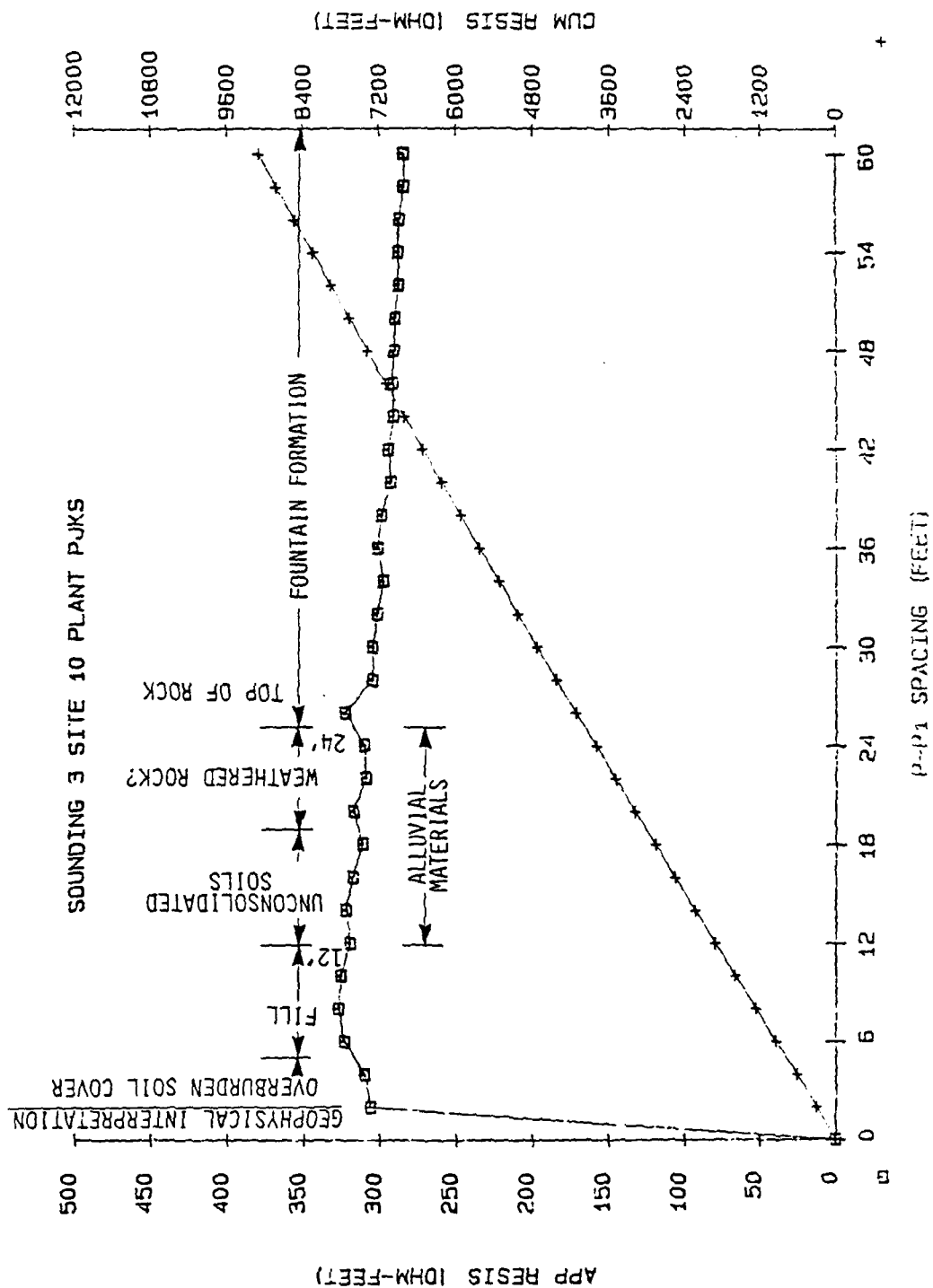
K = EMPIRICALLY DERIVED CONSTANT

Xz = HORIZONTAL COMPONENT OF THE MAXIMUM SLOPE LINE OF CURVE (ANOMALY)

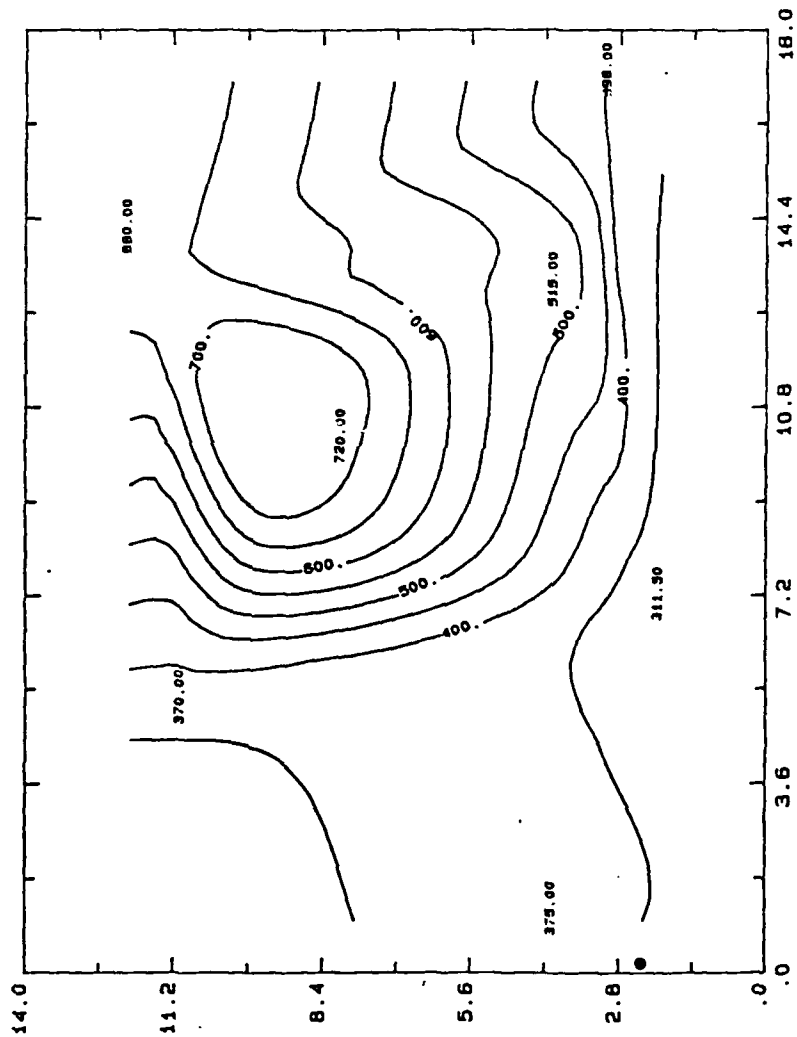
$$Xz = Q2 - Q1 \\ = 113.5 - 119.5 = 6.0 \text{ FEET}$$







RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 5 FEET)



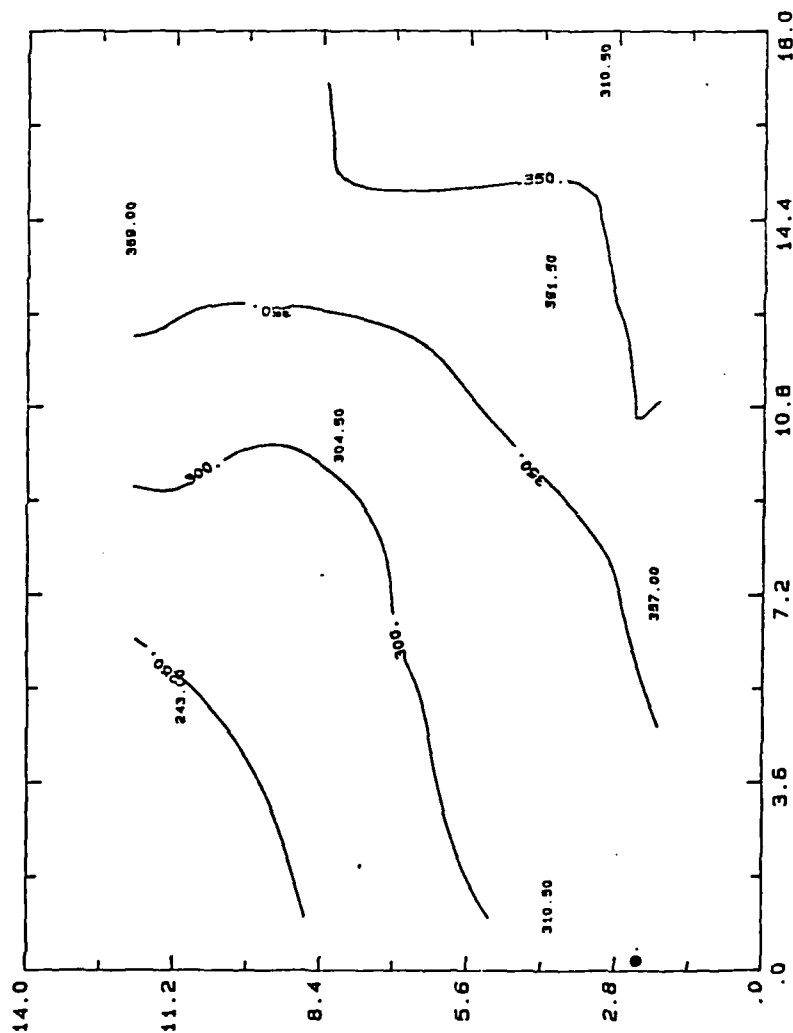
LEGEND

- Proposed Boring Location

COMPUTER GRID COORDINATE

CONTOUR FROM 350.00 TO 700.00 CONTOUR INTERVAL - 50.00

RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 15 FEET)

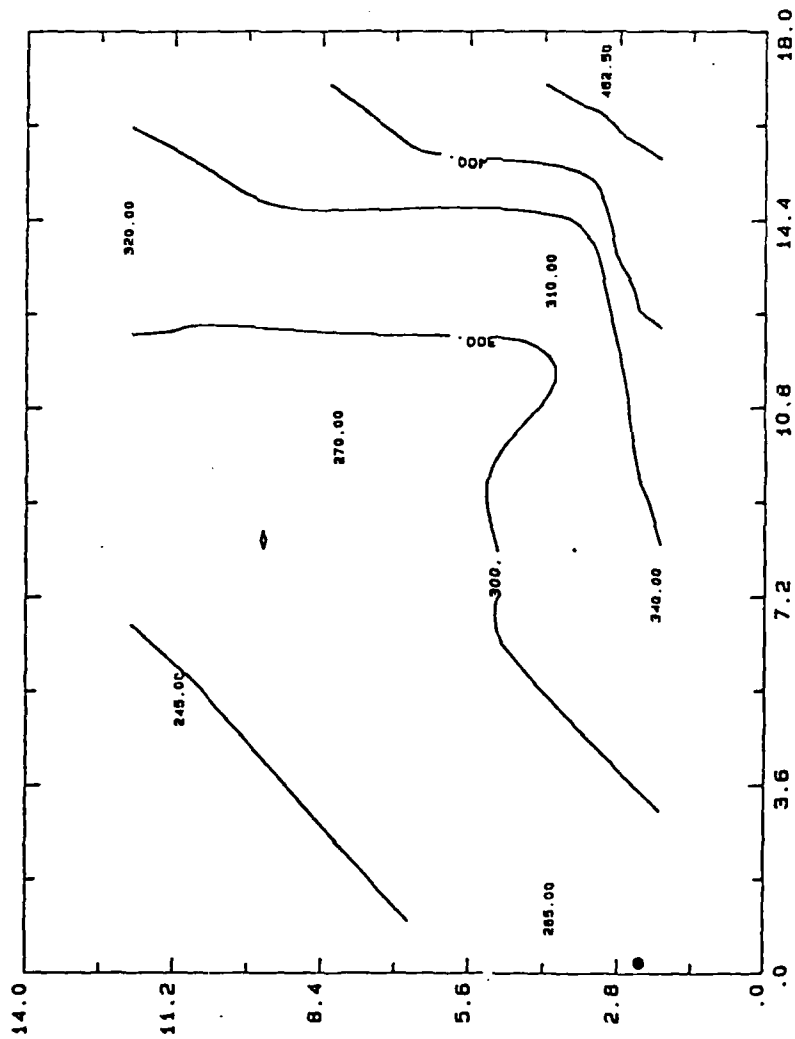


COMPUTER GRID COORDINATE

CONTOUR FROM 250.00 TO 350.00 CONTOUR INTERVAL - 50.00

5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

RESISTIVITY PROFILING CONTOUR MAP (DEPTH - 25 FEET)



COMPUTER GRID COORDINATE

CONTOUR FROM 250.00 TO 450.00 CONTOUR INTERVAL - 50.00

SOUNDING 1 PJKS PLANT, COLORADO
SITE 10

p-p1 spacing (feet)	dial reading (ohms)	scale multiplier	corrected reading (ohms)	*k (feet)	apparent resistivity (ohm-ft)	cumulative resistivity (ohm-ft)
2.00	34.00	0.010	0.3400	899.80	305.93	305.93
4.00	75.00	0.010	0.7500	449.50	337.13	643.06
6.00	110.00	0.010	1.1000	299.30	329.23	972.29
8.00	149.00	0.010	1.4900	224.00	333.76	1306.05
10.00	182.00	0.010	1.8200	178.80	325.42	1631.46
12.00	216.00	0.010	2.1600	148.50	320.76	1952.22
14.00	248.00	0.010	2.4800	125.80	314.46	2266.69
16.00	282.00	0.010	2.8200	110.50	311.61	2578.30
18.00	316.00	0.010	3.1600	97.80	309.85	2887.35
20.00	348.00	0.010	3.4800	87.50	304.50	3191.85
22.00	382.00	0.010	3.8200	79.10	302.16	3494.01
24.00	410.00	0.010	4.1000	72.00	295.28	3789.21
26.00	445.00	0.010	4.4500	70.00	311.50	4100.71
28.00	482.00	0.010	4.8200	60.80	303.86	4393.76
30.00	518.00	0.010	5.1800	56.30	291.63	4685.40
32.00	558.00	0.010	5.5800	53.30	291.83	4977.23
34.00	596.00	0.010	5.9600	48.70	290.25	5267.48
36.00	636.00	0.010	6.3600	45.50	289.38	5556.86
38.00	674.00	0.010	6.7400	43.60	287.12	5843.99
40.00	710.00	0.010	7.1000	40.00	284.00	6127.99
42.00	75.00	0.100	7.5000	37.60	292.00	6409.99
44.00	78.00	0.100	7.8000	35.40	276.12	6686.11
46.00	81.00	0.100	8.1000	33.40	270.54	6956.65
48.00	87.00	0.100	8.7000	31.00	274.25	7230.70
50.00	90.00	0.100	9.0000	29.00	269.20	7499.90
52.00	95.00	0.100	9.5000	27.50	266.35	7766.25
54.00	100.00	0.100	10.0000	26.00	268.00	8034.25
56.00	105.00	0.100	10.5000	25.10	263.55	8297.80
58.00	108.00	0.100	10.8000	23.80	267.24	8565.04
60.00	114.00	0.100	11.4000	22.50	255.50	8800.54

*APPARENT RESISTIVITY = $(2\pi kR) [1/r_1 - 1/r_2 + 1/r_3 - 1/r_4]$ where $k = [$

SOUNDING 2 PJKS PLANT, COLORADO
SITE 10

p-pl spacing (feet)	dial reading (ohms)	scale multiplier	corrected reading (ohms)	*k (feet)	apparent resistivity (ohm-ft)	cumulative resistivity (ohm-ft)
2.00	23.00	0.010	0.2300	899.80	206.95	206.95
4.00	86.00	0.010	0.8600	449.50	386.57	593.52
6.00	118.00	0.010	1.1800	299.30	353.17	946.70
8.00	170.00	0.010	1.7000	224.00	380.80	1327.50
10.00	224.00	0.010	2.2400	178.80	364.75	1692.25
12.00	236.00	0.010	2.3600	149.50	350.46	2042.71
14.00	330.00	0.010	3.3000	126.80	367.72	2410.43
16.00	329.00	0.010	3.2900	110.50	360.23	2770.66
18.00	368.00	0.010	3.6800	97.80	354.84	3124.70
20.00	401.00	0.010	4.0100	87.50	350.88	3475.57
22.00	440.00	0.010	4.4000	79.10	349.04	3823.61
24.00	478.00	0.010	4.7800	72.00	344.16	4167.77
26.00	529.00	0.010	5.2900	70.00	369.60	4537.37
28.00	520.00	0.010	5.2000	60.80	352.64	4890.01
30.00	622.00	0.010	6.2200	56.30	350.19	5240.20
32.00	672.00	0.010	6.7200	52.20	351.46	5591.66
34.00	716.00	0.010	7.1600	48.70	348.69	5940.35
36.00	76.00	0.100	7.6000	45.50	354.80	6295.15
38.00	31.00	0.100	8.1200	42.50	349.26	6644.41
40.00	86.00	0.100	8.6200	40.00	341.20	6985.61
42.00	1.00	0.100	0.1200	37.20	33.76	7019.37
44.00	36.00	0.100	3.6000	35.40	33.24	7052.61
46.00	102.00	0.100	10.2000	33.40	33.00	7085.61
48.00	107.00	0.100	10.7000	31.50	33.00	7118.61
50.00	112.00	0.100	11.2000	30.90	33.00	7151.61
52.00	118.00	0.100	11.8000	30.10	33.00	7184.61
54.00	123.00	0.100	12.3000	29.50	33.00	7217.61
56.00	129.00	0.100	12.9000	28.90	33.00	7250.61
58.00	134.00	0.100	13.4000	28.30	33.00	7283.61
60.00	138.00	0.100	13.8000	27.50	33.00	7316.61

*APPARENT RESISTIVITY = (211R) [1/1/r1-1/r2 1/r3+1/r4] where K=[

SOUNDING 3 PJKS PLANT, COLORADO
SITE 10

p-p1 spacing (feet)	dial reading (ohms)	scale multiplier	corrected reading (ohms)	*k (feet)	apparent resistivity (ohm-ft)	cumulative resistivity (ohm-ft)
2.00	34.00	0.010	0.3400	899.80	305.93	305.93
4.00	69.00	0.010	0.6900	449.50	310.16	616.09
6.00	108.00	0.010	1.0800	299.30	323.24	939.33
8.00	146.00	0.010	1.4600	224.00	327.04	1266.37
10.00	183.00	0.010	1.8300	178.80	325.42	1591.79
12.00	215.00	0.010	2.1500	148.50	319.28	1911.06
14.00	254.00	0.010	2.5400	126.80	322.07	2233.13
16.00	287.00	0.010	2.8700	110.50	317.14	2550.27
18.00	319.00	0.010	3.1900	97.80	311.00	2861.27
20.00	362.00	0.010	3.6200	87.50	316.75	3178.02
22.00	39.00	0.100	3.9000	79.10	308.49	3486.51
24.00	43.00	0.100	4.3000	72.00	309.60	3796.11
26.00	48.00	0.100	4.8000	70.00	322.00	4118.11
28.00	50.00	0.100	5.0000	60.80	304.00	4422.11
30.00	54.00	0.100	5.4000	56.30	304.02	4726.13
32.00	57.50	0.100	5.7500	52.30	300.73	5026.86
34.00	61.00	0.100	6.1000	48.70	297.07	5323.93
36.00	66.00	0.100	6.6000	45.50	300.30	5624.23
38.00	73.00	0.100	7.3000	42.60	298.20	5922.43
40.00	73.00	0.100	7.3000	40.00	292.00	6214.43
42.00	78.00	0.100	7.8000	37.60	292.28	6507.71
44.00	82.00	0.100	8.2000	35.40	290.38	6797.99
46.00	87.00	0.100	8.7000	33.40	290.58	7088.57
48.00	92.00	0.100	9.2000	31.50	289.80	7378.37
50.00	97.00	0.100	9.7000	29.80	288.06	7667.43
52.00	102.00	0.100	10.2000	28.10	286.62	7954.05
54.00	108.00	0.100	10.8000	26.60	287.28	8241.33
56.00	114.00	0.100	11.4000	25.10	286.14	8527.47
58.00	119.00	0.100	11.9000	23.80	283.22	8810.69
60.00	126.00	0.100	12.6000	22.50	283.50	9094.19

*APPARENT RESISTIVITY = $(2\pi kR) [1/r_1 - 1/r_2 - 1/r_3 + 1/r_4]$ where $k = [$

APPENDIX H

**DETECTION LIMITS, PRESERVATIVES, AND HOLDING TIMES
ELAPSED TIME BETWEEN SAMPLING AND LAB ANALYSES FOR PJKS SAMPLES
SAMPLE NUMBERING SYSTEM
SAMPLE HANDLING AND PACKAGING**

DETECTION LIMITS, PRESERVATIVES, AND HOLDING TIMES

Detection Limits, Preservatives and
Holding Times for AFP PJKS Analytical Parameters

<u>Parameter</u>	<u>Detection Limit</u>	<u>Preservative</u>	<u>Holding Times</u>
Purgeable organic compounds	Note 1	None required	14 days
	Note 2		14 days
Base/neutral/ acid extractable organic compounds	Note 3	None required	14 days
Oil and Grease	5.0 mg/L ⁴	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
	1.0 mg/g ⁵	Cool, 4°C	
Total Dissolved Solids (TDS)	10 mg/L ⁴	Cool, 4°C	7 days
Arsenic	0.002 mg/L ⁴ 0.04 mg/L ⁵	HNO ₃ to pH <2	6 months
Cadmium	0.02 mg/L ⁴ 0.40 ug/g ⁵	HNO ₃ to pH <2	6 months
Chromium (total)	0.11 mg/L ⁴ 2.10 ug/g ⁵	Cool, 4°C	6 hours
Chromium (hexavalent)	0.02 mg/L ⁴ 0.17 ug/g ⁵		24 hours
Lead	0.12 mg/L ⁴ 2.40 ug/g ⁵	HNO ₃ to pH <2	6 months
Mercury	0.0002 mg/L ⁴ .004 ug/g ⁵	HNO ₃ to pH <2	28 days
Selenium	0.002 mg/L ⁴ 0.04 ug/L ⁵	HNO ₃ to pH <2	6 months
Thorium	0.1 pCi/L ⁴ 0.1 pCi/g ⁵	HNO ₃ to pH <2	6 months
Gross alpha	20 pCi/L ⁴	None	1 year

Detection Limits, Preservatives and
Holding Times for AFP PJKS Analytical Parameters
(Continued)

<u>Parameter</u>	<u>Detection Limit</u>	<u>Preservative</u>	<u>Holding Times</u>
Gross beta	30 pCi/L ⁴	None	1 year
High resolution gamma	10 pCi/L ⁴	HNO ₃ , pH = 1	1 year
pH, in-situ	--	None required	Analyzed immediately
Temperature, in-situ	--	None required	Analyzed immediately
Specific cond. in-situ	--	None required	Analyzed immediately
Phenols	0.005 mg/L ⁴ 0.5 ug/g ⁵	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
MEK, 1 pond + 3 wells	10 mg/L ⁴ 10 ug/g ⁵	None	14 days
Hydrazine	1 mg/L ⁴ 6 mg/g ⁵	None	--
NDMA	0.25 mg/L ⁴ 0.25 ug/g ⁵	None	--
Total Kjeldahl Nitrogen	0.1 mg/L ⁴ 5 ug/g ⁵	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
Nitrate	0.1 mg/L ⁴ 1 ug/g ⁵	Cool, 4°C	48 hours
Nitrite	0.011 mg/L ⁴ 0.08 ug/g ⁵	Cool, 4°C	48 hours

NOTES:

- 1 Detection limits for halogenated and aromatic volatile organics are as specified for compounds by EPA Methods 8010/8020. If analyte analyses exceeded 10 ug/g in soil, second column confirmation was performed.

Detection Limits, Preservatives and
Holding Times for AFP PJKS Analytical Parameters
(Continued)

- 2 Detection limits for purgeable halocarbons and aromatics are as specified for the compounds by EPA Methods 601/602. Methods 601 and 602 for volatile organics require positive confirmation by a second gas chromatographic column. This was done before reporting positive values. Methods 601 and 602 specify the two columns to use. Second column confirmation was performed when values exceeded:

Benzene	0.7 ug/L
Carbon Tetrachloride	4.0 ug/L
1,2 Dichloroethane	0.1 ug/L
Methylene Chloride	4.0 ug/L
Tetrachloroethylene	4.0 ug/L
Trichloroethylene	1.0 ug/L
Vinyl Chloride	1.0 ug/L
Dichlorobenzene isomers	Sum greater than 10 ug/L
Other organics	Greater than 10 ug/L

- 3 Detection limits specified by the EPA for Method 625 are used.
- 4 Water sample detection limit.
- 5 Soil sample detection limit.

DETECTION LIMITS FOR
BASE/NEUTRAL COMPOUNDS

BASE/NEUTRAL/ACID EXTRACTABLE ORGANIC COMPOUNDS
EPA METHOD 625

<u>Compound</u>	<u>Detection Limit</u> ^{1/} (ug/L)
Di-n-butyl phthalate	5
Di-n-octyl phthalate	10
Diethyl phthalate	4
Dimethyl phthalate	8
Benzo (a) anthracene	10
Benzo (a) pyrene	14
3,4-benzofluoroanthene	20
Benzo (k) fluoroanthene	20
Chrysene	8
Acenaphthylene	2
Anthracene	4
Benzo (ghi) perylene	14
Fluorene	4
Phenanthrene	6
Dibenzo (a,h) anthracene	16
Ideno (1,2,3-cd) pyrene	14
Pyrene	6
Dieldrin	50
4,4' - DDD	50
4,4' - DDT	50
Endosulfan sulfate	50
Endrin aldehyde	50
Chlordane	50
Toxaphene	50
α- BHC	50
β - BHC	50
δ - BHC	50
Lindane	50
Endosulfan I	50
Endosulfan II	50
Heptachlor	50
Aldrin	50
PCB 1016	100
PCB 1221	100
PCB 1232	100
PCB 1242	100
PCB 1254	100
PCB 1260	100

1/ Detection limits from APPL. Inc. analysis.

ELAPSED TIME BETWEEN SAMPLING AND LAB ANALYSES FOR PJKS SAMPLES

Several sampling episodes were performed at PJKS between December 13, 1985 and April 24, 1986. The resampling was performed because several parameters analyzed exceeded recommended holding times and some analyses were incomplete.

The following tables summarize each sampling episode and compare the date analyzed, elapsed time, and recommended holding time.

Elapsed Time Between Sampling and Lab Analyses
for PJKS Soil Samples at Site 1

Sample	Sample Date	8010 + 8020*	NO ₂ ^{1/}	NO ₃ ^{1/}	Phenolics ^{1/}	TKN ^{1/}	6+ 2/ Cr
PJKS 1-ES-3	SS-1	12/23/85-10-14	12/20/85-7	12/20/85-7	1/3/86-21	12/18/85-5	12/23/85-10
	SS-2	12/23/85-10-14	12/20/85-7	12/20/85-7	1/3/86-21	12/18/85-5	12/23/85-10
	SS-3	12/24/85-11-14	12/20/85-7	12/20/85-7	1/3/86-21	12/23/85-10	12/23/85-10
	SS-4	12/24/85-11-14	12/20/85-7	12/20/85-7	1/3/86-21	12/23/85-10	12/26/85-13
	SS-5	12/24/85-11-14	12/20/85-7	12/20/85-7	1/8/86-26	12/23/85-10	12/23/85-10
	SS-6	12/26/85-13-14	12/20/85-7	12/20/85-7	1/8/86-26	12/23/85-10	12/23/85-10
	SS-7	12/26/85-13-14	12/20/85-7	12/20/85-7	1/8/86-26	12/26/85-13	12/23/85-10
1-ES-4	SS-1	12/26/85-13-14	12/20/85-7	12/20/85-7	1/8/86-26	12/26/85-10	12/23/85-10
	SS-2	12/26/85-13-14	12/20/85-7	12/20/85-7	1/8/86-26	12/26/85-13	12/26/85-13
	SS-3	12/26/85-13-14	12/20/85-7	12/20/85-7	1/8/86-26	12/26/85-13	12/26/85-13
	SS-4	12/26/85-13-14	12/20/85-7	12/20/85-7	1/9/86-27	12/26/85-13	12/23/85-10
	SS-5	12/26/85-13-14	12/20/85-7	12/20/85-7	1/9/86-27	12/26/85-13	12/23/85-10
	SS-6	12/26/85-13-14	12/20/85-7	12/20/85-7	1/9/86-27	12/26/85-13	12/23/85-10
1-ES-5	SS-1	12/27/85-11-14	12/20/85-4	12/23/85-7	1/9/86-24	12/26/85-10	12/23/85-7
	SS-2	12/27/85-11-14	12/20/85-4	12/23/85-7	1/9/86-24	12/26/85-10	12/23/85-7
	SS-3	12/27/85-11-14	12/20/85-4	12/23/85-7	1/9/86-24	12/26/85-10	12/23/85-7
	SS-4	12/27/85-11-14	12/20/85-4	12/23/85-7	1/9/86-24	12/26/85-10	12/23/85-7
	SS-5	12/27/85-11-14	12/20/85-4	12/23/85-7	1/9/86-24	12/26/85-10	12/23/85-7
	SS-6	12/27/85-11-14	12/20/85-4	12/23/85-7	1/9/86-24	12/26/85-10	12/23/85-7
1-ES-6	SS-1	12/28/85-11-14	12/20/85-3	12/20/85-3	1/9/86-23	12/26/85-9	12/23/85-6
	SS-2	12/28/85-11-14	12/27/85-10	12/27/85-10	1/9/86-23	12/26/85-9	12/23/85-6
	SS-3	12/28/85-11-14	12/20/85-3	12/20/85-3	1/9/86-23	12/26/85-9	12/23/85-6
	SS-4	1/3/86-17-14	12/27/85-10	12/27/85-10	1/9/86-23	12/26/85-9	12/23/85-6
	SS-5	1/3/86-17-14	12/27/85-10	12/27/85-10	1/9/86-23	1/21/86-35	12/23/85-6
	SS-6	1/3/86-17-14	12/27/85-10	12/27/85-10	1/9/86-23	1/21/86-35	12/23/85-6
1-ES-7	SS-1	1/1/86-15-14	12/27/85-10	12/24/85-7	1/9/86-23	1/21/86-35	12/30/85-13
	SS-2	1/1/86-15-14	12/27/85-10	12/24/85-7	1/9/86-23	1/21/86-35	12/30/85-13
	SS-3	1/1/86-15-14	12/27/85-10	12/24/85-7	1/9/86-23	1/21/86-35	12/30/85-13
	SS-4	1/1/86-15-14	12/27/85-10	12/24/85-7	1/9/86-23	1/21/86-35	12/30/85-13
	SS-5	1/1/86-15-14	12/27/85-10	12/24/85-7	1/9/86-23	1/21/86-35	12/30/85-13
	SS-6	1/1/86-15-14	12/27/85-10	12/24/85-7	1/9/86-23	1/21/86-35	12/30/85-13

* Date analyzed - Elapsed time (days) - Recommended holding time (days).

1/ Holding Times for soil and sediment samples have not been defined.

2/ Analyses performed on alkaline digestate that was prepared as soon as sample was received in the lab (within 24-hour holding time).

Elapsed Time Between Sampling and Lab Analyses
for PJKS Soil Samples at Site 2 and 3

Sample	Sample Date	8010 + 8020 *	NO ₂	NO ₃	Phenolics	TKN	6+ *2/ Ct
PJKS 2-ES-9	SS-1	12/19/85	1/2/86-14-14	1/21/86-33	2/5/86-48	1/21/86-33	--
	SS-2	12/19/85	1/2/86-14-14	1/21/86-33	2/5/86-48	1/30/86-42	--
	SS-3	12/19/85	1/2/86-14-14	1/21/86-33	2/5/86-48	1/30/86-42	--
	SS-4	12/19/85	1/2/86-14-14	1/21/86-33	2/5/86-48	1/30/86-42	--
	SS-5	12/19/85	1/2/86-14-14	1/21/86-33	2/5/86-48	1/30/86-42	--
2-ES-11	SS-1	12/30/85	1/6/86-7-14	2/6/86-38	2/12/86-44	1/30/86-31	--
	SS-2	12/30/85	1/6/86-7-14	2/6/86-38	2/12/86-44	1/30/86-31	--
	SS-3	12/30/85	1/6/86-7-14	2/6/86-38	2/13/86-45	1/30/86-31	--
	SS-4	12/30/85	1/6/86-7-14	2/6/86-38	2/13/86-45	1/30/86-31	--
	SS-5	12/30/85	1/6/86-7-14	2/6/86-38	2/13/86-45	1/30/86-31	--
2-ES-13	SS-1	12/31/85	1/6/86-6-14	2/6/86-37	2/13/86-44	1/31/86-31	--
	SS-2	12/31/85	1/7/86-7-14	2/6/86-37	2/13/86-44	1/31/86-31	--
	SS-3	12/31/85	1/7/86-7-14	2/6/86-37	2/13/86-44	1/31/86-31	--
2-ES-14	SS-1	12/31/85	1/7/86-7-14	2/10/86-41	2/18/86-49	1/31/86-31	--
	SS-2	12/31/85	1/7/86-7-14	2/10/86-41	2/18/86-49	1/31/86-31	--
	SS-3	12/31/85	1/7/86-7-14	2/10/86-41	2/18/86-49	1/31/86-31	--
	SS-4	12/31/85	1/7/86-7-14	2/10/86-41	2/18/86-49	1/31/86-31	--
	SS-5	12/31/85	1/7/86-7-14	2/10/86-41	2/18/86-49	1/31/86-31	--
3-ES-15	SS-1	1/2/86	1/8/86-6-14	--	--	--	1/17/86-15
	SS-2	1/2/86	1/8/86-6-14	--	--	--	1/17/86-15
	SS-3	1/9/86	1/13/86-4-14	--	--	--	1/20/86-11
	SS-4	1/9/86	1/13/86-4-14	--	--	--	1/20/86-11
	SS-5	1/9/86	1/13/86-4-14	--	--	--	1/20/86-11
	SS-6	1/9/86	1/13/86-4-14	--	--	--	1/20/86-11
3-ES-16	SS-1	1/2/86	1/8/86-6-14	--	--	--	1/17/86-15
	SS-2	1/2/86	1/8/86-6-14	--	--	--	1/17/86-15
	SS-3	1/2/86	1/9/86-7-14	--	--	--	1/17/86-15
	SS-4	1/2/86	1/9/86-7-14	--	--	--	1/17/86-15
	SS-5	1/2/86	1/9/86-7-14	--	--	--	1/17/86-15
	SS-6	1/2/86	1/9/86-7-14	--	--	--	1/17/86-15

* Date analyzed - Elapsed time (days) - Recommended holding time (days).

1/ Holding Times for soil and sediment samples have not been defined.

2/ Analyses performed on alkaline digestate that was prepared as soon as sample was received in the lab (within 24-hour holding time).

Elapsed Time Between Sampling and Lab Analyses
for PJKS Samples at Site 7 and 11

Sample	Sample Date	8010 + 8020 *	NO ₂ *	NO ₃ *	Phenolics *	TKN *	Cr ⁶⁺ #2/
PJKS 11-1	12/18/85	SD-1	12/27/85-1	12/27/86-9	1/9/86-22	1/21/86-34	12/26/85-8
11-2	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/9/86-22	1/21/86-34	12/26/85-8
11-3	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/9/86-22	1/21/86-34	12/26/85-8
11-4	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/26/85-8
11-5	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/26/85-8
11-6	12/18/85	SD-2	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/26/85-8
11-7	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/26/85-8
11-8	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/30/85-12
11-9	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/30/85-12
11-10	12/18/85	SD-1	12/27/85-9	12/27/86-9	1/13/86-26	1/21/86-34	12/30/85-12
7-1	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-2	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-3	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-4	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-5	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-6	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-7	12/19/85	SD-1	1/23/86-35	2/11/86-54	1/14/86-26	1/30/86-42	12/30/85-11
7-8	12/19/85	SD-1	1/23/86-35	2/12/86-55	1/14/86-26	1/30/86-42	12/30/85-11
7-9	12/19/85	SD-1	1/23/86-35	2/12/86-55	1/14/86-26	1/30/86-42	12/30/85-11
H-B							
11-1	12/18/85	SW-2	12/20/85-2-2	--	1/15/86-28-28	1/17/86-30-28	12/27/85-9
11-2	12/18/85	SW-2	12/20/85-2-2	12/20/86-2-2	1/15/86-28-28	1/17/86/30-28	12/27/85-9
11-3	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-4	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-5	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-6	12/18/85	SW-2	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-7	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-8	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-9	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/14/86-27-28	1/17/86/30-28	12/27/85-9
11-10	12/18/85	SW-1	12/20/85-2-2	12/20/86-2-2	1/13/86-26-28	1/17/86/30-28	12/27/85-9

* Date analyzed -- Elapsed time (days) - Recommended holding time (days).

1/ Holding Times for sediment samples have not been defined.

2/ Analyses performed on alkaline digestate that was prepared as soon as sample was received in the lab (within 24-hour holding time).

3/ First Sampling period for Site 11.

March 26, 1986 Sampling
 Elapsed Time Between Samples and Lab Analyses for
 Site 11- Surface Water Sampling

Sample	Sample Date	601 + 602 ^{2/}
11-1 SW-3	3/26/86	3/27/86-1-14
11-2 SW-3	3/26/86	3/27/86-1-14
11-3 SW-2	3/26/86	3/31/86-5-14
11-4 SW-2	3/26/86	3/27/86-1-14
11-5 SW-3	3/26/86	3/31/86-5-14
11-6 SW-2	3/26/86	3/31/86-5-14
11-7 SW-2	3/26/86	3/31/86-5-14
11-8 SW-2	3/26/86	3/31/86-5-14
11-9 SW-2	3/26/86	3/31/86-5-14
11-10 SW-2	3/26/86	3/31/86-5-14

1/ Second sampling period for site 11.

2/ Date analyzed - Elapsed time (days) - Recommended holding time (days).

April 11, 1986 Sampling
 Elapsed Time Between Samples and Lab Analyses at Site 11^{1/} Surface Water Sampling

<u>Sample</u>	<u>Sample Date</u>	<u>TKN^{2/}</u>
11-1 SW-4	4/11/86	4/17/86-6-28
11-2 SW-4	4/11/86	4/17/86-6-28
11-3 SW-3	4/11/86	4/17/86-6-28
11-4 SW-3	4/11/86	4/17/86-6-28
11-5 SW-5	4/11/86	4/17/86-6-28
11-5 SW-6	4/11/86	4/17/86-6-28
11-6 SW-3	4/11/86	4/17/86-6-28
11-7 SW-3	4/11/86	4/17/86-6-28
11-8 SW-3	4/11/86	4/17/86-6-28
11-9 SW-3	4/11/86	4/17/86-6-28
11-10 SW-3	4/11/86	4/17/86-6-28

1/ Third sampling period for site 11.

2/ Date analyzed - Elapsed time (days) - Recommended holding time (days).

Elapsed Time Between Sampling and Lab. Analyses
for PJKS Ground Water Samples¹

Sample	Sample Date	601 + 602*	625*	NO ₂ *	NO ₃ *	OGC*	TDS*
PJKS 1-MW-1 GW-1	1/14/86	1/29/86-15-14	1/20/86-6-14	1/16/86-2-2	1/16/86-2-2	1/22/86-8-28	1/21/86-7-7
1-MW-2 GW-1	1/14/86	1/29/86-15-14	1/20/86-6-14	1/16/86-2-2	1/17/86-3-2	1/22/86-8-28	1/21/86-7-7
2-MW-3 GW-1	1/15/86	1/29/86-14-14	1/20/86-5-14	1/16/86-1-2	1/16/86-1-2	1/22/86-7-28	1/21/86-6-7
2-MW-7 GW-1	1/16/86	1/29/86-13-14	1/22/86-6-14	1/17/86-1-2	1/22/86-6-2	1/22/86-6-28	--
4-MW-4 GW-1	1/16/86	1/29/86-13-14	--	1/17/86-1-2	1/22/86-6-2	1/22/86-6-28	--
4-MW-5 GW-1	1/16/86	1/29/86-13-14	--	1/17/86-1-2	1/22/86-6-2	1/22/86-6-28	--
4-MW-6 GW-1	1/15/86	1/29/86-14-14	--	1/16/86-1-2	1/17/86-1-2	1/22/86-7-28	1/21/86-6-7
4-MW-6 GW-2	1/15/86	1/29/86-14-14	--	1/16/86-1-2	1/17/86-2-2	1/22/86-7-28	1/21/86-6-7
10-MW-8 GW-1	1/15/86	1/29/86-14-14	--	1/16/86-1-2	1/16/86-1-2	--	1/21/86-6-7
PJKS 1-SW-1	1/9/86	--	2/7/86-29-11	1/10/86-1-2	1/10/86-1-2	1/22/86-13-28	--
1-SD-1	1/9/86	--	2/7/86-29-11	2/10/86-32-11	2/18/86-40-6m	1/22/86-13-28	--
PJKS 1-MW-1 GW-1	1/14/86	1/16/86-2-28	1/16/86-2-28	2/19/86-36-6m	2/21/86-38-28	--	--
1-MW-2 GW-1	1/14/86	1/16/86-2-28	1/16/86-2-28	2/19/86-35-6m	2/21/86-38-28	--	--
2-MW-3 GW-1	1/15/86	1/16/86-1-28	--	2/19/86-35-6m	2/21/86-37-28	--	--
2-MW-7 GW-1	1/16/86	1/20/86-4-28	1/21/86-5-28	2/19/86-34-6m	2/21/86-36-28	5/8/86-110-6m	5/8/86-110-6m
4-MW-4 GW-1	1/16/86	1/20/86-4-28	1/21/86-5-28	2/19/86-34-6m	2/21/86-36-28	5/8/86-109-6m	5/8/86-109-6m
4-MW-5 GW-1	1/16/86	1/20/86-4-28	1/21/86-5-28	2/19/86-34-6m	2/21/86-36-28	--	--
4-MW-6 GW-1	1/15/86	--	--	2/19/86-35-6m	2/21/86-37-28	--	--
4-MW-6 GW-2	1/15/86	--	--	2/19/86-35-6m	2/21/86-37-28	--	--
10-MW-8 GW-1	1/15/86	1/16/86-1-28	--	2/19/86-35-6m	2/21/86-37-28	--	--
PJKS 1-SW-1	1/9/86	1/16/86-7-28	1/16/86-7-28	2/19/86-41-6m	2/21/86-43-28	5/8/86-116-6m	5/8/86-116-6m
1-SD-1	1/9/86	1/20/86-11-28	1/31/86-22-28	2/19/86-41-6m	2/21/86-43-28	2/20/86-42-6m	2/20/86-42-6m

* Date analyzed - Elapsed time (days) - Recommended holding time (days).

1/ Holding Times for sediment sample's have not been defined.

2/ First sampling period for ground water samples.

April 11, 1986 Sampling
Elapsed Time Between Samples and Lab Analyses for PJKS Ground Water Sampling^{1/}

<u>Sample</u>	<u>Sample Date</u>	<u>601 and 602^{2/3/}</u>	<u>TKN^{2/}</u>	<u>TDS^{2/}</u>
1-MW-1, GW-2	4/11/86	4/15/86-4-14	--	--
1-MW-2, GW-2	4/11/86	4/15/86-4-14	--	--
2-MW-3, GW-2	4/11/86	4/15/86-4-14	4/15/86-4-28	--
5-MW-4, GW-2	4/11/86	4/15/86-4-14	--	4/16/86-5-7
5-MW-5, GW-2	4/11/86	4/15/86-4-14	--	4/11/86-0-7
4-MW-6, GW-3	4/11/86	4/15/86-4-14	--	--
4-MW-6, GW-4	4/11/86	4/15/86-4-14	--	--
2-MW-7	--	--	--	--
10-MW-8, GW-2	4/11/86	4/15/86-4-14	--	--

1/ Second Sampling period for Ground Water Sampling.

2/ Date analyzed - Elapsed time (days) - Recommended holding time (days).

3/ Analysis performed by IT Corporation. Second column confirmation for 601 analyses were not performed so results were not used.

April 23 and 24, 1986 Sampling
Elapsed Time Between Sampling and Lab Analyses for PJKS Ground Water Sampling

Sample	Sample Date	601-2/3/	602-2/3/	NO3-2/4/	Hg-2/4/	Pb-2/4/	Tl-2/4/
1-MW-1, GW-3	4/24/86	4/30/86-6-14	5/10/86-17-14	--	5/12/86-19-28	5/8/86-15-6m	5/8/86-15-6m
1-MW-2, GW-3	4/24/86	5/2/86-9-14	5/10/86-17-14	4/25/86-1-2	5/12/86-19-28	5/8/86-15-6m	5/8/86-15-6m
2-MW-3, GW-3	4/23/86	4/30/86-7-14	5/13/86-21-14	--	5/12/86-20-28	--	--
5-MW-4, GW-3	4/23/86	4/30/86-7-14	5/12/86-20-14	4/24/86-1-2	5/12/86-20-28	--	--
5-MW-5, GW-3	4/23/86	4/30/86-7-14	5/12/86-20-14	4/24/86-1-2	5/12/86-20-28	--	--
4-MW-6, GW-5	4/23/86	4/30/86-7-14	5/13/86-21-14	--	5/12/86-20-28	--	--
4-MW-6, GW-6	4/23/86	4/30/86-7-14	5/13/86-21-14	--	5/12/86-20-28	--	--
2-MW-7	Dry	--	--	--	--	--	--
10-MW-8, GW-3	4/24/86	5/2/86-9-14	5/12/86-19-14	--	5/12/86-20-28	--	--
1-SW-2	4/24/86	4/30/86-6-14	5/13/86-20-14	--	5/12/86-19-28	--	--

1/ Third sampling period for ground water samples.

2/ Date analyzed - Elapsed time (days) - Recommended holding time (days).

3/ Analyses performed by IT Corporation.

4/ Analyses performed by ES Laboratories.

SAMPLE NUMBERING SYSTEM

IRP-PHASE II
DRAFT - 4/17/86

SAMPLE NUMBERING SYSTEM

Project Identification - PJKS

Site Identification:

Site

1. T-8A Containment Pond
2. T-5A, T-5B, EPL Test Cell, Valve Shop, Ready Storage Area and Soil Cones Area
3. EPL Building T-6 and T-20
4. T-31 Storage Tank
5. D-1 Landfill
7. Systems and Components Test Facilities Storage Tanks
10. Construction Materials Fill Area
11. Brush Creek

Well or Boring Number (if appropriate):

ES - Soil Boring Prefix
MW - Monitor Well Prefix

Sequence Number:

SS - Soil sample collected during drilling
SD - Sediment sample
GW - Ground water sample
SW - Surface water sample

Sample Depth:

- Measured in feet

IRP-PHASE II
DRAFT - 4/17/86

Split Sampling:

ES - Engineering-Science
CA - California Analytical
OEHL - USAF OEHL Laboratory
EAL - EAL Laboratory

An example of a sample number is given below:

PJKS, 2-ES-1, SS-3, 10', ES. PJKS Air Force Plant, Site 2, Boring
ES-1 at the site, the third soil sample, collected at a depth of
10 feet below the surface, retained by ES.

SAMPLE HANDLING AND PACKAGING

IRP-PHASE II
DRAFT - 4/17/86

SAMPLE HANDLING AND PACKAGING

- Sample Handling:
 - . Identify and document sample collection point or points, depth increment of samples collected, and sampling devices used.
 - . Complete log book entries, sample tags, field record sheets with sample identification point, date, time and names or initials of all persons handling the sample in the field.
 - . Clean the outer surface of glass jars containing soil or water samples with paper towels and clean water.
 - . Place Sample Tags on sample containers.
 - . When filling jars, secure a small plastic bag around outside of the sample container with rubber band so that samples spilled outside of container will not contact jar.
 - . Sealed sample containers will be carried by the sampling team member to the packaging area. The outer plastic bag and rubber band should be removed by the sampler without touching the external surface of the jar any more than necessary. The volume level should then be placed by the sampler on a clean surface to be packaged for shipment.
 - . The contaminated plastic bags, rubber bands, and residual soil from the mixing pan will be bulked in large plastic bags for disposal as garbage.
- Sample Packaging:
 - . Three inches of cushioning material was placed in the bottom of the coolers.
 - . Sample tags were used on all samples and the tags were covered with clear plastic tape.

IRP-PHASE II
DRAFT - 4/17/86

- . The sample containers were placed in the coolers so that they did not touch. Each bottle was placed in a plastic net sleeve and then padded with newspaper.
- . The VOA bottles were placed in plastic netting, wrapped in plastic packing material, which was taped together.
- . The remaining space in the coolers was filled with newspaper.
- . Blue ice for refrigeration was added if refrigeration was required.
- . The chain of custody was put in a plastic bag and was taped to the inside lid of the cooler.
- . The coolers were taped shut in at least two locations.
- . The coolers were sent by Federal express to the appropriate laboratory.

APPENDIX I
CHAIN OF CUSTODY RECORDS

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

These samples were resampled

ES JOB NO.		PROJECT NAME/LOCATION		SHIP TO:		ANALYSES REQUIRED		SHIP TO:	
SAMPLER(S): (Signature)		Air Force PSXS		ENGINEERING-SCIENCE, INC. 1887 Tullie Circle Suite 106 Atlanta, GA. 30329 (404) 325-5923					
DATE	TIME	SAMPLE DESCRIPTION		NO. OF CONTAINERS	REMARKS				
9 DEC	1500	SW-1, 11-1, ES		2	X	X	X	X	Please unclasp
		11-1 Soil		1		X	X		We following
		11-2, SW-1, ES		2	X	X	X	X	samples for EPA
		11-2, Soil		1		X	X		601-4602, and
									EPA 8010, 8020.
		EACH SAMPLE							
		ARRIVED							If you have any
		BROKEN (FROZEN)							questions concerning
		JM (See MEMO)							these please call
		SAMPLES APPARENTLY FROZEN AND							me @ (404) 325-5523
		EXPANDED UNTIL CONTAINERS							Johnny.
		CRACKED							
		UNABLE TO RUN ANALYSES							
Relinquished by: (Signature)		Date/Time		Received by: (Signature)		Date/Time		Received by: (Signature)	
Johnny P. [Signature]		9 Dec 1500		[Signature]		[Signature]		[Signature]	
Relinquished by: (Signature)		Date/Time		Received for Laboratory by: (Signature)		Date/Time		Remarks	
				[Signature]					

CHAIN OF CUSTODY RECORD

Distribution: Original Accompanies Agreement, Copy to Coordinator Field Office



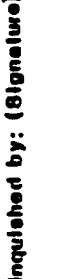
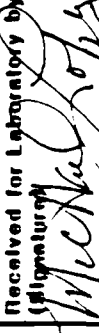
CHAIN OF CUSTODY RECORD

Distribution: Original Accompanying Document, Copy to Coordinator Fold File

CHAIN OF CUSTODY RECORD

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CHAIN OF CUSTODY RECORD

ES JOB NO.	PROJECT NAME/LOCATION	NO. OF CONTAINERS	ANALYSES REQUIRED	SHIP TO:		
56423-04	PSKS, Air Force / Denver, CO			ENGINEERING-SCIENCE, INC. 800 Bancroft Way Berkeley, CA. 94710 (415) 841-7353		
SAMPLER(S): (signature)		DATE	TIME	SAMPLE DESCRIPTION	REMARKS	
		12/10	12:10	PSKS, 1-ES-7, SS-1, 0'-2', CA	Samples good in Good Condition.	
		12/10	12:10	PSKS, 1-ES-7, SS-2, 2'-4', CA		
		12/10	12:30	PSKS, 1-ES-7, SS-3, 5'-7', CA		
		12/10	1:10	PSKS, 1-ES-7, SS-4, 9'-11', CA		
		12/10	1:30	PSKS, 1-ES-7, SS-5, 14'-16', CA		
		12/10	1:50	PSKS, 1-ES-7, SS-6, 19'-21', CA		
Relinquished by: (Signature)		Date/Time	Received by: (Signature)		Date/Time	
		12/17/85	5:00			
Relinquished by: (Signature)		Date/Time	Received for Laboratory by: (Signature)		Date/Time	
		12/17/85	5:00			
				Remarks: Samples good in Good Condition.		

Distribution: Original Accompanies Shipment, Copy to Coordinated Field Files

CHAIN OF CUSTODY RECORD

	DATE	FILE	FOR SHIPMENT ONLY TO COORDINATOR FIELD FILES
10-10-68	10-10-68	10-10-68	10-10-68

CHAIN OF CUSTODY RECORD

Attachment: Original Accompanying Shipment, Copy to Coordinator Field Files

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CHAIN OF CUSTODY RECORD

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CHAIN OF CUSTODY RECORD

Appendix A: Survey Instrument

CHAIN OF CUSTODY RECORD

1442
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CHAIN OF CUSTODY RECORD

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ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO.		PROJECT NAME/LOCATION		NO. OF CONTAINERS	ANALYSES REQUIRED	SHIP TO:
56423		PTKS				
SAMPLER(S): (Signature) L. Korman						
DATE	TIME	SAMPLE DESCRIPTION				REMARKS
12/19/85	11:30	PTKS 7-1, SD-1, ES		✓	✓	
12/19/85	11:45	PTKS 7-2, SD-1, ES		✓	✓	
12/19/85	12:00	PTKS 7-3, SD-1, ES		✓	✓	
12/19/85	1:28	PTKS 7-ES-9, SS-1, 0-2', ES		✓	✓	
12/15/85	1:40	PTKS 2-ES-9, SS-2, 2-40', ES		✓	✓	
12/14/85	2:00	PTKS 2-ES-9, SS-3, 5-0'-7.0', ES		✓	✓	
12/19/85	2:20	PTKS 2-ES-9, SS-4, 9-11.0', ES		✓	✓	
12/19/85	2:50	PTKS 2-ES-9, SS-5, 14-0-16.0, ES		✓	✓	
12/19/85	2:00	PTKS 7-4, SD-1, ES		✓	✓	
12/19/85	2:15	PTKS 7-5, SD-1, ES		✓	✓	
12/19/85	2:30	PTKS 7-6, SD-1, ES		✓	✓	
12/19/85	2:50	PTKS 7-7, SD-1, ES		✓	✓	
12/19/85	3:50	PTKS 7-8, SD-1, ES		✓	✓	
12/19/85	4:05	PTKS 7-9, SD-1, ES		✓	✓	

Relinquished by: (Signature)		Date/Time	Received by: (Signature)		Date/Time
L. Korman		12/19/85 4:15			
Relinquished by: (Signature)		Date/Time	Received for Laboratory by: (Signature)		Date/Time
			J. G. Gorman		12/20/85
			Remarks (Sample Act 12-85-1192 - 1205) (RCA)		

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO.		PROJECT NAME/LOCATION		NO. OF CONTAINERS	ANALYSES REQUIRED	SHIP TO:
56423		PJKS				
SAMPLER(S): (Signature)		SAMPLE DESCRIPTION		REMARKS		
L. Lisa Kovine						
DATE	TIME					
12/19/85	11:30	PJKS, 7-1, SD-1, CA		✓		
12/19/85	11:45	PJKS, 7-2, SD-1, CA		✓		
12/19/85	12:00	PJKS, 7-3, SD-1, CA		✓		
12/19/85	1:28	PJKS, 2-ES-9, SS-1, 0-2.0', CA		✓		
12/19/85	1:40	PJKS, 2-ES-9, SS-2, 2-4.0', CA		✓		
12/19/85	2:00	PJKS, 2-ES-9, SS-3, 5-7.0', CA		✓		
12/19/85	2:20	PJKS, 2-ES-9, SS-4, 9-11.0', CA		✓		
12/19/85	2:50	PJKS, 2-ES-9, SS-5, 14-16.0', CA		✓		
	3:00	PJKS, 2-ES-9, 7-4, SD-1, CA		✓		
	2:15	PJKS, 7-5, SD-1, CA		✓		
	2:30	PJKS, 7-6, SD-1, CA		✓		
	2:50	PJKS, 7-7, SD-1, CA		✓		
	3:50	PJKS, 7-8, SD-1, CA		✓		
	4:00	PJKS, 7-9, SD-1, CA		✓		
Relinquished by: (Signature)		Received by: (Signature)		Relinquished by: (Signature)		Received by: (Signature)
Lisa Kovine		12/19/85 4:00				
Relinquished by: (Signature)		Date/Time		Date/Time		Remarks
						* Samples Rec'd in good condition.

CHAIN OF CUSTODY RECORD

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CHAIN OF CUSTODY RECORD

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916 572-1393

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Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	

CHAIN OF CUSTODY RECORD

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Attachment	Order	Accompanying Attachment	Copy to Coordinator Field Plan

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111

Call with requests 151P
303-825-8100

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	DATE	BY	TO	FROM	REMARKS
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For more information

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303-825-8100

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO.		PROJECT NAME/LOCATION		NO. OF CON-TAINERS		ANALYSES REQUIRED		SHIP TO: 404-325-5923 Engineering-Science 1687 Tullie Circle, Suite 105 Atlanta, GA 30329	
SAMPLER(S): (Signature) Lisa A. Korner						TKN NOS			
DATE	TIME	SAMPLE DESCRIPTION						REMARKS	
4/11/86	8:45	PJKS, 11-10, SW-3, ES		1		✓			
4/11/86	8:50	PJKS, 11-9, SW-3, ES		1		✓			
4/11/86	8:55	PJKS, 11-8, SW-3, ES		1		✓			
4/11/86	9:10	PJKS, 11-7, SW-3, ES		1		✓			
4/11/86	9:15	PJKS, 11-6, SW-3, ES		1		✓			
4/11/86	9:20	PJKS, 11-5, SW-5, ES		1		✓			
4/11/86	9:20	ATKS, 11-5, SW-6, ES		1		✓			
4/11/86	12:00	PJKS, 10-MW-8, SW-3, ES		1		✓			
4/11/86		ATKS							
4/11/86		PJKS							
4/11/86		PJKS							
4/11/86		PJKS							
4/11/86		PJKS							
4/11/86		PJKS							
4/11/86		PJKS							
4/11/86		PJKS							
Relinquished by: (Signature) Lisa Korner		Date/Time 4/11/86 5:30		Received by: (Signature)		Date/Time		Received by: (Signature)	
Relinquished by: (Signature)		Date/Time		Received for Laboratory by: (Signature) E. Bruce		Date/Time 4/14/86 9am		Remarks	

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Please see page 10

LISA Korner - Engineering-Science
1100 Stout St, Suite 1100

36528

CHAIN OF CUSTODY RECORD

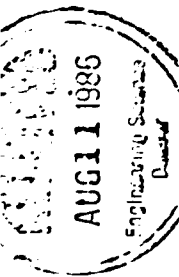
ES JOB NO.	PROJECT NAME/LOCATION	NO. OF CONTAINERS	ANALYSES REQUIRED	SHIP TO:
56528	PJKS - Air Force Denver CO		601 602 MEK	Attn. Stephen Jones IT Corporation 17605 Fabrica Way Cerritos CA 90701
SAMPLER(S): (Signature)				
Lisa A. Kerner				
DATE	TIME	SAMPLE DESCRIPTION		REMARKS
4/11/86	9:30	PJKS, 1-SW-2, IT	✓	
4/11/86	10:25	PJKS, 1-MW-1, IT	✓	
4/11/86	12:00	PJKS, 10-MW-8, IT	✓	
4/11/86	2:15	PJKS, 5-MW-6, GW-3, IT	✓	
4/11/86	2:15	PJKS, 5-MW-6, GW-4, IT	✓	
4/11/86	3:15	PJKS, 4-MW-4, GW-3, IT	✓	
Relinquished by: (Signature)		Received by: (Signature)	Date/Time	Relinquished by: (Signature)
Lisa A. Kerner			4/11/86 5:30	
Relinquished by: (Signature)		Received for Laboratory by: (Signature)	Date/Time	Date/Time
		J. F. Fitch		4-14-86 11:00

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W

Please Analyze within ASAP

Please send results to



ENGINEERING-SCIENCE
36686
CHAIN OF CUSTODY RECORD

LISA Korner-Engineering-Science
1100 Stout St, Suite 1100
Denver CO 80204

ES JOB NO.		PROJECT NAME/LOCATION		NO. OF CONTAINERS		ANALYSES REQUIRED		SHIP TO: Attn. Stephen Jones IT Corporation 17605 Fabrica Way Cerritos CA 90701 714-523-9200	
56423		Air Force PJKS							
SAMPLER(S): (Signature) Lisa A Korner		SAMPLE DESCRIPTION							
DATE	TIME							REMARKS	
4/23/86	9:00	PJKS, 5-MW-4, GW-3, ES IT		4		602	625		
4/23/86	10:00	PJKS, 5-MW-5, GW-3, IT		4		602	625		
4/23/86	11:15	PJKS, 4-MW-6, GW-5, IT		4		602	625		
4/23/86	11:15	PJKS, 4-MW-6, GW-6, IT		4		602	625		
4/23/86	2:45	PJKS, 2-MW-3, GW-3, IT		4		602	625		
4/23/86	4:00	PJKS, Field blank		1					
4/23/86	4:00	PJKS, Trip blank		1					
4/24/86	9:00	PJKS, 1-MW-1, GW-3, IT		4		602	625		
4/24/86	10:15	PJKS, 1-MW-2, GW-3, IT		4		602	625		
4/24/86	11:15	PJKS, 1-MW-2, IT		7		602	625		
4/24/86	1:15	PJKS, 10-MW-8, GW-3, IT		4		602	625		
		1-SW-1 for 1 liter bottle							
Not Inquired by: (Signature) Lisa A Korner		Date/Time 4/24/86 3:50 PM		Received by: (Signature) BE		Date/Time		Received by: (Signature)	
Not Inquired by: (Signature) BE		Date/Time		Received for Laboratory by: (Signature) Lisa A Korner		Date/Time 4-25-86 1230		Remarks	

Original Accompanies Shipment Copy to Coordinator Field Files

APPENDIX J
QUALITY ASSURANCE/QUALITY CONTROL

APPENDIX J
LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

Sample Handling. Each shipment of samples to the laboratory is sealed and is accompanied by a chain-of-custody form. Upon arrival at the lab, the seal is checked to ascertain that it has not been broken. The shipping container is then opened and the sample containers are checked against the chain-of-custody form. If everything is in order, the chain-of-custody form is signed by the laboratory technician and is retained as a permanent record in the client file.

Each sample is assigned a unique laboratory number. Both the laboratory number and the collector's identifier for the samples are then logged into the laboratory notebook, providing a double reference for each sample. The lab number is attached to the sampling container along with the collector's original label, also providing a double reference. Laboratory numbers are color coded by month to further identify the sample.

Samples are stored in a locked sample room. Access is permitted only to authorized laboratory personnel. Sample storage and holding times are in conformance with EPA's "Methods for Chemical Analysis of Waters and Wastewaters" (1979) and SW-846.

Technical Analysis. Prior to each analysis, the instrument is calibrated for the specific analyte (for example, chromium) by running at least three known solutions of that analyte to develop a standard curve. The standard curve is compared to standard curves developed previously for the same analyte to detect changes that would indicate problems such as deterioration of reagents. Records for each method are kept in separate notebooks to facilitate comparisons among standard curves. Prior to analysis for the next analyte (for example, arsenic), the instrument is calibrated using at least three solutions containing known amounts of that analyte.

At least one duplicate, blank, and spike are included in each batch of analyses run. For larger batches, one set of these QA/QC checks is included for every 10 samples. Therefore, they always constitute at least 23 percent (3 of 13) of all analyses. Blanks consisting of laboratory-pure (reagent) water as the sample, are carried through the entire analytical procedure, including digestions, distillations, and/or extractions as appropriate. Duplicates and spikes are set up from separate aliquots of the sample, and are carried through the entire procedure as are samples and blanks. Precision of duplicate determinations is calculated as the relative percent difference (RPD). Accuracy of spikes is calculated as percent recovery (PR). Blanks, samples analyzed in duplicate, and spiked samples, along with their RPD's and PR's, are reported on quality control summary sheets. The quality control summary sheets are provided in Appendix J.

As part of its QA/QC program, the laboratory regularly participates in the testing of unknown samples provided by the EPA. These tests involve recovery of analytes from artificially prepared samples where the concentration of the analyte is known by the EPA. Tests have been both blind, where the laboratory knows it is a test but does not know either the analyte or its concentration, and double-blind, where the chemist does not know he is being tested.

Reporting of Data. Results are permanently recorded in the laboratory notebook. Carbon copies are made during the data entry to prevent errors in transcribing data. The carbon copies are then sent to the laboratory office where the calculations are checked. At the same time, the sample number on the bench sheet is checked against the sample check-in data to make sure samples were not mixed up. Results are then reported from the laboratory office.

Lab Sample Nos.

Duplicates 12-85-1120Spike 12-85-1125QC Report No. PJRS-01Date Analyzed (D) 12/24/85 (S) 12/26/85

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)☒ Soil (ug/g) ~~ug/kg~~☐ Other _____

Dilution Factor _____

*Moisture _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	< 4	<	<						
bis(2-chloroethoxy) methane	< 12	<	<						
bis(2-chloroisopropyl) ether	< 25	<	<						
Bromobenzene	< 8	<	<						
Bromodichloromethane	< 2	<	<						
Bromoform	< 4	<	<						
Bromomethane	< 24	<	<						
Carbon tetrachloride	< 3	<	<						
Chloroacetaldehyde	< 10	<	<						
Chloral	< 10	<	<						
Chlorobenzene	< 5	<	<						
Chloroethane	< 10	<	<						
Chloroform	< 1	<	<						
1-Chlorohexane	< 2	<	<						
2-Chloroethyl vinyl ether	< 3	<	<						
Chloromethane	< 2	<	<						
Chloromethyl methyl ether	< 20	<	<						
Chlorotoluene	< 4	<	<						
Dibromochloromethane	< 2	<	<						

continued on next page

12-85-1120

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<		0.7	<5	<5	0	①
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Note 1: Spike level too low J-4

Lab Sample Nos.

Duplicates 12-85-1144Spike 12-85-1130QC Report No. PJKS-02Date Analyzed (D) 12/28/85 / (S) 12/27/85Laboratory Supervisor Approval:

Sample Matrix:

 / Water (ug/L) / Soil (ug/g) (ug/g) / Other Dilution Factor *Moisture Spike Source

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	< 4	<	<						
bis(2-chloroethoxy) methane	< 12	<	<						
bis(2-chloroisopropyl) ether	< 25	<	<						
Bromobenzene	< 8	<	<						
Bromodichloromethane	< 2	<	<						
Bromoform	< 4	<	<						
Bromomethane	< 24	<	<						
Carbon tetrachloride	< 3	<	<						
Chloroacetaldehyde	< 10	<	<						
Chloral	< 10	<	<						
Chlorobenzene	< 5	<	<						
Chloroethane	< 10	<	<						
Chloroform	< 1	<	<						
1-Chlorohexane	< 2	<	<						
2-Chloroethyl vinyl ether	< 3	<	<						
Chloromethane	< 2	<	<						
Chloromethyl methyl ether	< 20	<	<						
Chlorotoluene	< 4	<	<						
Dibromochloromethane	< 2	<	<						

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Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<		.4	<1	<1	0	
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<		.400	<1	.445	111	
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. PJKS-03Duplicates 12-85-1149

Date Analyzed _____

Spike 12-85-1160

Laboratory Supervisor Approval: _____

Sample Matrix:

/ Water (ug/L)

Dilution Factor _____

/X Soil (ug/g) ~~(ug/kg)~~

*Moisture _____ %

/ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	<4	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<						
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<2	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

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Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<		2	<1	<1	0	
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. PJKS-04Duplicates 12-85-1171

Date Analyzed _____

Spike 12-85-1165

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)

Dilution Factor _____

☒ Soil (ug/g) ~~(ug/kg)~~

*Moisture _____

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	<4	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<						
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<2	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

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Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<		4.0	<6	2.87	72	
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. PJKS-05Duplicates 12-85-1195

Date Analyzed _____

Spike 12-85-1200

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ / Water (ug/L)

Dilution Factor _____

☒ / Soil (ug/g) (~~ug/kg~~)

*Moisture _____

☐ / Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	<4	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<		1.0	<5	1.53	153	
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<2	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

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Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

Duplicates 12-85-1205

Spike _____

QC Report No. PJKS-06

Date Analyzed _____

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ / Water (ug/L)☒ / Soil (ug/g) ~~(ug/kg)~~☐ / Other _____

Dilution Factor _____

*Moisture _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	<4	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<						
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<2	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

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12-85-1205

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. PJKS-07Duplicates 1-86-1005

Date Analyzed _____

Spike 1-86-1010

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)

Dilution Factor _____

☒ Soil (ug/g) (~~ug/kg~~)

*Moisture _____

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	24	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<		1.0	25	1.6	160	
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<8	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

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Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<		1.0	<10	0.88	88	
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

Duplicates 1-86-1030Spike 1-86-1037QC Report No. PJKS-08

Date Analyzed _____

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)☒ Soil (ug/g) ~~(ug/kg)~~☐ Other _____

Dilution Factor _____

*Moisture _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	<4	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<						
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<2	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

continued on next page

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1								
1,2-Dichlorobenzene	<3								
1,3-Dichlorobenzene	<6								
1,4-Dichlorobenzene	<5								
Dichlorodifluoromethane	<30								
1,1-Dichloroethane	<1				1.0	<1	1.08	108	
1,2-Dichloroethane	<1								
1,1-Dichloroethylene	<3								
trans-1,2-Dichloroethylene	<2								
Dichloromethane	<5								
1,2-Dichloropropane	<1								
1,3-Dichloropropylene	<6								
1,1,2,2-Tetrachloroethane	<7								
1,1,1,2-Tetrachloroethane	<7								
Tetrachloroethylene	<1				1.0	<1	0.8	80	
1,1,1-Trichloroethane	<1				1.0	<1	1.02	102	
1,1,2-Trichloroethane	<1								
Trichloroethylene	<2								
Trichlorofluoromethane	<1								
Trichloropropane	<2								
Vinyl chloride	<4								

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. PJKS-09Duplicates 1-86-1087

Date Analyzed _____

Spike _____

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)

Dilution Factor _____

☒ Soil (ug/g) ~~1-86-1087~~

*Moisture _____

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	<4	<	<						
bis(2-chloroethoxy) methane	<12	<	<						
bis(2-chloroisopropyl) ether	<25	<	<						
Bromobenzene	<8	<	<						
Bromodichloromethane	<2	<	<						
Bromoform	<4	<	<						
Bromomethane	<24	<	<						
Carbon tetrachloride	<3	<	<						
Chloroacetaldehyde	<10	<	<						
Chloral	<10	<	<						
Chlorobenzene	<5	<	<						
Chloroethane	<10	<	<						
Chloroform	<1	<	<						
1-Chlorohexane	<2	<	<						
2-Chloroethyl vinyl ether	<3	<	<						
Chloromethane	<2	<	<						
Chloromethyl methyl ether	<20	<	<						
Chlorotoluene	<4	<	<						
Dibromochloromethane	<2	<	<						

continued on next page

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	<1	<	<						
1,2-Dichlorobenzene	<3	<	<						
1,3-Dichlorobenzene	<6	<	<						
1,4-Dichlorobenzene	<5	<	<						
Dichlorodifluoromethane	<30	<	<						
1,1-Dichloroethane	<1	<	<						
1,2-Dichloroethane	<1	<	<						
1,1-Dichloroethylene	<3	<	<						
trans-1,2-Dichloroethylene	<2	<	<						
Dichloromethane	<5	<	<						
1,2-Dichloropropane	<1	<	<						
1,3-Dichloropropylene	<6	<	<						
1,1,2,2-Tetrachloroethane	<7	<	<						
1,1,1,2-Tetrachloroethane	<7	<	<						
Tetrachloroethylene	<1	<	<						
1,1,1-Trichloroethane	<1	<	<						
1,1,2-Trichloroethane	<1	<	<						
Trichloroethylene	<2	<	<						
Trichlorofluoromethane	<1	<	<						
Trichloropropane	<2	<	<						
Vinyl chloride	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. 56528-1Duplicates 12-85-1120Date Analyzed 12/24/85Spike 12-85-1125

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)

Dilution Factor _____

☒ Soil (ug/g) (~~ug/kg~~)

*Moisture _____ %

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<						
Chlorobenzene	<4	<	<		0.4	<4	<4	0	①
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<		0.7	<6	<6	0	①
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Note 1: spike level too low

Lab Sample Nos.

QC Report No. 56528-2Duplicates 12-85-1144Date Analyzed 12/28/85Spike 12-85-1130

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ / Water (ug/L)

Dilution Factor _____

☒ / Soil (ug/g) (~~ug/kg~~)

*Moisture _____ %

☐ / Other _____Spike Source 8010 & 8020 compounds were analyzed at the same
Time. 12-85-1130 was spiked with 8010 compounds.

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<						
Chlorobenzene	<4	<	<						
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. 56528-3Duplicates 12-85-1149

Date Analyzed _____

Spike 12-85-1160

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ Water (ug/L)

Dilution Factor _____

☒ Soil (ug/g) (~~ug/kg~~)

*Moisture _____ %

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<						
Chlorobenzene	<4	<	<						
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<		5.86	<4	5.94	101	
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. 56528-4Duplicates 12-85-1171Date Analyzed 1/1/86Spike 12-85-1165

Laboratory Supervisor Approval: _____

Sample Matrix:

/ / Water (ug/L)

Dilution Factor _____

/X / Soil (ug/g) ~~12-85-1165~~

*Moisture _____ %

/ / Other _____

Spike Source 8010 & 8020 compounds were analyzed at the same time. 12-85-1165 was spiked with 8010 compounds

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<						
Chlorobenzene	<4	<	<						
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

Lab Sample Nos.

Duplicates 12-85-1195Spike 12-85-1200

Sample Matrix:

☐ / Water (ug/L)☒ / Soil (ug/g) (ug/Kg)☐ / Other _____QC Report No. 56528-5Date Analyzed 1/2/86

Laboratory Supervisor Approval: _____

Dilution Factor _____

*Moisture _____ %

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<		.66	<4	.86	130	
Chlorobenzene	<4	<	<		1.00	<4	1.53	153	
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. 56528-6Duplicates 12-85-1205Date Analyzed 1/2/86

Spike _____

Laboratory Supervisor Approval: _____

Sample Matrix:

☐ / ☐ Water (ug/L)

Dilution Factor _____

☒ / ☒ Soil (ug/g) ~~(ug/kg)~~

*Moisture _____ %

☐ / ☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<						
Chlorobenzene	<4	<	<						
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

Lab Sample Nos.

QC Report No. 56528-7Duplicates 1-86-1005Date Analyzed 1/7/86Spike 1-86-1010

Laboratory Supervisor Approval: _____

Sample Matrix: _____

☐ / Water (ug/L)

Dilution Factor _____

☒ / Soil (ug/g) (ug/Kg)

*Moisture _____ %

☐ / Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<		.66	<4	.50	76	
Chlorobenzene	<4	<	<		1.0	<4	1.6	160	
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

QC Report No. 56528-8Duplicates 1-86-1030Date Analyzed 1/8/86Spike 1-86-1037

Laboratory Supervisor Approval: _____

Sample Matrix: _____

☐ / ☐ Water (ug/L)

Dilution Factor _____

☒ / ☒ Soil (ug/g) ~~(ug/kg)~~

*Moisture _____ %

☐ / ☐ Other _____Spike Source 8010 & 8020 compounds were analyzed at the same time. 1-86-1037 was spiked with 8010 compounds.

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<4	<	<						
Chlorobenzene	<4	<	<						
1,2-Dichlorobenzene	<8	<	<						
1,3-Dichlorobenzene	<8	<	<						
1,4-Dichlorobenzene	<6	<	<						
Ethyl benzene	<4	<	<						
Toluene	<4	<	<						
Xylenes (Dimethyl benzene)	<4	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

Lab Sample Nos.

Duplicates 1-86-1087

Spike _____

Sample Matrix:

☐ / Water (ug/L)☐ / Soil (ug/g) (ug/Kg)☐ / Other _____QC Report No. 56528-9Date Analyzed 1/10/86

Laboratory Supervisor Approval: _____

Dilution Factor _____

*Moisture _____ %

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	< 4	<	<						
Chlorobenzene	< 4	<	<						
1,2-Dichlorobenzene	< 8	<	<						
1,3-Dichlorobenzene	< 8	<	<						
1,4-Dichlorobenzene	< 6	<	<						
Ethyl benzene	< 4	<	<						
Toluene	< 4	<	<						
Xylenes (Dimethyl benzene)	< 4	<	<						
<i>methyl ethyl ketone</i>	< 4	23.3	56.0	.82					①

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad \begin{array}{l} SSR = \text{Spiked Sample Result} \\ SR = \text{Sample Result} \\ SA = \text{Spike Added (Concentration)} \end{array}$$

note 1: Interference prevented good duplication of results on column 1.

J-29

Lab Sample Nos.

QC Report No. 56528-11Duplicates 1-86-1126Date Analyzed 2/19/86Spike 1-86-1132

Laboratory Supervisor Approval: _____

Sample Matrix:

☒ Water (ug/L)

Dilution Factor _____

☐ Soil (ug/g) (ug/Kg)

*Moisture _____ %

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Bromodichloromethane	< 0.10	<	<						
Bromoform	< 0.20	<	<						
Bromomethane	< 1.18	<	<						
Carbon tetrachloride	< 0.12	<	<						
Chlorobenzene	< 0.25	<	<						
Chloroethane	< 0.52	<	<						
2-Chloroethylvinyl ether	< 0.13	<	<						
Chloroform	< 0.05	<	<						
Chloromethane	< 0.08	<	<						
Dibromochloromethane	< 0.09	<	<		0.8	< 0.09	0.39	48	
1,2-Dichlorobenzene	< 0.15	<	<						
1,3-Dichlorobenzene	< 0.32	<	<						
1,4-Dichlorobenzene	< 0.24	<	<						
Dichlorodifluoromethane	< 1.81	<	<						
1,1-Dichloroethane	< 0.07	<	<						
1,2-Dichloroethane	< 0.03	<	<						
1,1-Dichloroethene	< 0.13	<	<						
trans-1,2-Dichloroethene	< 0.10	20.4	5.8	1.36					(1)
1,2-Dichloropropane	< 0.08	<	<						
cis-1,3-Dichloropropene	< 0.20	14.3	1.65	1.58					(1)
trans-1,3-Dichloropropene	< 0.10	<	<						
Methylene chloride	< 0.25	<	<						
1,1,2,2-Tetrachloroethane	< 0.03	<	<						
Tetrachloroethene	< 0.03	<	<						
1,1,1-Trichloroethane	< 0.03	<	<						
1,1,2-Trichloroethane	< 0.02	<	<						
Trichloroethene	< 0.12	224	105	.72					(1)
Trichlorofluoromethane	< 0.01	<	<						
Vinyl chloride	< 0.18	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

Relative Percent Difference (RPD) = $\frac{C1 - C2}{(C1 + C2)/2}$ C1 = Concentration One
C2 = Concentration Two

Percent Recovery (PR) = $\frac{SSR - SR}{SA} \times 100$ SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

859J111

J-30

Note 1: Poor quantitative replicates is further evidence of interference. The 2nd column did not confirm the high result.

Lab Sample Nos.

Duplicates 3-86-1261Spike 3-86-1268

Sample Matrix:

☒ Water (ug/L)☐ Soil (ug/g) (ug/Kg)☐ Other _____QC Report No. 56528 - 30Date Analyzed 3/31/86

Laboratory Supervisor Approval:

Johnny R. Adams

Dilution Factor _____

*Moisture _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Bromodichloromethane	<0.1	<	<						
Bromoform	<0.1	<	<						
Bromomethane	<1.18	<	<						
Carbon tetrachloride	<0.12	<	<						
Chlorobenzene	<0.25	<	<		3.06	<.25	3.27	107	
Chloroethane	<0.52	<	<						
2-Chloroethylvinyl ether	<0.13	<	<						
Chloroform	<0.05	<	<		3.63	<.05	3.64	100	
Chloromethane	<0.08	<	<						
Dibromochloromethane	<0.09	<	<						
1,2-Dichlorobenzene	<0.15	<	<						
1,3-Dichlorobenzene	<0.32	<	<						
1,4-Dichlorobenzene	<0.24	<	<						
Dichlorodifluoromethane	<1.81	<	<						
1,1-Dichloroethane	<0.07	<	<						
1,2-Dichloroethane	<0.03	<	<						
1,1-Dichloroethene	<0.13	<	<						
trans-1,2-Dichloroethene	<0.10	<	<						
1,2-Dichloropropane	<0.08	<	<						
cis-1,3-Dichloropropene	<0.20	<	<						
trans-1,3-Dichloropropene	<0.10	<	<						
Methylene chloride	<0.25	<	<		2.11	<.25	3.05	113	
1,1,2,2-Tetrachloroethane	<0.03	<	<						
Tetrachloroethene	<0.03	<	<						
1,1,1-Trichloroethane	<0.03	<	<						
1,1,2-Trichloroethane	<0.02	<	<						
Trichloroethene	<0.12	1.23	1.31	.063	3.03	<.12	2.83	93	
Trichlorofluoromethane	<0.01	<	<						
Vinyl chloride	<0.18	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

Relative Percent Difference (RPD)

$$= \frac{C1 - C2}{(C1 + C2)/2}$$

C1 = Concentration One

C2 = Concentration Two

Percent Recovery (PR) =

$$\frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result

SR = Sample Result

SA = Spike Added (Concentration)

859J111

J-31

Engineering Science
Page 2

QUALITY CONTROL RESULTS SUMMARY
Purgeable Halocarbons
EPA Method 601

Lab Sample Nos. DW4-2-ITC
Duplicates 36675-10, 36676-12
Spike 36675-13

QC Report No. 601-28
Date Analyzed 4-29-86
Laboratory Supervisor Approval: _____

Sample Matrix:

☒ / Water (ug/L)

☐ / Soil

☐ / Other _____

Dilution Factor N/A

*Moisture _____ %

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzyl chloride	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Bis(2-Chloroethoxy)methane	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Bis(2-Chloroisopropyl)ether	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Bromobenzene	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Bromodichloromethane	ND< 1.0	ND< 1.0	ND< 1.0	---	10.0	<1.0	11.0	110	
Bromoform	ND< 1.0	ND< 1.0	ND< 1.0	---	10.0	<1.0	11.0	110	
Bromomethane	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Carbon tetrachloride	ND< 1.0	ND< 1.0	ND< 1.0	---	10.0	<1.0	11.0	110	
Chloroacetaldehyde	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Chloral	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Chlorobenzene	ND< 1.0	ND< 1.0	ND< 1.0	---	10.0	<1.0	10.0	100	
Chloroethane	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Chloroform	ND< 1.0	ND< 1.0	ND< 1.0	---	10.0	<1.0	12.0	120	
1-Chlorohexane	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
2-Chloroethyl vinyl ether	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Chloromethane	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Chloromethyl methyl ether	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Chlorotoluene	ND< 1.0	ND< 1.0	ND< 1.0	---	---	<1.0	---	---	
Dibromochloromethane	ND< 1.0	ND< 1.0	ND< 1.0	---	31.0	<1.0	37.0	119	

continued on next page

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Page 3

QUALITY CONTROL RESULTS SUMMARY
Purgeable Halocarbons
EPA Method 601

DW4-2-ITC

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Dibromomethane	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
1,2-Dichlorobenzene	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
1,3-Dichlorobenzene	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
1,4-Dichlorobenzene	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
Dichlorodifluoromethane	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
1,1-Dichloroethane	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	11.0	110	
1,2-Dichloroethane	ND<1.0	ND<1.0	ND<1.0	---	10.0	<0.1	11.0	110	
1,1-Dichloroethylene	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	14.0	140	
trans-1,2-dichloroethylene	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	10.0	100	
Dichloromethane	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	11.0	110	
1,2-Dichloropropane	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	12.0	120	
1,3-Dichloropropylene	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	10.0	100	
1,1,2,2-Tetrachloroethane	ND<1.0	ND<1.0	ND<1.0	---	20.0	<1.0	21.0	105	
1,1,1,2-Tetrachloroethane	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
Tetrachloroethylene	ND<1.0	ND<1.0	ND<1.0	---	20.0	<1.0	21.0	105	
1,1,1-Trichloroethane	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	10.0	100	
1,1,2-Trichloroethane	ND<1.0	ND<1.0	ND<1.0	---	31.0	<1.0	37.0	119	
Trichloroethylene	ND<1.0	ND<1.0	ND<1.0	---	10.0	<1.0	12.0	120	
Trichlorofluoromethane	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
Trichloropropane	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	
Vinyl chloride	ND<1.0	ND<1.0	ND<1.0	---	---	<1.0	---	---	

* - If % moisture is reported, results are presented on a dry-weight basis.

ND - This compound was not detected; the limit of detection for this analysis is less than the amount stated in the table above.

TR - Trace, this compound was present, but was below the level at which concentration could be determined.

Lab Sample Nos.

Duplicates 1-86-1126Spike 1-86-1132QC Report No. 56528-10Date Analyzed 2/11/86

Laboratory Supervisor Approval: _____

Sample Matrix:

☒ Water (ug/L)

Dilution Factor _____

☐ Soil (ug/g) (ug/Kg)

*Moisture _____ %

☐ Other _____

Spike Source _____

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	< 0.2	<	<						
Chlorobenzene	< 0.2	<	<						
1,2-Dichlorobenzene	< 0.4	<	<						
1,3-Dichlorobenzene	< 0.4	<	<						
1,4-Dichlorobenzene	< 0.3	<	<						
Ethylbenzene	< 0.2	<	<						
Toluene	< 0.2	<	<						
<i>methyl ethyl ketone</i>	< 1.1	90.4	120	.28					

* If % moisture is reported, results are presented on a dry-weight basis.

Relative Percent Difference (RPD) = $\frac{C1 - C2}{(C1 + C2)/2}$ C1 = Concentration One
C2 = Concentration Two

Percent Recovery (PR) = $\frac{SSR - SR}{SA} \times 100$ SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

Lab Sample Nos.

Duplicates 3-86-1261Spike 3-86-1268

Sample Matrix:

☒ Water (ug/L)☐ Soil (ug/g) (ug/Kg)☐ Other QC Report No. 56528-31Date Analyzed 3/31/86

Laboratory Supervisor Approval:

Johnny R. AdamsonDilution Factor *Moisture %Spike Source

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	<0.2	<	<		2.91	<0.3	3.05	105	
Chlorobenzene	<0.2	<	<		3.06	<0.2	3.27	107	
1,2-Dichlorobenzene	<0.4	<	<						
1,3-Dichlorobenzene	<0.4	<	<						
1,4-Dichlorobenzene	<0.3	<	<						
Ethylbenzene	<0.2	<	<						
Toluene	<0.2	<	<						

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad \begin{array}{l} C1 = \text{Concentration One} \\ C2 = \text{Concentration Two} \end{array}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

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QUALITY CONTROL RESULTS SUMMARY
Purgeable Aromatics
EPA Method 602

Lab Sample Nos. PJKS, 1-SW-2, IT

Duplicates 36686-5, 36686-6

Spike 36686-7

Sample Matrix:

☒ Water (ug/L)

☐ Soil (ug/Kg)

☐ Other

QC Report No. 602-23

Date Analyzed 5-13-86

Laboratory Supervisor Approval: _____

Dilution Factor N/A

*Moisture _____ %

Spike Source 10 ppb 602 std.

Compound	Blank	Duplicates			Spike Recovery				Notes
		C1	C2	RPD	SA	SR	SSR	PR	
Benzene	ND< 1.0	ND< 1.0	ND< 1.0	---	10.0	ND< 1.0	10.5	105	
Chlorobenzene	ND< 1.0	TR< 1.0	ND< 1.0	---	10.6	ND< 1.0	9.6	91	
1,2-Dichlorobenzene	ND< 1.0	ND< 1.0	ND< 1.0	---	10.7	ND< 1.0	10.3	96	
1,3-Dichlorobenzene	ND< 1.0	ND< 1.0	ND< 1.0	---	11.2	ND< 1.0	10.4	93	
1,4-Dichlorobenzene	ND< 1.0	ND< 1.0	ND< 1.0	---	10.6	ND< 1.0	10.2	96	
Ethyl benzene	ND< 1.0	ND< 1.0	ND< 1.0	---	10.7	ND< 1.0	9.6	90	
Toluene	ND< 1.0	TR< 1.0	TR< 1.0	---	11.6	TR< 1.0	8.9	77	
Xylenes (Dimethyl benzene)	TR< 1.0	ND< 1.0	ND< 1.0	---	---	ND< 1.0	---	---	

ND - This compound was not detected; the limit of detection for this analysis is less than the amount stated in the table above.

TR - Trace, this compound was present, but was below the level at which concentration could be determined.

QUALITY CONTROL RESULTS SUMMARY
Environmental Quality Parameters

Sample Matrix:

X / Water (ug/L) 12

/ / Soil (ug/g) (ug/Kg)

/ / Other

Dilution Factor

*Moisture

QC Report No.

Laboratory Supervisor Approval:

Johnny R. Anderson

Spike Source(s)

Analytical Parameter	Laboratory Duplicates	Sample Nos. Spike	Date Anal	Anal Method	Blank	Duplicates		Spike Recovery			Notes
						C1	C2	SA	SR	SSR	
T.D.S.	12-85-1173	N/A		EPH 140.3		12/23/85	12/23/86				A
	12-85-1174					300	400				
	12-85-1175					300	320				
	12-85-1176					300	340				
	12-85-1177					300	320				
	12-85-1178					310	320				
	12-85-1179					330	340				
	12-85-1180					330	360				A
	12-85-1181					340	340				
	12-85-1182					340	320				

* If moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad C1 = \text{Concentration One} \quad C2 = \text{Concentration Two}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad SSR = \text{Spiked Sample Result} \quad SR = \text{Sample Result}$$

$$A: RPD = \frac{C1 - C2}{(C1 + C2)/2} \times 100 \quad C1 = \text{Measured Value} \quad C2 = \text{Measured Value} \quad SA = \text{Spike Added (Concentration)}$$

Sample Matrix:

1. X/ Water (mg/L) (mg/L)

/ / Soil (ug/g) (ug/kg)

/ / Other

Dilution Factor

*Moisture

QC Report No.

Laboratory Supervisor Approval:

Johnny R. Coleman

Spike Source(s)

[illegible]

* If a moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2}$$

$$\text{Percent Recovery (PR)} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100$$

SSR = Spiked Sample Result
 SR = Sample Result
 SA = Spike Added (Concentration)

SSR = Spiked Sample Result

SR = Sample Result

SSA = Spike Added (Concentration)

QUALITY CONTROL RESULTS SUMMARY
Environmental Quality Parameters

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QC Report No. _____

Sample Matrix:

Dilution Factor _____

/ / Water (ug/L)

*Moisture _____

/ / Soil (ug/g) (ug/Kg)

/ / Other _____

Spike Source(s) _____

Laboratory Supervisor Approval:

Johnny P. Adames

Analytical Parameter	Laboratory Duplicates	Sample Nos. Spike	Date Anal	Anal Method	Blank	Duplicates			Spike Recovery			Notes
						C1	C2	RPD	SA	SR	SSR	PR
Phenolics	12-86-1116	—	1/3	EPA 420.1	—	0.5	0.7	33%	—	—	—	—
	—	—	1/6		<0.5	—	—	—	—	—	—	—
	12-86-1124	—	1/3		—	<0.5	<0.5	—	—	—	—	—
	12-86-1127	—	↓		—	<0.5	<0.5	—	—	—	—	—
	12-86-1129	12-86-1130	1/8 1/9		1/8 1/9 <0.5	0.5	0.5	0%	2.0	0.5	2.9	120%
	12-86-1138	12-86-1160	1/9		<0.5	<0.5	<0.5	—	2.0	<0.5	1.8	90%
	12-86-1154	—	↓		<0.5	<0.5	<0.5	—	—	—	—	—
	12-86-1161	12-86-1170	1/13		<0.5	<0.5	<0.5	—	2.0	<0.5	1.8	90%
	12-86-1176	—	1/13 1/9	✓	1/13 1/9 <0.5	<0.5	0.67	—	—	—	—	—

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad C1 = \text{Concentration One} \quad C2 = \text{Concentration Two}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad SSR = \text{Spiked Sample Result} \quad SR = \text{Sample Result} \quad SA = \text{Spike Added (Concentration)}$$

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Sample Matrix:

/ / Water (ug/L)

Dilution Factor

[illegible]

*Moisture

/ / Other

QC Report No.

Laboratory Supervisor Approval:

Johnny R Coleman

Spike Source(s)

[illegible]

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2}$$

$$\text{Percent Recovery (PR)} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100$$

SSR = Spiked Sample Result
 SR = Sample Result
 SA = Spike Added (Concentration)

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

C1 = Concentration One
C2 = Concentration Two

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Report

Sample Matrix:

Dilution Factor

*Moisture

QC Report No.

Laboratory Supervisor Approval:

Johann R Adenauer

Spike Source(s)

[illegible]

* If moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2}$$

$$\text{Percent Recovery (PR)} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100$$

SSR = Spiked Sample Result
 SR = Sample Result
 SA = Spike Added (Concentration)

QUALITY CONTROL RESULTS SUMMARY
Environmental Quality Parameters

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Sample Matrix:

/ / Water (ug/L)

Dilution Factor _____

/X/ Soil (ug/g) (ug/Kg)

*Moisture _____

/ / Other _____

Spike Source(s) _____

QC Report No. _____

Laboratory Supervisor Approval:

Johnny R. Adkinson

Analytical Parameter	Laboratory Duplicates	Sample Nos. Spike	Date Anal	Anal Method	Blank	Duplicates			Spike Recovery			Notes
						C1	C2	RPD	SA	SR	SSR	PR
TKN	12-85-1120	12-85-1128	12/10/97	EPA 351.03	—	42	44	9%	60	58	91	55%
	12-85-1130	12-85-1148	12/11/97	"	—	580	600	3%	50	50	51	2%
	12-85-1141	12-85-1169	12/11/97	"	—	790	840	6%	99	110	200	90%
	12-85-1145	12-85-1202	12/11/97	"	—	170	140	90%	200	140	350	105%
	12-85-1146	12-85-1159	12/11/97	"	—	830	200	121%	590	600	740	24%
	12-85-1172	12-85-1154	12/11/97	"	—	85	45	62%	30	28	85	190%
	1-86-1103	12-85-1131		"	—	400	390	3%	400	410	730	72%
	1-86-1105			"	—	54	85	41%				
	1-86-1145			"	—	140	150	7%				

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \quad C1 = \text{Concentration One} \quad C2 = \text{Concentration Two}$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100 \quad SSR = \text{Spiked Sample Result} \quad SR = \text{Sample Result} \quad SA = \text{Spike Added (Concentration)}$$

QUALITY CONTROL, RESULTS SUMMARY

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QC Report No. PJKS-W-CV 17

Laboratory Supervisor Approval:

Johnny R Adams

Spike Source(s)[illegible]

* If moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2}$$

$$\text{Percent Recovery (PR)} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100$$

SSR = Spiked Sample Result
 SR = Sample Result
 SA = Spike Added (Concentration)

Engineering-Science

QUALITY CONTROL RESULTS SUMMARY Environmental Quality Parameters

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Sample Matrix:

 / Water (ug/L) Dilution Factor
 / Soil (ug/g) (ug/Kg) *Moisture
 / Section
 / Other

QC Report No. PJES-S-CR²⁴

Laboratory Supervisor Approval:

Johnny R Adams

Spike Source(s)

Analytical Parameter	Laboratory Duplicates	Sample Nos. Spike	Date Anal	Anal Method	Blank	Duplicates		Spike Recovery			Notes
						C1	C2	SA	SR	SSR	PR
C ₂ FI	12-35-1122	—	12/23	EPH-7196	<0.17	<0.17	<0.17	—	—	—	—
	12-35-1137	—	↓	↓	—	<0.17	<0.17	—	—	—	—
	12-35-1148	—	12/24	↓	<0.17	<0.17	<0.17	—	—	—	—
	12-35-1152	—	↓	↓	—	<0.17	<0.17	—	—	—	—
	12-35-1160	—	12/26	↓	—	<0.17	<0.17	—	—	—	—
	12-35-1171	—	12/30	↓	—	<0.17	<0.17	—	—	—	—
	12-36-1055	12-36-1057	1/17	↓	—	<0.17	<0.17	250	<0.17	182	73%
	—	—	1/20	↓	<0.17	—	—	—	—	—	—

* If % moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \times 100$$

C1 = Concentration One
C2 = Concentration Two

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added (Concentration)

Sample Matrix:

☒ Water (ug/L) (mg/L)☐ Soil (ug/g) (ug/kg)☐ Other

Dilution Factor _____

*Moisture _____

QC Report No. _____

Laboratory Supervisor Approval:

Johnny R. Anderson

Spike Source(s) _____

Analyte Metal	Laboratory Sample Nos.		Date Anal	**Anal Method	Blank	Duplicates		Spike Recovery			Notes
	Duplicates	Spike				C1	C2	SA	SR	PR	
As ↓	01-86-1133	01-86-1178	2/19/86	H	<0.002	<0.002	<0.002	0.200	<0.002	0.091	45%
	01-86-1130	01-86-1086	↓	↓	—	<0.002	<0.002	0.200	<0.002	0.099	49%
	—	01-86-1127	↓	↓	—	—	—	0.200	<0.002	0.102	51%
Cd ↓	01-86-1133	01-86-1178	2/18/86	F	<0.02	<0.02	<0.02	1.0	<0.02	1.01	101%
	—	01-86-1086	↓	↓	—	—	—	1.0	<0.02	0.992	99%
Cr ↓	01-86-1130	01-86-1127	2/18/86	F	<0.11	<0.11	<0.11	1.0	<0.11	1.11	111%
	—	—	—	—	—	—	—	—	—	—	—

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* If % moisture is reported, results are presented on a dry-weight basis.

** F = Flame AAS

G = Graphite Furnace AAS

H = Hydride Vapor AAS

C = Cold Vapor AAS

P = Inductively Coupled Plasma

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \times 100$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result

SR = Sample Result

SA = Spike Added (Concentration)

859J111

Sample Matrix:

 / Water (ug/L) Dilution Factor

 / Soil (ug/g) (ug/Kg) *Moisture

 / Other Drediment (ug/g)

Spike Source(s)

QC Report No.

Laboratory Supervisor Approval:

Johnny P. Adamson

Analyte Metal	Laboratory Sample Nos.		Date Anal	**Anal Method	Blank (mg/L)	Duplicates			Spike Recovery			Notes
	Duplicates	Spike				C1	C2	RPD	SA	SR	SSR	
As	01-86-1087	—	2/18/86	H	<0.002	2.9	3.4	16%	—	—	—	—
Cd	01-86-1087	—	2/18/86	F	<0.02	0.007	0.010	35%	—	—	—	—
Cu	01-86-1087	—	2/18/86	F	<0.11	0.024	0.030	22%	—	—	—	—
Pb	01-86-1087	—	2/18/86	F	<0.12	0.009	0.011	20%	—	—	—	—
Se	01-86-1087	—	2/20/86	H	<0.33	0.095	0.026	114%	—	—	—	—

* If % moisture is reported, results are presented on a dry-weight basis.

** F = Flame AAS

G = Graphite Furnace AAS

H = Hydride Vapor AAS

C = Cold Vapor AAS

P = Inductively Coupled Plasma

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2} \times 100$$

$$\text{Percent Recovery (PR)} = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result

SR = Sample Result

SA = Spike Added (Concentration)

859J111

QUALITY CONTROL RESULTS SUMMARY

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QC Report No. _____

Dilution Factor

Moisture

Spike Source(s)

Laboratory Supervisor Approval:

John F. Adamson

[illegible]

* If moisture is reported, results are presented on a dry-weight basis.

$$\text{Relative Percent Difference (RPD)} = \frac{C1 - C2}{(C1 + C2)/2}$$

$$\text{Percent Recovery (PR)} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100$$

APPENDIX K
LIST OF CONTACTS

CONTACTS

Environmental Protection Agency, Region VIII, Denver, Colorado

1. Mr. Eric Johnson (303) 293-1534
2. Mr. James Littlejohn (303) 293-1527

Colorado Department of Health, Division of Hazardous Wastes

1. Mr. Greg Starkebaum (303) 320-8333 ext. 4364
2. Mr. Paul Williamson (303) 320-8333 ext. 4170
3. Dr. Fred Dowsett (303) 320-8333

Martin Marietta Aerospace, Denver, Colorado

1. Mr. Todd Kisling (303) 977-3840
2. Mr. William Bath (303) 977-3997
3. Dr. William Haas (303) 977-3441

U.S. Air Force, PJKS Site, Waterton, Colorado

1. Captain Robert Catlin (303) 977-6192