Reference No.: 01
Former Macon Naval Ordnance Landfill
EPA ID No. GAD0000102178

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FINAL
SITE INVESTIGATION REPORT
FORMER MACON NAVAL ORDNANCE PLANT
LANDFILL SITE
MACON, GEORGIA

September 1997

Prepared for:
SAVANNAH DISTRICT - U.S. ARMY CORPS OF ENGINEERS
USACE Contract DACA 21-93-D-0029
Delivery Order No. 24

Prepared by:
RUST ENVIRONMENT & INFRASTRUCTURE
Atlanta, Georgia

Rust Project No. 33941.000
Rust Document Control 33941-0051

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Lester J. Williams, P.G.
Project Geologist

Kenneth P. Bechely, P.G.
Project Manager

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9/25/97

Quality through teamwork

CERTIFICATION

SITE INVESTIGATION REPORT
LANDFILL SITE
(FORMER MACON NAVAL ORDNANCE PLANT)
MACON, GEORGIA

PREPARED FOR:
U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

I certify that I am a qualified groundwater scientist who has received a baccalaureate or post-graduate degree in the natural sciences or engineering, and have sufficient training and experience in groundwater hydrogeology and related fields, and demonstrated by state registration and completion of accredited university courses, that enable me to make sound professional judgments regarding groundwater monitoring and contaminant fate and transport. I further certify that this report was prepared by myself or by a subordinate working under my direction.

KENNETH P. BECHELY
10-2-97
No. 000937
GEORGIA REGISTERED PROFESSIONAL GEOLOGIST

Kenneth P. Bechely

Kenneth P. Bechely, P.G.
Project Director

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LIST OF ACRONYMS

AIP	Allied Industrial Park
AST	Above Ground Storage Tank
ASTM	American Society for Testing and Materials
bls	below land surface
COC	Chain of Custody
CSR	Compliance Status Report
DCE	dichloroethene
DNR	Department of Natural Resources
DPT	Direct Push Technology
EPA	Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
ft/min	feet per minute
HSI	Hazardous Site Inventory
HSRA	Hazardous Site Response Act
MBCIA	Macon-Bibb County Industrial Authority
MCL	Maximum Contaminant Level
mgd	million gallons per day
MNOP	Macon Naval Ordnance Plant
msl	mean sea level
OVM	Organic Vapor Meter
PAH	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
PCE	tetrachloroethene
PETN	Pentaerythritoltetranitrate
PPE	Personal Protective Equipment
ppm	part per million
QA	Quality Assurance
QC	Quality Control
QCSR	Quality Control Summary Report
RRS	risk reduction standards
SOP	Standard Operating Procedures
SVOC	Semi-Volatile Organic Chemicals
TCE	Trichloroethene
USACE	U. S. Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	U. S. Geological Survey
UST	Underground Storage Tank
VOC	volatile organic chemicals
WEGS	Westinghouse Environmental and Geotechnical Services

EXECUTIVE SUMMARY

The former Macon Naval Ordnance Plant (MNOP) Landfill site is located in an industrial setting of south Macon, Bibb County, Georgia. Other than the landfilled area, the site is undeveloped. Land use in the area is primarily industrial with some undeveloped areas to the south. The site was originally a part of the MNOP which included the Allied Industrial Park (AIP) property immediately to the north. The MNOP was constructed and operated by Reynolds Corporation prior to World War II. The Navy assumed operations in 1941 and continued operations until 1965 for the production of ordnance. The Georgia Hazardous Site Inventory (HSI) currently lists the former MNOP Landfill site (HSI number 10167) as a Class II site under the Georgia Hazardous Site Response Act (HSRA).

Rust Environment and Infrastructure (Rust) was contracted by the Savannah District of the U.S. Army Corps of Engineers (USACE) to complete parallel site investigations at the former MNOP Landfill site and at the AIP. The AIP study is described under a separate cover. The purpose of the former MNOP Landfill investigation was to collect sufficient information concerning site contamination to prepare a Compliance Status Report (CSR) as required under Section 391-3-19-.06 of the HSRA regulations.

Historical information indicated that potential sources of contamination may include the inactive landfill located on the site, an area noted as having been an explosives demolition area, and an off-site landfill located immediately west of the site. To evaluate these sources and general site conditions, the scope of work included collecting soil samples from on-site borings, field screening groundwater collected from temporary sampling points, installing and sampling groundwater wells, collecting biota samples from a nearby creek, and collecting surface water and sediment samples from on-site and off-site drainage features.

The results of the groundwater sampling indicate that a release of trichloroethene (TCE), and other constituents has occurred. Site groundwater contamination appears to be localized to areas immediately surrounding the landfill. The extent of groundwater contamination has not been determined. The analytical results did not reveal any evidence of contamination for explosive residues, semi-volatiles, pesticides, or polychlorinated biphenyls (PCBs).

The results of soil sampling indicate that elevated levels of metals and PCBs are present throughout the subsoils of the site. The contamination is present adjacent to the source areas and at locations in the floodplain to the south. These contaminants will not likely undergo significant natural degredations, but will strongly sorb to soil. No evidence of explosive residues contamination was identified in the soils sampled.

Surface water and sediment samples collected found no evidence of contamination in Rocky Creek, south of the site. However, surface water samples collected north and southeast of the source areas were found to contain metals and volatile organic compounds (VOCs). Sediment samples from the same areas detected VOCs, semi-volatiles, and metals. Detections in the samples collected to the north indicate the possibility of an off-site source to the north or northwest.

Potential receptors include hunters and fisherman, environmental samplers, and trespassers. Ecological receptors are numerous and include a variety of small and large mammals, birds, and aquatic organisms. The most feasible routes by which exposure to contaminants could occur include ingestion and/or dermal contact with contaminated soil or surface waters, inhalation of soil particulates, and ingestion of contaminated fish or game.

Based on the analytical results, the on-site landfill appears to be a likely source of the contaminants identified. There is no indication of explosives residues in soil or groundwater.

It is concluded that contaminant levels in the shallow groundwater currently exceeds the state of Georgia's risk reduction standards (RRS) as promulgated in the Hazardous Sites Response Act (HSRA). While a large number of constituents were detected in the groundwater samples, only lead, arsenic, TCE, 1,1-DCE, and vinyl chloride were detected at more than one location in concentrations greater than the Type 4 (nonresidential) RRS. The Type 4 RRS for soil were exceeded for only lead and para-cymene.

Based on the results of investigation and current site conditions it is recommended that further definition of the vertical and horizontal extent of soil and groundwater contamination be completed to meet the requirements of a HSRA Compliance Status Report. Further definition of the sources identified in this report will also be necessary. A full description of the project conclusions and recommendations can be found in Section 11 of this report.

1.0 INTRODUCTION

This report documents the site investigation conducted by Rust Environment and Infrastructure at the former Macon Naval Ordnance Plant Landfill (MNOP Landfill) site. The Georgia Hazardous Site Inventory (HSI) currently lists the site (HSI number 10167) as a Class II site under the Georgia Hazardous Site Response Act (HSRA). Historically, the site was part of the Macon Naval Ordnance Plant (MNOP) which was owned by the United States Navy until 1965.

This report was prepared by Rust for the Savannah District of the U.S. Army Corps of Engineers (USACE) in accordance with Contract Number DACA 21-93-D-0029, Delivery Order No. 24. The original intent of the investigation was to collect sufficient information concerning site contamination to prepare a Compliance Status Report (CSR) as required under Section 391-3-19-.06 of the HSRA regulations. Little was known concerning the types, sources, and extent of contamination prior to this site investigation. Due to the lack of knowledge concerning specifics of the potential contamination, the scope of work was designed to provide an understanding of site conditions through a broad scale investigation.

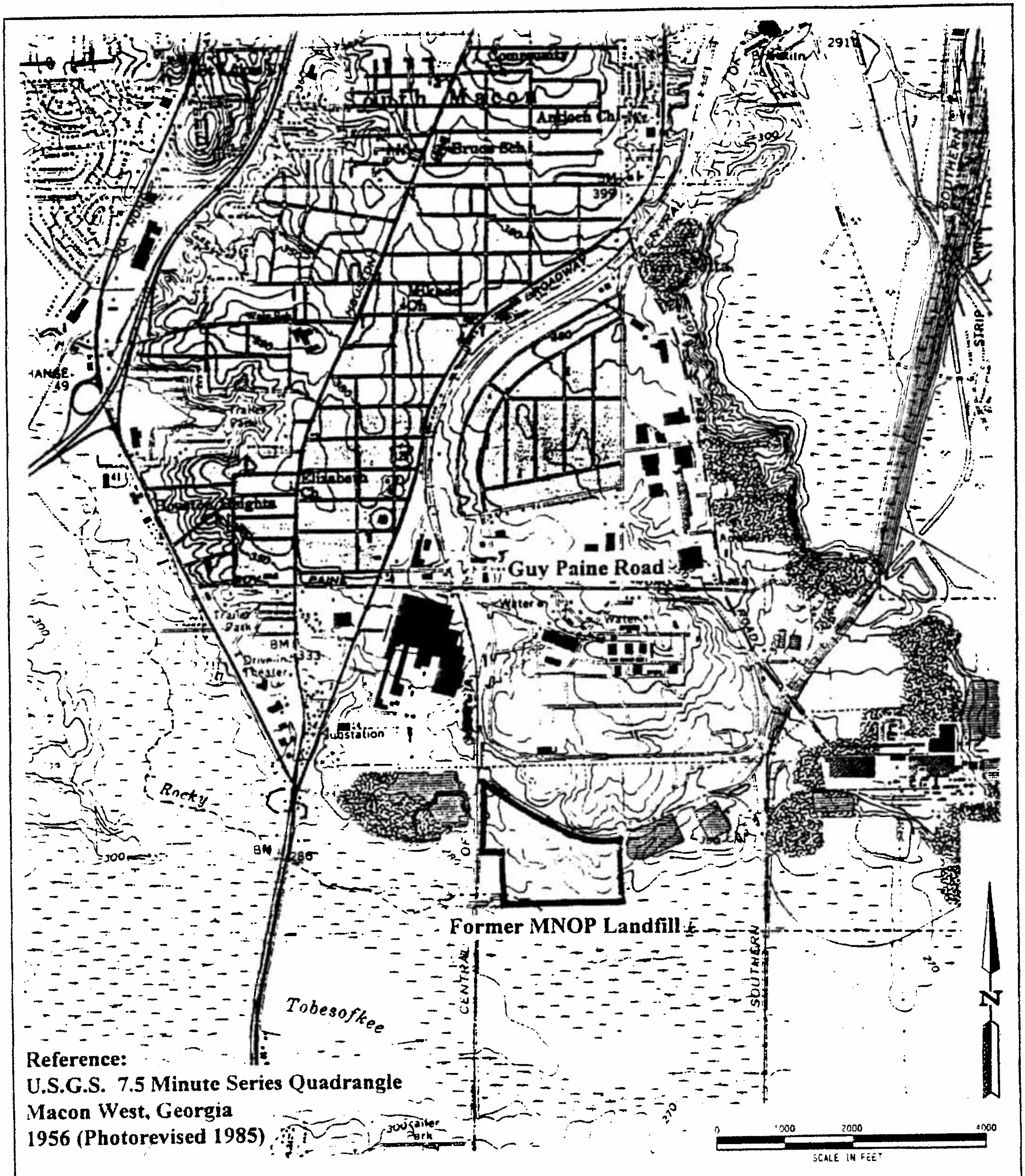
The investigation included the sampling of subsurface and surface soils, groundwater, surface water, and stream sediment from multiple locations across the site. While this investigation has provided a good estimate of the general nature and extent of the contamination, not all of the requirements of a CSR were met (specifically the full delineation of the horizontal and vertical extent of contamination).

The following report is structured to provide information applicable to the creation of a CSR following further study. Therefore, the report includes information concerning the physical setting an evaluation of environmental data collected, an evaluation of potential environmental receptors, a discussion of current and historical property ownership, an evaluation of the site's compliance with the HSRA Risk Reduction Standards, and recommendations for further actions to be taken.

Geologic, hydrogeologic, and chemical data used in this evaluation were obtained by Rust from January through May 1996.

1.1 SITE DESCRIPTION

The landfill site is in Bibb County on the south side of Macon, Georgia (Figure 1-1) on the property formerly occupied by the Macon Naval Ordnance Plant. The topography in this area slopes to the south from approximately 300 feet above mean sea level (msl) to 275 feet msl at Rocky Creek



Reference:
U.S.G.S. 7.5 Minute Series Quadrangle
Macon West, Georgia
1956 (Photorevised 1985)

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 1-1
SITE LOCATION MAP
FORMER MNOP LANDFILL
MACON, GEORGIA
RUST PROJECT 33941.000
33941102 7/96

1a

immediately south of the landfill. Although the exact boundaries and construction of the landfill are not known, it is estimated to be 12 to 15 acres in size and unlined.

Land use in the area around the site is primarily industrial. The landfill is bordered on the south by Rocky Creek. The Rocky Creek Waste Water Treatment Plant, operated by the Macon Water Authority, is located east of the landfill. The Riverwood International plant site is east of the treatment plant. The western side of the property is bordered by the Armstrong Cork Company's (Armstrong Cork) plant site. The property to the north is occupied by the Allied Industrial Park (AIP). The Armstrong Cork plant and the AIP are Class II HSRA sites (HSI site numbers 10131 and 10308, respectively). The Riverwood International site is a Class IV HSRA site (HSI site number 10027).

1.2 BACKGROUND

As stated earlier, the former MNOP Landfill site was once part of the MNOP which included the AIP property to the north. The MNOP was constructed and operated by the Reynolds Corporation prior to World War II. The Navy assumed operations in 1941 and continued operations until 1965 for the production of ordnance. Items manufactured included flares, small primers, detonators, and other triggering mechanisms. The MNOP owned and operated the landfill south of the manufacturing areas.

After being declared surplus by the Navy, the MNOP property was sold in December 1965 to the Maxson Electronics Company of New York. Maxson continued to produce ordnance under contract with the Navy. Maxson subsequently sold the property to Allied Chemical Corporation in 1973 which manufactured automobile seat belts at the site. Allied sold the property in 1980 to the Macon-Bibb County Industrial Authority (MBCIA). The MBCIA deeded the southern portion of the MNOP property containing the landfill to the Macon Water Authority in 1989. The landfill was used by all owners subsequent to the Navy until approximately 1974, at which time the site was closed. However, evidence at the site indicates that intermittent dumping of construction and demolition debris has continued.

The landfill is said to have received explosives and flammable wastes during Navy operations, but in interviews and previous studies (ESE, 1990) the landfill wastes were indicated to be limited primarily to solid waste, used parts, and construction debris. A burn pit was located in the same general area as the landfill. The burn pit was used for explosives testing and the disposal of flammable waste.

In 1989 and 1990, groundwater, soil, and sediment samples were collected and analyzed from the areas upgradient and downgradient of the landfill and on the adjacent property owned by Armstrong Cork. The Armstrong Cork property sampled contained a drum storage area and a pond. Organic and inorganic analytes were detected in each media (ESE, 1990). The analytical results for groundwater and soil are found on Tables 1-1 and 1-2, respectively. Figure 1-2 shows the locations sampled as part of the 1989-90 investigation.

Also during this investigation, groundwater samples were collected from five monitor wells installed around the landfill, including one upgradient of the landfill (MW-1). Various metals were detected in almost all of the samples, however, cyanide, arsenic, and selenium were detected in down gradient samples only. The explosives compounds 1,3-DNB and 2,4-DNT were detected in groundwater samples collected downgradient of the landfill. Pentaerythritoltetranitrate (PETN), a common component of fuses and primers, was detected in a sample collected from only the upgradient well (MW-1). Trichloroethene and vinyl chloride were also detected in groundwater samples collected downgradient of the landfill. Bis(2-ethylhexyl)phthalate was detected in every well and the equipment blank, which probably indicates it is laboratory contamination and is therefore, not considered significant.

Soil samples were collected from the explosives demolition area on the east side of the landfill on two occasions. The only reported detections in these samples were for arsenic, barium, chromium and lead. No background soil data were provided.

Two composite soil samples were collected from the Armstrong property, one from the pond containing the discolored water and one from the soils in the area of the drums (Figure 1-2). The sample from the pond contained a number of polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons. The sample from the soil around the drums contained several metals, one PAH (benzo(g,h,i)perylene), nitrogen, and petroleum hydrocarbons.

Table 1-1
Summary of Previous Groundwater Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Compound	Sample Identification									Water Quality Criterion	Regulation
	MW-1	MW-2	MW-3	MW-4	MW-5	MW-3-DP	MW-EB	MW-TB	SO-TB		
cyanide (mg/L)	--	0.133	0.005	--	--	--	--	NRQ	NRQ	0.0035	GA
nitrogen NO_2+NO_3 (mg/L as N)	5.45	0.151	0.040	--	--	0.073	0.021	NRQ	NRQ	10	MCL
arsenic, total (mg/L)	--	0.0032	0.0029	--	--	--	--	NRQ	NRQ	0.005	MCL
barium, total (mg/L)	0.0507	0.120	0.0556	0.0418	0.109	0.0569	0.0015	NRQ	NRQ	1.0	MCL
chromium, total (mg/L)	0.0140	0.0259	0.0181	0.0091	--	0.0118	--	NRQ	NRQ	0.05	MCL
iron, total (mg/L)	4.42	19.0	5.91	19.2	17.3	6.04	0.0124	NRQ	NRQ	0.3	MCL
manganese, total (mg/L)	0.428	0.590	0.0970	0.248	0.530	0.100	--	NRQ	NRQ	0.05	MCL
selenium, total (mg/L)	--	--	0.0023	--	--	--	--	NRQ	NRQ	0.01	MCL
sodium, total (mg/L)	20.6	28.7	13.6	8.12	9.30	14.3	0.169	NRQ	NRQ	20	GA Recom
pentaerythritol tetranitrate (μg/L)	68.8	--	--	--	--	33.3	--	NRQ	NRQ	NC	--
1,3-dinitrobenzene (μg/L)	--	--	1.18	--	--	1.23	--	NRQ	NRQ	NC	--
2,4-dinitrotoluene (μg/L)	--	--	1.83	--	--	1.68	--	NRQ	NRQ	1.1	Rosenblatt
trichloroethene (μg/L)	--	7,000	3,800	110	19	3,900	--	--	--	5	MCL
vinyl chloride (μg/L)	--	--	--	170	--	--	--	--	--	2	MCL
bis(2-ethylhexyl)phthalate(μg/L)	1.6	1.7	6.4	2.4	1.2	3.0	1.2	NRQ	NRQ	10,000	WQC

Note: GA = Georgia state standard described in EPA (1988).
GA Recom = recommended Georgia standard - nonenforceable (Personal Communication, Fred Lehman).
MCL = maximum contaminant level specified in the National Primary drinking Water Regulations, 40 CFR 141.11 (July 1, 1986) and the National Secondary Drinking Water Regulations, 40 CFR 143.3 (July 1, 1986).
mg/L = milligrams per liter.
NRQ = not required.
Rosenblatt = criteria suggested by Rosenblatt (1981) for the permissible concentration level for the contaminant in drinking water.
μg/L = micrograms per liter.
WQC = suggested ambient water quality criteria for the protection of human health from the toxic properties or carcinogenic effects of the compound; criteria associated with cancer risk levels (CRLs) of 1 x 10-6 are reported where available; these criteria are summarized in the document Quality Criteria for Water 1986, EPA, May 1, 1986, Washington, DC; criteria were previously announced in 45 FR 79318 (November 28, 1984), 49 FR 5831 (February 15, 1984), and 50 FR 30784 (July 29, 1984).
-- = not detected at method detection limit.

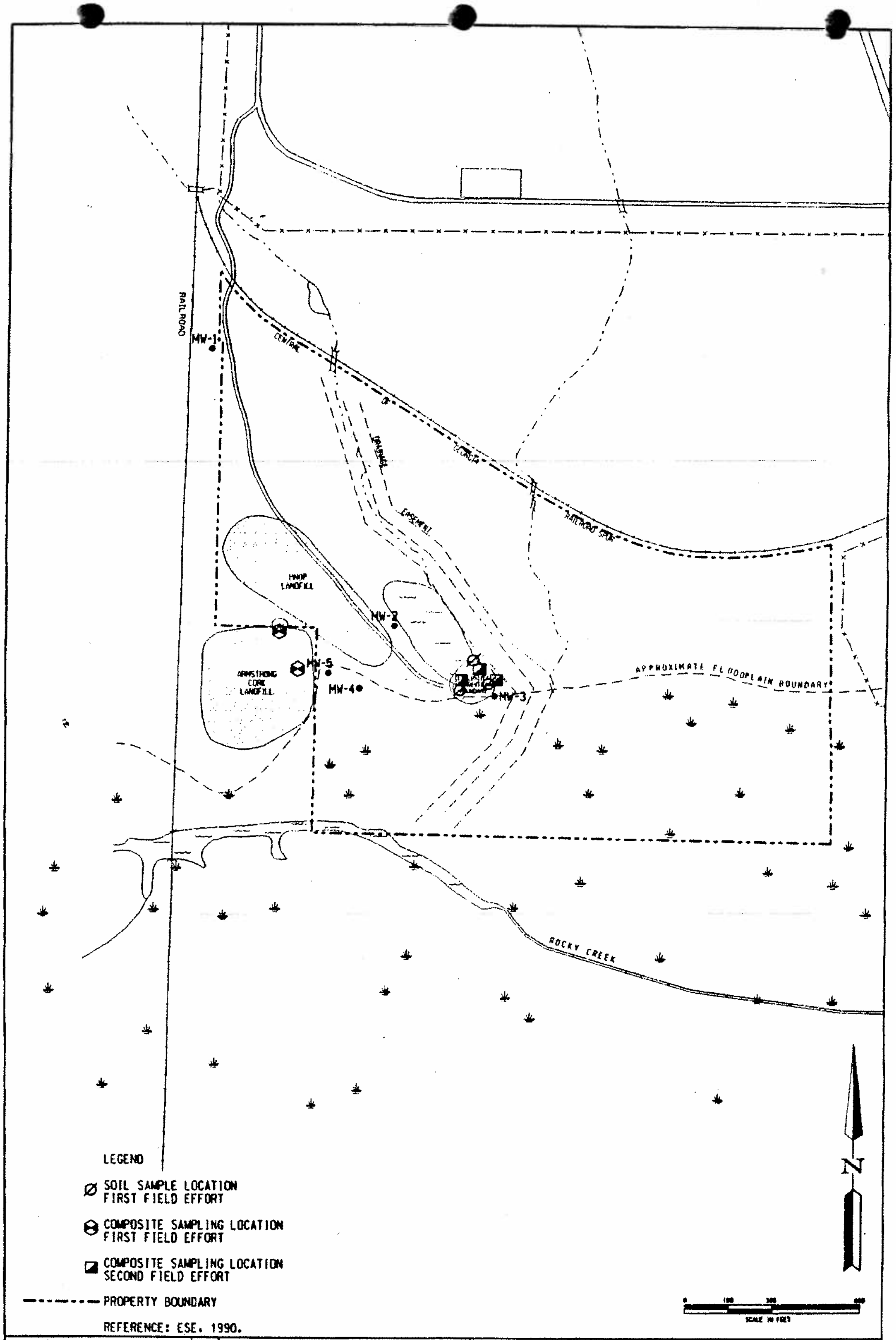
Source: ESE, 1990

Table 1-2
Summary of Previous Soil Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Compound*	Sample Identification					
	SO-1	SO-2	SO-3	SO-4	SO-5	SO-3-DP
moisture (% wet wt.)	9.3	14.2	11.6	44.3	52.6	13.4
arsenic	0.650	1.55	0.574	0.781	4.83	0.502
barium	6.92	11.4	8.71	196	70.5	7.26
chromium	7.02	8.87	5.82	22.1	29.6	3.99
lead	--	5.00	--	41.8	39.3	--
anthracene	--	--	--	--	0.32	--
benzo(a)anthracene	--	--	--	--	1.4	--
benzo(b)fluoranthene	--	--	--	--	0.92	--
benzo(k)fluoranthene	--	--	--	--	0.67	--
benzo(a)pyrene	--	--	--	--	0.69	--
benzo(g,h,i)perylene	--	--	--	1.9	0.72	--
chrysene	--	--	--	--	0.95	--
fluoranthene	--	--	--	--	2.1	--
indeno(1,2,3-cd)pyrene	--	--	--	--	0.75	--
phenanthrene	--	--	--	--	1.0	--
pyrene	--	--	--	--	1.8	--
nitrogen, NO_2+NO_3, sediment (μg/g-dry)	4.3	--	--	196	--	0.71
hydrocarbons, petroleum (μg/g-dry)	--	--	--	1,020	207	--

Note: μg/g-dry = micrograms per gram, dry weight.
-- = not selected at method detection limit.
* = units are in milligrams per kilogram, dry weight (mg/kg-dry) unless otherwise noted.

Source: ESE, 1990



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RUST ENVIRONMENT & INFRASTRUCTURE
ATLANTA, GEORGIA

FIGURE 1-2
PREVIOUS ENVIRONMENTAL STUDIES
FORMER MNOP LANDFILL
MACON, GEORGIA

3c

2.0 PHYSICAL SETTING

2.1 SUBSURFACE GEOLOGY

The former MNOP Landfill site is underlain by a thin surficial deposit composed primarily of red-brown silty sands, clayey silts and silty clays at ground surface which in turn is underlain by sands, silts, and clay of the Tuscaloosa formation. The surficial materials from north to south, toward Rocky Creek, becomes increasingly organic rich and, in places, are composed of peat and organic-rich silts/clay.

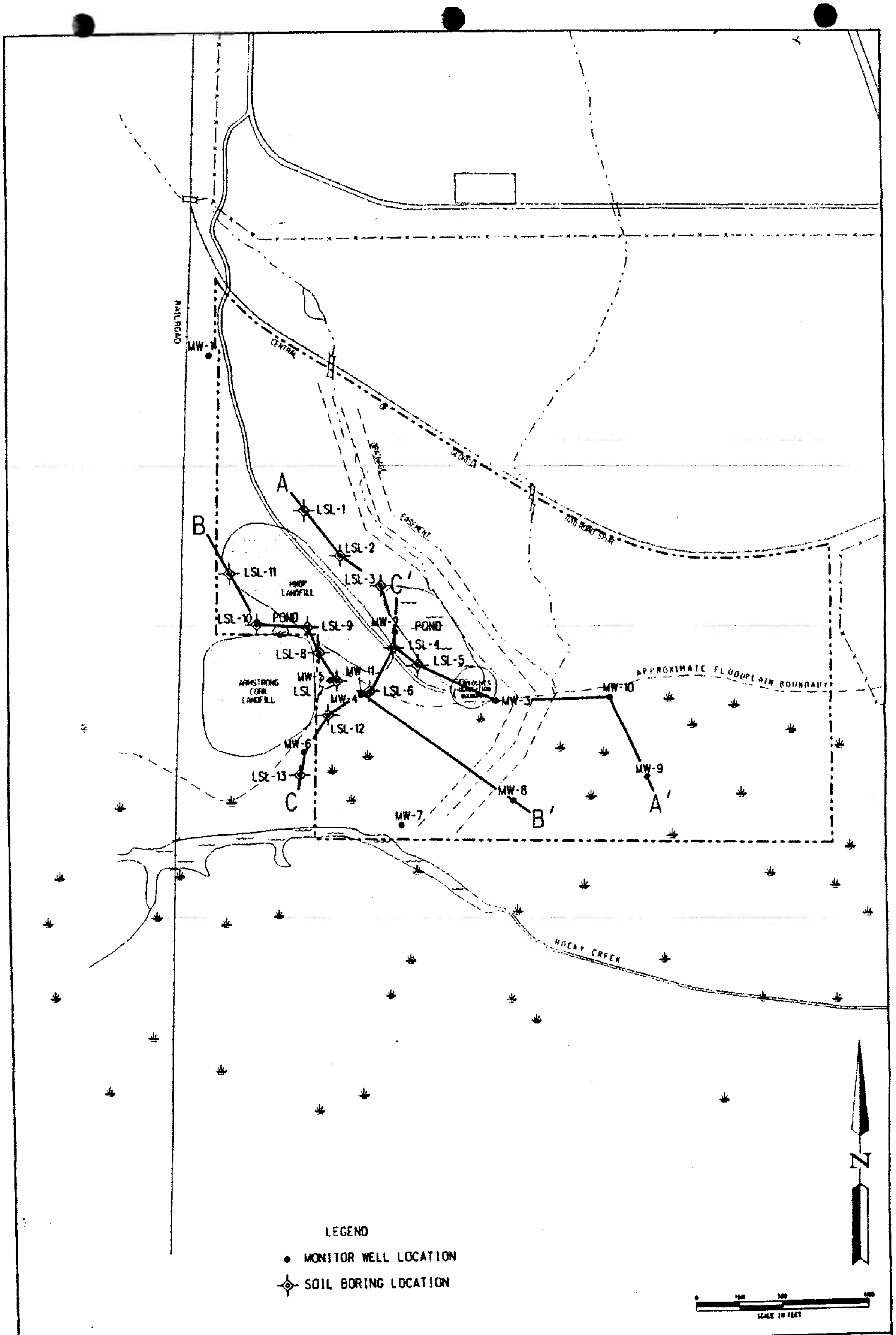
Geologic profiles were generated using data gathered during this and previous investigations. Figure 2-1 is a cross section location map, while the cross sections are represented in Figures 2-2 through 2-4. The boring logs and well construction summaries for the historical data used in this report and those generated as part of the current investigation are found in Appendix A. The cross sections generated define two distinctive (shallow) lithologic units:

- surficial deposits composed of silty sand, clay, peat and organic silts/clay (Quaternary)
- clayey sand, clean sands, clay and silt (Tuscaloosa)

The surficial unit varies in thickness from 4 to 7 feet and is composed of residual soils to the north and organic rich, mostly clayey deposits (Quaternary) to the south. The organic rich deposits were probably laid down as a result of vertical accretion of the flood plain adjacent to Rocky Creek. The base of the surficial unit is estimated to be at elevation 280 feet msl sloping to 272 feet msl near Rocky Creek. Below the surficial materials, the Tuscaloosa is composed of what appears to be predominantly sand and clayey sand with interbeds of clay and silt. The Tuscaloosa has distinctive grey/green-grey silts and clays and white-tan kaolinitic clayey sands.

The surficial materials are saturated throughout the floodplain area, and is sufficiently thick to form a distinctive hydrogeologic unit in these areas. Monitoring wells near the former MNOP Landfill site are predominantly screened into the underlying Tuscaloosa silts, sands, and clays, while monitoring wells near Rocky Creek, such as MW-6, MW-7, MW-8, MW-9 and MW-10 are predominantly screened into the surficial unit.

The deeper stratigraphic and lithologic units are known only from the drillers logs available for many of the deep water-supply wells which surround the site and from review of available literature. The Cretaceous aged Tuscaloosa formation consists of light-colored sand, sandy clay, and discontinuous



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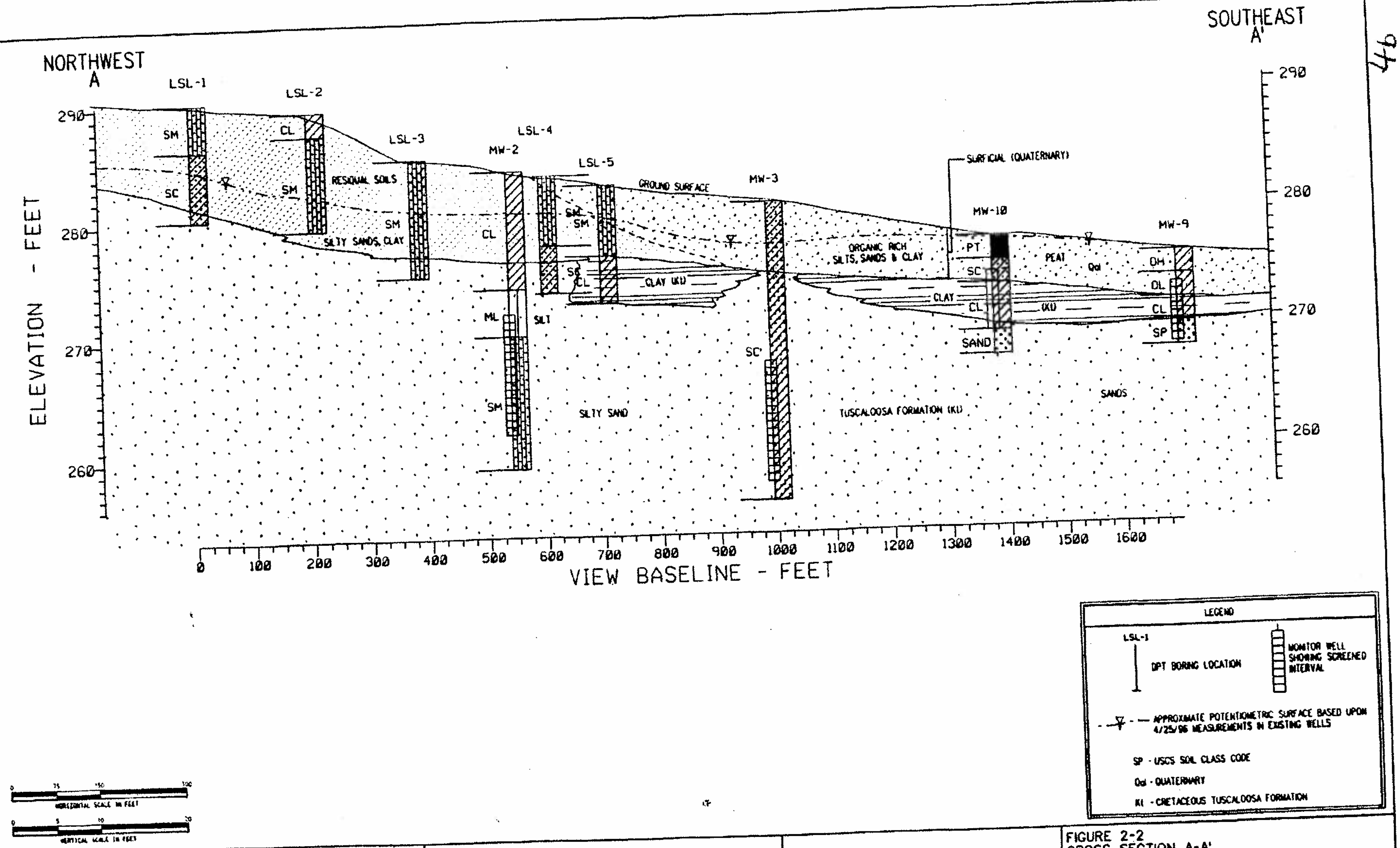
RUST ENVIRONMENT & INFRASTRUCTURE
ATLANTA , GEORGIA

FIGURE 2-1
CROSS SECTION LOCATION MAP
FORMER MNOP LANDFILL
MACON, GEORGIA



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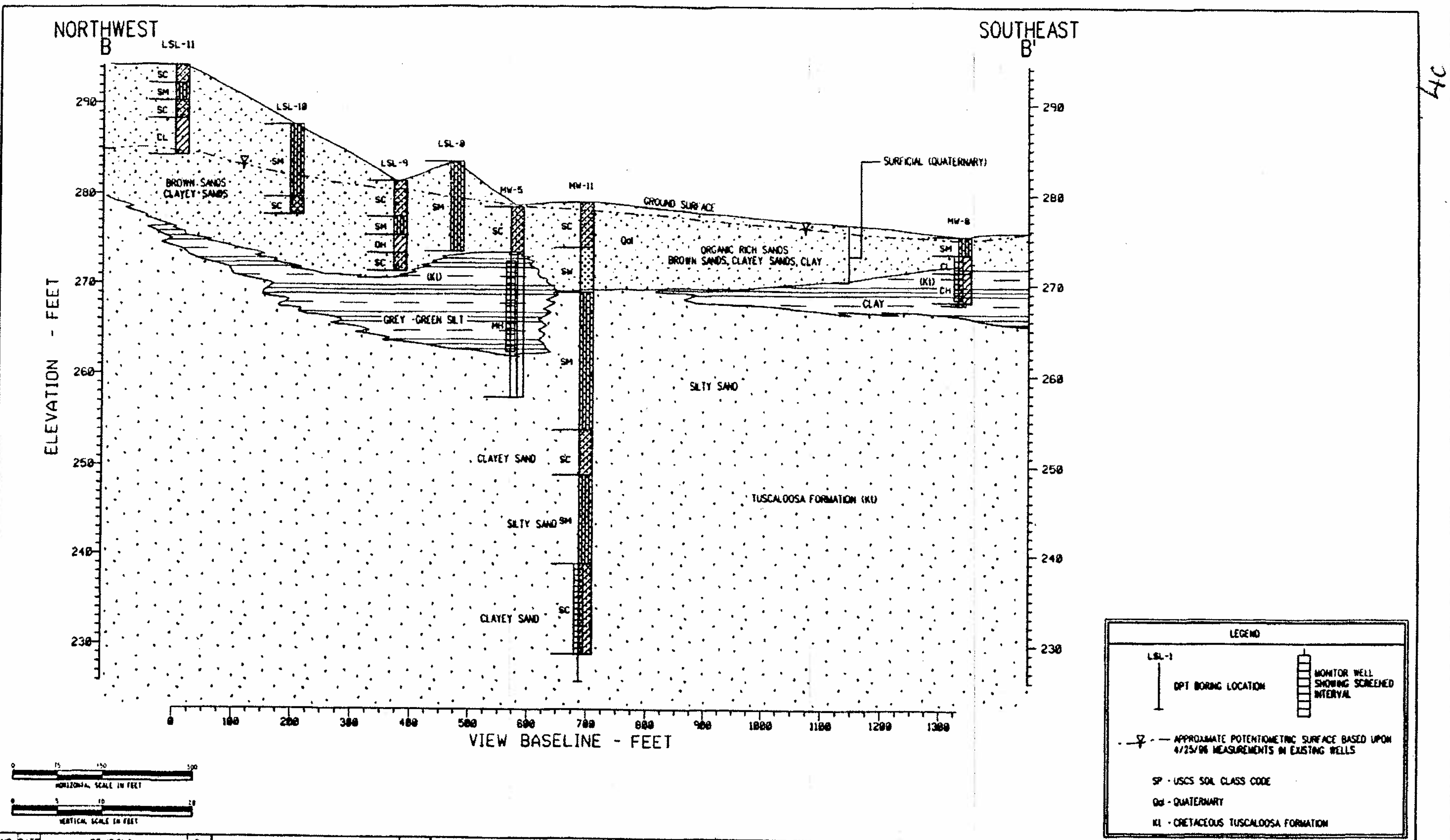
RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 2-2
CROSS SECTION A-A'
FORMER MNOP LANDFILL
MACON, GEORGIA

4c



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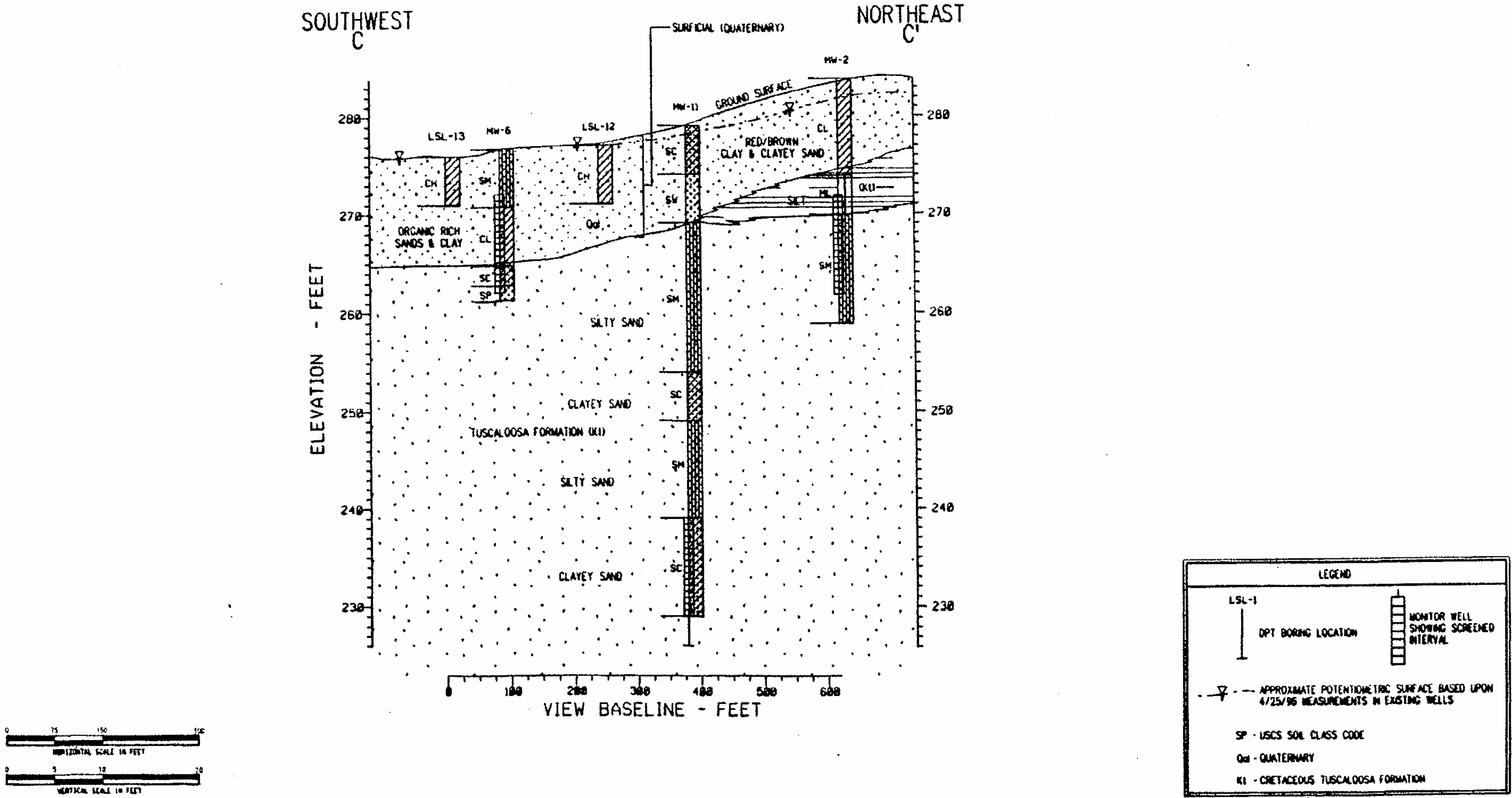
RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 2-3
CROSS SECTION B-B'
FORMER MNOP LANDFILL
MACON, GEORGIA



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RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 2-4
CROSS SECTION C-C'
FORMER MNOP LANDFILL
MACON, GEORGIA

clay (LeGrand, 1962). Sand beds within the Tuscaloosa formation are exceptionally productive and form an ample source of fresh, high quality water used for industrial and potable purposes. The Tuscaloosa is approximately 280 to 285 feet thick (260 to 265 feet thick below former MNOP Landfill site) and directly overlies what is described in drillers logs as "granite", "marl", or "limestone". In several of the drilled wells, 10 to 20 feet of marl or limestone is described to overlie granite but is not always present.

In each of the drilled wells reviewed from Armstrong Cork (seven deep wells located west and north of MNOP landfill), Riverwood International Corp (3 deep wells located east), and Keebler (one deep well to the north of AIP), a consistent stratigraphic sequence can be observed. At an elevation of approximately 248 feet msl a white and pink clay unit is encountered. This clay, which appears to be discontinuous across the area, is roughly 12 feet thick where present. In Armstrong well No. 7, which is the closest well to the former MNOP landfill, this clay appears to be absent and may be represented by what is described as a coarse sand with streaks of white clay. This unit is interpreted to be the base of the shallow water-table aquifer making the shallow aquifer approximately 30 feet thick assuming the water-table is at 280 feet msl.

Between the "shallow aquifer" and the first significant water bearing sand aquifer is a sequence of interbedded sand and clay (predominantly sand with clay and clay interbeds) that measures roughly 59 feet thick. In the Armstrong No.7 well this unit is approximately 62 feet thick. Below the interbedded sands and clay, between approximately 95 and 120 feet bls, is a medium to coarse grained water producing sand. Almost all water-supply wells in the area are screened across this 25 foot thick sand. Two or more water bearing sands or sequences of sands and clays are encountered between 120 feet bls and the base of the Tuscaloosa formation. Distinctive clay units are encountered between about 160 and 180 feet bls and between 200 and 220 feet bls.

2.2 HYDROGEOLOGY

Based upon literature review, evaluation of geologic logs both on-site and from deep water-supply wells, the following hydrogeologic units are defined:

- _shallow water-table aquifer_: the shallow aquifer extends from the water-table to approximately 30 feet bls. The shallow aquifer is comprised primarily of clayey sands, clean sands, and silty sands with frequent but discontinuous silt-clay intervals. The shallow aquifer also includes saturated portions of the surficial clay, silty sand and organic rich silt/clay deposits. Rocky Creek forms a discharge boundary for the shallow aquifer.

- *interbedded sand and clay units*: This unit is characterized by a distinctive red-white 12-foot thick clay unit overlying an approximately 60-foot thick sequence of interbedded sand and clay. Note that near the MNOP landfill, the distinctive red-white clay appears to be absent based upon logs from nearby water-supply wells. The "interbedded" unit is encountered between 35 and 95 feet bls. The clay and interbedded sand and clay units may form a confining unit or leaky confining unit to the deeper water producing aquifer zones.

- *Tuscaloosa sand aquifer(s)*: the Tuscaloosa sand aquifers consist of three or more primary water bearing sands or sequences of interbedded sand and clay separated by clay. This includes a shallow interval, from approximately 95 to 120 feet bls at Armstrong No. 7 well, and deeper aquifers between approximately 135 bls and the base of the Tuscaloosa at approximately 265 feet bls.

The following discussion on groundwater flow primarily deals with the *shallow aquifer* under study. Table 2-1 provides a summary of well construction details which groundwater flow and measurement data are based upon. All monitor wells are screened into the shallow aquifer except for MW-11 which is interpreted to be screened into the "interbedded" unit.

The groundwater flow direction for the shallow aquifer at the former MNOP Landfill site is generally in a south direction toward Rocky Creek, based on water levels taken on April 25, 1996. The potentiometric surface map (Figure 2-5) shows a predominant flow direction to the south except for in the vicinity of the pond where the potentiometric surface appears to be slightly mounded, possibly due to recharge from this surface water feature.

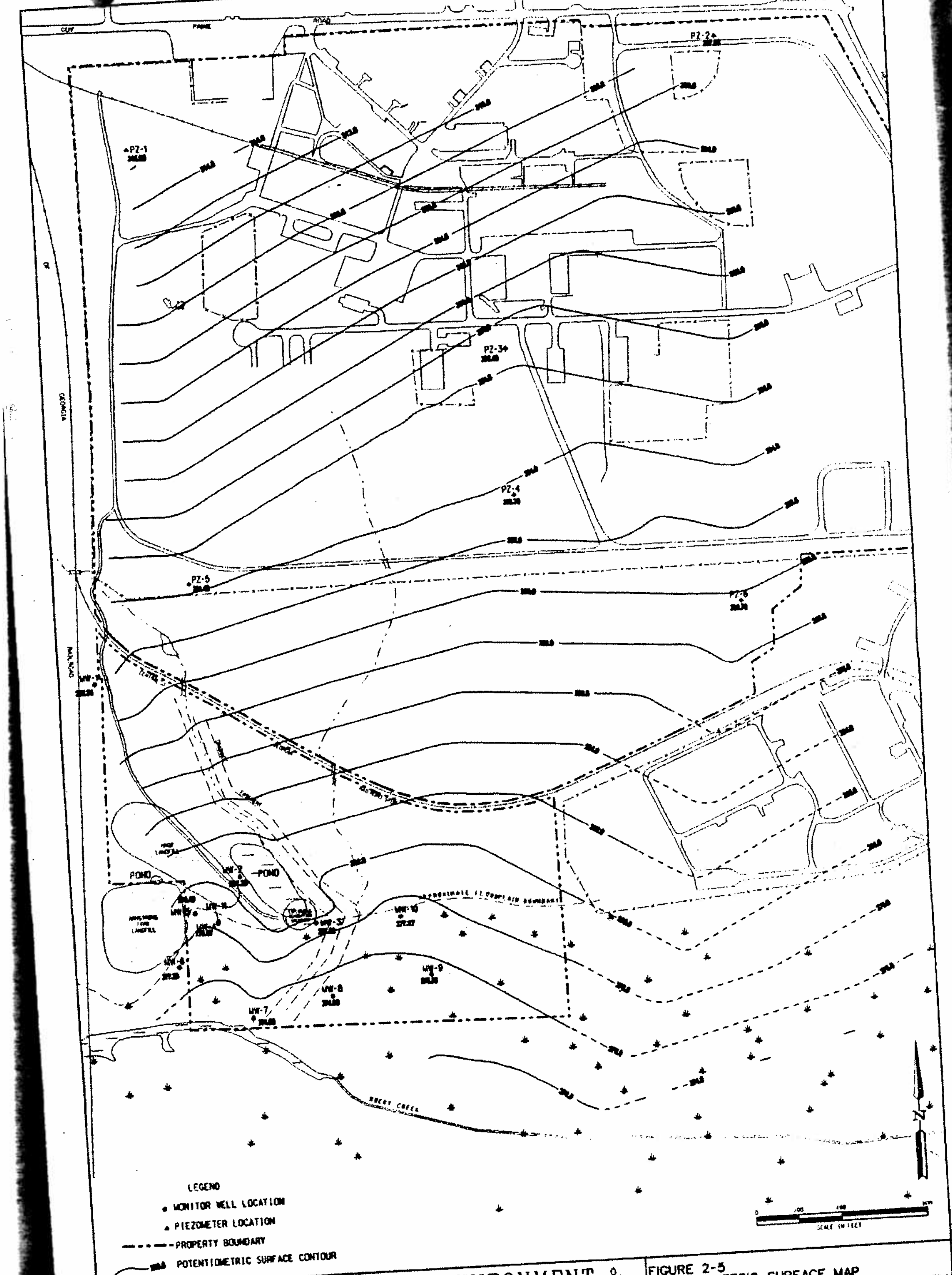
Depth to groundwater varies from about 14 feet bls at MW-1 to less than 2 feet bls in the area of the former MNOP Landfill site (Table 2-2). Saturated ground surface conditions exist all through the floodplain areas south of the former MNOP landfill. Static water levels correlated to elevations msl ranged from 292.34 feet msl at MW-1 to approximately 275 feet msl at monitoring wells MW-7 and MW-8 near Rocky Creek.

Rust conducted a study of the former MNOP which included the installation of piezometers on the AIP property, north of the former MNOP Landfill site (Rust, 1994). The hydraulic conductivity of the shallow aquifer was estimated by conducting hydraulic slug tests on the piezometers installed. Because no slug testing has been conducted on monitoring wells at the former MNOP Landfill, the results obtained from the AIP are included here as estimated conductivity values for the similar types of materials observed at the Landfill site. These results are expected to be representative of the Tuscaloosa sands, silts and clay units.

Table 2-1
Well Construction Summary
Macon Naval Ordnance Plant
Macon, Georgia
Rust Project No. 33941.000

Well No.	Northing Coordinate	Easting Coordinate	Ground Elev. ft-msl	Top of Casing Elevation ft-msl	Top Screen ft-bls	Bottom Screen ft-bls	Bottom Well ft-bls	Top Seal ft-bls	Bottom Seal ft-bls	Well Material	Date Installed
MW-1	1008453.52	658704.01	306.4	308.87	24.2	34.2	34.2	17.5	21.0	2"-PVC	9/12/89
MW-2	1007495.06	659335.07	283.9	286.06	12.1	22.1	22.1	2.0	4.0	2"-PVC	9/13/89
MW-3	1007249.66	659675.89	280.8	283.04	13.4	23.4	23.4	8.1	10.8	2"-PVC	9/14/89
MW-4	1007276.37	659217.75	278.9	281.12	5.4	15.4	15.4	1.4	3.7	2"-PVC	9/14/89
MW-5	1007329.30	659110.10	278.5	280.69	6.0	16.0	16.0	2.2	4.4	2"-PVC	9/15/89
MW-6	1007074.45	659019.61	276.8	279.3	4.8	14.8	15.3	0.5	1.5	2"-PVC	1/29/96
MW-7	1006814.08	659355.04	276.9	278.2	3.8	8.8	9.1	0.0	3.8	2"-PVC	2/6/96
MW-8	1006893.75	659730.93	275.4	277.87	2.0	7.0	7.3	0.0	2.0	2"-PVC	2/8/96
MW-9	1006972.18	660189.45	275.7	278.20	2.7	7.7	8.0	0.0	2.7	2"-PVC	2/7/96
MW-10	1007259.72	660061.84	277.4	279.92	3.0	8.0	8.3	0.0	3.0	2"-PVC	2/6/96
MW-11	1007284.82	659218.67	279.0	281.52	40.0	50.0	50.5	28.6	32.6	2"-PVC	1/26/96
PZ-1	1010971.39	658986.27	322.6	325.17	21.0	31.0	31.5	11.0	17.0	2"-PVC	10/11/94
PZ-2	1011352.85	661746.59	351.0	350.70	39.5	49.5	50.0	31.0	37.0	2"-PVC	10/6/94
PZ-3	1009930.01	660709.40	343.8	346.12	44.5	54.5	55.0	36.0	42.0	2"-PVC	10/13/94
PZ-4	1009238.56	660710.80	333.0	335.11	39.5	49.5	50.0	32.0	37.0	2"-PVC	10/5/94
PZ-5	1008907.39	659173.21	308.2	310.48	14.5	24.5	25.0	5.5	10.5	2"-PVC	10/6/94
PZ-6	1008681.53	661729.58	304.9	307.21	19.5	29.5	30.0	10.7	16.0	2"-PVC	10/7/94

ft-msl = feet mean sea level
ft-bls = feet below land surface



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RUST ENVIRONMENT & INFRASTRUCTURE
ATLANTA, GEORGIA

FIGURE 2-5
POTENTIOMETRIC SURFACE MAP
ALLIED INDUSTRIAL PARK & FORMER MNOP LANDFILL
MACON, GEORGIA

66

Table 2-2
Groundwater Elevation Summary
Macon Naval Ordnance Plant
Macon, Georgia
Rust Project No. 33941.000

Well No.	Northing Coordinate	Easting Coordinate	Ground Surface Elevation ft. msl	Top of Casing Elevation ft. msl	Depth to Water ft. TOC	Water Elevation ft. msl
MW-1	1008453.52	658704.01	306.4	308.87	16.53	292.34
MW-2	1007495.06	659335.07	283.9	286.06	4.86	281.20
MW-3	1007249.66	659675.89	280.8	283.04	4.22	278.82
MW-4	1007276.37	659217.75	278.9	281.12	3.05	278.07
MW-5	1007329.30	659110.10	278.5	280.69	2.23	278.46
MW-6	1007074.45	659019.61	276.8	279.3	1.96	277.29
MW-7	1006814.08	659355.04	276.9	278.2	3.25	274.93
MW-8	1006893.75	659730.93	275.4	277.90	3.24	274.66
MW-9	1006972.18	660189.45	275.7	278.20	2.82	275.38
MW-10	1007259.72	660061.84	277.4	279.90	2.73	277.17
MW-11	1007284.82	659218.67	279.0	281.50	7.15	274.35
PZ-1	1010971.39	658986.27	322.6	325.17	8.19	316.98
PZ-2	1011352.85	661746.59	351.0	350.70	43.04	307.66
PZ-3	1009930.01	660709.40	343.8	346.12	49.72	296.40
PZ-4	1009238.56	660710.80	333.0	335.11	41.38	293.73
PZ-5	1008907.39	659173.21	308.2	310.48	16.05	294.43
PZ-6	1008681.53	661729.58	304.9	307.21	17.45	289.76

ft. msl = feet mean sea level
ft. bls = feet below land surface
ft. TOC = feet below top of casing
Note: all measurements taken 4/25/96
MW-1 through MW-11 at former MNOP Landfill
PZ-1 through PZ-6 at AIP

Hydraulic conductivity is a measure of a fluid's ability to move through a porous media under a unit gradient and is an important variable in evaluating groundwater flow velocities. Calculations indicate the average hydraulic conductivity for the six piezometers tested to be 2.1 x 10^{-3} feet per minute (ft/min) while the highest calculated value was 6.3 x 10^{-3} ft/min.

The horizontal average linear groundwater flow velocities were calculated for the former MNOP Landfill site using the Darcy equation (Fetter, 1988). The results indicate groundwater flow in the shallow aquifer is estimated to be 32 feet per year using the average hydraulic conductivity value reported and a high of 100 feet per year using the high hydraulic conductivity reported. The average hydraulic gradient used in these calculations was 0.0074 (see calculations in Appendix A).

Information on the vertical flow gradients between the two aquifers is only known from the observed gradients between monitoring wells MW-4 and MW-11 which are nested together and screened across the shallow aquifer, and deeper (interbedded) aquifer respectively. Vertical gradient was calculated by dividing the groundwater head difference between nested wells by the vertical elevation difference from screen interval midpoints. Positive gradients indicate upward flow, and negative gradients indicate downward flow. The head difference between MW-4 and MW-11 for April 25, 1996 was a -3.72 feet over a 34.4 foot vertical distance giving a gradient of -0.108 ft/ft. Based upon differing water levels in this well nest, a strong downward gradient appears to exist between the shallow aquifer and the underlying interbedded water bearing unit. It is interesting to note that the groundwater elevation at MW-11 (274.35 msl) is almost half a foot lower than groundwater elevations measured in shallow monitor wells near Rocky Creek. This may be a general indication that the water-supply wells adjacent to the site may have locally reversed the natural hydraulic gradient in this interbedded unit and underlying aquifers.

Groundwater within the shallow aquifer is expected to move from north to south and discharge to Rocky Creek and/or it's poorly defined tributaries which drain the floodplain area between the former MNOP landfill and the creek. The shallow aquifer may also recharge deeper aquifers by downward infiltration through underlying geologic units.

2.3 WATER USE

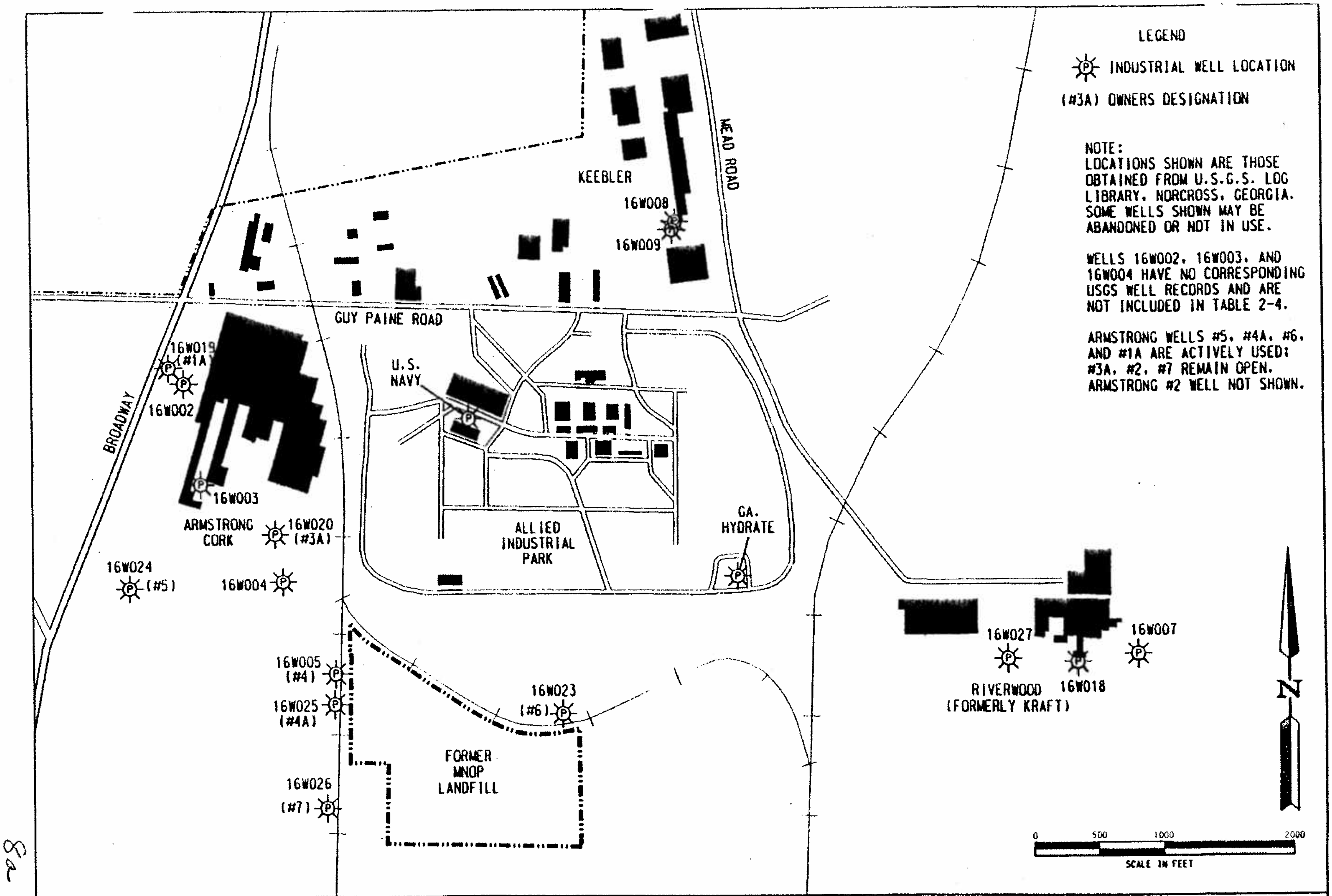
According to LeGrand (1962), all municipalities within the vicinity of the study area use water from wells except for the city of Macon, which treats water from the Ocmulgee River. The Macon-Bibb county water system indicates that all water is collected at one intake on the Ocmulgee River near the intersection of interstates I-75 and I-16. Industrial groundwater use is more frequent south of Macon. Local irrigation using well-water is practiced, but the overall use is small.

Three water-supply wells currently exist on the AIP property and a number of other supply wells operate to the east, west and north (Figure 2-6). Table 2-3 summarizes available well construction details for well records on file at the USGS Log Library. One of the wells at the AIP site, a 287-foot deep water well installed during Navy ownership, provided non-potable water for use in plant operations. According to site personnel, the pumping apparatus is still in place, but is nonfunctional. It is unclear when the well was last used. No well construction details on this well were available from the USGS. Another non-potable water-supply well (16W023 on Figure 2-6) is located on the southern portion of the AIP property, between the southern perimeter road and the Central of Georgia railroad spur. This 243 foot well is owned by Armstrong Cork and is currently active. A third water-supply well was drilled on the AIP property at the same time as the initial 1994 Rust investigation. The well is owned by the Georgia Hydrate Corporation, which recently acquired property from the Macon-Bibb County Industrial Authority. The well is located in the southeastern corner of the AIP property, near the railroad spur used during past site operations. The well was drilled to 290 feet by Green's Water Well Company of Gray, Georgia. It is understood from discussions with Georgia Hydrate Corporation personnel that the well is now active and it is used for both process and potable water-supply (Ashley Vickers, personal communication, February 1996).

Nine water-supply wells exist on the Armstrong Cork Property, located west of the AIP (Figure 2-6). Also, as described above, one Armstrong Cork well is located on the AIP property. According to Armstrong Cork personnel, the plant operates four primary wells which are designated as Well No. 1, 4, 5, and 6. Well No. 2 has not been used for years but remains open, well No. 3 has not been used for approximately 3 years, and well No. 7 is used occasionally (Bill Hahan, personal communication). Armstrong Cork indicates that average groundwater use is a combined 1.1 million gallons per day (mgd) with a maximum of 1.3 mgd from active water-supply wells. All groundwater supplies are used as make-up water for the process. Potable water for the Armstrong Cork plant is obtained from the Macon-Bibb county water system. According to USGS well records, Armstrong Cork's supply-wells are screened across multiple intervals from approximately 100 feet bls to approximately 250 feet bls.

The Keebler Company, located north of the AIP property, currently has one active supply well. According to site personnel this well is used for lawn irrigation, and process make-up water (Geraldine Jones, personal communication). Keebler personnel were unable to provide any records on groundwater withdrawals from the supply-well. USGS well records indicate this well is screened across multiple intervals from 150 feet bls to 290 feet bls.

The Riverwood International Corporation (formerly Kraft) operates 3 wells east of the AIP property. Riverwood personnel indicated that these three wells are used for process make-up waters and that



LEGEND

INDUSTRIAL WELL LOCATION

(#3A) OWNERS DESIGNATION

NOTE:
LOCATIONS SHOWN ARE THOSE OBTAINED FROM U.S.G.S. LOG LIBRARY, NORCROSS, GEORGIA. SOME WELLS SHOWN MAY BE ABANDONED OR NOT IN USE.

WELLS 16W002, 16W003, AND 16W004 HAVE NO CORRESPONDING USGS WELL RECORDS AND ARE NOT INCLUDED IN TABLE 2-4.

ARMSTRONG WELLS #5, #4A, #6, AND #1A ARE ACTIVELY USED; #3A, #2, #7 REMAIN OPEN. ARMSTRONG #2 WELL NOT SHOWN.

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RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 2-6
INDUSTRIAL WELL LOCATION MAP
FORMER MNOP LANDFILL
MACON, GEORGIA

Table 2-3
Summary of Well Constuction Details Obtained From USGS Records
Wells Located Near MNOP and AIP Sites
Rust Project No. 33941.000

USGS ID	Well ID	Company	Date Comp.	GS Elev.[1]	Total Depth	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Yield	Spec Capacity	Use	Status
16W024	Armstrong #5	Armstrong Cork	11/23/64	320	243	100 to 105	133 to 153	168 to 173	228 to 243	N/A	465	4.1	Industrial Supply	Active
16W025	Armstrong #4A	Armstrong Cork	11/24/69	290	240	120 to 155	225 to 240	N/A	N/A	N/A	524	7.2	Industrial Supply	Active
16W026	Armstrong #7	Armstrong Cork	3/18/68	270	210	80 to 120	128 to 133	195 to 210	N/A	N/A	305	6.3	Industrial Supply	Active
16W020	Armstrong #3A	Armstrong Cork	5/20/64	320	256	128 to 148	155 to 160	186 to 191	230 to 235	251 to 256	360	2.8	Industrial Supply	Active
16W023	Armstrong #6	Armstrong Cork	10/5/66	303	260	140 to 160	240 to 260	N/A	N/A	N/A	510	7.1	Industrial Supply	Active
16W019	Armstrong #1A	Armstrong Cork	4/15/64	340	238	120 to 145	223 to 238	N/A	N/A	N/A	448	4.9	Industrial Supply	Active
16W005	Armstrong #4	Armstrong Cork	1/19/60	290	285	130 to 140	165 to 180	235 to 245	260 to 265	N/A	632	N/G	Industrial Supply	Abandoned
16W009	16W009	Keebler	10/9/89	N/G	300	150 to 165	175 to 195	250 to 265	280 to 290	N/A	270	11.25	Industrial Supply	Active
16W008	Keebler #1	Keebler	9/1/53	370	N/G	N/G	N/G	N/G	N/G	N/G	N/G	N/G	Industrial Supply	Abandoned (?)
16W018	Kraft #1	Riverwood	3/27/46	310	244	60 to 70	160 to 170	212 to 217	N/A	N/A	411	8.93	Industrial Supply	Active
16W007	Kraft #2	Riverwood	9/30/68	354	183	100 to 120	135 to 160	178 to 183	N/A	N/A	285	8.63	Industrial Supply	Active
16W027	Kraft #3	Riverwood	9/10/79	315	290	150 to 190	200 to 210	270 to 280	N/A	N/A	250	2.84	Industrial Supply	Active

1: Groundsurface elevations are approximate
N/G: Not Given
N/A: Not Applicable
All screen depths given below land surface.
Specific Capacity in gallons per minute per foot drawdown
Yield in gallons per minute

all potable water is obtained from Macon-Bibb water authority. Riverwood has indicated that approximately the same amount of water is withdrawn from these wells as under previous ownership by Kraft (Marion Bard, personal communication). USGS records indicate that during the previous ownership by Kraft two wells were operated and produced a combined flow of 0.537 mgd during the period of August 1976 and January 1978. The Riverwood International wells are screened similar to other industrial wells in the area.

Public water supply wells are indicated to be within 0.5 to 1.0 miles from the site (HSI, 1995), however the locations of these wells was not specified. Access to the Department of Natural Resources (DNR) Drinking Water Program databases indicates at least one public water system potentially within 0.5 miles from the site. The presence and geographic location of the public water systems has not yet been verified in the field, as suggested by the Drinking Water Program when using the public access databases.

2.4 SURFACE WATER FEATURES AND HYDROLOGY

The former MNOP Landfill site lies within the drainage basin of the Ocmulgee River. The Ocmulgee is located approximately 2.6 miles east of the site, flowing through eastern Bibb County. The floodplain of the Ocmulgee is generally about 2 miles wide. All streams flowing into the Ocmulgee have a predominantly southeast course. Almost all small tributaries flow southward to join the larger creeks at an acute angle (LeGrand, 1962).

Within the vicinity of the site, the dominant drainage feature is Rocky Creek, which defines the southern boundary of the former MNOP Landfill site. This stream exhibits a well developed floodplain and enters Tobesofkee Creek about 1 mile southeast of the site. Tobesofkee Creek in turn forms a confluence with the Ocmulgee River 5 miles farther to the southeast.

Surface water run-off, at the former MNOP Landfill site, generally follows the land topography which slopes gently southward across the site. There are two primary tributaries which drain southward; one enters into a surface water pond northwest of the landfill and the other continues onto the floodplain of Rocky Creek. South of the landfill and pond areas, the soil is saturated. This floodplain area does not have any defined surface water or tributary drainage areas. During periods of heavy rainfall and flooding, the floodplain areas are often submerged.

3.0 POTENTIAL SOURCE AREAS

3.1 FORMER MNOP LANDFILL

The landfill is considered to be the primary probable source of subsurface contamination on the site. The exact boundaries and construction of the landfill are not known, but it is estimated to be 12 to 15 acres in size and unlined. The approximate landfill location is shown on Figure 3-1. Based on interviews and previous studies, the waste disposed of in the landfill was limited to solid waste, used parts, and construction debris. However, no documentation of disposal activities has been identified and it is uncertain what waste streams generated by the MNOP or later property owners may have been disposed of at the site (ESE, 1990; Rust, 1994).

Based on the information available, the scope of potential contaminants from this area is unknown.

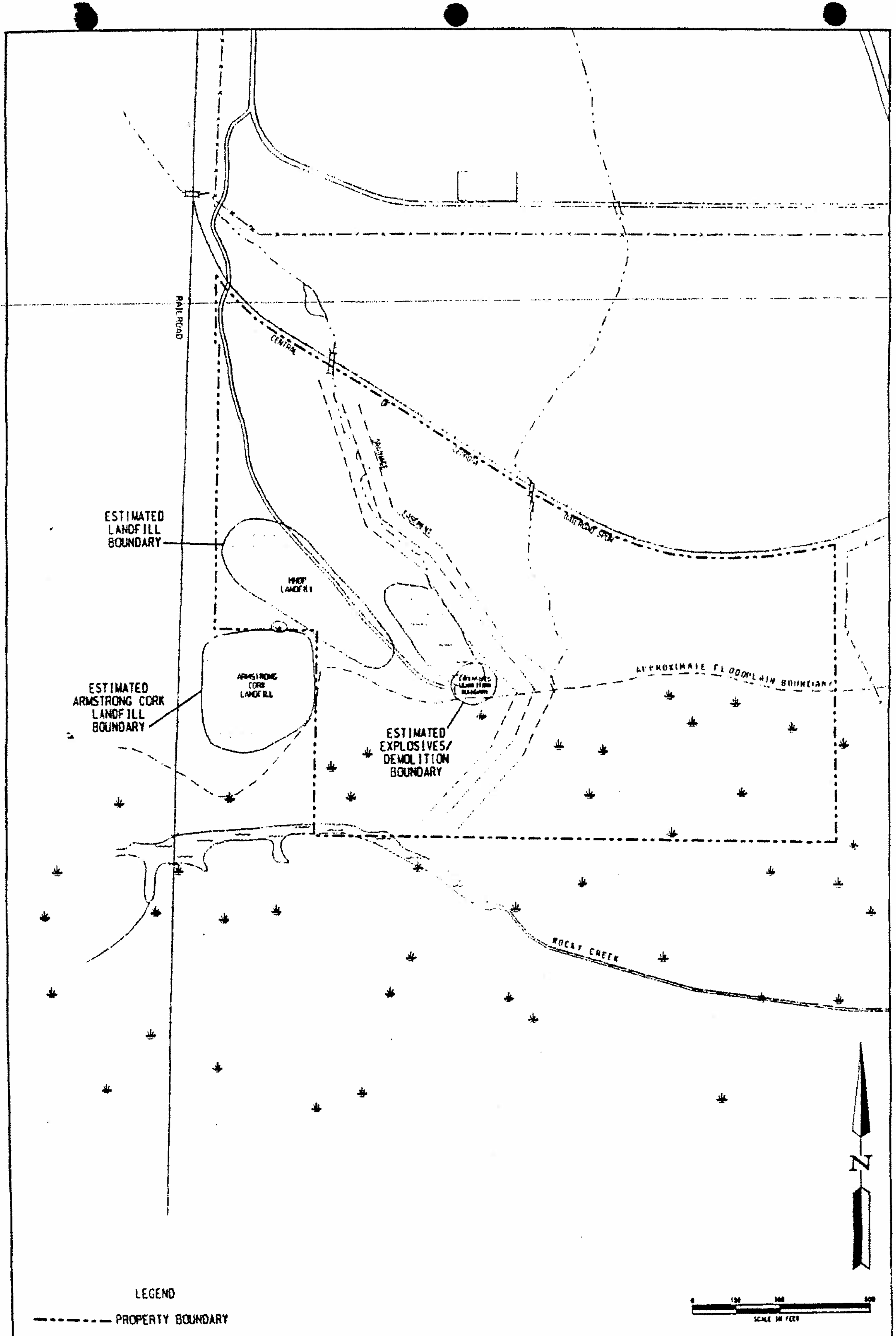
3.2 EXPLOSIVE DEMOLITION AREA

The explosive demolition area is located at the southeastern side of the landfill. This area was used for the testing and demolition of explosives manufactured at the MNOP, primarily detonators, flares and primers. Also, a pit used to burn flammable wastes was located in this area (ESE, 1990). The explosive demolition area is shown on Figure 3-1. Currently, the northern portion of the area is submerged by ponded water. The pond was not discussed nor indicated on maps in the 1990 ESE report. However, the report does describe the area as marshy. Based on this information it appears that the pond is recent in origin. Evidence of beaver activity near the pond was observed and may account for its existence.

Based on available information the explosive demolition area could be the source of explosive residues and chemical by-products of the flammable liquids burned there.

3.3 OFF-SITE SOURCES

An inactive landfill exists immediately west of the MNOP Landfill on property owned by the Armstrong Cork (Figure 3-1). During the period from approximately 1948 to 1970, wastes generated at the facility were disposed of in the remote landfill site according to the site investigation report prepared by ERM Southeast, Inc. (ERM) in 1994. Historically, the processes conducted at Armstrong included the pulping of wood and newsprint, mixing of the pulp with additives including perlite, mineral wool, clay, and starch. The wastes disposed of in the landfill include wood fiber, paper, scrap metal, construction debris, and filler materials used in the manufacture of ceiling tiles. According to Environmental Science and Engineering (ESE) the remote landfill area also contained



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RUST ENVIRONMENT & INFRASTRUCTURE
ATLANTA , GEORGIA

FIGURE 3-1
SOURCE AREA MAP
FORMER MNOP LANDFILL
MACON, GEORGIA

a drum storage area (ESE, 1990). The ESE report also indicated that fill material appears to extend up to the western edge of the former MNOP landfill property boundary.

The Armstrong landfill property has been listed on the HSI based on lead levels detected in groundwater and is classified as a Class II HSRA site. Soil samples collected as part of the initial study of the Armstrong landfill by ERM detected trace amounts of VOCs in the subsoils including trichlorofluoromethane, methylene chloride, 1,2-dichloroethane, 1,2 dichloropropane, ethyl benzene, and toluene. Analysis also detected bis(2-ethylhexyl) phthalate and metals in the subsoils. ERM reported total petroleum hydrocarbons in the soils ranging from 7 mg/Kg to 4,100 mg/Kg. Results of sampling seven on-site monitoring wells indicated no presence of priority pollutant VOCs, BNAs, pesticides, or PCBs in the collected groundwater samples. Detectable concentrations of beryllium (0.001 to 0.003 mg/L), cadmium (0.0006 to 0.0015 mg/L), chromium (0.01 to 0.100 mg/L), copper (0.01 to 0.11 mg/L), mercury (0.0002 to 0.0007 mg/L), nickel (0.02 to 0.07 mg/L), lead (0.004 to 0.15 mg/L), and zinc (0.02 to 0.4 mg/L) were, however, reported in groundwater samples (ERM, 1994).

The regulatory status of the Armstrong HSI landfill site is not known at this time, however, the site has recently been secured with a chain-link fence to limit access. Due to the close proximity of the Armstrong landfill to the former MNOP Landfill site it is considered a potential source of the groundwater contamination on the former MNOP Landfill site.

4.0 SOIL CONTAMINATION

4.1 GENERAL APPROACH USED

Sampling and analysis of subsurface soils was used to determine whether the MNOP Landfill has impacted the site subsoils. The majority of boring locations were placed around the outer limits of the landfill boundary, or in marshy areas downgradient from the landfill (Figure 4-1). These borings were believed to be the best locations to assess potential soils contamination from the landfill. Two borings also serve as property boundary sampling points (LSL-12 and LSL-13) which were placed specifically to evaluate the Armstrong off-site landfill source. Routine soil sampling was also conducted at each of the installed monitor wells to evaluate soils in the floodplain areas. Borings were drilled and sampled using standard hollow-stem auger techniques where access permitted. Borings located in marshy and dense wooded areas were hand-augered.

Quality control (QC) samples, consisting of replicates and trip blanks, were collected. In addition, replicate quality assurance (QA) samples were sent to the USACE, South Atlantic Division (SAD) Laboratory.

4.2 ANALYTICAL PARAMETERS

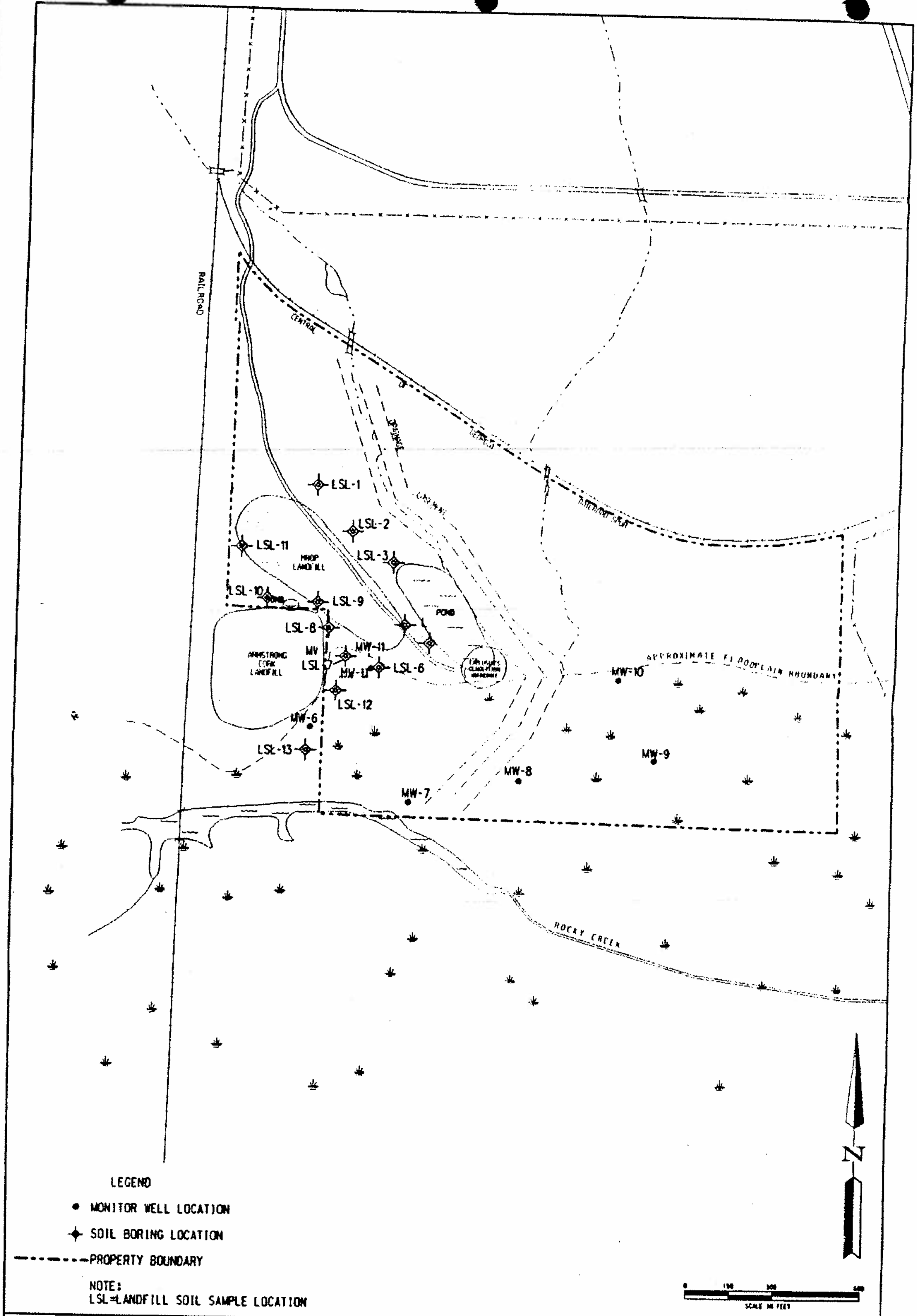
Based on the suspected contaminants and historical activities at the landfill, the analytical parameters for site soils included:

- volatile organic chemicals (VOC)
- semivolatile organic chemicals (SVOC)
- priority pollutant metals
- pesticides and polychlorinated biphenyls (PCB)
- explosive residues

Table 4-1 summarizes the sampling and analytical requirements for this work. The table includes the analytical methods used, the sample preservation and holding times, and the number of quality control and quality assurance samples to be collected.

4.3 LOCATION OF SAMPLING POINTS

Soil samples were collected from 13 soil borings and 5 monitor well installations. The locations of the soil borings were based on historical data and a visual inspection of the landfill. Two (2) soil samples were collected from each boring and one (1) sample collected from each monitor well



LEGEND

● MONITOR WELL LOCATION

✦ SOIL BORING LOCATION

-·-·-·-PROPERTY BOUNDARY

NOTE:
LSL=LANDFILL SOIL SAMPLE LOCATION

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ATLANTA , GEORGIA

FIGURE 4-1
SOIL BORING SAMPLE LOCATIONS
FORMER MNOP LANDFILL
MACON, GEORGIA

12a

Table 4-1
Soil Sampling and Analytical Requirements
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Matrix	Field Samples	QC Samples	QA Samples	Trip Blanks	Total Samples	Analysis	Protocol	Analytical Procedures	Holding Time	Preservation Requirements	Sample (1) Containers	Total Containers
Soil from soil borings (landfill and property line)	26	3	3	0	32	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C	1-125 mL glass septa vial	32
	26	3	3	0	32	SVOC/PAH BNA	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	1-8 oz glass	32
	26	3	3	0	32	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days, 28 days for mercury	Ice to 4 degrees C	1-8 oz glass	32
	26	3	3	0	32	Pesticides/ PCBs	SW-846	EPA 8080	7/40 days	Ice to 4 degrees C	1-8 oz glass	32
Soil from monitor well installation	5	1	1	0	7	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C	1-125 mL glass septa vial	7
	5	1	1	0	7	SVOC/PAH BNA	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	1-8 oz glass	7
	5	1	1	0	7	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days, 28 days for mercury	Ice to 4 degrees C	1-8 oz glass	7
	5	1	1	0	7	Pesticides/ PCBs	SW-846	EPA 8080	7/40 days	Ice to 4 degrees C	1-8 oz glass	7

(1) Per EM-200-1-3, Table I-1, 31 March 95

boring. The soil boring locations are designated LSL-1 through LSL-13 and shown on Figure 4-1. Soil samples collected from borings were designated as "LSL" followed by the boring number and the depth interval sampled. Soils collected from monitoring well locations MW-6 through MW-10 (Figure 4-1) were designated as "MW" followed by the well number and the depth interval sampled. Replicate samples were designated with the parent name followed by an "A". Replicates were collected from borings LSL-2, LSL-3, LSL-9 and MW-6.

4.4 SAMPLING AND ANALYSIS PROCEDURES

4.4.1 Sampling Equipment

Samples were collected from standard split spoon samplers in those borings drilled with hollow-stem augers. Several other borings were completed using hand augers. In these borings, the samples were collected directly from the hand auger.

4.4.2 Collection Techniques

Two soil samples for laboratory chemical analyses were collected from each of the "LSL" borings. One sample was taken between 0-2 feet bls and one at the depths of probable contamination as determined by headspace monitoring of the collected soils using an PID/OVM.

Eleven of the 13 "LSL" borings and the boring for MW-6 were completed using 3.25-inch inside diameter (ID), hollow stem augers (HSA). Continuous split-spoons were collected as in accordance with American Society for Testing and Materials (ASTM) D1586-67. ASTM methods designate that the split-spoon be driven 18 inches into the soil, however, in order to achieve the soil sample volumes required for this project the split spoons were driven a maximum of 24 inches. Each soil sample was collected in accordance with the following procedures:

- The 3.25-inch ID hollow-stem augers were advanced to the desired depth. A 140-pound automatic hammer free falling 30 inches was used to drive the split spoon approximately 24 inches.

- The split-spoon was removed from borehole, opened, and the recovered soil sample described in the test boring log using the Unified Soil Classification System (USCS).

- A portion of the soil was immediately packed into a clean, glass sample container with a teflon-lined cap and set aside for possible chemical analysis. This sample, to be analyzed for VOC 8260 parameters, was placed in the sample container in a manner to minimize headspace.

- The remaining soil sample from the split-spoon sampler was containerized in a plastic bag and sealed. The sealed bag was allowed to sit for a minimum of five minutes at which time the headspace was screened with a PID/OVM. At each borehole location, the soil sample with the highest headspace readings and a near surface sample was sent for chemical analysis.

- The soil samples chosen for laboratory chemical analyses consisted of the bagged sample showing the highest headspace reading and the corresponding bottled VOC sample. Soil from the bagged sample was removed from the sealed bag, placed in a clean stainless-steel or glass bowl, and mixed using the sampling spoon. The sample was then carefully placed in appropriate sample containers using the stainless-steel spoon or a spatula.

- Upon completion of sample collection, the sample container was labeled, the sample identification entered in field log book, and the Chain-of-Custody record completed.

- The sample was placed in a cooler at 4°C and prepared for shipping.

Two of the soil borings sites (LSL-12 and LSL-13) adjacent to the western property boundary and borings for monitor wells MW-7 through MW-10 were inaccessible using a truck mounted rig. At these locations, soil samples were collected by hand augering down to the designated depth or until refusal.

Each hand auger sample was collected in accordance with the following procedures:

- The hand auger was advanced to the full depth of the auger head.

- The hand auger was removed from the borehole and the soil from the auger head emptied onto a clean sheet of aluminum foil. The recovered soil sample was described using the Unified Soil Classification System (USCS).

- The remaining sampling procedures are the same as those listed previously for the split spoon samples.

4.4.3 Field Screening Techniques

Once the soil sample descriptions were recorded, and the VOC sample bottle was filled, the remaining soil from the sampler was placed in a plastic bag and sealed. After waiting at least 5 minutes, a Thermo Environmental Instruments, Inc. Model 580B Organic Vapor Meter (OVM) was used to measure the headspace reading.

4.4.4 Sample Handling

Sample bottles were cleaned prior to delivery to the field by the laboratory. Once collected, the samples were placed in a cooler to maintain a temperature of approximately 4°C. Coolers were prepared for shipping when full or at the end of each day. Sample volumes and holding times are presented in Table 4-1.

4.4.5 Decontamination Procedures

Equipment decontamination was performed within a decontamination pad, designed to contain cleaning fluids. The drill rig was decontaminated upon mobilization to the site and prior to leaving the site. The sample collection equipment and downhole tools were steam cleaned with high pressure steam within the decontamination area. Persistent dirt and other foreign materials were removed with a scrub brush. The sample collection equipment and downhole tools were decontaminated upon mobilization to the site and between each borehole.

Sampling and monitoring equipment, including spoons, bowls, and the split spoon sampler were decontaminated according to EPA Region IV SOP and Quality Assurance (QA) manual (see Section 8.4 of EPA, 1991) prior to each sampling location.

4.4.6 Chain of Custody Procedures

Information regarding the sample analyses was recorded on the Chain of Custody (COC) form. This information included:

- sample identification
- sampling time and date
- location of sampling point
- sampling personnel
- analytical parameters

The orig OC form was packed ith the samples and copies maintained in the project files. Sample s v was accomplished b placing custody seals on individual sample containers and across th f the cooler after secu ly taping the cooler. The sample coolers were shipped via overnight ss carrier to the labor ory. A copy of the shipping bill has been retained by Rust to become of the sample custody ocumentation.

4.4.7 La tory Analytical Tech ques

Soil sampl e shipped to HydroLo c Laboratories Inc., in Brighton, Colorado for analyses of organic an anic analytes. The a ytical methods used are described in EPA's *Test Methods for Evalua lid Waste* (SW-846) hird edition. Specific methods and analytes used for this project are in Table 4-1.

Data qualit ectives were set for the analytical methods by specifying control limits for QC samples inte to the laboratory. Q ality control (QC) samples included laboratory control samples, lab ory duplicates, and method blanks. Control limits used to evaluate the QC sample results inclu percent recovery and percent difference and are functions of the analytical method and sample ix.

HydroLogic formed regular inspection, maintenance, cleaning, calibration, and servicing of all laborator quipment according to the manufacturers' recommendations. Calibration and maintenance s are kept for each piece of laboratory and field instrumentation, detailing any malfunction the steps taken to correct the problem.

4.5 BACK ROUND SOIL SAMPLING

No specific bac ground soil sampling was performed as part of this study. However, background soil samples col cted from the AIP serve as background soils to the MNOP landfill site. A total of four background oil samples were taken from two borings located along the northern border of the AIP property. T e results of background soil sampling are provided in Table 4-2.

4.6 DATA SUMMARY

4.6.1 Field Data

Soils were screened in the field with an OVM to evaluate the presence of volatile organic compounds (VOC). The results of screening, which are presented on boring logs contained in Appendix A, generally indicated that soils in the area of the MNOP landfill exhibited moderate to

Table 4-2
Former MNOP Landfill
Background Samples Collected at Allied Industrial Park
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	ISL-18 (1'-2')	ISL-18 (55'-56')	ISL-19 (1'-2')	ISL-19 (70'-71')
Inorganics					
antimony	mg/kg	< 2.6	< 2.5	< 2.6	< 2.5
beryllium	mg/kg	.29 J	.028 J	.34 J	.024 J
cadmium	mg/kg	< .22	< .21	.28 J	< .21
chromium	mg/kg	18.3	5.68	24.3	1.56
copper	mg/kg	6.2	1.37	8.67	< .82
lead	mg/kg	9.4	2.44	10.3	4.89
mercury	mg/kg	.13	< .028	.14	< .028
nickel	mg/kg	5.23	4.1	7.12	< .062
selenium	mg/kg	< .086	< .082	< .086	.678
silver	mg/kg	< .23	< .22	< .23	< .22
thallium	mg/kg	< .092	< .088	< .093	< .088
zinc	mg/kg	15.2	3.04	20.7	1.2 J
Volatile Organics					
cis-1,2-dichloroethene	mg/kg	< .0021	< .002	< .0021	< .002
ethylbenzene	mg/kg	< .00088 J	< .00083	< .00088	< .00083
hexachlorobutadiene	mg/kg	< .0013	< .0012	< .0013	< .0012
m+p-xylene	mg/kg	< .0027 J	< .0026	< .0027	< .0026
naphthalene	mg/kg	< .0012	< .0012	< .0012	< .0012
o-xylene	mg/kg	< .0017	< .0016	< .0017	< .0016
tetrachloroethene	mg/kg	< .00057	< .00054	< .00057	< .00054
toluene	mg/kg	< .00099	< .00094	< .00099	< .00094
trans-1,2-dichloroethene	mg/kg	< .00064	< .0006	< .00064	< .00061
trichloroethene	mg/kg	< .00049	< .00047	< .00049	< .00047
Semivolatile Organics					
benzo(b)fluoranthene	mg/kg	< .096	< .091	< .096	< .091
bis(2-ethylhexyl)phthalate	mg/kg	< 1	< .97	< 1	< .97
di-n-butyl phthalate	mg/kg	< .18	< .17	< .18	< .17
fluoranthene	mg/kg	< .18	< .17	< .18	< .17
phenanthrene	mg/kg	< .11	< .1	< .11	< .1
pyrene	mg/kg	< .15	< .14	< .15	< .14
Explosive Residues					
2,4-dinitrotoluene	mg/kg	< .024	R	< .024	< .024
nitrobenzene	mg/kg	< .057	R	< .057	< .057
Pesticides/PCBs					
4,4'-DDD	mg/kg	NA	NA	NA	NA
4,4'-DDE	mg/kg	NA	NA	NA	NA
4,4'-DDT	mg/kg	NA	NA	NA	NA
endrin	mg/kg	NA	NA	NA	NA

mg/kg = milligrams per kilogram
NA = not analyzed
J = indicates an estimated value
R = indicates data rejected during validation as unsuable

high VOC readings. However, some of these elevated headspace readings are believed to have been due to the presence of organic debris and humus found throughout the surficial deposits of the floodplain area. Therefore, no correlation has been attempted between elevated OVM headspace readings and presence of VOC soils contamination.

4.6.2 Laboratory Results

A summary of soil analytical results is presented in Table 4-3. Analytical data quality evaluations were performed on all data by both the analytical laboratory and Rust. A summary of the data quality review is included as part of the Quality Control Summary Report (QCSR) in Appendix B. The results of analyses indicate that elevated levels of heavy metals (compared to background values, Table 4-2) are present throughout the site subsoils; primarily for antimony, cadmium, chromium, copper, lead, and zinc. Antimony was detected at it's highest levels in LSL-8 at concentrations of 18.7 milligrams per kilogram (mg/Kg) (0-2 feet) and 10.9 mg/Kg (4-5 feet). Antimony was not detected in background soil samples. Cadmium was detected in samples ranging from less than 0.5 mg/Kg up to 370 mg/Kg. The highest concentrations of cadmium were observed in samples collected from borings LSL-7, LSL-8, and LSL-9, which are located adjacent to the MNOP Landfill (Figure 4-2). Cadmium was detected in only one background soil sample at a concentration of 0.28 mg/Kg.

Chromium, copper, and lead were detected in every soil sample collected at the landfill area. Chromium concentrations ranged from 4.33 mg/Kg to 224 mg/Kg (LSL-8, 4-5 feet). Four other detected concentrations were greater than 100 mg/Kg. Chromium was detected in the background samples at concentrations up to 24.3 mg/Kg. Copper concentrations ranged from 1.71 mg/Kg to 1730 mg/Kg at LSL-6 (0-2 feet). Background samples detected copper at values up to 8.67 mg/Kg. Lead concentrations in the landfill soil samples ranged from 3.18 mg/Kg to 1020 mg/Kg at LSL-3-A (0-2 feet). Lead had a maximum background concentration of 10.3 mg/Kg. Zinc was not detected in three landfill soil samples, but was detected in the other samples at concentrations up to 1730 mg/Kg at LSL-8 (4-5 feet). Zinc was detected in the background samples at a maximum concentration of 20.7 mg/Kg.

Volatile organic compounds were detected generally at trace or low level concentrations in only a few of the samples collected. The deep sample at LSL-2 (6-8 feet) exhibited the presence of a number of compounds including isomers of trimethylbenzene (1,2,4 and 1,3,5), isopropylbenzene, n-butylbenzene, n-propylbenzene, naphthalene, sec-butylbenzene, tert-butylbenzene, para-cymene, and o-xylene. The deep sample at LSL-5 (8 to 10 feet) also exhibited the presence of trimethylbenzene and n-butylbenzene, ethyl benzene, m-xylene/p-xylene and napthalene. These two samples account for most of the volatile organic compound detections. The soil sample from MW-9

Table 4-3
Former Macon Naval Ordnance Landfill
Soil Analytical Data
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSL-1 (0'-2')	LSL-1 (6'-8')	LSL-2 (0'-2')	LSL-2 (6'-8')	LSL-2-A (0'-2')	LSL-3 (0'-2')	LSL-3 (6'-8')
Inorganics								
antimony	mg/kg	< 2.5	< 2.5	< 2.6	< 2.5	< 2.6	< 2.5	< 2.6
beryllium	mg/kg	.15 J	.018 J	.13 J	.048 J	.14 J	.12 J	.15 J
cadmium	mg/kg	2.42	< .2	6.59	.29 J	10.5	9.23	2.23
chromium	mg/kg	26.6	4.33	17.1	10.6	75.5	15.5	9.32
copper	mg/kg	15.1	1.71	76.1	4.19	138	95.9	28.9
lead	mg/kg	17.7	3.18	471	46.9	442	178	117
mercury	mg/kg	< .028	< .027	< .029	< .028	< .029	< .028	< .029
nickel	mg/kg	4.43	1.2 J	6.26	3.17	18.1	7.57	3.38
selenium	mg/kg	.579	< .081	1.19	.29 J	1.27	.32 J	.39 J
silver	mg/kg	< .22	< .21	< .23	< .22	1.1 J	< .21	< .22
thallium	mg/kg	< .09	< .087	< .092	< .09	< .091	< .087	< .091
zinc	mg/kg	24.7	< 4.1 J	296	< 16.4	556	162	60.1
Volatile Organics								
1,2,4-trimethylbenzene	mg/kg	< .00063	< .00061	< .00065	.74	< .00064	< .00061	< .00064
1,3,5-trimethylbenzene	mg/kg	< .00062	< .0006	< .00064	.13	< .00063	< .00061	< .00063
cis-1,2-dichloroethene	mg/kg	< .002	< .0019	< .002	< .002	< .002	< .0019	< .002
ethylbenzene	mg/kg	< .00085	< .00082	< .00087	< .00085	< .00087	< .00083	< .00086
isopropylbenzene	mg/kg	< .00061	< .00059	< .00063	012	< .00062	< .0006	< .00062
m+p-xylene	mg/kg	< .0026	< .0025	< .0027	< .0026	< .0027	< .0026	< .0027
n-butylbenzene	mg/kg	< .00068	< .00065	< .00069	036	< .00069	< .00066	< .00068
n-propylbenzene	mg/kg	< .0007	< .00068	< .00072	.066	< .00072	< .00069	< .00071
naphthalene	mg/kg	< .0012	< .0011	< .0012	.0036 J	< .0012	< .0012	< .0012
o-xylene	mg/kg	< .0016	< .0016	< .0017	.0026 J	< .0016	< .0016	< .0016
paracymene	mg/kg	< .00072	< .0007	< .00074	.072	< .00073	< .0007	< .00073
sec-butylbenzene	mg/kg	< .00071	< .00069	< .00073	.03	< .00072	< .00069	< .00072
tert-butylbenzene	mg/kg	< .00066	< .00064	< .00068	.051	< .00067	< .00065	< .00067
toluene	mg/kg	< .00096	< .00093	< .00098	< .00096	< .00097	< .00094	< .00097
trichloroethene	mg/kg	< .00048	< .00046	< .00049	< .00048	< .00048	< .00047	< .00048
Semivolatile Organics								
2-methyl naphthalene	mg/kg	< .089	< .086	< .091	< .088	< .09	< .086	< .09
acenaphthene	mg/kg	< .16	< .15	< .16	< .16	< .16	< .16	< .16
acenaphthylene	mg/kg	< .12	< .12	< .13	< .12	< .13	< .12	< .13
anthracene	mg/kg	< .11	< .11	< .12	< .11	< .11	< .11	< .11
benzo(a)anthracene	mg/kg	< .12	< .11	< .12	< .12	< .12	< .12	< .12
benzo(a)pyrene	mg/kg	< .15	< .14	< .15	< .15	< .15	.83	.21
benzo(b)fluoranthene	mg/kg	< .093	< .09	< .095	< .093	< .095	.79	.24
benzo(g,h,i)perylene	mg/kg	< .14	< .13	< .14	< .14	< .14	.97	.18 J
benzo(k)fluoranthene	mg/kg	< .16	< .15	< .16	< .16	< .16	.24	< .16
bis(2-ethylhexyl)phthalate	mg/kg	< .99	< .95	< 1	< .99	< 1	< .96	< 1
chrysene	mg/kg	< .18	< .18	< .19	< .18	< .18	.56	< .18
di-n-butyl phthalate	mg/kg	< .17	.16 J	< .17	.18 J	< .17	< .17	< .17
dibenz(a,h)anthracene	mg/kg	< .15	< .14	< .15	< .15	< .15	< .14	< .15
dibenzofuran	mg/kg	< .14	< .13	< .14	< .14	< .14	< .13	< .14
fluoranthene	mg/kg	< .17	< .16	< .17	< .17	< .17	.48	.24
fluorene	mg/kg	< .14	< .13	< .14	< .14	< .14	< .13	< .14
indeno(1,2,3-cd)pyrene	mg/kg	< .14	< .13	< .14	< .14	< .14	.52	.14 J
naphthalene	mg/kg	< .094	< .091	< .097	< .094	< .096	< .092	< .095
phenanthrene	mg/kg	< .1	< .1	< .11	< .1	< .1	.25	.11 J
pyrene	mg/kg	< .15	< .14	< .15	< .15	< .15	.51	.23
Pesticides/PCBs								
4,4'-DDD	mg/kg	< .0029	< .0028	< .03	< .0029	< .012	< .014	.0172
4,4'-DDE	mg/kg	.0331	< .00061	.062	< .00063	.0323	.0428 J	.0209
4,4'-DDT	mg/kg	.012	< .0011	.233	< .0012	.106	.0631 J	.00847
aroclor 1248	mg/kg	< .0041	< .004	< .0042	< .0041	< .004	9.23 J	.408
aroclor 1260	mg/kg	< .0041	< .004	.089	< .0041	.092	< .4	.107
methoxychlor	mg/kg	< .0019	< .0018	< .019	< .0019	< .0076	< .0091	< .0019

mg/kg = milligrams per kilogram
R = indicates data rejected during validation as unusable
J = indicates an estimated value

17 0

Table 4-3 (continued)
Former Macon Naval Ordnance Landfill
Soil Analytical Data
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSL-3-A (0'-2')	LSL-4 (0'-2')	LSL-4 (4'-6')	LSL-5 (0'-2')	LSL-5 (8'-10')	LSL-6 (0'-2')	LSL-6 (6'-8')
Inorganics								
antimony	mg/kg	< 2.5	< 2.6	< 2.6	< 2.5	< 2.7	3.6 J	< 2.6
beryllium	mg/kg	.085 J	.22 J	.039 J	.041 J	.093 J	.45 J	.13 J
cadmium	mg/kg	6.52	1.79	.41 J	1.32	.681	81.3	23
chromium	mg/kg	11.2	8.82	4.99	8.04	11.4	101	26.1
copper	mg/kg	66.7	88.3	3.88	4.99	8.75	1730	151
lead	mg/kg	1020	25.2	4.2	6.12	13.8	282	122
mercury	mg/kg	< .028	< .029	< .028	< .028	< .031	.125	< .029
nickel	mg/kg	5.4	4.1	1.5 J	< 1.4 J	2.56	63.8	35.4
selenium	mg/kg	.38 J	< .087	< .084	< .083	< .09	.941	.822
silver	mg/kg	< .22	< .23	< .22	< .22	< .24	2.38	.29 J
thallium	mg/kg	< .088	< .093	< .09	< .089	< .096	< .097	< .091
zinc	mg/kg	131	47.2	< 6.58	10.1	14.2	1270	147
Volatile Organics								
1,2,4-trimethylbenzene	mg/kg	< .00062	< .00065	< .00063	< .00063	.048 J	< .00068	< .00064
1,3,5-trimethylbenzene	mg/kg	< .00061	< .00065	< .00063	< .00062	.028	< .00067	< .00064
cis-1,2-dichloroethene	mg/kg	< .002	< .0021	< .002	< .002	< .011	< .0022	< .002
ethylbenzene	mg/kg	< .00083	< .00088	< .00085	< .00085	.0095	< .00092	< .00087
isopropylbenzene	mg/kg	< .0006	< .00064	< .00061	< .00061	< .0033	< .00066	< .00063
m+p-xylene	mg/kg	< .0026	< .0027	< .0026	< .0026	.029	< .0028	< .0027
n-butylbenzene	mg/kg	< .00066	< .0007	< .00068	< .00067	.048	< .00073	< .00069
n-propylbenzene	mg/kg	< .00069	< .00073	< .0007	< .0007	< .0038	< .00076	< .00072
naphthalene	mg/kg	< .0012	< .0012	< .0012	.062	55	< .0013	< .0012
o-xylene	mg/kg	< .0016	< .0017	< .0016	< .0016	< .0087	< .0017	< .0016
paracymene	mg/kg	< .0007	< .00075	< .00072	< .00072	< .0039	< .00078	< .00073
sec-butylbenzene	mg/kg	< .00069	< .00074	< .00071	< .00071	< .0038	< .00076	< .00072
tert-butylbenzene	mg/kg	< .00065	< .00069	< .00066	< .00066	< .0036	< .00072	< .00068
toluene	mg/kg	< .00094	< .001	< .00096	< .00096	< .0052	< .001	< .00098
trichloroethene	mg/kg	< .00047	< .0005	< .00048	< .00048	< .0026	< .00051	< .00049
Semivolatile Organics								
2-methyl naphthalene	mg/kg	< .087	< .092	< .089	< .088	6.3	< .095	< .09
acenaphthene	mg/kg	< .16	< .17	< .16	< .16	9.8	< .17	< .16
acenaphthylene	mg/kg	< .12	< .13	< .13	< .12	.28	< .13	< .13
anthracene	mg/kg	< .11	< .12	< .11	< .11	5	< .12	< .11
benzo(a)anthracene	mg/kg	< .12	< .12	< .12	< .12	3.1	< .13	< .12
benzo(a)pyrene	mg/kg	.67	< .15	< .15	< .15	1.1	< .16	< .15
benzo(b)fluoranthene	mg/kg	.71 J	< .097	< .093	< .093	2.6	< .1	< .095
benzo(g,h,i)perylene	mg/kg	.81	< .14	< .14	< .14	< .15	< .15	< .14
benzo(k)fluoranthene	mg/kg	.17	< .17	< .16	< .16	1.1	< .17	< .16
bis(2-ethylhexyl)phthalate	mg/kg	< .97	< 1	< .99	< .99	< 1.1	< 1.1	< 1
chrysene	mg/kg	.53	< .19	< .18	< .18	4.3	< .2	< .19
di-n-butyl phthalate	mg/kg	.19 J	< .18	< .17	.17 J	.29 J	.18 J	.21 J
dibenz(a,h)anthracene	mg/kg	< .14	< .15	< .15	< .15	< .16	< .16	< .15
dibenzofuran	mg/kg	< .13	< .14	< .14	< .14	5.9	< .15	< .14
fluoranthene	mg/kg	.51	< .18	< .17	< .17	17	< .18	< .17
fluorene	mg/kg	< .13	< .14	< .14	< .14	8.1	< .15	< .14
indeno(1,2,3-cd)pyrene	mg/kg	.36	< .14	< .14	< .14	< .15	< .15	< .14
naphthalene	mg/kg	< .092	< .098	< .094	.11 J	10	< .1	< .096
phenanthrene	mg/kg	.33	< .11	< .1	.36	32	< .11	< .11
pyrene	mg/kg	.49	< .15	< .15	< .15	13	< .16	< .15
Pesticides/PCBs								
4,4'-DDD	mg/kg	< .014	< .0031	< .0029	< .0029	< .0032	< .0063	.0091
4,4'-DDE	mg/kg	.0377	< .00065	< .00063	.00388	< .00067	.0102	.0054 J
4,4'-DDT	mg/kg	.0844	.0057	< .0012	.0051	< .0013	.0342	.0139
aroclor 1248	mg/kg	5.86	< .0043	< .0041	.129	< .0044	.53	.44
aroclor 1260	mg/kg	< .2	< .0043	< .0041 J	< .0041	< .0044	.56	.41
methoxychlor	mg/kg	< .0092	< .0019	< .0019	< .0019	< .002	< .004	< .0038

mg/kg = milligrams per kilogram

R = indicates data rejected during validation as unusable

J = indicates an estimated value

Table 4-3 (continued)
Former Macon Naval Ordnance Landfill
Soil Analytical Data
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSL-7 (0'-2')	LSL-7 (6'-8')	LSL-8 (0'-2')	LSL-8 (4'-5')	LSL-9 (0'-2')	LSL-9 (6'-8')	LSL-9-A (0'-2')
Inorganics								
antimony	mg/kg	5.1 J	8.3 J	18.7	10.9	< 2.5	< 2.8	< 2.5
beryllium	mg/kg	.38 J	.929	.69	.77	.23 J	.49 J	.24 J
cadmium	mg/kg	100	1.52	119	370	180	223	170
chromium	mg/kg	111	35.4	108	224	86.7	102	128
copper	mg/kg	931	46.8	504	1610	219	204	713
lead	mg/kg	707	119	579	628	124	991	139
mercury	mg/kg	.052 J	.041 J	.101 J	.351	< .028	< .031	.118
nickel	mg/kg	42.6	6.4	52.4	193	15.8	22.5	20
selenium	mg/kg	.42 J	< .1	.52 J	.76	.585	.49 J	.36 J
silver	mg/kg	1.77	< .28	1.39	1.95	.34 J	.43 J	.47 J
thallium	mg/kg	< .095	< .11	< .097	< .1	< .089	< .099	< .089
zinc	mg/kg	1000	91.5	1210	1730	304	229	392
Volatile Organics								
1,2,4-trimethylbenzene	mg/kg	< .00067	.0046 J	< .00068	< .00072	< .00062	< .0007	< .00062
1,3,5-trimethylbenzene	mg/kg	< .00066	< .00078	< .00068	< .00071	< .00062	< .00069	< .00062
cis-1,2-dichloroethene	mg/kg	< .0021	< .0025	< .0022	< .0023	< .002	< .0022	< .002
ethylbenzene	mg/kg	< .0009	< .0011	< .00092	< .00097	< .00084	< .00094	< .00084
isopropylbenzene	mg/kg	< .00065	< .00077	< .00066	< .0007	< .00061	< .00068	< .00061
m-p-xylene	mg/kg	< .0028	< .0033	< .0028	< .003	< .0026	< .0029	< .0026
n-butylbenzene	mg/kg	< .00071	< .00085	< .00073	< .00077	< .00067	< .00075	< .00067
n-propylbenzene	mg/kg	< .00074	< .00088	< .00076	< .0008	< .0007	< .00078	< .0007
naphthalene	mg/kg	< .0012	< .0015	< .0013	.0035 J	< .0012	< .0013	< .0012
o-xylene	mg/kg	< .0017	< .002	< .0017	< .0018	< .0016	< .0018	< .0016
paracymene	mg/kg	< .00076	< .00091	< .00078	< .00082	< .00071	< .0008	< .00071
sec-butylbenzene	mg/kg	< .00075	< .00089	< .00077	< .00081	< .0007	< .00078	< .0007
tert-butylbenzene	mg/kg	< .0007	< .00083	< .00072	< .00075	< .00066	< .00073	< .00066
toluene	mg/kg	< .001	< .0012	< .001	< .0011	< .00095	.0044	< .00095
trichloroethene	mg/kg	< .0005	< .0006	< .00052	< .00054	< .00047	< .00053	< .00047
Semivolatile Organics								
2-methyl naphthalene	mg/kg	< .094	< .11	< .48	< .1	< .088	< .098	< .088
acenaphthene	mg/kg	< .17	< .2	< .86	< .18	< .16	< .18	< .16
acenaphthylene	mg/kg	< .13	< .16	< .68	< .14	< .12	< .14	< .12
anthracene	mg/kg	< .12	< .14	< .61	.5	< .11	< .12	< .11
benzo(a)anthracene	mg/kg	.26	< .15	< .64	< .13	< .12	< .13	< .12
benzo(a)pyrene	mg/kg	.2	.3	< .8	2.1	< .15	< .16	< .15
benzo(b)fluoranthene	mg/kg	.78	.12 J	< .5	3.9	< .092	< .1	< .092
benzo(g,h,i)perylene	mg/kg	< .14	.31	< .74	1.3	< .13	< .15	< .13
benzo(k)fluoranthene	mg/kg	.26	< .2	< .86	1.1	< .16	< .18	< .16
bis(2-ethylhexyl)phthalate	mg/kg	< 1	< 1.2	< 5.3	< 1.1	< .98	< 1.1	< .98
chrysene	mg/kg	.52	< .23	< .98	2.3	< .18	< .2	< .18
di-n-butyl phthalate	mg/kg	.23 J	.23 J	< .92	< .19	< .17	< .19	< .17
dibenz(a,h)anthracene	mg/kg	< .16	< .19	< .8	.34	< .15	< .16	< .15
dibenzofuran	mg/kg	< .14	< .17	< .74	< .15	< .13	< .15	< .13
fluoranthene	mg/kg	.58	< .21	< .92	3.1	< .17	< .19	< .17
fluorene	mg/kg	< .14	< .17	< .74	< .15	< .13	< .15	< .13
indeno(1,2,3-cd)pyrene	mg/kg	.14 J	< .17	< .74	1.3	< .13	< .15	< .13
naphthalene	mg/kg	< .1	< .12	< .51	< .11	< .093	< .1	< .093
phenanthrene	mg/kg	.32	< .13	< .56	1.9	< .1	< .11	< .1
pyrene	mg/kg	.61	.23 J	< .8	2.6	< .15	< .16	< .15
Pesticides/PCBs								
4,4'-DDD	mg/kg	< .031	< .018	.0442	.0115	< .029	.642 J	< .029
4,4'-DDE	mg/kg	.0676	.0713	.0281	.00885	.295	.118 J	.26
4,4'-DDT	mg/kg	.317	< .0073	.0355	.0253	.261	.0838 J	.236
aroclor 1248	mg/kg	< .088	7.51	.819	< .019	< .041	< .045 J	< .041
aroclor 1260	mg/kg	2.4	< .26	.576	.546	1.03	1.38 J	.902
methoxychlor	mg/kg	< .02	< .012	< .002	< .0021	< .019	< .0083 J	< .019

mg/kg = milligrams per kilogram
R = indicates data rejected during validation as unusable
J = indicates an estimated value

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Table 4-3 (continued)
Former Macon Naval Ordnance Landfill
Soil Analytical Data
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSL-10 (0'-2')	LSL-10 (8'-10')	LSL-11 (0'-2')	LSL-11 (4'-6')	LSL-12 (1'-2')	LSL-12 (3'-4')	LSL-13 (1'-2')
Inorganics								
antimony	mg/kg	3.7 J	4.5 J	3.1 J	< 2.7	< 6.3	< 3.3	< 3.2
beryllium	mg/kg	.711	.887	.22 J	.43 J	.42 J	.831	1.26
cadmium	mg/kg	29.6	.68 J	2.31	2.32	68.9	.61 J	2.88
chromium	mg/kg	52.2	13.7	23.1	28.3	53	25.9	29.3
copper	mg/kg	408	39.1	11	22	43.4	6.35	20
lead	mg/kg	65.1	28.1	12.6	17.6	62.3	20.4	27.8
mercury	mg/kg	< .036	< .047	< .029	< .03	1.34	.074 J	.098 J
nickel	mg/kg	20.9	5.08	4.62	6.44	10.2	5.59	12.2
selenium	mg/kg	.5 J	.45 J	.649	.41 J	< .21	.59 J	1.3 J
silver	mg/kg	.36 J	< .37	< .23	< .23	< .54	< .29	< .27
thallium	mg/kg	< .11	< .15	< .093	< .094	< .22	.4 J	.73
zinc	mg/kg	353	63	32.9	154	92.3	45.4	67.3
Volatile Organics								
1,2,4-trimethylbenzene	mg/kg	.0024 J	< .001	< .00065	< .00066 J	< .0016	< .00082	< .00078
1,3,5-trimethylbenzene	mg/kg	< .00079	< .001	< .00065	< .00066 J	< .0015	< .00081	< .00077
cis-1,2-dichloroethene	mg/kg	< .0025	< .0033	< .0021	< .0021 J	< .0049	< .0026	< .0025
ethylbenzene	mg/kg	< .0011	< .0014	< .00088	< .0009 J	< .0021	< .0011	< .0011
isopropylbenzene	mg/kg	< .00077	< .001	< .00064	< .00065 J	< .0015	< .0008	< .00076
m+p-xylene	mg/kg	< .0033	< .0044	< .0027	< .0028 J	< .0065	< .0034	< .0032
n-butylbenzene	mg/kg	< .00085	< .0011	< .0007	< .00071 J	< .0017	< .00088	< .00084
n-propylbenzene	mg/kg	< .00089	< .0012	< .00073	< .00074 J	< .0017	< .00092	< .00087
naphthalene	mg/kg	.13 J	.015 J	< .0012	.94 J	< .0029	< .0015	< .0015
o-xylene	mg/kg	< .002	< .0027	< .0017	< .0017 J	< .004	< .0021	< .002
paracymene	mg/kg	.023 J	.02 J	< .00075	< .00076 J	< .0018	< .00094	< .00089
sec-butylbenzene	mg/kg	< .00089	< .0012	< .00074	< .00075 J	< .0017	< .00093	< .00088
tert-butylbenzene	mg/kg	< .00084	< .0011	< .00069	< .0007 J	< .0016	< .00087	< .00082
toluene	mg/kg	< .0012	< .0016	< .001	< .001 J	< .0024	< .0013	< .0012
trichloroethene	mg/kg	< .0006	< .00079	< .0005	< .0005 J	< .0012	< .00062	< .00059
Semivolatile Organics								
2-methyl naphthalene	mg/kg	R	< 2.8	< .092	< .093	< .22	< .12	< .11
acenaphthene	mg/kg	R	< 5	< .17	< .17	< .39	< .21	< .2
acenaphthylene	mg/kg	R	< 3.9	< .13	< .13	< 31	< .16	< .15
anthracene	mg/kg	R	< 3.5	.27	< .12	< .28	< .15	< .14
benzo(a)anthracene	mg/kg	R	< 3.7	.56	.18 J	< .29	< .15	< .15
benzo(a)pyrene	mg/kg	R	< 4.7	.52	.19 J	.39 J	< .19	< .18
benzo(b)fluoranthene	mg/kg	R	< 2.9	.79	.31	< .23	< .12	< .12
benzo(g,h,i)perylene	mg/kg	4.4 J	4.5 J	.32	< .14	.61	< .18	< .17
benzo(k)fluoranthene	mg/kg	R	< 5	.31	< .17	< .39	< .21	< .2
bis(2-ethylhexyl)phthalate	mg/kg	R	< 31	< 1	12	< 2.4	< 1.3	< 1.2
chrysene	mg/kg	R	< 5.7	.59	< .19	< .45	< .24	< .22
di-n-butyl phthalate	mg/kg	R	< 5.4	.21 J	.2 J	< .42	< .22	< .21
dibenz(a,h)anthracene	mg/kg	R	< 4.7	< .15	< .16	< .36	< .19	< .18
dibenzofuran	mg/kg	R	< 4.3	< .14	< .14	< .34	< .18	< .17
fluoranthene	mg/kg	R	< 5.4	1.3	.36	< .42	< .22	< .21
fluorene	mg/kg	R	< 4.3	< .14	< .14	< .34	< .18	< .17
indeno(1,2,3-cd)pyrene	mg/kg	R	< 4.3	.34	< .14	< .34	< .18	< .17
naphthalene	mg/kg	R	< 3	< .098	< .099	< .23	< .12	< .12
phenanthrene	mg/kg	R	< 3.3	1.1	.25	< .25	< .13	< .13
pyrene	mg/kg	R	< 4.7	.98	.36	< .36	< .19	< .18
Pesticides/PCBs								
4,4'-DDD	mg/kg	< .0037	< .0049	< .0031	< .0031	< .14	< .0038	< .0036
4,4'-DDE	mg/kg	.0111	< .001	.0413	.0112	< .031	< .00082	< .00078
4,4'-DDT	mg/kg	.0587	.0187	.017	< .0012	< .058	< .0015	< .0014
aroclor 1248	mg/kg	.91	.945	< .0043	.295	9.11	< .0054	< .0051
aroclor 1260	mg/kg	.215	< .027	< .0043	.039	< .2	< .0054	< .0051
methoxychlor	mg/kg	< .0024	< .0031	< .0019	< .002	.2 J	< .0024	< .0023

mg/kg = milligrams per kilogram

R = indicates data rejected during validation as unusable

J = indicates an estimated value

Table 4-3 (continued)
Former Macon Naval Ordnance Landfill
Soil Analytical Data
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSL-13 (3'-4')	MW-6 (2'-4')	MW-6A (2'-4')	MW-7 (0'-2')	MW-8 (0'-2')	MW-9 (6'-8')	MW-10 (0'-2')
Inorganics								
antimony	mg/kg	< 2.9	R	R	R	11.1 J	R	R
beryllium	mg/kg	1.27	.15 J	.26 J	.18 J	.071 J	< .02	.33 J
cadmium	mg/kg	.663	29.8	64.2	2.16	31	< .23	14.8
chromium	mg/kg	26.7	23.2	41.4	16.3	39.1	4.67	19.5
copper	mg/kg	10.2	24.6	98.1	7.16	56	1.34	25
lead	mg/kg	18.6	36.7 J	91.3 J	15.9 J	61.8 J	5.43 J	123 J
mercury	mg/kg	.077 J	.249	.045 J	< .035	1.37	.047 J	.081 J
nickel	mg/kg	9.08	9.69	6.59	3.24	4.02	1.3 J	6.09
selenium	mg/kg	.809	< .15	< .13	< .1	1.12	< .45	< .17
silver	mg/kg	< .25	< .39	< .33	< .27	.69 J	< .24	< .45
thallium	mg/kg	.45 J	< .16	.45 J	< .11	< .12	< .098	< .18
zinc	mg/kg	60.6	58.9	71.2	23.2	86.4	4.5	162
Volatile Organics								
1,2,4-trimethylbenzene	mg/kg	< .00071	< .0011	< .00095	< .00077	< .00088	< .00069	< .0013
1,3,5-trimethylbenzene	mg/kg	< .00071	< .0011	< .00094	< .00076	< .00087	< .00068	< .0013
cis-1,2-dichloroethene	mg/kg	< .0023	< .0035	< .003	< .0024	< .0028	.0053 J	< .0041
ethylbenzene	mg/kg	< .00096	< .0015	< .0013	< .001	< .0012	< .00093	< .0017
isopropylbenzene	mg/kg	< .00069	< .0011	< .00093	< .00075	< .00085	< .00067	< .0013
m+p-xylene	mg/kg	< .003	NA	NA	NA	NA	NA	NA
n-butylbenzene	mg/kg	< .00076	< .0012	< .001	< .00082	< .00094	< .00073	< .0014
n-propylbenzene	mg/kg	< .0008	< .0012	< .0011	< .00086	< .00098	< .00077	< .0014
naphthalene	mg/kg	< .0013	< .0021	< .0018	< .0014	< .0016	< .0013	< .0024
o-xylene	mg/kg	< .0018	< .0029	< .0024	< .002	< .0022	< .0018	< .0033
paracymene	mg/kg	< .00082	< .0013	< .0011	< .00088	< .001	< .00078	< .0015
sec-butylbenzene	mg/kg	< .0008	< .0013	< .0011	< .00087	< .00099	< .00077	< .0015
tert-butylbenzene	mg/kg	< .00075	< .0012	< .001	< .00081	< .00092	< .00072	< .0014
toluene	mg/kg	< .0011	< .0017	< .0014	< .0012	< .0013	< .001	< .002
trichloroethene	mg/kg	< .00054	< .00084	< .00072	< .00058	< .00066	.004 J	< .00098
Semivolatile Organics								
2-methyl naphthalene	mg/kg	< .1	< .16	< .13	< .11	< .62	< .096	< .18
acenaphthene	mg/kg	< .18	< .28	< .24	< .19	< 1.1	< .17	< .33
acenaphthylene	mg/kg	< .14	< .22	< .19	< .15	< .87	< .14	< .26
anthracene	mg/kg	< .13	< .2	< .17	< .14	< .78	< .12	< .23
benzo(a)anthracene	mg/kg	< .13	< .21	< .18	< .14	< .82	< .13	< .24
benzo(a)pyrene	mg/kg	< .17	3	< .22	< .18	10	< .16	.86
benzo(b)fluoranthene	mg/kg	< .11	< .16	< .14	< .11	1.5	< .1	< .19
benzo(g,h,i)perylene	mg/kg	< .15	6.2	< .21	< .17	25	< .15	1.6
benzo(k)fluoranthene	mg/kg	< .18	< .28	< .24	< .19	1.6	< .17	< .33
bis(2-ethylhexyl)phthalate	mg/kg	< 1.1	< 1.7	< 1.5	< 1.2	< 6.9	< 1.1	< 2
chrysene	mg/kg	< .21	2.4	< .27	< .22	5.7	< .2	< .37
di-n-butyl phthalate	mg/kg	< .19	< .3	< .26	< .21	< 1.2	< .19	.47 J
dibenz(a,h)anthracene	mg/kg	< .17	< .26	< .22	< .18	< 1	< .16	< .3
dibenzofuran	mg/kg	< .15	< .24	< .21	< .17	< .95	< .15	< .28
fluoranthene	mg/kg	< .19	< .3	< .26	< .21	< 1.2	< .19	< .35
fluorene	mg/kg	< .15	< .24	< .21	< .17	< .95	< .15	< .28
indeno(1,2,3-cd)pyrene	mg/kg	< .15	< .24	< .21	< .17	2.8	< .15	< .28
naphthalene	mg/kg	< .11	< .17	< .14	< .11	< .66	< .1	< .19
phenanthrene	mg/kg	< .12	< .18	< .16	< .13	< .72	< .11	< .21
pyrene	mg/kg	< .17	< .26	< .22	< .18	2.1	< .16	< .3
Pesticides/PCBs								
4,4'-DDD	mg/kg	< .0033	< .01	< .0044	< .0036	< .41 J	< .0032	< .006
4,4'-DDE	mg/kg	< .00071	< .0022	< .00095	< .00076	< .087 J	< .00068	< .0013
4,4'-DDT	mg/kg	< .0013	< .0041	< .0018	< .0014	< .16 J	< .0013	< .0024
aroclor 1248	mg/kg	< .0047	4.3	.23	< .005	23.4 J	< .0045	1.61
aroclor 1260	mg/kg	< .0047	< .015	< .0062	< .005	< .57 J	< .0045	< .0084
methoxychlor	mg/kg	< .0021	< .0066	< .0028	< .0023	< .26 J	< .002	< .0038

mg/kg = milligrams per kilogram
R = indicates data rejected during validation as unusable
J = indicates an estimated value

(6-8 feet) showed estimated concentrations of cis-1,2-dichloroethene (0.0053J mg/Kg) and trichloroethene (0.004 J mg/Kg). Naphthalene was the most frequently detected VOC, with detections in 7 samples.

SVOCs were detected at several sample locations (LSL-1, LSL-3, LSL-5, LSL-6, LSL-7, LSL-8, LSL-10, LSL-11, LSL-12, MW-6, MW-8, and MW-10). At locations LSL-3, LSL-7, and LSL-11, semi-volatile parameters were detected in samples collected at all depths. Of the SVOCs detected the most significant is the presence of benzo(a)pyrene in a number of samples at concentrations ranging from less than 0.5 mg/Kg to up to 10 mg/Kg. The highest concentration of benzo(a)pyrene was detected in the shallow soil sample collected from MW-8 (0-2 feet).

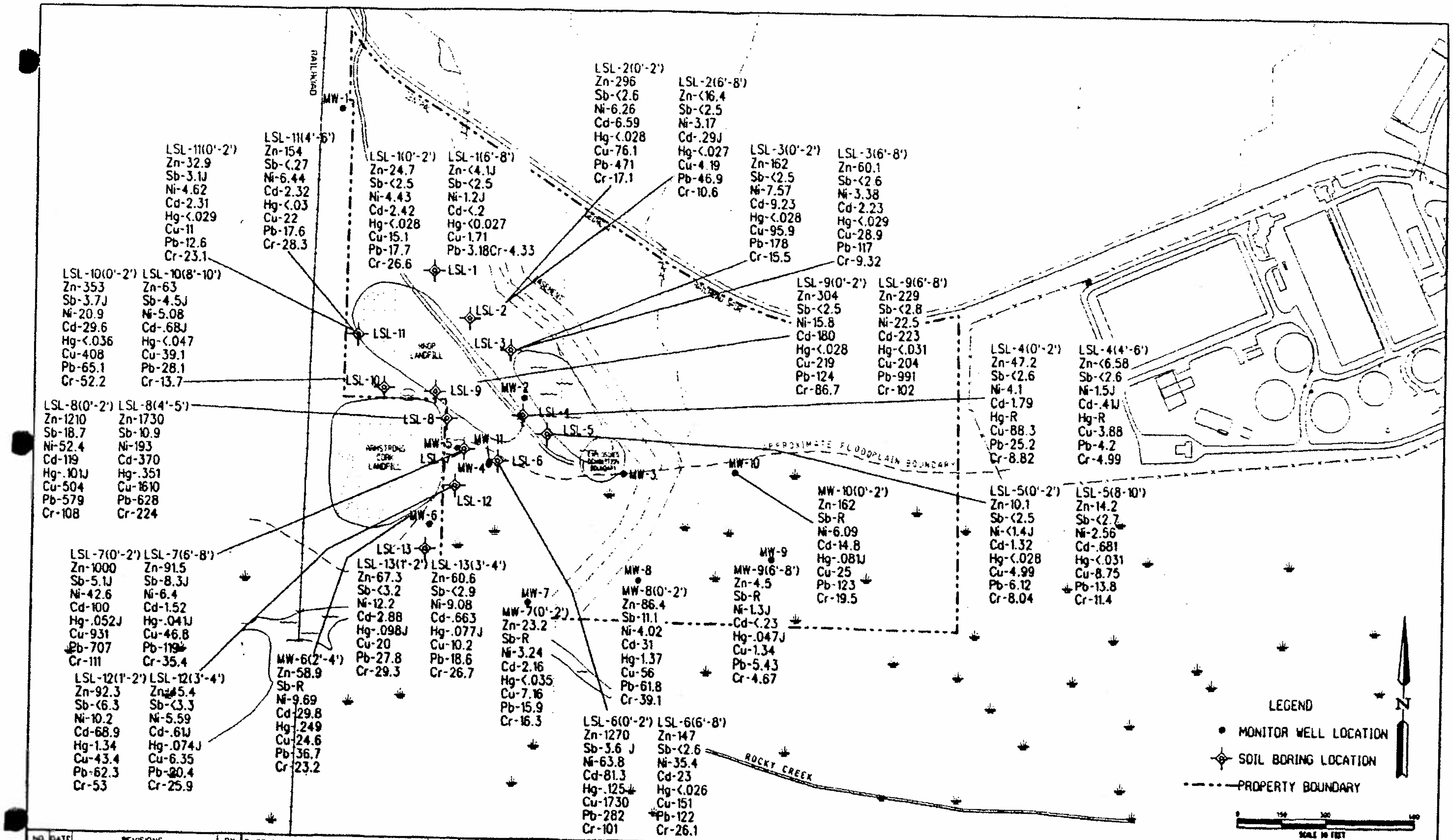
Both pesticides and PCBs were detected in soil samples collected at the landfill area. Pesticide compounds were detected at all but seven soil boring locations; LSL-12, LSL-13, MW-6, MW-7, MW-8, MW-9, and MW-10. Concentrations of pesticides in the collected soils were found to be below applicable regulatory criteria and are not discussed further. The PCB compounds detected were Aroclor 1248 and 1260. Aroclor 1248 was the primary PCB which was detected at 10 boring locations (Figure 4-3). The highest levels of Aroclor were observed in shallow soil samples collected from MW-8 (23.4 J mg/Kg), LSL-12 (9.11 mg/Kg), and LSL-3 (9.23 J mg/Kg).

4.6.3 Extent of Contamination

The results of soil sampling indicate that elevated levels of metals, SVOCs, and PCBs are present in subsurface soils at the former MNOP Landfill site. Distribution of metals and PCBs are illustrated in Figures 4-2 and 4-3 and are further discussed below. In addition, trace amounts of VOCs are present in isolated soil samples. Based upon the distribution and relative concentration of each analyte the following can be said concerning extent of soils contamination:

- Cadmium is present in both surface soils (0-2 feet) and to a lesser extent deeper soils throughout the site at levels that exceed background concentrations and relevant regulatory criteria (see Section 10.0). The highest cadmium levels are at locations LSL-7, LSL-8 and LSL-9 near the MNOP landfill with lower concentrations at more remote locations to the east and south (Figure 4-2). The aerial extent of elevated levels of cadmium has not yet been defined for surface soils, nor has it been defined vertically at some locations near the landfill mass.

- Chromium and copper are present in both surface soils and to a lesser extent deeper soils at locations LSL-6, LSL-7, LSL-8, and LSL-9 at concentrations that exceed background and regulatory criteria (Figure 4-2).



NO.	DATE	REVISIONS	BY

RUST PROJECT 33941.000 DATE
DESIGNED BY L.WILLIAMS 6/96
DRAWN BY M.PEARCE 6/96
CHECKED BY
FILE NO. 33941082

RUST ENVIRONMENT & INFRASTRUCTURE

NOTES:
1 - ALL VALUES IN mg/kg
2 - J - ESTIMATED VALUE
3 - R - DATA REJECTED DURING VALIDATION

FIGURE 4-2
ANALYTICAL RESULTS FOR METALS IN SOIL
FORMER MNOP LANDFILL
MACON, GEORGIA

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- Lead is present in both surface soils and to a lesser extent deeper soils at concentrations which exceed background and regulatory criteria for borings LSL-2, LSL-3, LSL-6, LSL-7, LSL-8, and LSL-9 located near the landfill mass.

- Aroclor 1248 is present in both surface soils and deeper soils collected throughout the site (Figure 4-3). This constituent is present in soils near the landfill and in soils south and east of the landfill. The aerial extent of Aroclor has not yet been determined, however it's concentration appears to be greatest in surface soils. Aroclor 1260 was detected less frequently (Figure 4-3).

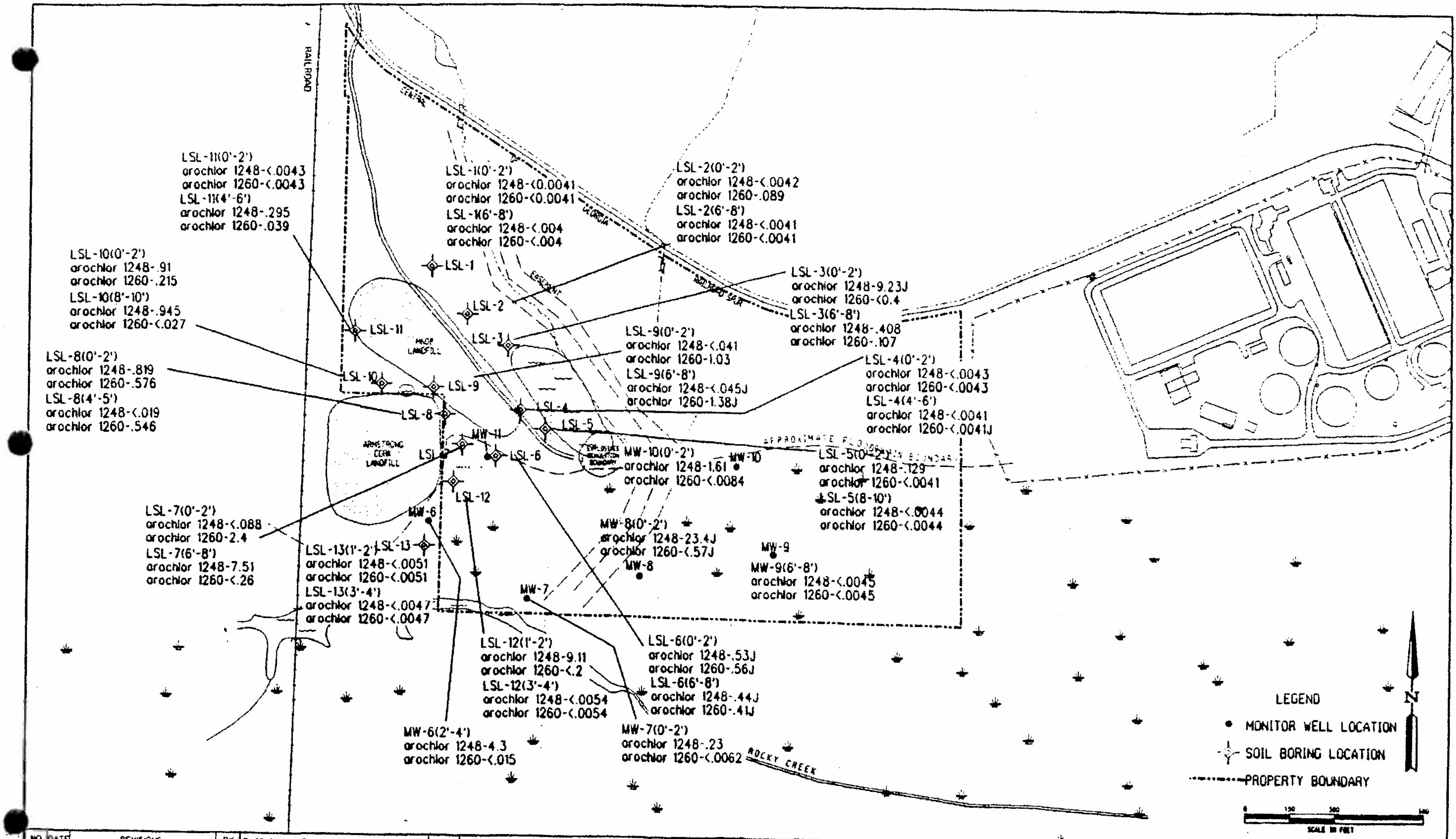
- The highest concentrations of copper, chromium, cadmium, and lead were found in samples collected in a small area just east of the Armstrong Cork Landfill and just south of the MNOP Landfill. It is likely that both of these landfills are now or have been contributing to the contamination in this area.

In summary, it appears that contamination, primarily by heavy metals and PCBs, has occurred in the site soils. The data generated during this investigation provides basic information to sufficiently characterize the area but does not fully delineate the extent of constituents with elevated levels. It is also noted that approximately half of the soil samples were collected from the vadose zone and half from saturated soils. No significant difference in the elevated concentrations between vadose zone and saturated zone soils can be distinguished. The source of metals and PCBs appears to be from the landfill mass via subsurface infiltration or possibly from run-off and sediment deposition. Because a portion of the site is located within the Rocky Creek floodplain off-site sources are possible from surface run-off and sedimentation.

4.6.4 Fate and Transport

4.6.4.1 PCBs

PCBs are mixtures of different congeners of chlorobiphenyl. Once released to soils, PCBs are strongly sorbed and will generally not leach significantly in aqueous soil systems (Micromedex, 1996). This is mostly due to the fact that PCBs have relatively low octanol-water partition coefficients and low solubilities and are hence strongly adsorbed by mineral and organic materials in soils. The literature reviewed indicates that PCBs with high chlorine content such as Aroclor 1248, 1254, and 1260, are resistant to biodegradation and PCBs with low chlorine content (Aroclor 1221 and 1232) biodegrade very rapidly (Micromedex, 1996). Chapelle, 1993, indicates that emerging research suggests that some of the highly chlorinated PCBs may be resistant to aerobic



NO	DATE	REVISIONS	BY

		DATE
RUST PROJECT	33841.000	
DESIGNED BY	L.WILLIAMS	6/96
DRAWN BY	M.PEARCE	6/96
CHECKED BY		
FILE NO.	33841083	

RUST ENVIRONMENT & INFRASTRUCTURE

NOTES:
1 - ALL VALUES IN mg/kg
2 - J - ESTIMATED VALUE

FIGURE 4-3
ANALYTICAL RESULTS FOR PCB's (AROCHLOR) IN SOIL
FORMER MNOP LANDFILL
MACON, GEORGIA

oxidation (degradation) but could be subject to reductive dehalogenation in anaerobic environments. Conversely, lightly chlorinated PCBs are resistant to reductive dehalogenation but can be aerobically oxidized (Chapelle, 1993). This PCB research generally demonstrates that microbial processes have the potential to completely degrade these compounds under the proper conditions, however, such cases are not yet documented.

Based upon the presence of abundant organic materials within the floodplain area and clayey soils throughout the site, PCBs are expected to be tightly sorbed and are probably immobile in the subsoils. Degradation of PCBs, as indicated in the literature, is not likely an important removal process, however, no data is available to determine if such processes are at work here. Erosion and deposition of surface soils appears to be the most likely mechanism for transport of PCBs across the site and possibly into the surface waters of Rocky Creek.

4.6.4.2 Metals

The following provides a discussion on the fate and transport of antimony, cadmium, chromium, copper, lead, nickel, and zinc. These constituents were the primary inorganics detected in soils at elevated levels, and are of greatest interest to this investigation. The discussion is intended to provide only general fate and transport information available from the literature. Limited soils and metals speciation data precludes making any specific conclusions concerning fate and transport of metals.

The retention of metals in soil depends on a number of physical, chemical, and in some cases biological factors. Soil properties such as texture, bulk density, pH, organic matter, type and amount of clay minerals, and the presence of mineral oxides, especially iron oxides, influence the retention and release of metals by soil. The partitioning between aqueous and solid phase are controlled by a number of processes including adsorption, precipitation, co-precipitation, and complexation. Partitioning may be influenced by the aqueous pH, redox potential, ionic strength of the water, the concentration of complexing ions, the type of anions present, and the metal concentration and type.

Physical deposition by fluvial and wind processes are the most common mechanism for transport and distribution of metals and are probably the most important transport processes at the MNOP landfill site. Metals can be released to the atmosphere in the form of particulate matter, dispersed by wind, and deposited by gravitational settling. Regional metals deposition has been widely studied and is characterized by large temporal and spatial variability. For example, cadmium deposition in urban areas is about one order of magnitude higher than in rural areas of the United States (ATSDR, 1993a). Metals released to waterways are generally associated with particulate matter and are transported and deposited in areas of active sedimentation.

Little is known about the adsorptive behavior of antimony, its compounds, and ions (ATSDR, 1992a). Some studies suggest that antimony is mobile under a variety of environmental conditions, while other references cited that it is strongly sorbed to soil. ATSDR (1992a) suggests that antimony is not expected to have an affinity for organic carbon and the cation exchange capacity of clay soils may not be an important factor to adsorption of this element. Antimony does not appear to bio-concentrate in fish and aquatic organisms (ATSDR, 1992a).

Cadmium exists in natural waters as the hydrated ion Cd(+2) 6H2O and can be complexed with humic substances (ATSDR, 1993a). In the literature, cadmium is cited to be more mobile in aquatic environments than other heavy metals such as lead (ATSDR, 1993a). Precipitation and sorption of cadmium compounds onto soils are the most important removal precesses cited in the literature. It is also cited that cadmium may redissolve from sediments under varying ambient conditions of pH, salinity, and redox potential (ATSDR, 1993a). Cadmium bio-accumulates in all levels of the food chain.

Chromium is present in soils primarily as an insoluble oxide Cr2O3(nH2O) and is not considered very mobile in soil (EPA, 1984a). A much smaller percentage of total chromium in soil exists as soluble hexavalent chromium (Cr^{+6}) and the less soluble trivalent chromium (Cr^{+3}). As with other metals, the sorption of chromium to soil depends on a number of factors including the clay content and to a lesser extent the presence of iron oxides and organic matter (ATSDR, 1993b).

Copper is cited in the literature to bind to soil much more strongly than other divalent cations (ATSDR, 1990). The literature reviewed suggested that copper will adsorb to organic matter, carbonate minerals. clay minerals, or hydrous iron and manganese oxides (ATSDR, 1990). Copper has a low potential for bio-accumulation.

The amount of lead in soil is affected by the adsorptive properties of various soil types, precipitation of soluble solid forms of the lead, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter (ATSDR, 1993c). Under most conditions lead is strongly sorbed to soil (especially organic matter) and very little is transported to surface water or groundwater (EPA, 1986a; NSF 1977). Leaching of lead from soil to groundwater is very slow under most natural conditions except for highly acidic environments (ATSDR, 1993c).

Nickel is also described in the literature to be strongly adsorbed by soil, although to a lesser degree than lead and copper discussed above. Nickel is strongly adsorbed to oxides and hydrous oxides of iron, manganese, and aluminum (ATSDR, 1995). Nickel is expected to be primarily present as sorbed to soils.

Zinc occurs in the environment primarily in the +2 oxidation state (ATSDR, 1992b). Zinc in aerobic waters is expected to be partitioned into sediments through sorption onto hydrous iron and manganese oxides, clay minerals, and organic material. The degree of sorption varies according to cation exchange capacity, pH, salinity, redox potential, and concentration of complexing ligands and zinc. (ATSDR, 1992b). In anaerobic environments zinc sulfide is the controlling species (EPA 1980d; Kalbasi et al. 1978) and, since sulfide is insoluble, the mobility of zinc in anaerobic environments is low.

In summary, the metals (antimony, cadmium, chromium, copper, lead, nickel, and zinc) reviewed will most likely have an affinity to sorb onto organic rich soils and/or clayey soils under most natural conditions. These metals are not expected to significantly leach from soils and partition into groundwater to any large degree. Further, it is likely that the dominant transport mechanism for metals may be from erosion and sedimentation processes.

5.0 GROUNDWATER CONTAMINATION

5.1 GENERAL APPROACH

Groundwater quality at the site was evaluated by collecting groundwater samples from HydroPunch™ /drive point wells and permanently installed monitoring wells. The primary purpose of the groundwater sampling was to determine the horizontal and vertical extent of contamination in the shallow water-table aquifer.

In the first phase of the investigation, groundwater screening samples were collected using HydroPunch™ and drive point methods. The samples were field analyzed using a portable gas chromatograph (GC). These results were used to determine permanent monitor well locations. Finally, groundwater samples were collected from both the newly installed monitor wells and existing monitor wells in the former MNOP Landfill site.

Quality control (QC) samples, consisting of replicates and trip blanks were collected. Quality assurance (QA) samples were also sent to the USACE, South Atlantic Division (SAD) Laboratory.

5.2 ANALYTICAL PARAMETERS (Monitoring Wells)

Based on the suspected contaminants and historical activities at the landfill, the analytical parameters for the site included:

- volatile organic compounds (VOC)
- semivolatile organic compounds (SVOC)
- radium 226 and 228
- priority pollutant metals
- pesticides and polychlorinated biphenyls (PCB)

Table 5-1 summarizes the sampling and analytical requirements for this work. The table includes the analytical methods used, the sample preservation and holding times, and the number of quality control and quality assurance samples collected.

5.3 DRIVE POINT WELL/ HYDROPUNCH SCREENING

To aid in determining the outer boundaries of the groundwater contaminant plume known to exist locally near the landfill, eleven groundwater samples were collected by utilizing a combination

Table 5-1
Groundwater Sampling and Analytical Requirements
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Matrix	Field Samples	QC Samples	QA Samples	Trip Blanks	Total Samples	Analysis	Protocol	Analytical Procedures	Holding Time	Preservation Requirements	Sample (1) Containers	Total Containers
Groundwater from monitor wells	11	1	1	2	15	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C Add HCl to pH<2 or NaHSO4	2-40 mL glass septa vial	30
	11	1	1	0	13	SVOC/PAH BNA	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	2-1L amber glass	26
	11	1	1	0	13	Pesticides/ PCBs	SW-846	EPA 8080	7/40 days	Ice to 4 degrees C	2-1L amber glass	26
	11	1	1	0	13	Radium 226 & 228	SW-846	EPA 9310, 9315,9320	NA	Ice to 4 degrees C HNO3 to pH<2	1-8 oz glass	13
	11	1	1	0	13	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days 28 days for mercury	Ice to 4 degrees C HNO3 to pH<2	1-1L glass or plastic	13

(1) Per EM-200-1-3, Table I-1, 31 March 95.

of HydroPunch™ methods and the installation of drive point wells. These samples were screened in the field using a portable GC.

5.3.1 HydroPunch™

One HydroPunch™ sample was collected upgradient from the landfill (Figure 5-1). During the HydroPunch™ sampling process, a borehole was advanced by hollow-stem auger drilling to approximately 3 to 5 feet below static water level. The HydroPunch™ was lowered through the auger stem and driven approximately 5 feet further into the aquifer. The HydroPunch™ was then retracted several feet to allow water under hydrostatic pressure to enter the tool. After approximately 30 minutes, the HydroPunch™ was retrieved and the groundwater sample transferred to the appropriate laboratory container.

5.3.2 Drive Point Wells

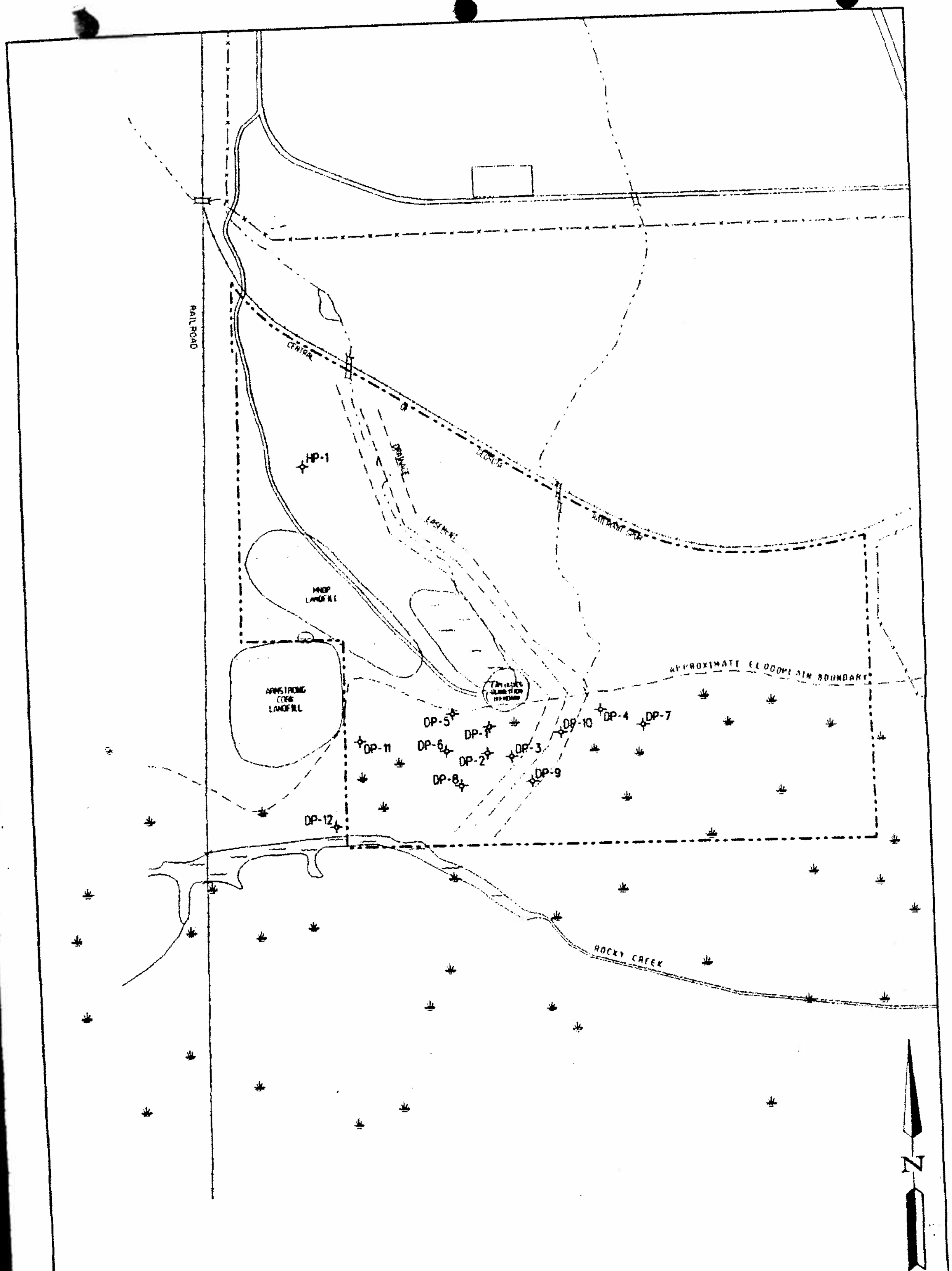
Temporary drive point wells were installed because access to sampling point locations prohibited the use of a truck mounted rig needed for HydroPunch™ sampling. Each drive point well consisted of a 5-foot long, 1.25 inch ID stainless steel mesh screen and 5-foot galvanized steel riser. Drive point locations are shown on Figure 5-1. Stainless steel risers are not standard equipment and were not considered necessary for field screening of groundwater. Each drive point was installed to a depth of approximately 10 feet by hand auger methods. At each of the drive points, one groundwater sample was collected by bailer. Two of the drive points (DP-11 and DP-12) were used for water level measurements.

After sample collection, the drive point well was either removed from the ground or cut below the ground surface and abandoned by backfilling with grout.

5.3.3 Gas Chromatography

The groundwater screening results generated from the drive point well/HydroPunch™ testing were performed using a Shimadzu 14A gas chromatograph (GC) and flame ionizing detector (FID). Concentrations were calculated using the Shimadzu Chromatopack GC integrator and calibration standards.

Analytical screening procedures were performed using a modified version of SW-846 Method 3810. Modifications include using a two point initial calibration, forty microliter (ul) headspace injection, and ambient temperature sample equilibration. Continuing calibration checks on the initial calibration were performed each day of analysis using the initial standard stock solution. Syringe



LEGEND

⌖ HYDROPUNCH/DRIVE POINT LOCATION

-·-·-·-·- PROPERTY BOUNDARY

0 100 300 600
SCALE IN FEET

	DATE
RUST PROJECT 33941.000	
DESIGNED BY C.ADAMS	7/96
DRAWN BY M.PEARCE	7/96
CHECKED BY	
FILE NAME 33941107	

RUST ENVIRONMENT & INFRASTRUCTURE
ATLANTA , GEORGIA

FIGURE 5-1
HYDROPUNCH/DRIVE POINT LOCATION MAP
FORMER MNOP LANDFILL
MACON, GEORGIA

24a

blanks were performed at the beginning of each day and after concentrated samples. Initial calibration standards were prepared at low parts per billion (ppb) levels using the following target analytes: trichloroethene, vinyl chloride, cis-1,2-dichloroethene. Standards were prepared using serial dilutions from neat standards and injected into air tight forty milliliter (ml) septa vials containing twenty ml of water via a syringe.

Due to the target organic compounds high vapor pressure, these compounds partitioned from the aqueous phase into the gaseous phase. An aliquot of the twenty ml of air (headspace) in each of the sample vials was collected using an air tight 50 ul syringe which was then injected into the GC.

5.4 MONITOR WELL INSTALLATION PROCEDURE

5.4.1 Monitor Well Installation

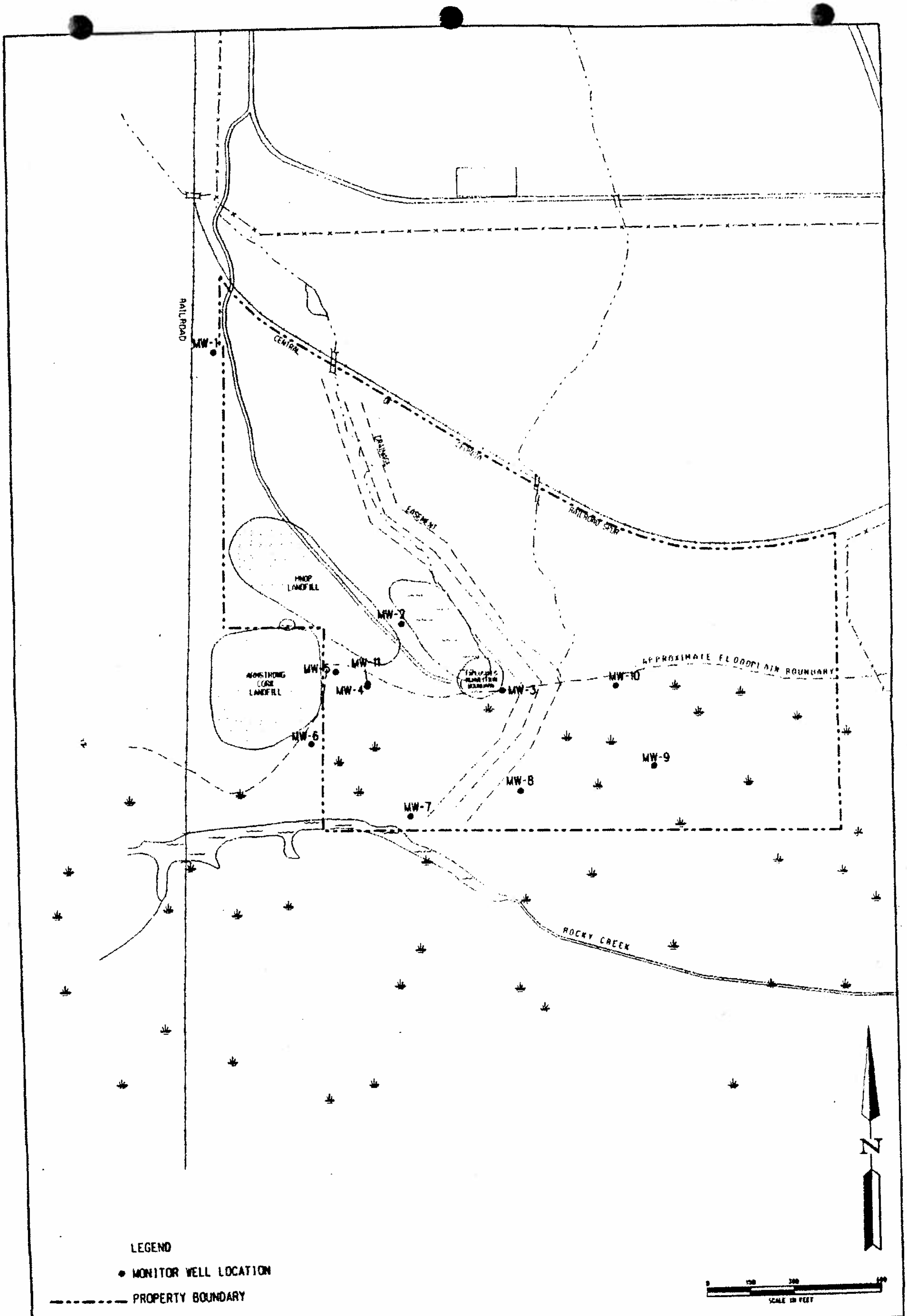
A total of six monitoring wells were installed during this investigation at locations indicated in Figure 5-2. The installation of monitor wells conformed to the applicable regulations in construction and sampling. Specifically, the following guidelines were adhered to:

- Manual for Groundwater Monitoring, Georgia Environmental Protection Division (GAEPD), 1991.
- EPA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD), EPA No., OSWER-9950.1-RCRA.
- Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites, Corps of Engineers, EM1110-1-4000.

Monitor well installation for MW-6 and MW-11 were accomplished using a truck-mounted drill rig equipped with hollow stem augers. Monitor wells MW-7 through MW-10 were installed by using a hand auger. Two-inch ID, Schedule 40 polyvinyl chloride (PVC) well screens, casings, and fittings were used in the construction of each well. Each well was completed with a steel protective cover, protective posts (where appropriate) and a square concrete pad.

5.4.2 Well Development

Each well was developed within two weeks of construction, but no sooner than 48 hours after grouting. Well development was accomplished by a combination of bailing and pumping. Development began with mechanical surging with a bailer and bailing for a minimum of two



	DATE
RUST PROJECT 33941.000	
DESIGNED BY C. ADAMS	7/96
DRAWN BY M. PEARCE	7/96
CHECKED BY	
FILE NAME 33941106	

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ATLANTA, GEORGIA

FIGURE 5-2
MONITOR WELL LOCATION MAP
FORMER MNOP LANDFILL
MACON, GEORGIA

hours. At the end of two hours, the wells were pumped using a submersible pump or a bailer. Field personnel monitored groundwater temperature, pH, specific conductivity (SC), and turbidity as indicator parameters.

A minimum of 5 times the volume of water present in the well and the filter pack (assuming 30% porosity) was removed from the well. In addition to this minimum volume, the following criteria were met before development ceased:

- The well water is clear to the unaided eye.
- The sediment thickness remaining in the well is less than 1% of the screen length.
- Temperature, pH, and specific conductivity stabilized to less than a ten percent change between two well and filter pack volumes. The pH was considered stable when a variation of +/- 0.2 pH units was achieved.

5.4.3 Water Level Measurement

The water level in the wells were measured using an electric water level indicator. This was accomplished by inserting the electric probe into the well, lowering until ground water is encountered, and recording the depth to ground water. All measurements were made and recorded to the nearest 0.01 foot, using the top of casing as a reference.

5.4.4 Surveying

The locations of the drive point wells, soil borings and permanent monitoring wells were surveyed by Entech, Inc. of Marietta, Georgia. Horizontal coordinates and elevations were determined at each point.

5.5 SAMPLING AND ANALYSIS PROCEDURES

5.5.1 Well Evacuation

Monitor wells were purged before collecting samples. For moderate to high yielding wells (i.e. wells that are not purged dry), a minimum of five well volumes were evacuated from the well. Additional water was removed from the well, as necessary, until three consecutive measurements of pH and specific conductivity from successive bails varied by 10 percent or less. Well evacuation was accomplished by bailers, or centrifugal pumps.

5.5.2 Sample Collection

As soon as sufficient recharge had occurred, or at the end of evacuation, samples were collected using a single-use, teflon, or stainless-steel bailer. For sample collection, the bailer was lowered with minimum splash to just below the water surface.

To comply with Georgia Environmental Protection Division regulations, the samples (including those for metals) were not filtered in the field prior to preservation.

Sample handling, decontamination, and Chain of Custody procedures for groundwater sampling activities are the same as those described in Section 4.4 for soil sampling activities. General laboratory analytical requirements are also the same as those described in Section 4.4.7. The specific sample preservation and laboratory analytical methods used for groundwater analyses are discussed in Section 5.2 and summarized in Table 5-1.

5.6 BACKGROUND WATER QUALITY

Background water quality data was obtained from MW-1. This well is upgradient from the Landfill source.

5.7 DATA SUMMARY

5.7.1 Drive Point Well/HydroPunch Screening Data

Groundwater screening was performed for the following compounds:

- TCE
- cis-1,2-dichloroethene
- vinyl chloride

The results of the drive point/HydroPunch screening data are summarized on Table 5-2 and depicted on Figure 5-3. These results indicate the presence of vinyl chloride at 6 locations, cis-1,2-dichloroethene at 7 locations, and TCE at 1 location. Concentrations of vinyl chloride ranged from 12 ug/L (DP-8) to 540 ug/L (DP-5). Cis-1,2-dichloroethene was detected at concentrations ranging from a low of 5 J ug/L to a high of 6330 ug/L (DP-8). TCE was detected at a concentration of 48 ug/L at DP-8. No target compounds were detected in samples collected from HP-1 located upgradient from the landfill area or at drive point locations DP-2 and DP-3.

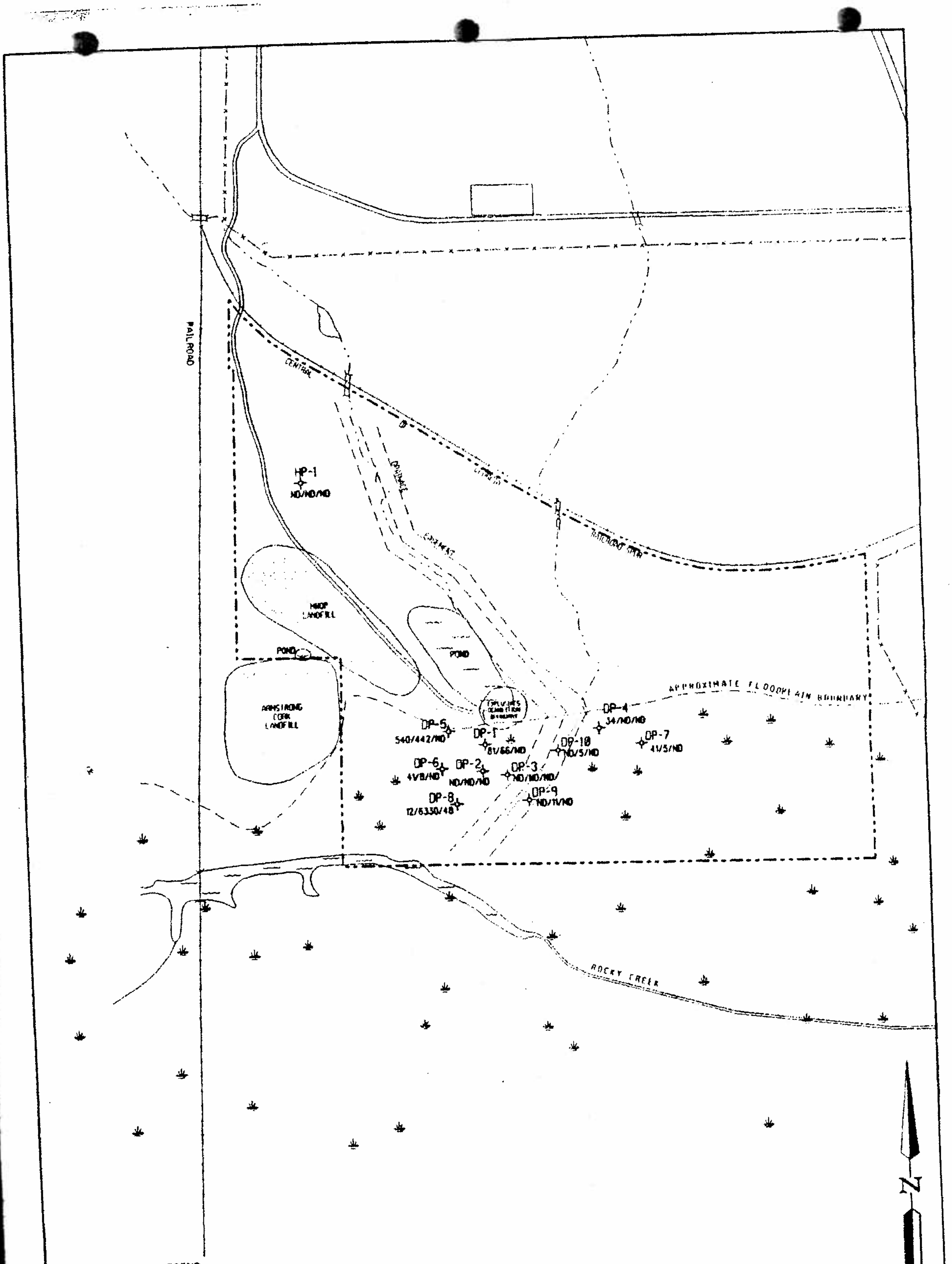
Table 5-2
Summary of HydroPunch/Drive Point Screening
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

	Compound	vinyl chloride	cis-1,2-dichloroethene	trichloroethene
	Units	ug/L	ug/L	ug/L
	Detection Limit	10	10	10
Sample ID	**Date Collected**			
HP-1	1/16/96	ND	ND	ND
DP-1	1/22/96	81	66	ND
DP-1-a[1]	1/22/96	74	69	ND
DP-2	1/22/96	ND	ND	ND
DP-3	1/16/96	ND	ND	ND
DP-3-a[1]	1/16/96	ND	ND	ND
DP-4	1/16/96	34	ND	ND
DP-4-c[2]	1/16/96	ND	ND	ND
DP-5	1/16/96	540	442	ND
DP-6	1/22/96	41	8	ND
DP-7	1/22/96	41	5	ND
DP-8	1/22/96	12	6330	ND
DP-9	1/22/96	ND	11	48
DP-10	1/22/96	ND	5	ND

[1] -a indicates that the sample is a duplicate.

[2] -c indicates that the sample is a trip blank.

ND indicates that the analyte was not detected above the method detection limit.



LEGEND

⌖ HYDROPUNCH/DRIVE POINT WELL LOCATION

–·–·–·– PROPERTY BOUNDARY

ND/ND/ND- VINYL CHLORIDE/ CIS-1,2 DICHLOROETHENE/TRICHLOROETHENE

ALL VALUES IN ug/L

0 150 300 600
SCALE IN FEET

	DATE
RUST PROJECT 33941.000	
DESIGNED BY D.WANDLING	6/96
DRAWN BY M.PEARCE	6/96
CHECKED BY	
FILE NAME 33941062	

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FIGURE 5-3
HYDROPUNCH/DRIVE POINT & SCREENING SUMMARY
FORMER MNOP LANDFILL
MACON, GEORGIA

27b

5.7.2 Laboratory Results

The results of monitor well sampling are summarized in Table 5-3. All analytical data were evaluated with regards to data quality by both the analytical laboratory and Rust. A summary of the data quality review is included as part of the QCSR in Appendix B. Monitor well MW-1 is considered the background well for the MNOP landfill site. Monitor wells MW-2 through MW-5 are downgradient of the Landfill and were installed by ESE, Inc. in 1990. The six additional wells installed as part of this investigation were located south and southeast of the landfill. One well, MW-11, was installed adjacent to MW-4 and screened at a lower depth to evaluate vertical contaminant migration.

The results of sampling indicate the presence of primarily TCE, cis-1,2-dichloroethene and vinyl chloride in the groundwater of the former MNOP Landfill site. Detections of other VOCs and metals were also observed.

TCE was detected in groundwater samples collected from seven of the eleven monitoring wells sampled. Concentrations ranged from a high of 12 mg/L at MW-4 to a low of 0.061 mg/L at MW-10. TCE was not detected in samples collected from MW-6, MW-7 and MW-8 which are all located south (downgradient) of the former landfill and within the floodplain area. It should be noted that these three wells are installed and screened predominantly into the surficial (Quaternary) unit composed of clay. TCE also was detected in monitoring well MW-11 (screened into the deeper unit) at a concentration of 0.22 mg/L as compared to 12 mg/L at MW-4 (screened into the shallow aquifer at this nested location).

Cis-1,2-dichloroethene, a common breakdown product of TCE, was detected in the same groundwater samples described above for TCE. Concentrations of cis-1,2-dichloroethene ranged from 0.94 mg/L at MW-3 to 0.046 mg/L at MW-11.

Except for MW-11, vinyl chloride was detected in groundwater samples from the same wells described above for TCE. Vinyl chloride concentrations ranged from 0.130 mg/L at MW-2 to 0.022 mg/L at MW-5. Vinyl chloride is also a common breakdown product from the dehalogenation (degredation) of TCE. Other VOCs detected included 1,1,2-trichloroethane, 1,1-dichloroethene, chloroform, chloromethane, isopropylbenzene, sec-butylbenzene, tetrachloroethene, toluene, and trans-1,2-dichloroethene.

Ten metals were detected in the samples collected in the landfill area. Three of these, antimony, arsenic, and mercury were detected in the background well MW-1. Selenium was also detected in the background well, but not in any of the wells around the landfill. Of the ten metals detected,

Table 5-3
Monitor Well Groundwater Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	MW-1	MW-1D	MW-2	MW-3	MW-4	MW-5
Inorganics							
antimony	mg/L	< .022	.024 J	< .022	.029 J	< .022	< .022
arsenic	mg/L	.1 J	.077 J	.085 J	< .049	< .049	< .049
beryllium	mg/L	< .00016	< .00016	< .00016	.0004 J	< .00016	< .00016
cadmium	mg/L	< .0019	< .0019	< .0019	.0023 J	< .0019	.006
chromium	mg/L	< .0045	< .0045	< .0045	.0367	< .0045	< .0045
copper	mg/L	< .0073	< .0073	< .0073	.0468	< .0073	.0192
lead	mg/L	< .00089	< .00089	< .00089	.027	.0033	.0093
mercury	mg/L	.0005	.0004	.0003	.0002 J	< .00005	< .00005
nickel	mg/L	< .0056	< .0056	< .0056	.0085 J	< .0056	.0067 J
selenium	mg/L	.003 J	< .00074 J	< .00074 J	.0026 J	< .00074 J	< .00074 J
zinc	mg/L	< .011 J	< .019 J	< .0061 J	< .0261	< .0244	.105
Volatile Organics							
1,1,2-trichloroethane	mg/L	< .0012	< .00124	< .0012	< .0012	.0031 J	< .0012
1,1-dichloroethene	mg/L	< .00048	< .000475	< .00048	.044	.011	< .00048
chloroform	mg/L	< .0014	< .00136	< .0014	< .0014	.002 J	< .0014
chloromethane	mg/L	< .002	< .00202	< .002	< .002	< .002	< .002
cis-1,2-dichloroethene	mg/L	< .0018	< .00176	.16	.94	.5 J	.2 J
isopropylbenzene	mg/L	< .00054	< .00054	< .00054	< .00054	.0044 J	< .00054
sec-butylbenzene	mg/L	< .00063	< .000625	< .00063	< .00063	.0078 J	< .00063
tetrachloroethene	mg/L	< .00049	< .00049	< .00049	< .00049	.0022 J	< .00049
toluene	mg/L	< .00085	< .000845	< .00085	< .00085	< .00085	< .00085
trans-1,2-dichloroethene	mg/L	< .00055	< .000545	< .00055	.011	< .00055	< .00055
trichloroethene	mg/L	< .00042	< .00042	4.6	2.5	12	1.8 J
vinyl chloride	mg/L	< .00047	< .00047	.13	.12	.11	.022 J
Radiologicals							
radium 226	pCi/L	4.6	6.2	2.5	5.8	1.4	2.2
radium 228	pCi/L	.8	1	.7	1.7	.6	1

mg/L = milligrams per liter
pCi/L = picoCurie per liter
J = indicates an estimated value

Table 5-3 (continued)
Monitor Well Groundwater Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11
Inorganics							
antimony	mg/L	< .022	< .022	< .022	< .022	< .022	< .022
arsenic	mg/L	< .049	< .049	< .049	< .049	< .049	.049 J
beryllium	mg/L	.0015 J	< .00016	< .00016	< .00016	< .00016	< .00016
cadmium	mg/L	.0032 J	< .0019	.0285	< .0019	< .0019	< .0019
chromium	mg/L	.0348	.0052 J	.0056 J	.0064 J	.0125	.0139
copper	mg/L	.0215	< .0073	< .0073	< .0073	< .0073	.0103
lead	mg/L	.034	.0036	.0028 J	.0056	.012	< .00089
mercury	mg/L	< .00005	.0004	< .00005	< .00005	.0003	< .00005
nickel	mg/L	< .0056	< .0056	< .0056	< .0056	.0062 J	< .0056
selenium	mg/L	< .00074	< .00074	< .00074	< .00074	< .00074	< .00074
zinc	mg/L	.0673	< .023	.187	.0625	< .0291	< .0236
Volatile Organics							
1,1,2-trichloroethane	mg/L	< .0012	< .0012	< .0012	< .0012	< .0012	< .0012
1,1-dichloroethene	mg/L	< .00048	< .00048	< .00048	.0067	< .00048	< .00048
chloroform	mg/L	< .0014	< .0014	< .0014	< .0014	< .0014	< .0014
chloromethane	mg/L	< .002	.0021 J	< .002	< .002	< .002	< .002
cis-1,2-dichloroethene	mg/L	< .0018	< .0018	< .0018	.36	.13	.046
isopropylbenzene	mg/L	< .00054	< .00054	< .00054	< .00054	< .00054	< .00054
sec-butylbenzene	mg/L	< .00063	< .00063	< .00063	< .00063	< .00063	< .00063
tetrachloroethene	mg/L	< .00049	< .00049	< .00049	< .00049	< .00049	< .00049
toluene	mg/L	< .00085	< .00085	< .00085	.0017 J	< .00085	.0026 J
trans-1,2-dichloroethene	mg/L	< .00055	< .00055	< .00055	.0015 J	< .00055	< .00055
trichloroethene	mg/L	< .00042	< .00042	< .00042	.2	.061	.22
vinyl chloride	mg/L	< .00047	< .00047	< .00047	.079	.04	< .00047
Radiologicals							
radium 226	pCi/L	.55	1.65	.46	1.16	1.35	.7
radium 228	pCi/L	3.08	.49	4.02	.21	-1.47	2.2

mg/L = milligrams per liter
pCi/L = picoCurie per liter
J = indicates an estimated value

chromium and lead were detected the most frequently, with 7 and 8 detections respectively. One or more samples had detected concentrations of antimony, arsenic, and cadmium that exceeded the analyte's MCL.

Chromium was detected in concentrations ranging from 0.0052J mg/L to 0.0367 mg/L (at MW-3). None of these detections exceed chromium's MCL of 0.1 mg/L. The two highest lead concentrations occurred in MW-3 and MW-6 (0.027 mg/L and 0.034 mg/L respectively). Both of these detections are above the 0.015 mg/L MCL for lead.

Antimony was detected in MW-3 at a concentration of 0.029J mg/L. This exceeds the MCL for antimony (0.006 mg/L), however, antimony was also detected in the duplicate sample of the background well MW-1 at a concentration of 0.024J. Arsenic was detected in MW-2 at 0.085J mg/L, which exceeds the MCL of 0.05 mg/L. Arsenic was detected in the background well sample at a concentration of 0.1J mg/L. Two detections of cadmium exceeded it's MCL of 0.005 mg/L - 0.006 mg/L at MW-5 and 0.0285 at MW-8. Cadmium was not detected in the background well.

5.7.3 Extent of Contamination

The following discussion provides a summary of the extent of groundwater contamination based upon the data collected during this investigation. The following compounds are not discussed as explained below:

- 1,1,2-trichloroethane, 1,1-dichloroethene, chloroform, chloromethane, isopropylbenzene, sec-butylbenzene, tetrachloroethene, toluene, and trans-1,2-dichloroethene were detected in samples collected from isolated wells, and although these compounds may be present in groundwater they do not form a contiguous or mappable plume area.

- Antimony, arsenic, and mercury were detected in both the background well and in samples from downgradient monitoring wells. Based upon this, it appears that these metals may be naturally occurring.

- Several other metals are detected at isolated and infrequent points which do not form a continuous plume area that can be defined.

The analytical results indicate that the primary constituent detected in groundwater is TCE with lesser amounts of cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride. The latter two compounds likely are degradation products of TCE. These three compounds appear to have had the most significant impact to groundwater quality and form mappable plume areas.

Trichloroethene

As described above, TCE is the most widely distributed compound and is present at the highest concentrations of any of the contaminants detected in groundwater. The analytical data indicate TCE is present at it's highest concentration in the shallow groundwater surrounding the landfill mass (wells MW-2, MW-4, and MW-5) and in the explosive demolition area (MW-3). The lateral distribution of TCE is shown on Figure 5-4.

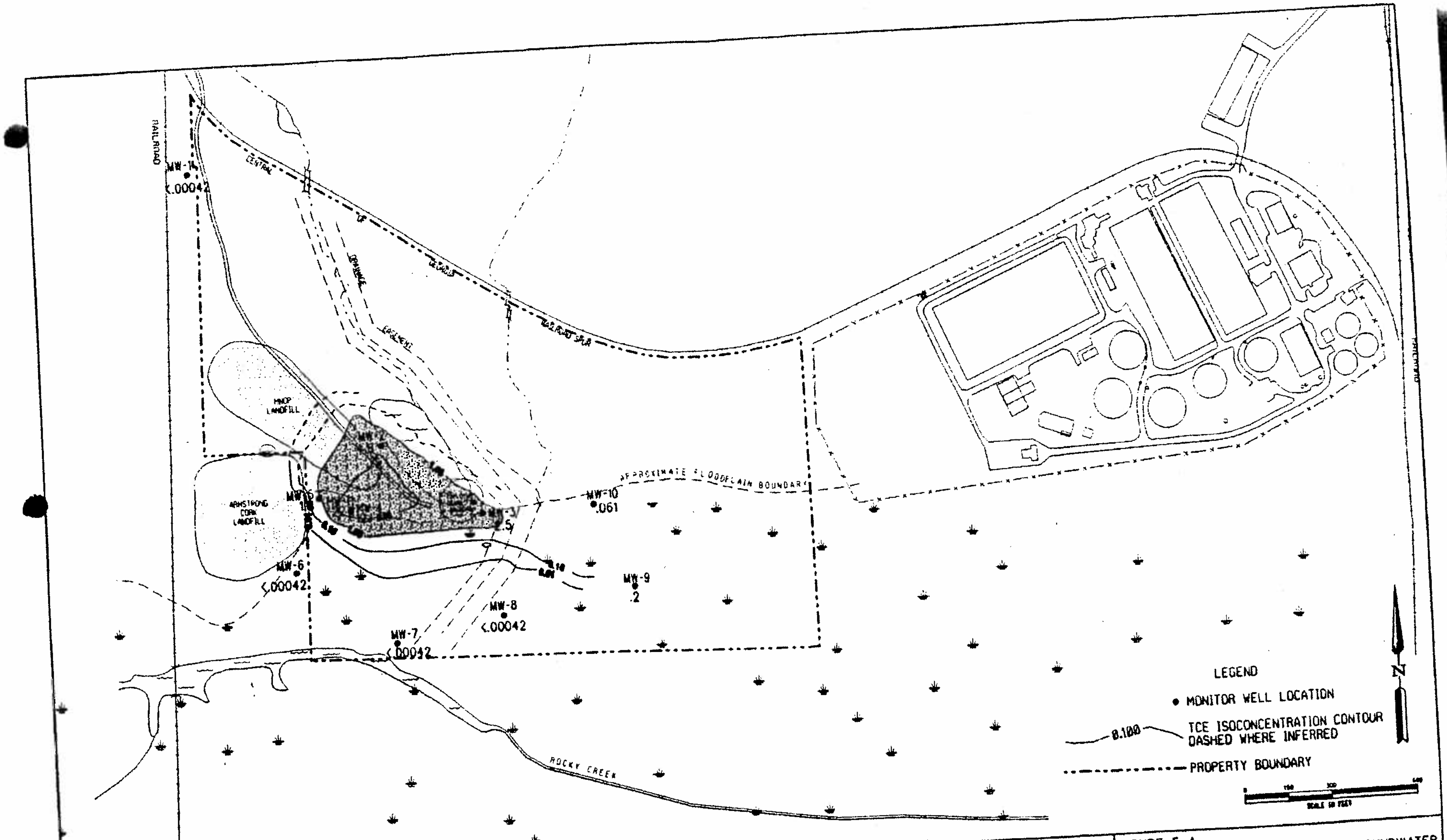
The data indicate that TCE has migrated vertically downward through the shallow aquifer(s) to a depth of at least 50 feet (MW-11). Also, based upon geologic/lithologic units, the primary contaminant migration pathways are expected to be the more permeable sands and silty sands of the underlying Tuscaloosa formation. The downward gradients observed at the well nest (MW-4/MW-11) indicate a mechanism for downward infiltration of shallow groundwater into the deeper portions of the aquifer. Shallow strata throughout the floodplain (being composed primarily of clay) may form a less conductive water bearing unit in the hydrogeologic system.

The lateral extent of TCE cannot be determined at this time based upon the data collected. It can be said, however, that TCE is present at relatively high concentrations in the shallow groundwater localized to the MNOP landfill mass and to the explosive demolition area. Lower level concentrations of TCE at MW-9 and MW-10, which are located side-gradient to the source areas, may be indications of horizontal movement of the TCE in the shallow surficial units (Figure 5-4). However, it is also possible that the detections in these two wells are from an upgradient source of TCE which has been recently delineated within the AIP area (Rust, 1996). There are no upgradient wells north of MW-10 to establish the relationship to the AIP plume(s) at this time.

Based upon the data, it can be concluded that TCE does not appear to be significantly migrating through the shallow surficial unit as evidenced by an almost complete absence of TCE in the drive point and monitoring wells (MW-6, MW-7 and MW-8) located hydraulically down gradient from the landfill. Further, screening data suggest that while TCE is absent, the breakdown products of TCE (cis-1,2-DCE and vinyl chloride) were found to be present in the shallow groundwater in the drive point screening data.

Cis-1,2-Dichloroethene

The lateral and vertical extent of cis-1,2-DCE appears to be the same as TCE described above. This is as expected since this compound is believed to be present as an intermediate breakdown product of TCE. It is noted that in MW-9 and MW-10 the ratio of TCE to cis-1,2-DCE is about proportional



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RUST ENVIRONMENT & INFRASTRUCTURE

NOTES:

1 - ALL VALUES IN mg/L

2 - J - ESTIMATED VALUE

FIGURE 5-4
ANALYTICAL RESULTS FOR TCE IN GROUNDWATER
FORMER MNOP LANDFILL
MACON, GEORGIA

verses the ratios of these compounds in wells near the landfill which show a predominance of TCE. A cis-1,2-DCE map is not presented in this report because it has a similar distribution to TCE.

Vinyl Chloride

The lateral extent of vinyl chloride in the shallow groundwater is similar to that described above for TCE and cis-1,2-DCE. The distribution of vinyl chloride is shown on Figure 5-5. Vinyl chloride is an expected breakdown product of both TCE and cis-1,2-DCE.

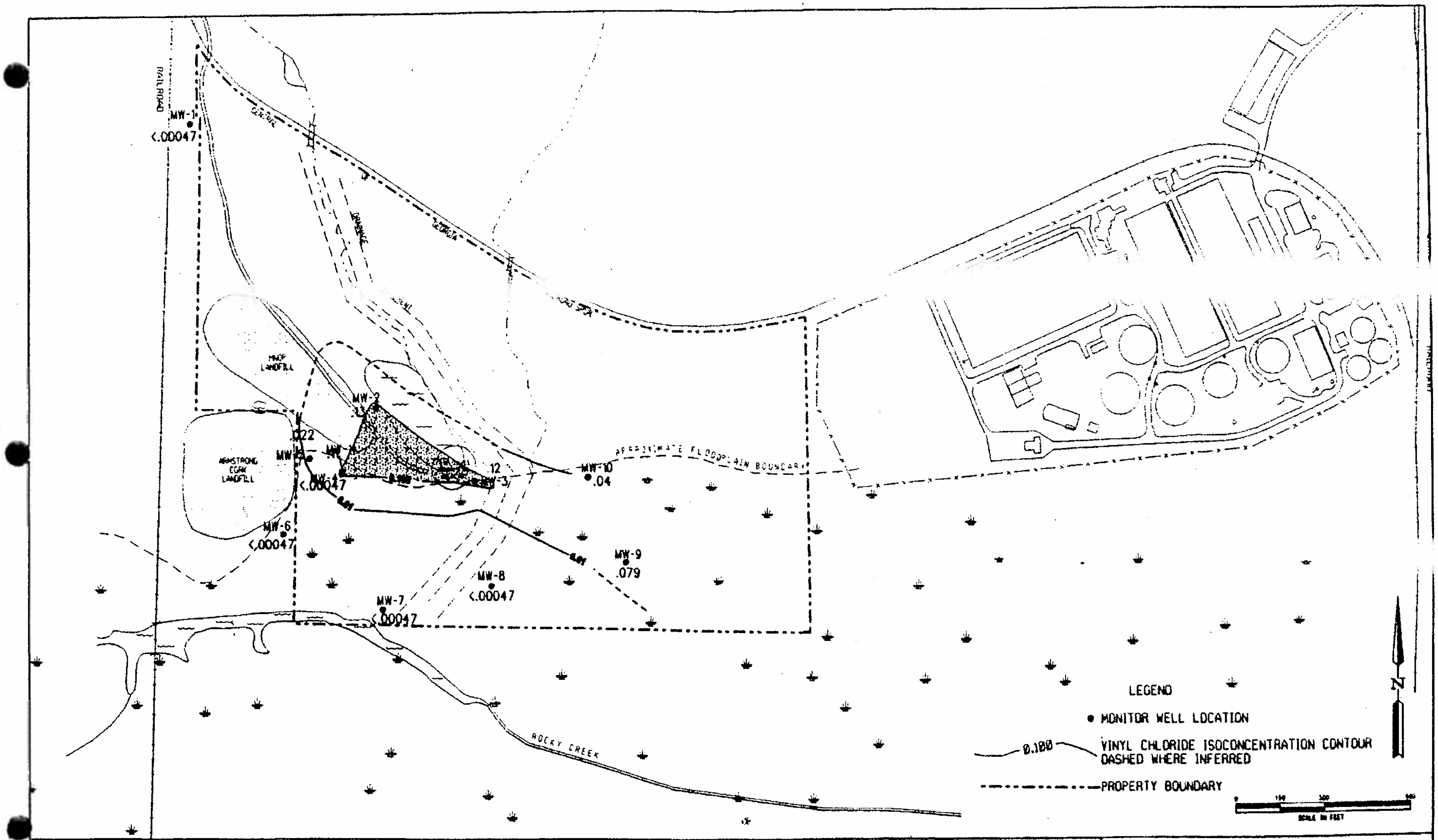
5.7.4 Fate and Transport

This section discusses transport and fate of the primary detected contaminants; TCE, cis-1,2-DCE and vinyl chloride. These constituents belong to a class of compounds referred to as halogenated aliphatic compounds, often referred to as alkyl halides. When released to soils and surface water this class of compounds are primarily lost to volatilization. This is due to the relatively high vapor pressure of these compounds. Once these compounds enter subsurface soils or groundwater the principal attenuating mechanisms are sorption, biodegradation and possibly volatilization in the vadose zone.

Halogenated aliphatic compounds are subject to biodegradation under both aerobic and anaerobic conditions (Chapelle, 1993). However, aerobic biodegradation only occurs under special conditions and has generally been found to play a minor role in the degradation process of halogenated aliphatic compounds. Hence, this explains the observed persistence of TCE in most shallow aerobic aquifer systems. Anaerobic degradation of these compounds is much more commonly observed and documented in the literature. Numerous studies have indicated that compounds such as TCE are progressively dechlorinated under anaerobic conditions. The tendency of reductive dehalogenation is to transform TCE to isomers of dichloroethene (cis- or trans-) and then to vinyl chloride. Research has also shown that complete dehalogenation in the subsurface environment is difficult to achieve (Chapelle, 1993).

Based upon site data, it appears that the contaminants of interest are probably undergoing slow dechlorination in the shallow water-table aquifer. Due to the proximity of the adjacent floodplain, conditions appear to be favorable for these processes to take place.

While some transformation may be occurring in the shallow water-table aquifer, these compounds are expected to be relatively persistent in the deeper groundwater systems of the Tuscaloosa. TCE and it's breakdown products should be transported at approximately the same rate as groundwater flow. Only slight retardation will occur from adsorption to aquifer materials. The ultimate fate



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RUST ENVIRONMENT & INFRASTRUCTURE

NOTES:

1 - ALL VALUES IN mg/L

2 - J - ESTIMATED VALUE

FIGURE 5-5
ANALYTICAL RESULTS FOR VINYL CHLORIDE
IN GROUNDWATER
FORMER MNOP LANDFILL
MACON, GEORGIA

of these contaminants will primarily be discharge to the floodplain and surface waters of Rocky Creek, or continued transport and migration into deeper aquifers.

6.0 ADDITIONAL ENVIRONMENTAL SAMPLING

6.1 SURFACE WATER

Surface water samples were collected from (1) multiple points along Rocky Creek, (2) overland drainage areas between the MNOP Landfill and Rocky Creek, and (3) sampling points along the up slope drainages to the landfill site. The Rocky Creek sampling locations included two sampling points approximately 1000 feet downstream of the landfill (LSW-8 and LSW-9), a number of points near the probable point of entry for overland drainage from within the MNOP property boundaries (LSW-4 through LSW-7) and two sampling locations up gradient (LSW-1 and LSW-2) as shown on Figure 6-1. Two of the overland drainage area sampling locations were located in the drainage easement right of way (LSW-5 and LSW-10) and one point was located at the outfall from the pond area (LSW-11). QC samples, consisting of replicates and trip blanks were also collected. Quality assurance (QA) samples (splits) were also collected and submitted to the USACE, SAD Laboratory located in Marietta, Georgia.

All surface water samples were analyzed for volatile organic compounds (EPA, 8260), semivolatile organic compounds and polynuclear aromatic hydrocarbons (EPA, 8270) and priority pollutant metals (EPA, 6010, 7060, 7421, 7740). Explosive residues (EPA, 8330) were tested in all samples except for LSW-12 and LSW-13. The sampling and analytical program implemented is outlined in Table 6-1.

6.1.1 Procedure

Surface water sample locations were approached from the creek bank and from the downstream direction to prevent possible disturbance of sediments or contamination of surface water by field personnel during sampling. Field parameters (pH, temperature, and conductivity) of the surface water were determined at each sample location. Samples for VOC analysis were collected at a depth of 0-2 inches from the water surface using a new glass jar. Sample vials were filled with in such a manner as to exclude air bubbles. Sample containers for other analyses were filled in a similar manner. The samples were properly documented, placed on ice, and shipped to the analytical laboratory.

6.1.2 Results

A total of thirteen surface water samples were collected in the Landfill area at the sampling locations depicted in Figure 6-1. The results of these analyses are summarized in Table 6-2.

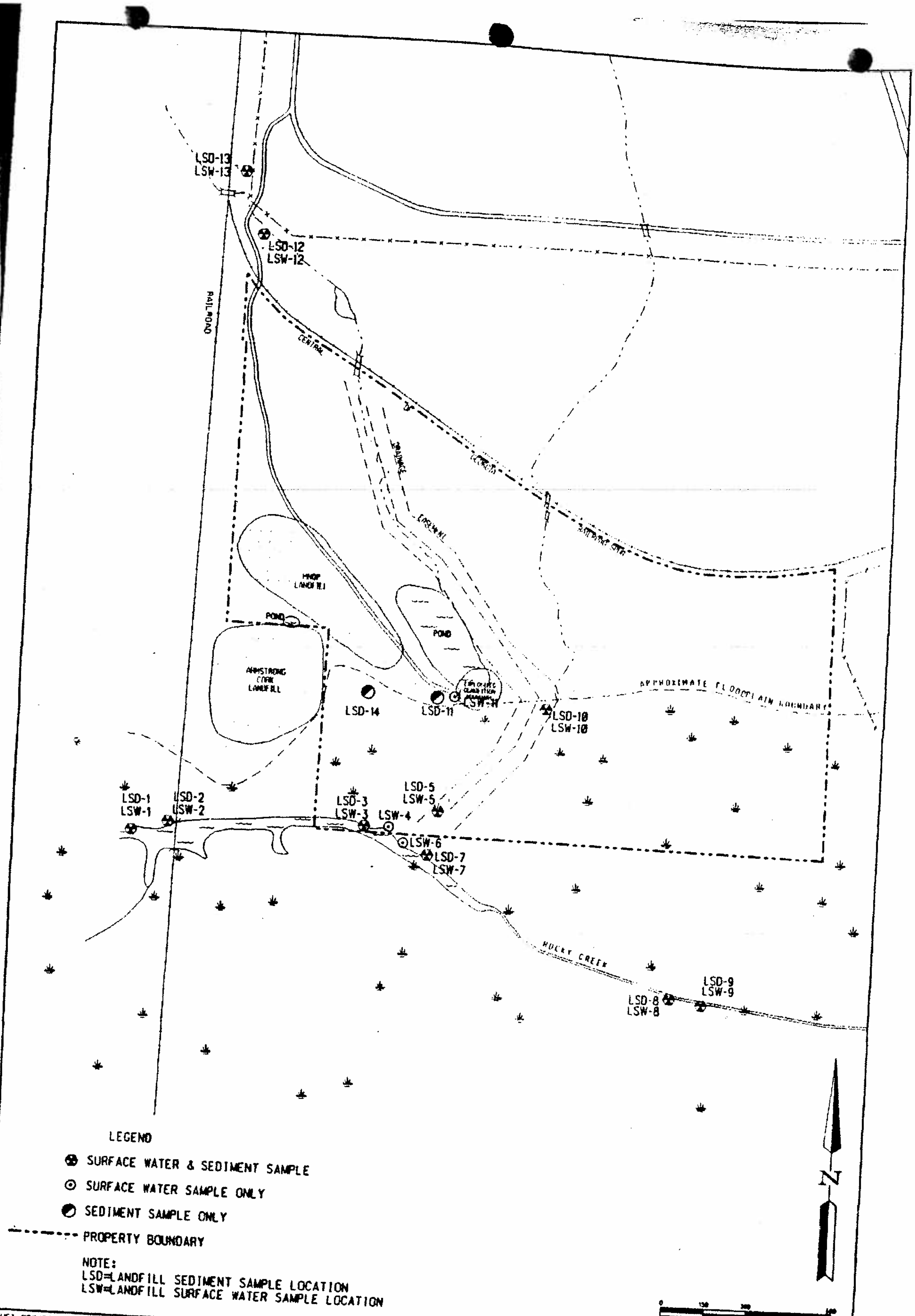

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FIGURE 6-1
SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
FORMER MNOP LANDFILL
MACON, GEORGIA

Table [illegible]-1
Surface Water, Sediment Sampling and Analytical Requirements
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Matrix	Field Samples	QC Samples	QA Samples	Trip Blanks	Total Samples	Analysis	Protocol	Analytical Procedures	Holding Time	Preservation Requirements	Sample (1) Containers	Total Containers
Surface Water from Rocky Creek and downgradient of landfill	11	1	1	2	15	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C Add HCl to pH<2 or NaHSO4	2-40 mL glass septa vial	30
	11	1	1	0	13	SVOC/PAH	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	2-1L amber glass	26
	11	1	1	0	13	Explosive Residues	SW-846	EPA 8330	14/40 days	Ice to 4 degrees C	2-1L amber glass	26
	11	1	1	0	13	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days, 28 days for mercury	HNO3 to pH<2 Ice to 4 degrees C	1-1L glass or plastic	26
Surface Water from property line	2	1	1	1	5	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C Add HCl to pH<2 or NaHSO4	2-40 mL glass septa vial	10
	2	1	1	0	4	SVOC/PAH	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	2-1L amber glass	8
	2	1	1	0	4	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days, 28 days for mercury	HNO3 to pH<2 Ice to 4 degrees C	1-1L glass or plastic	4
Sediment from Rocky Creek and downgradient of landfill	10	1	1	0	12	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C	1-125 mL glass septa vial	12
	10	1	1	0	12	SVOC/PAH	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	1-8 oz glass	12
	10	1	1	0	12	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days, 28 days for mercury	Ice to 4 degrees C	1-8 oz glass	12
	10	1	1	0	12	Explosive Residues	SW-846	EPA 8330	14/40 days	Ice to 4 degrees C	1-4 oz glass	12
Sediment from property line	2	1	1	0	4	VOC	SW-846	EPA 8260	14 days	Ice to 4 degrees C	1-125 mL glass septa vial	4
	2	1	1	0	4	Priority Pollutant Metals	SW-846	EPA 6010, 7060, 7421, 7740	180 days, 28 days for mercury	Ice to 4 degrees C	1-8 oz glass	4
	2	1	1	0	4	SVOC/PAH	SW-846	EPA 8270	7/40 days	Ice to 4 degrees C	1-8 oz glass	4

(1) Per EM-200-1-3, Table I-1, 31 March 95.

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Table 6-2
Surface Water Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSW-1	LSW-2	LSW-3	LSW-4	LSW-5	LSW-6	LSW-7	LSW-8
Inorganics									
cadmium	mg/L	<.0019	<.0019	<.0019	<.0019	<.0019	<.0019	<.0019	<.0019
chromium	mg/L	<.0045	<.0045	<.0045	<.0045	<.0045	<.0045	<.0045	<.0045
copper	mg/L	<.0073	<.0073	<.0073	<.0073	<.0073	<.0073	<.0073	<.0073
lead	mg/L	<.00089	<.00089	<.00089	<.00089	<.00089	<.00089	<.00089	<.00089
mercury	mg/L	<.00005	<.00005	<.00005	<.00005	<.00005	<.00005	<.00005	<.00005
nickel	mg/L	<.0056	<.0056	<.0056	<.0056	<.0056	.014 J	<.0056	<.0056
zinc	mg/L	<.0207	<.017 J	<.02 J	<.018 J	<.019 J	<.0479	<.019 J	<.018 J
Volatile Organics									
bromomethane	mg/L	<.00049 J	<.00049	<.00049	<.00049	<.00049	<.00049	<.00049	<.00049
cis-1,2-dichloroethene	mg/L	<.0018 J	<.0018	<.0018	<.0018	<.0018	<.0018	<.0018	<.0018
trichloroethene	mg/L	<.00042 J	<.00042	<.00042	<.00042	<.00042	<.00042	<.00042	<.00042

mg/L = milligrams per liter
J = indicates an estimated value

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Table 6-2 (continued)
Surface Water Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSW-9	LSW-10	LSW-11	LSW-11D	LSW-12	LSW-12D	LSW-13
Inorganics								
cadmium	mg/L	< .0019	.0023 J	< .0019	.0033 J	.00949	< .0019	< .0019
chromium	mg/L	< .0045	< .0045	< .0045	< .0045	< .0045	.0052 J	< .0045
copper	mg/L	< .0073	< .0073	.0097 J	.0083 J	< .0073	< .0073	< .0073
lead	mg/L	< .00089	.0049	.0053	.0037	< .00089	< .00089	< .00089
mercury	mg/L	< .00005	< .00005	.0003	.0003	.0002 J	< .00005	.0002 J
nickel	mg/L	< .0056	< .0056	< .0056	< .0056	< .0056	< .0056	< .0056
zinc	mg/L	< .016 J	.0574	.107	.106	.046	< .0424	< .0346
Volatile Organics								
bromomethane	mg/L	< .00049	< .00049	< .00049	< .00049	< .00049	< .00049	.0026 J
cis-1,2-dichloroethene	mg/L	< .0018	.051	< .0018	< .0018	< .0018	< .0018	.0049 J
trichloroethene	mg/L	< .00042	.38	< .00042	< .00042	.0086	.0069	.032

mg/L = milligrams per liter
J = indicates an estimated value

The results of the eight surface water samples collected from Rocky Creek indicate that surface waters do not exhibit the presence of VOCs, SVOCs, explosive residues, or priority pollutant metals except for a single detection of nickel in the sample collected at location LSW-6. Nickel was detected at a concentration of 0.014 J mg/L which is below the Georgia in-stream water quality standard of 0.088 mg/L.

The remaining five surface water sample locations were collected from drainage features located within the boundary of the former MNOP. Two of these points are located on the tributary of Rocky Creek where it flows onto the northwest side of the MNOP property, LSW-12 and LSW-13. These locations are the point of entry for surface waters entering the northern part of the site. The results of sampling indicate the presence of TCE at a concentration of 0.007 mg/L to 0.032 mg/L at LSW-12 and LSW-13, respectively. In addition, trace concentrations (less than 0.005 mg/L) of bromomethane and cis-1,2-dichloroethene were also detected in samples collected from LSW-13. Inorganics detected at these points include cadmium, chromium, mercury and zinc. Georgia in-stream standards were exceeded for cadmium (0.0007 mg/L) at LSW-12 and for mercury (0.000012 mg/L) at both LSW-12 and LSW-13. TCE has an in-stream standard of 0.080 mg/L but was not exceeded at these upstream points.

The results of surface water sampling at LSW-10, located in the drainage easement east of the pond and landfill refuse area, indicate the surface water in this overland flow area exhibits the presence of TCE (0.38 mg/L), cis-1,2-dichloroethene (0.051 mg/L), and a number of inorganics including cadmium (0.0023 J mg/L), lead (0.0049 mg/L), and zinc (0.0574 mg/L). Georgia in-stream water quality standards were exceeded for TCE, cadmium and lead at this point. Cadmium and lead have Georgia in-stream standards of 0.0007 mg/L and 0.0013 mg/L, respectively.

The results of sampling at LSW-11, which sampled surface water discharging from the pond located immediately east of the landfill, indicated that no VOCs, SVOCs or explosive residues were detected in surface water at this location. However, several inorganic parameters were detected including lead (0.0053 mg/L), mercury (0.0003 mg/L), copper (0.0097 J mg/L) and zinc (0.107 J mg/L). Georgia in-stream water quality standards were exceeded for lead, mercury (0.000012 mg/L), and copper (0.0065 mg/L).

The remaining surface water point located in the drainage easement (LSW-5) did not reveal any target analytes above the laboratory quantitation limit.

6.2 SEDIMENT SAMPLING

Twelve sediment samples were collected at the locations depicted in Figure 6-1. Six sediment samples were collected within the former MNOP Landfill property and six were collected from Rocky Creek. QC samples, consisting of replicates and trip blanks were collected. Quality assurance (QA) samples (splits) were also collected and submitted to the USACE, SAD Laboratory located in Marietta, Georgia.

All sediment samples were analyzed for volatile organic compounds (EPA, 8260), semivolatile organic compounds/polynuclear aromatic hydrocarbons (EPA, 8270) and priority pollutant metals (EPA, 6010, 7060, 7421, 7740). Explosive residues (EPA, 8330) were tested in all samples except for LSD-12 and LSD-13 located at the northwest (upgradient) corner of the site. The sampling and analytical program implemented is outlined in Table 6-1.

6.2.1 Procedure

Sediment samples were collected at each station to represent stream bed or drainage area sediments. A clean, stainless steel spoon or grain scoop was used to collect the sample. For VOCs, the sample container was gently tapped as the sample was placed in the container, and the container was completely filled to eliminate any headspace. For other analyses the sediment was gently mixed, quartered, and placed in the sample containers.

6.2.2 Results

The results of sediment sampling are provided in Table 6-3. All samples within the boundary of the MNOP property had various inorganic parameters. The inorganics detected included beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. Beryllium, chromium, copper, lead, nickel and zinc were detected at similar concentrations in LSD-12 and LSD-13 (northwest tributaries upgradient from Landfill) and in LSD-1 and LSD-2 (upgradient points in Rocky Creek) as compared to sediment sampling points within the MNOP boundary (LSD-5, LSD-10, LSD-11, and LSD-14). Hence, it is concluded that these inorganic parameters are probably naturally occurring in the sediments. Cadmium, however, was detected at concentrations which appear elevated. In addition mercury, selenium, and silver were not detected in any upgradient sediment sampling points. Cadmium was detected at it's highest concentration within the MNOP boundary at LSD-14 (17 mg/Kg) compared to the 0.95 mg/Kg to 1.42 mg/Kg detected at upgradient sediment locations. Mercury and selenium were detected at one sampling point (LSD-5) at concentrations of 0.975 mg/Kg and 0.9 J mg/Kg. Silver was detected in one sample (LSD-11) at a concentration of 1.7 mg/Kg.

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Table 6-3
Sediment Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSD-1	LSD-2	LSD-3	LSD-5	LSD-7	LSD-8	LSD-9
Inorganics								
beryllium	mg/kg	.3 J	.38 J	.24 J	.43 J	.04 J	.35 J	.38 J
cadmium	mg/kg	< .42	.47 J	.49 J	5.09	< .23	.65 J	4.88
chromium	mg/kg	14.5	15.7	8.29	35	1.1 J	10.9	15.6
copper	mg/kg	9.41	9.09	4.74	20.3	< .9	7.1	11.5
lead	mg/kg	42	28.7	18.6	53.4	3.79	13.9	22.5
mercury	mg/kg	< .13	< .067	.058 J	.975	< .038	.15 J	< .077
nickel	mg/kg	3.2 J	4.54	2.4 J	5.88	.6 J	3.1 J	3.1 J
selenium	mg/kg	< .17	< .12	.61 J	.9 J	< .09	.69 J	.57 J
silver	mg/kg	< .44	< .31	< .28	< .38	< .24	< .33	< .34
zinc	mg/kg	27.2	31.2	27.6	45.7	4.73	30.6	37.7
Volatile Organics								
bromomethane	mg/kg	< .0011	< .00079 J	< .0007 J	< .00095	< .00059	< .00082	< .00084
cis-1,2-dichloroethene	mg/kg	< .004	< .0029 J	< .0026	< .0034	< .0022	< .003	< .0031
o-xylene	mg/kg	< .0032	< .0023 J	< .0021	< .0028	< .0017	< .0024	< .0025
sec-butylbenzene	mg/kg	< .0014	< .001 J	< .00091	< .0012	< .00076	< .0011	< .0011
tert-butylbenzene	mg/kg	< .0013	< .00095 J	< .00085	< .0011	< .00072	< .00099	< .001
trans-1,2-dichloroethene	mg/kg	< .0012	< .00088 J	< .00079	< .0011	< .00067	< .00092	< .00095
trichloroethene	mg/kg	< .00095	< .00068 J	< .00061	< .00082	< .00051	< .00071	< .00073
vinyl chloride	mg/kg	< .0011	< .00076 J	< .00068	< .00092	< .00057	< .00079	< .00082
Semivolatile Organics								
benzo(a)pyrene	mg/kg	< .3	< .21	< .19	.76	< .16	< .22	.75
benzo(b)fluoranthene	mg/kg	< .19	< .13	< .12	< .32	< .1	< .14	.21 J
benzo(g,h,i)perylene	mg/kg	< .27	< .19	< .17	1.2	< .15	< .2	1.1
bis(2-ethylhexyl)phthalate	mg/kg	< 2	< 1.4	< 1.3	< 3.4	< 1.1	< 1.5	< 1.5
chrysene	mg/kg	< .36	< .26	< .23	< .62	< .2	< .27	.59
di-n-butyl phthalate	mg/kg	< .34	< .24	< .22	< .58	< .18	< .25	< .26
phenanthrene	mg/kg	< .21	< .15	< .13	< .35	< .11	< .15	< .16
pyrene	mg/kg	< .3	< .21	< .19	< .51	< .16	< .22	.26 J

mg/kg = milligrams per kilogram
J = indicates an estimated value

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Table 6-3 (continued)
Sediment Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	LSD-10	LSD-11	LSD-11D	LSD-12	LSD-12D	LSD-13	LSD-14
Inorganics								
beryllium	mg/kg	.19	.15	.16	.19	.17	.058	.23
cadmium	mg/kg	9.87	8.91	7.41	1.42	2.64	.95	17
chromium	mg/kg	9.27	19.3	16.4	8.14	7.3	3.57	15.8
copper	mg/kg	15.9	48.8	51	7.48	9.42	2.4	73.7
lead	mg/kg	42.4	52.2	49.1	32.1	29.2	9.31	41.6
mercury	mg/kg	< .036	< .047	< .044	< .039	< .038	< .032	< .11
nickel	mg/kg	3.35	8.18	5.2	2.8	2.4	< 1.3	10
selenium	mg/kg	< .11	< .14	< .13	< .11	< .11	< .094	< .33
silver	mg/kg	< .28	1.7	1.89	< .3	< .29	< .25	< .86
zinc	mg/kg	72.6	136	140	58.3	53.2	22.7	230
Volatile Organics								
bromomethane	mg/kg	< .0007	< .00092	< .00086	< .00075	.015	< .00062	< .0021 J
cis-1,2-dichloroethene	mg/kg	.0086	.0081 J	< .0031	< .0027	< .0026	< .0022	< .0078 J
o-xylene	mg/kg	< .002	< .0027	.0027 J	< .0022	< .0021	< .0018	< .0063 J
sec-butylbenzene	mg/kg	< .0009	< .0012	< .0011	< .00097	< .00094	< .0008	.019 J
tert-butylbenzene	mg/kg	< .00084	< .0011	< .001	< .00091	< .00088	< .00075	.015 J
trans-1,2-dichloroethene	mg/kg	< .00078	.0034 J	.0023 J	< .00085	< .00082	< .0007	< .0024 J
trichloroethene	mg/kg	< .0006	.0042 J	< .00074	< .00065	< .00063	< .00054	< .0019 J
vinyl chloride	mg/kg	.0033	< .00089	< .00083	< .00073	< .00071	< .0006	< .0021 J
Semivolatile Organics								
benzo(a)pyrene	mg/kg	.8	< .25	< .23	< .2	< .2	< .17	< .58 J
benzo(b)fluoranthene	mg/kg	.36	< .16	< .14	.14	< .12	< .1	< .36 J
benzo(g,h,i)perylene	mg/kg	.83	< .23	< .21	< .19	< .18	< .15	< .53 J
bis(2-ethylhexyl)phthalate	mg/kg	1.6	2.3	1.8	< 1.4	< 1.3	< 1.1	< 3.8 J
chrysene	mg/kg	.66	< .3	< .28	< .25	< .24	< .2	< .71 J
di-n-butyl phthalate	mg/kg	< .22	< .28	.32	< .23	< .23	< .19	< .66 J
phenanthrene	mg/kg	< .13	< .17	< .16	.15	< .14	< .12	< .4 J
pyrene	mg/kg	.34	< .25	< .23	< .2	< .2	< .17	< .58 J

mg/kg = milligrams per kilogram
J = indicates an estimated value

Two locations, LSD-10 and LSD-11, contained multiple detections of both SVOCs and VOCs (Table 6-3). These two locations are southeast of the landfill area. Two locations, LSD-5 and LSD-14, evidenced detections of a limited number of SVOCs and VOCs. VOCs and SVOCs were generally not detected in the upgradient sediment locations except for a single, possibly anomalous, detection of bromomethane (0.015 mg/Kg) in LSD-12D, a replicate sample taken at LSD-12. No explosive residue compounds were detected in any of the samples analyzed.

All six sediment samples from Rocky Creek contained one or more of the inorganic parameters listed above for samples collected within the MNOP boundary. However, concentrations of these inorganic parameters were generally found to be within the same range of values as the upgradient sediment sample locations. No VOCs or explosive residue compounds were detected in any of the Rocky Creek sediment samples. SVOCs were not detected in any other samples except for LSD-9 (downstream point) which exhibited the presence of benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, and pyrene (Table 6-3).

6.3 BIOTA SAMPLING

6.3.1 Procedures

Biota sampling was conducted at Rocky Creek, which runs along the southern portion of the former MNOP Landfill site. Collection of aquatic life (i.e., fish) was done by electrofishing both up stream and down stream of the landfill.

Electrofishing of Rocky Creek took place on March 25 and May 1, 1996. Fish collected during both sampling events, include: redear sunfish (*Lepomis microlophus)*, redbreast sunfish (*Lepomis auritus*), longear sunfish (*Lepomis megalotis*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), redfin pickerel (*Esox americanus*), American eel (*Anguilla rostrata*), gizzard shad (*Dorosoma cepedianum*), silver redhorse sucker (*Moxostoma anisurum*), spotted sucker (*Minytrema melanops*), creek chub (*Semotilus atromaculatus*), golden shiner (*Notemigonus crysoleucas*), Ocmulgee shiner (*Cyprinella callizera*), and inland silverside (*Menidia beryllina*). During the March sampling, no samples for contaminant analysis were collected due to stream access problems, and rising water levels due to thunderstorms. Samples for contaminant analysis were obtained during the May 1, 1996 sampling event. Samples collected include four fish caught from down stream locations- a bluegill (138mm), white crappie (185mm), spotted sucker (438mm), and a silver redhorse sucker (345mm). A spotted sucker (394mm) was also caught up stream (200-500 feet upstream of the Central Railroad tracks) of the landfill area. All fish were filleted in the field prior to shipment to the lab.

6.3.2 Results

Fish were analyzed for selected ICP metals (Method 6010), Pesticides/PCB's (Method 8080), PAH's (Method 8100), selected volatiles (TCE & vinyl chloride) (Method 8240), explosives (Method 8330), cyanide (Method 9010), and total recoverable petroleum hydrocarbons (Method 418.1). All analytes, except for TRPH, barium, selenium, and Aroclor 1254, were not detected at or above the limits of detection. The results of analyses are summarized in Table 6-4.

TRPH was detected in the 2 spotted suckers and the silver redhorse sucker (not enough sample was available to analyze for TRPH in the bluegill and the white crappie). TRPH levels in the downstream spotted sucker were 260 mg/kg while levels in the upstream spotted sucker were 940 mg/kg. TRPH levels in the silver redhorse sucker were 510 mg/kg. No benchmarks are available against which to directly compare these levels. However, by using a common surrogate chemical for TRPH, such as hexane, these levels can be compared to the EPA Region III Risk-based Concentration (RBC) for fish. The RBC for hexane is 81 mg/kg. This comparison assumes that all of the TRPH is present as hexane, which is unlikely.

Barium (1.5 mg/kg) and selenium (1.4 mg/kg) were detected in the silver redhorse sucker. No benchmark exists for barium. The RBC for selenium is 6.8 mg/kg.

Aroclor 1254 was detected in all of the fish analyzed. Levels detected in the down stream fish were 0.42 mg/kg (bluegill), 0.45 mg/kg (white crappie), 0.49 mg/kg (spotted sucker), and 0.35 mg/kg (silver redhorse sucker). The upstream spotted sucker had a level of 0.2 mg/kg. All of these samples are greater than the RBC of 0.027 mg/kg.

Table 6-4
Biota Analytical Data
Former MNOP Landfill
Macon, Georgia
Rust Project No. 33941.000

Parameter	Unit	BG-1 5/01/96	SU-1 5/01/96	SU-2 5/01/96	SU-3 5/01/96	WC-1 5/01/96
Inorganics						
barium	mg/kg	< 1.1	< 1.1	1.5	< 1	< 1
selenium	mg/kg	< 1.1	< 1.1	1.4	< 1	< 1
Pesticides/PCBs						
aroclor 1254	mg/kg	.42	.49	.35	.2	.45
PAH						
total petroleum hydrocarbons	mg/kg	NA	260	510	940	NA

mg/kg = milligrams per kilograms
NA = not analyzed
BG-1 = Bluegill (138 mm)
SU-1 = Spotted Sucker (438 mm)
SU-2 = Silver Redhorse Sucker (345 mm)
SU-3 = Spotted Sucker (394 mm - Upstream)
WC-1 = White Crappie (185 mm)

7.0 ENVIRONMENTAL RECEPTORS

Access to the former MNOP Landfill site is gained through several routes including two dirt roads entering the property from the AIP property to the north and one from a gravel road entering from the Armstrong Cork property to the west. All three roads converge at the northwest corner of the property where a dirt road leads south to the landfilled area. The landfill occupies approximately 15 acres while the remaining property is undeveloped. A new chain-link property fence has been erected on the Armstrong Cork property near the southwestern edge of the landfill. All other portions of the site have unrestricted access. Several drainage features flow across the site from north to south discharging into Rocky Creek. Two areas of ponded water have been identified, one west and the other immediately east of the landfill.

An ecological reconnaissance of the former MNOP Landfill site was conducted on May 2, 1996. The Rocky Creek floodplain, which lies immediately south and downgradient of the landfill, was also visited as part of the biota sampling discussed in Section 6.0. The following paragraphs discuss the findings of the reconnaissance.

- The vegetation over the landfill had recently been disturbed due to field investigation efforts. There was no canopy layer, although small scattered trees were noted. The trees present were small (up to 20 feet) and included loblolly pine (*Pinus taeda*), box-elder (*Acer negundo*), white ash (*Fraxinus americana*), chinaberry (*Melia azedarach*), and wild black cherry (*Prunus serotina*). The shrub layer was also patchy, and contained the following species: Groundsel-tree (*Baccharis halimifolia*), smooth sumac (*Rhus glabra*), and Chickasaw plum (*Prunus angustifolia*). The herb layer was dense over all of the landfill except for the north-central portion, where the ground was bare due to recent bulldozer activity. Herbs which are present over the rest of the landfill included trumpet-creeper (*Campsis radicans*), red sorrel (*Rumex acetosella*), Japanese honeysuckle (*Lonicera japonica*), goldenrod (*Solidago* sp.), blackberry (*Rubus allegheniensis*), broom-sedge (*Andropogon virginicus*), passion flower (*Passiflora incarna*), vetch (*Vicia* sp.), and sassafras (*Sassafras albidum*) seedlings.

  The Rocky Creek floodplain, located immediately south of and downgradient from the landfill, is fairly mature, and has a closed canopy. Dominant species in the canopy layer include red maple (*Acer rubrum*), sycamore (*Platanus occidentalis),*black willow (*Salix nigra*), black gum (*Nyssa sylvatica* var. *biflora*), box-elder, and cherrybark oak (*Quercus falcata* var. *pagodaefolia*). The shrub layer is sparse, and most components are saplings of the previously noted tree species (especially red maple). Other species present in this stratum include dog-hobble (*Leucothoe axillaris*), strawberry bush (*Euonymus americanus*), bayberry (*Myrica cerifera*), and Virginia-willow (*Itea virginica*). Dominants in the herb stratum include manna grass (*Glyceria striata*), soft rush (*Juncus effusus*), lizard's-tail (*Saururus cernuus*), sensitive fern (*Onoclea sensibilis*), green arum (*Peltandra virginica*), sedge (*Carex comosa*), bur-reed (*Sparganium americanum*), cane (*Arundinaria gigantea*), false nettle (*Boehmeria cylindrica*), butterweed (*Senecio glabellus*), Virginia-creeper (*Parthenocissus quinquefolia*), poison-ivy (*Toxicodendron radicans*), muscadine grape (*Vitis rotundifolia*) and, in the wettest areas (including some sluggish portions of Rocky Creek proper), parrot-feather (*Myriophyllum aquaticum*).

- The only mammals observed in the immediate vicinity of the landfill were two coyote (*Canis latrans*). Tracks of white-tailed deer (*Odocoileus virginianus*) were also observed. Birds noted in the immediate vicinity of the landfill include indigo bunting (*Passerina cyanea*), northern cardinal (*Cardinalis cardinalis*), and mourning dove (*Zenaida macroura*).

  Mammal signs observed within the Rocky Creek floodplain include trees gnawed by beaver (*Castor canadensis*), and tracks of dogs (*Canis domesticus*) and white-tailed deer. Birds observed in the floodplain (including Rocky Creek) include a great blue heron (*Ardea herodias*), Carolina chickadee (*Parus carolinensis*), brown-headed cowbird (*Molothrus ater*), and numerous other songbirds. Reptiles observed within the floodplain include an eastern box turtle (*Terrapene carolina*) and an unidentified snake.

- Invertebrates observed within Rocky Creek include water striders (Order Hemiptera; Family Gerridae), water boatmen (Order Hemiptera; Family Corixidae), and crayfish (*Cambarus* sp.). Fishes observed in Rocky Creek (via electrofishing) were bluegill (*Lepomis macrochirus*), redbreast sunfish (*Lepomis auritus*), longear sunfish (*Lepomis megalotis*), white crappie (*Pomoxis annularis*), largemouth bass (*Micropterus salmoides*), creek chub (*Semotilus atromaculatus*), redfin pickerel (*Esox americanus*), longnose gar (*Lepisosteus osseus*), gizzard shad (*Dorosoma cepedianum*), golden shiner (*Notemigonus crysoleucas*), spotted sucker (*Minytrema melanops*), silver redhorse sucker (*Moxostoma anisurum*), Ocmulgee shiner (*Cyprinella callizera*), and inland silverside (*Menidia beryllina*).

- Evidence of human activity near the landfill included tire tracks, spent shotgun shells, and discarded appliances and construction/demolition debris. Two monitoring wells are located near the southern edge of the landfill.

  The most utilized access to Rocky Creek and its associated floodplains is via a dirt road which parallels the Central of Georgia railroad tracks, and cross Rocky Creek approximately 250 feet upstream of the landfill. Evidence of human activity in Rocky Creek and its associated floodplain included hunting tree stands, fishing debris (tangled line, lures in overhanging trees, bait containers, etc.), a trash barrel, and trodden paths along the creek in the immediate vicinity of the trestle. Conversation with three fisherman indicated that their catch consisted of bluegill and crappie. They also reported having seen an alligator (*Alligator mississippiensis*) in the backwater area upstream of the trestle.

In summary, potential receptors may come into contact with contaminated media associated with the former MNOP Landfill site. Evidence in the vicinity of the landfill indicates that hunters utilize the area. Rocky Creek is frequently used by fishermen. Other possible human receptors for the landfill are environmental samplers or trespassers (dumping debris etc.). Exposure to human receptors could potentially occur via incidental ingestion of and dermal contact with soil, inhalation of particulates from soil, and ingestion of contaminated fish or game. Ecological receptors are numerous and include a variety of small and large mammals, birds, and aquatic organisms in Rocky Creek.

8.0 PROPERTIES AND RESPONSIBLE PARTIES

8.1 SITE PROPERTY OWNERSHIP HISTORY

The public records reviewed by Rust during research for the Project Action Plan indicated that the former MNOP Landfill site was purchased by the Navy from the City of Macon in 1955. The landfill site was included in the sale of the entire MNOP to Maxson Electronics in 1965, and in the subsequent sale to Allied Chemical Corporation in 1973 and the Macon-Bibb County Industrial Authority in 1981. In 1989, the Macon-Bibb County Industrial Authority exchanged property with the Macon Water Authority, swapping the 40 acre parcel of land containing the Landfill for 19 acres located north of the Central of Georgia railroad tracks. Therefore, the current property owner of the former MNOP Landfill site is the Macon Water Authority.

8.2 OFF-SITE PROPERTY OWNERSHIP

The former MNOP Landfill site is bordered to the west and south by property owned by Armstrong Cork. The property to the west contains an inactive landfill once operated by Armstrong Cork. The property to the north consists of the AIP which consists of light industrial and commercial businesses. Property in the AIP is either owned by individual businesses or is leased from the Macon-Bibb County Industrial Authority. Property to the east is owned by the Macon Water Authority and contains a waste water treatment facility.

9.0 SUMMARY OF PREVIOUS ACTIONS

Limited environmental investigations have been conducted at the former MNOP Landfill site prior to this investigation. These studies are described in Section 1.2.

Only one action has been identified as having reduced the environmental risk posed by the source areas. During the sites' ownership by Allied Chemical Company, the landfill was covered with soil and active use was discontinued. No actions have been identified for the explosive demolition area.

10.0 COMPLIANCE WITH RISK REDUCTION STANDARDS

The Georgia HSRA regulations specify that a site listed on the HSI must meet one of five risk reduction standards (RRS). The requirements of the RRS, identified as Type 1 through Type 5, are described in Rule 391-3-19-.07 of Georgia Department of Natural Resources Environmental Protection Division Hazardous Site Response (HSRA). Type 1 and 2 RRS criteria apply to residential properties and provide for either a standardized approach to exposure assumptions and defined risk levels (Type 1) or a site-specific risk assessment (Type 2). The Type 3 and 4 RRS apply to non-residential properties following the same standardized versus site-specific approach to risk evaluation. The Type 5 RRS applies to sites where the application of Type 1 through 4 is not appropriate and allows for the use of measures to control the regulated substances on the property where the regulated substances are located.

A detailed description of the evaluation procedure applied to the analytical data collected is found in Appendix C. The appendix presents the evaluation grouped by the RRS risk evaluation approach. Therefore, Type 1 and 3 RRS are discussed first as they require a standardized approach to exposure assumptions and defined risk levels. A discussion of Type 2 and 4 RRS follows in which a site-specific approach to risk evaluation is applied.

10.1 GROUNDWATER DATA

The results of the RRS evaluations indicate that the primary regulated substances in groundwater are TCE and vinyl chloride and to a lesser extent metals depending on the RRS criteria being compared. A total of 10 analytes were found to exceed the Type 1 (residential) and Type 3 (non-residential) RRS at some point in the groundwater of the landfill. Of these, the primary constituents exceeding the Type 1 or Type 3 criteria were TCE and vinyl chloride. Four metals also (antimony, arsenic, cadmium, and lead) exceeded the criteria. The metals criteria, however, were not exceeded in more than one or two groundwater samples each.

A comparison of the calculated Type 2 RRS to site groundwater concentrations indicate that antimony, arsenic, cadmium and cis-1,2-dichloroethene and lead exceeded the standard in two samples. Arsenic was detected at a concentration above the Type 2 RRS in the sample from the background well (MW-1). Antimony, arsenic, cadmium, and cis-1,2-dichloroethene are dropped when compared to the Type 4 RRS, leaving only TCE, vinyl chloride and lead as regulated substances with respect to the non-residential scenario.

10.2 SOIL DATA

The soils evaluation indicated a number of inorganic and organic parameters that were detected in samples at concentrations in excess of the Type 1 and Type 3 soil RRS. Metals (antimony, cadmium, chromium, copper, lead, mercury, nickel, and zinc), PCBs (arochlor 1248 and arochlor 1260) and two semi-VOCs (benzo(a)pyrene and chrysene) exceeded the standards. In addition, a number of VOCs and SVOCs were detected in the Landfill soils that do not have established standards. Based upon the levels detected for metals and PCBs it was concluded that the landfill soils did not meet the Type 1 or Type 3 criteria and further evaluation of these standards were not performed.

For the evaluation of Type 2 (residential) and Type 4 (non-residential) standards the regulated substances were screened against several criteria to limit the number of parameters evaluated. The results of this evaluation indicated that the Type 2 RRS is exceeded for PCBs, benzo(a)pyrene, lead, and para-cymene at multiple points. Lead and para-cymene exceed the calculated Type 4 concentrations at several points. It is noted that since some compounds were not included in the Type 2 and 4 evaluations additional compounds may be present above their respective RRS.

10.3 SUMMARY

Based upon the data evaluation, all four of the RRS are exceeded at some point in the groundwater and soil. In addition, while the Type 2 (residential) or Type 4 (non-residential) standards would apply to any off-site properties affected, the Type 4 (non-residential) standards would likely apply to the non-residential use of the subject property at this time. The Type 2 and Type 4 standards (see Table C4-4 and C5-1 in Appendix C) are considered "safe concentrations" by the State of Georgia, based upon the two scenarios presented in Appendix C, and may be considered preliminary remedial goals.

11.0 CONCLUSIONS AND RECOMMENDATIONS

11.1 CONCLUSIONS

11.1.1 Extent of Contamination

Based upon data collected during the current and past investigations we conclude that:

Groundwater

- A release of HSRA regulated substances has occurred to the groundwater of the MNOP landfill site. TCE was the primary organic constituent released to groundwater.

- Gross contamination by TCE and other regulated substances appears to be localized to areas immediately surrounding the landfill mass and near the explosive demolition area.

- No evidence of explosive residues, semi-volatiles, pesticides, or PCBs were detected in groundwater samples analyzed.

- Downgradient of the landfill, TCE does not appear to be migrating significantly in the surficial (Quaternary) unit, as evidenced by an almost complete absence of TCE in samples collected from shallow drive point and monitoring wells south of the landfill. Also, based on screening data (drive point wells), it appears that since the breakdown products of TCE (cis-1,2-DCE and vinyl chloride) are present in the shallow groundwater of the floodplain area, TCE may be actively degrading in these areas.

- TCE and other site related constituents were detected in samples collected from monitor wells MW-9 and MW-10 which are located some 600 to 900 feet east and southeast of the landfill. The horizontal extent of the contaminant plume in the surficial aquifer of this area has not been determined. Also, since these wells are located side-gradient to the source areas an upgradient source is possible.

- The contaminant plume has migrated vertically downward through the shallow aquifer(s) to a depth of at least 50 feet (MW-11) in the landfill source area. The downward hydraulic gradients observed at the landfill indicate a clear mechanism for downward infiltration of shallow groundwater into the deeper portions of the aquifer.

Based upon geologic/lithologic units, the primary contaminant migration pathways are likely the more permeable sands and silty sands of the underlying Tuscaloosa formation. The current investigation did not fully investigate vertical or horizontal extent in the Tuscaloosa aquifer(s).

- While some transformation may be occurring in the shallow water-table aquifer, TCE, cis-1,2-DCE and vinyl chloride will probably be relatively persistent in the deeper groundwater systems of the Tuscaloosa. TCE and it's breakdown products should be transported at approximately the same rate as groundwater flow. However, the detectable concentrations of TCE are found in fairly close proximity to the landfill. Only slight retardation is expected from adsorption to aquifer materials, but the swampy areas of Rocky Creek may be diluting concentrations below detection limits. The ultimate fate of these contaminants will primarily be discharge to surface waters of Rocky Creek or continued migration into deeper aquifers.

Soil

- Elevated levels of heavy metals and PCBs are present throughout the subsoils of the MNOP landfill site. Detected metals are primarily antimony, cadmium, chromium, copper, lead and zinc. PCBs are primarily Arochlor 1248. Based on the data, metals and PCB contamination is present adjacent to the landfill as well as in remote sampling locations throughout floodplain areas. The extent of elevated metals and PCBs have not been fully determined from the data collected.

- Based upon the chemical characteristics of PCBs, these compounds will not likely undergo significant biodegradation, but are expected to be strongly sorbed to soil. Detected metals may also have an affinity to sorb onto soil.

- Volatile organic compounds were detected generally at trace or low level concentrations in only a few of the samples collected. Naphthalene was the most frequently detected VOC, with detections in 7 samples. Two of the deeper soil samples (LSL-2 at 6-8 feet and LSL-5 at 8 to 10 feet) exhibited the presence of a number of VOCs. These two samples account for most of the volatile organic compound detections.

- SVOCs were detected at several sample locations. At three locations, LSL-3, LSL-7, and LSL-11, SVOC parameters were detected in samples collected at all depths. Of the SVOCs detected the most significant is the presence of benzo(a)pyrene in a number of samples at concentrations ranging from less than 0.5 mg/Kg to up to 10 mg/Kg.

- No evidence of explosive residues were detected in the samples and concentrations of pesticides were not significant in terms of regulatory compliance.

Surface Water

- Surface water sampling conducted along Rocky Creek does not indicate the presence of target VOCs, SVOCs, explosive residues, or priority pollutant metals in the waterway.

- Samples of surface water entering the site from the northwest corner contain detectable amounts of TCE, cis-1,2-DCE, bromomethane, and several metals including cadmium and mercury. The source of these constituents is likely from an off-site source to the north or northwest.

- In the drainage easement area, near LSW-10, elevated levels of TCE and other site related contaminants were detected in surface water. Since TCE levels are more than 10 times that detected in the upgradient (northwest) tributary the levels observed may be related to seepage of contaminated groundwater from the on-site source. The tributary stream coming in from the north may also be bringing contamination from the Allied Industrial Park site.

Sediment

- Sediment samples collected from Rocky Creek did not reveal any evidence of VOCs or explosive residues. The farthest downgradient sample collected from Rocky Creek (LSD-9) did contain detections of several SVOCs.

- Sediments samples collected in overland flow areas between the on-site sources indicate some evidence of SVOCs and VOCs and elevated levels of cadmium in places.

Biota

- The results of biota sampling indicate that PCBs (Aroclor 1254) are present in the fish tested.

- Due to the limited study conducted it cannot be concluded that the PCBs detected in the biota were from on-site sources. The PCB isomer detected in the fish (Aroclor 1254) was not the same as that detected in the site subsoils (Aroclor 1248).

- Total petroleum hydrocarbons were detected in all 3 samples in which they were analyzed for, including the upgradient sample. Values for all three fish were greater than any of the surrogate compound RBCs, suggesting a potential for risk. However it should also be kept in mind that TPH can be associated with urban non-point source runoff. Therefore it cannot be concluded that TPH are from on-site sources.

11.1.2 Evaluation of Potential Source Areas

With respect to source areas, we conclude that:

- The former MNOP landfill is a continuing source of TCE and to a lesser degree, other VOCs to groundwater. The landfill site is also a source of metals and PCBs, as evidenced by elevated concentrations of these constituents in subsoils. No evidence of explosive residues was detected in the samples, nor were pesticides above the RRS levels. The exact boundaries of the landfill are not known at this time.

- The explosives demolition area does not appear to be a source of contamination. Groundwater samples collected downgradient do not show significant levels of contamination originating from the demolition area. No soil sampling was conducted in this area during the recent investigation; however, soil samples were collected during a previous investigation (Environmental Science and Engineering, 1990) and analyzed for VOCs, SVOCs, metals, petroleum hydrocarbons, and explosives compounds. No organic compounds and no significant levels of metals were detected during this previous investigation.

- There is no evidence to suggest that the Armstrong Cork Landfill site is impacting the MNOP property in terms of VOCs and SVOCs. However, based on the fact that the Armstrong Cork property was placed on the HSI due to the presence of lead, it is unclear as to whether or not this site is contributing metals, particularly lead. More information on the Armstrong Cork site will be needed to make this determination.

11.1.3 Compliance with HSRA Risk Reduction Standards

11.1.3.1 Soils

Based on an evaluation of the analytical data collected, soils at the site do not comply with the Type 1 or Type 3 Risk Reduction Standards (RRS), which use a standardized approach to exposure assumptions for residential (Type 1) and non-residential (Type 3) property classifications. The criteria for both RRS were exceeded for 9 inorganic compounds.

The Type 2 and Type 4 RRS apply site-specific risk data to the evaluation of residential (Type 2) and non-residential (Type 4) property classifications. An analysis of the soil data collected revealed that the Type 2 RRS is exceeded due to the levels of Aroclor 1248 (10 locations), Aroclor 1260 (one location), benzo(a)pyrene (3 locations), lead (14 locations) and para-cymene (2 locations) detected in the samples. Under the Type 4 RRS the PCBs (Aroclor) and benzo(a)pyrene are eliminated, leaving only lead (14 locations) and para-cymene (2 locations) above the RRS.

11.1.3.2 Groundwater

Evaluation of groundwater analytical data indicates that shallow groundwater beneath the site does not comply with the Type 1 or Type 3 RRS, which use a standardized approach to exposure assumptions for residential (Type 1) and non-residential (Type 3) property classifications. The samples analyzed failed to meet the criteria for TCE, vinyl chloride, 1,1-DCE, antimony, arsenic, cadmium and lead.

The results of screening groundwater data against the Type 2 (residential) and Type 4 (non-residential) standards indicate that the levels of TCE, vinyl chloride, and lead exceed both RRS. Antimony, arsenic and cadmium exceed only the Type 2 standards at one to two points individually.

11.1.3.3 Summary

Based on the non-residential use of the property at this time, it is assumed that the calculated Type 4 RRS for soil and groundwater (Table C5-1 of Appendix C) may apply as remedial goals for the site. In order to prepare a CSR it will be necessary to obtain sufficient data to adequately define the vertical and horizontal extent of contamination. The CSR should be compiled on the basis of site conditions which exist after the completion of any voluntary corrective actions that will be taken at the site. The CSR must certify compliance with one of the five HSRA risk reduction standards.

No determination on the need or types of corrective action can be made without further evaluation. However, based upon site conditions, it would appear that the site will not comply with the Type 1 through Type 4 RRS without corrective action. Compliance with the applicable Type 1 through 4 standards requires that all source materials must be removed or decontaminated to the RRS media criteria (see Table C5-1 in Appendix C for calculated Type 4 criteria). HSRA allows for concentrations in excess of soil and groundwater criteria to be left in place under special conditions of the Type 5 risk reduction standard. However, remedial measures designed to meet the Type 5 standard must meet a number of performance criteria for carcinogens, systemic toxicant, air, groundwater and soil as defined in 391-3-19-.07 (10)(d).

The Type 5 RRS requires long-term monitoring and maintenance, restrictive covenant, and requires that the Type 1 through 4 RRS be met beyond the boundary of the area for which compliance with Type 5 standards are sought whenever implementation of remedial measures is complete. This standard allows for engineering controls to remove the principal threats however it does not allow substitution of institutional controls for active remedial measures unless such measures are determined not to be practicable.

11.2 RECOMMENDATIONS

Based upon the results of the site investigation and current site conditions, we recommend that:

- The vertical and horizontal extent of groundwater contamination be further defined in order to meet the requirements of a HSRA Compliance Status Report. Monitoring wells should be specifically installed along the south, east, and western property boundaries to establish a point of compliance. Nested well locations may be required to evaluate deeper aquifers beneath the site. Also, at least one upgradient well nest will be required to evaluate potential migration of the recently identified contaminant plumes from the AIP onto the MNOP landfill property. The additional data gathering should focus on collecting site specific data that will support compliance with the Type 4 RRS at the property boundary. Routine monitoring of upgradient and downgradient wells may be required to develop a broader statistical base concerning groundwater quality for risk-evaluation purposes.

- The contaminant sources impacting the shallow groundwater should be further evaluated. Specifically, a survey should be conducted to locate the landfill boundaries, condition and thickness of cover, and possibly the thickness and character of waste material if a removal action is being considered. The boundary of the explosive demolition area, as well as the extent of soils contamination, should be evaluated. These additional investigations should determine if a cost effective remedial action can help achieve one of the HSRA risk reduction standards.

- An additional investigation concerning the PCB contamination be conducted. It is recommended that this include a literature review to help establish PCB levels in the Macon area, specifically with the Rocky Creek drainage area.

- Levels of TRPH and PCBs observed in biota samples collected from Rocky Creek are greater than EPA RBCs, implying that there is a potential risk to humans from consuming these fish. Further analysis of fish in Rocky creek should be conducted. This includes collection of additional samples downgradient of the site and from several background locations. These data should be analyzed for full scan TCL/TAL to determine what the total contaminant body burden is. A full scan for total petroleum hydrocarbons should also be conducted.

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