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US Army
Environmental Center

LEXINGTON-BLUEGRASS ARMY DEPOT GROUNDWATER INVESTIGATION REPORT

PHASE I - FINAL

Volume II

Lexington-Bluegrass Army Depot
Lexington, Kentucky

Submitted to:

Commander
Department of the Army
United States Army Environmental Center
Aberdeen Proving Ground, Maryland

Submitted by:

Metcalf & Eddy, Inc.
2800 Corporate Exchange Drive
Suite 250
Columbus, Ohio 43231

Prepared Under:

Contract No. DAAA15-90-D-0016
Task Order Number 4

September 1995

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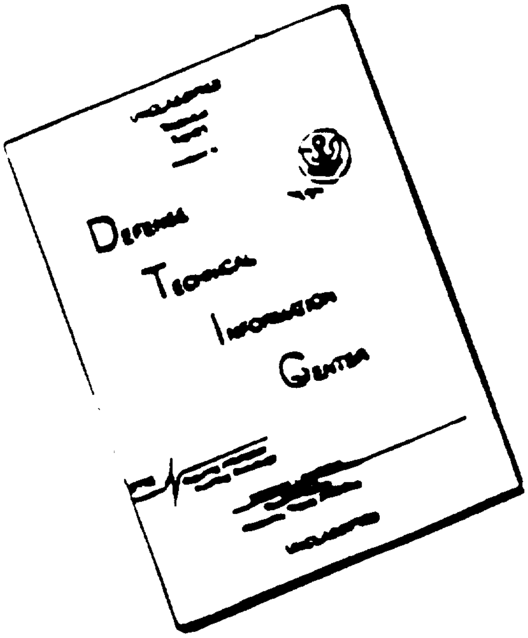

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

Section | Page

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF APPENDICES

TABLE OF CONTENTS
(Continued)

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

6.1 INTRODUCTION

This baseline risk assessment section provides an evaluation of the potential risks to human health from exposure to chemicals detected in groundwater in areas of concern at the LBAD. By definition, a baseline risk assessment (risk assessment) is an analysis of the potential adverse health effects (current or future) caused by hazardous substance releases from the site in the absence of any actions to control or mitigate these releases (U.S. EPA 1989a).

6.1.1 Objectives and Scope of the Risk Assessment

The results of the risk assessment for the LBAD will be used to :

- Document the magnitude of risk at the site and the primary causes of that risk;
- Help determine what additional response actions are necessary; and
- Aid in modifying preliminary remediation goals.

Thus, the risk assessment is an integral part of the RFI process for the LBAD. For the purposes of the baseline risk assessment portion of this groundwater assessment report. The evaluation of groundwater will be used on a geographical division of the LBAD into a northern or southern portion. These two areas will be evaluated separately in order to reflect the distinct differences in groundwater availability.

The scope of this risk assessment is limited to potential risks to human populations posed by exposure to chemicals in groundwater associated with former operations at the LBAD. These operations are described in Section 1.0 of the associated RFI report. Potential risks due to exposure to other environmental media (soil, surface water and sediment) were addressed earlier in the LBAD RFI submitted in April of 1994. This assessment focuses on groundwater data collected during both Phase I and Phase II of the RFI. Data from previous site investigations were not evaluated in detail beyond a qualitative review of the results of each investigation (summarized in Section 1.3.1). As a final summary of risks and hazards associated with sampled media at LBAD, Appendix R. of this report presents SWMU-specific risk/hazard results across all media.

The scope of this assessment and the procedures used in its performance are based on, and are consistent with U.S. EPA guidance, policies, and procedures as set forth in the U.S. EPA RFI Guidance, Volume I, Health and Environmental Assessment guidelines (U.S. EPA, 1989a); U.S. EPA Risk Assessment Guidance for Superfund, Volume I [Human Health Evaluation Manual (HHEM)] (U.S. EPA 1989b), the U.S. EPA HHEM Supplemental Guidance for Standard Exposure Factors (U.S. EPA, 1991a), Supplemental Region IV Risk Assessment Guidance (U.S. EPA, 1991b); Commonwealth of Kentucky, Department for Environmental Protection's "Outline for a Baseline Risk Assessment Report" (KDEP, 1991b); and related guidance documents.

6.1.2 Physical Setting

The LBAD is located in Fayette and Bourbon Counties, about 12 miles east of Lexington, 12 miles south of Paris, and 12 miles north of Winchester, Kentucky. The LBAD Facility encompasses approximately 782 acres and is surrounded by farm and timberland. The community of Avon, with a population of 50, borders the LBAD Facility on the southeast side of the property. The Army Depot is bordered on the east by Briar Hill Road, on the north by private farmland, on the west by Ware Road, and on the south by a concrete plant (see Figure 6-1).

The LBAD Facility is not included in the zoned areas for Fayette County. Rather, the Army property land uses are designated in the 1988 Comprehensive Plan for Lexington-Fayette County. Under the Comprehensive Plan, the Army property is divided between light industrial to general rural areas. The surrounding land use is primarily general rural with some heavy industrial, light industrial, and retail trade and personal services in and around the town of Avon (see Figure 6-2). Industries are located along the railroad tracks which parallel the property's southwestern boundary.

6.1.3 Site History

The LBAD is an activity of the Depot System Command, (DESCOM) Chambersburg, Pennsylvania. Its mission includes the storage and overhaul of Communications Security (COMSEC) Support equipment. The COMSEC Support Directorate provides such items as tactical manpack devices, secure squad level FM radio communications, and satellite telemetry encryption devices. It also provides facilities for receipt, storage, surveillance and disposal of critical supplies and surplus property.

The LBAD began operation in 1941 as a Signal Depot. The present administration building, eight warehouses, the motor pool building, power plant, and 40 wood framed, concrete based, temporary buildings comprised the original depot complex. Additional equipment and facilities have been added almost yearly. The buildings are concentrated in the southwestern portion of the property, near the railroad. Two landfills have been developed, operated and closed north and west of the main building complex. The now abandoned airstrip, a golf course and a third closed landfill comprise the remaining portion of the facility northeast of the building complex.

Hazardous materials have historically been stored at various buildings around the facility. Materials used in current operations generally are maintained in small quantities; however, some materials have accumulated in storage. Lithium batteries are stored in Buildings 100, 101 and 110 and in cold storage in Building 5. Flammable materials are stored in the flammable storage Buildings 103 and 107, and acid is stored in Building 110.

The hazardous waste storage facility, Building 27, is a concrete structure with four major, individual compartments which provides storage for all hazardous waste generated at the LBAD. The hazardous waste stored at this building has included acids, asbestos material, air filter cloths from paint spray booths, sand blasting dust, lubricating oil, waste paints and solvents. The wastes are then transported to an off-site location for disposal.

Three sanitary landfills were utilized for disposal of all waste generated at the LBAD prior to 1980. The Old Landfill was an area-fill disposal operation located adjacent to the tributary to Elkhorn Creek and operated between 1940 and the early 1950's for burning and disposal of all waste including sanitary waste and industrial waste. Indications are that most of the waste was burned in this landfill prior to being covered with fill dirt. Disposal of the waste at this site ceased in the early 1950's. The Industrial and Sanitary Waste Disposal Landfill was then constructed to replace operations at the Old Landfill. (Department of the Army, 1984, USAEHA, 1988). No closure plan was prepared for the Old Landfill and the depth of the cover is uncertain.

The Industrial and Sanitary Disposal Landfill was utilized as a burning ground and fill area from the early 1950's until 1971. The landfill was an area-fill landfill located south of the tributary to Elkhorn Creek. Waste disposed in this landfill included paper products, construction debris, packing material, office waste and industrial waste including metal plating sludge, paints, and solvents. Waste disposal practices consisted of burning wastes, and then covering the waste residue with soil. Disposal at this site ceased in 1971 when the most recently constructed landfill was put into operation (Department of the Army, 1984, USAEHA, 1988). In 1984 a 30-inch soil cover was placed over the closed landfill and the area was stabilized by seeding. The State Regulatory Authority approved the closure plan for this site; however, this plan did not include a geophysical study.

The LBAD is authorized to operate its hazardous waste management facilities under interim status as required under 40 CFR 270 and has applied for its RCRA Part B Permit (submitted November 1988). The Part B application is currently being reviewed by state and federal regulatory authorities. Interim status allows the facility to continue operations related to hazardous waste management in accordance with the Kentucky hazardous waste rules and regulations, 401KAR Chapters 30 through 40, until final approval is issued.

Air emissions are authorized under Permit No. 0-92-054 by the Kentucky Natural and Environmental Protection Cabinet for the following LBAD areas: coal fired power plant, paint spray booths, gasoline storage tanks, paper shredder, sand blasting, wood working, and the ash silo. The permit was issued March 6, 1985 and does not include more recently constructed facilities for painting, sand blasting, sanding, and gasoline and diesel fuel tank vents.

The Sewage Treatment Plant, Industrial Waste Lagoons and two runoff discharges are permitted under the Kentucky Pollutant Discharge Elimination System (KPDES) Permit No. KY0020699, which became effective August 1, 1991 and expires July 31, 1996.

Radioactive materials are used for instrument calibration in Buildings 134 and 139 and are covered under three licenses. Radioactive byproduct materials are covered under License No. 16-05033-01, which expires September 30, 1993. Radioactive source materials are covered under License No. Sub-417, which expires January 31, 1993. Special nuclear materials are covered under License No. SNM-623, which expires on July 31, 1994.

6.1.4 Summary of Potential Chemical Release

Groundwater is the primary source media for chemicals at the LBAD to be evaluated in this report. Soil, surface water, and sediments may also be considered as primary chemical sources, but were evaluated separately in a previous report (USAEC 1994). Groundwater chemicals, in turn, may be transported into other environmental media via migration into seeps or surface water. Direct and indirect interconnections exist between each of the environmental media, such that chemicals in one media may serve as a source of future chemical release to another media (i.e., chemicals leaching from groundwater to soil etc.).

6.1.5 Summary of Groundwater Sampling Activities

Samples of environmental media have been obtained during Phase I and II of the RFI. During each phase, samples were collected to characterize the chemical concentrations in groundwater and tap water at the LBAD. It should be noted that the locations of samples were purposely selected to be representative of possible contamination. Historical information, visual observation, and screening techniques were employed during the RFI sampling phase to identify site locations where chemical releases may have occurred. The intent of sampling location selection was to characterize the maximum chemical concentrations at each SWMU/Area of Concern. Site-specific information was also considered (i.e., historical information, visual observation of site conditions, site size, potentially impacted media, possible migration pathways, etc.) to determine the appropriate sample locations and numbers for characterizing the nature and extent of chemical concentrations. Further evaluation of the nature and extent of chemicals at sites may be performed in the event that the maximum concentrations are associated with conditions requiring remediation based on the Corrective Measures Study (CMS) for the LBAD. Sampling performed to date was conducted in conformance with the Field Sampling Plan which was approved by U.S. EPA Region IV and KDEP. Appropriate QA/QC samples were also obtained for data validation purposes. Background samples were also obtained to provide a baseline for comparison of site-related conditions to typical environmental conditions for the region. Groundwater wells were sampled throughout the site for volatiles, semivolatiles, metals, pesticides, and PCBs. Background samples were located in areas which were considered to be upgradient of the Facility operations, or in areas which were expected to be unaffected by historical activities at the Facility.

6.1.6 Organization of the Baseline Risk Assessment

In addition to this Introductory section, the baseline risk assessment of the LBAD consists of the following Sections:

- Chemicals of Potential Concern,
- Exposure Assessment,
- Toxicity Assessment,
- Risk Characterization,

- Uncertainties in the Baseline Risk Assessment, and
- Summary and Conclusions.

The organization and content of each section is consistent with the guidance provided in the HHEM (U.S. EPA 1989a) and in U.S. EPA Region IV and KDEP Requirements for Risk Assessment (U.S. EPA, 1991a; KDEP, 1992). The final summary of risk and hazard results from the previously submitted RFI (U.S AEC 1994), added to the results of this report, are summarized in Appendix R.

6.2 CHEMICALS OF POTENTIAL CONCERN

The process of designating the chemicals of potential concern for the LBAD consisted of a detailed evaluation of the analytical data, an analysis of the sources of contamination and site characteristics, and a review of potential migration pathways. Chemicals of concern were selected through a process designed to identify the most frequently detected, toxic, mobile, and persistent chemicals in the groundwater at the LBAD. The methodologies used in this evaluation are consistent with those presented in the HHEM (U.S. EPA 1989a) and U.S. EPA guidance for data usability for risk assessments (U.S. EPA, 1992). The objective of this process was to:

- Identify the set of chemicals most likely to be site related; and
- Ensure that reported concentrations are of acceptable quality for use in quantitative risk assessment.

Chemicals which remained after this evaluation process were then considered in the qualitative and quantitative assessment of risks to human populations.

6.2.1 Data Selected for Risk Assessment

The groundwater risk assessment is limited to an evaluation of the data generated during the RFI (during Phase I and II sampling). During the RFI field activities, environmental media in 50 SWMUs or Areas of Concern were sampled. A listing of the SWMUs or Areas of Concern is provided in Table 6-1. Groundwater wells were installed throughout the base in order to evaluate potential groundwater contamination at these SWMUs. However, groundwater contamination was evaluated on an area-specific basis instead of a SWMU-specific basis. This approach was taken due to groundwater availability and groundwater migration. A SWMU-specific approach was not taken because of the somewhat erratic migration potential of groundwater in a karst environment such as that present in portions of LBAD. A karst environment is usually characterized by extensive subterranean drainage. Cracks and fissures in the underlying limestone can cause the groundwater to flow in unpredictable directions. A SWMU-specific approach would give minimal insight into potential future excess risk or hazard because of the difficulty in accurately predicting the extent of groundwater migration. Instead, the conservative approach of assessing the two large areas as individual areas of concern compiles data from all neighboring wells in order to assess the SWMUS as being interconnected. Therefore, groundwater migration and availability were considered in order to divide the site into a northern portion and southern portion.

The northern portion of LBAD is a relatively hydrologically undeveloped area with minimal limestone dissolution and limited groundwater availability. Of the 23 wells installed in the northern portion of LBAD, 12 were dry. In addition, another 5 wells did not produce enough water for sampling. In an attempt to find more groundwater, 2 of the 23 wells were installed at the interface of the soil and bedrock. This was an attempt to capture the water travelling along the interface. Although these wells (S001MW43I0 and S001MW44I0) were sampled, there was not enough groundwater available to meet the required purge volume for sampling. Given this lack of water in the higher elevated northern portion of the site, it is highly unlikely that residential wells will ever be installed in this area. However, the concentrations detected in the sampled wells will be quantitatively evaluated in the risk assessment to account for migration of groundwater to other areas.

The southern portion of LBAD is characterized by highly fractured bedrock, plentiful groundwater, and relatively unrestricted groundwater migration. As opposed to the northern portion, very few wells came up dry and most had adequate recharge for sampling in the southern portion. Since the southern portion of LBAD is much more hydrologically developed, groundwater availability is greater due to the more extensive dissolution of limestone. In addition, the northern portion is upgradient of the southern portion. The wells from these two areas were compiled into two separate data sets and evaluated independently. A list of groundwater wells and the associated groupings are provided below. In addition, Figure 6-3 displays the relative location of these wells.

Well ID	Data Grouping	Well Depth (ft)
A00CMW1009	Northern	50
S001MW1134	Northern	28.5
S001MW2300	Northern	43
S001MW23D0	Northern	88
S001MW43I0	Northern	13
S001MW44I0	Northern	15.8
A00BMW1123	Southern	37
B004MW4700	Southern	40
B004MW47D0	Southern	75
B018MW4800	Southern	38
B018MW48D0	Southern	73
S003MW1052	Southern	NA
S003MW4000	Southern	32
S003MW40D0	Southern	68
S003MW0600	Southern	35
S003MW6D00	Southern	72.5
S003MW1051	Southern	NA
S003MW1053	Southern	27
S003MW1600	Southern	23
S003MW3900	Southern	81.5
S003MW4100	Southern	26
S004MW0500	Southern	33
S004MW1900	Southern	32
S004MW19DD	Southern	68
S004MW4200	Southern	25.5
S004MW0200	Southern	43
S004MW0300	Southern	23
S004MW0400	Southern	29
S004MW4700	Southern	39
S2567MW080	Southern	31
S2567MW8D0	Southern	64
S2567MW090	Southern	69
S2567MW122	Southern	31
S2567MW124	Southern	15
S2567MW180	Southern	69
S2567MW18D	Southern	105
S2567MW320	Southern	54
S2567MW32D	Southern	89.5
S2567MW330	Southern	62.5
S2567MW450	Southern	42
S2567MW460	Southern	51
W008SW0176	Southern	75
W01WS01150	Southern	150
W09WS01150	Southern	53
FACLMW0700	Background	82
S2567MW070	Background	82

NA = Not Available

Summaries of the analytical results from Phase I and II sampling for the two groundwater areas are provided in Appendix K. These data, which served as the basis for selecting chemicals of interest for the risk assessment, are reported for site and background sampling locations.

Each of the chemical-specific results have associated laboratory QA/QC qualifiers. These qualifiers provide an indication of the reliability and validity of the results. Table 6-2 provides a listing of each of these qualifying codes, the definition of the codes, and the ultimate interpretation of the code with regard to the use of the associated chemical result in the risk assessment. Overall, "U" qualified data, indicating an unconfirmed analysis, were the only data not included in the risk analysis. In addition, the following assumptions were made in defining the data set to be further evaluated in the risk assessment:

FIELD DUPLICATE SAMPLES: If a sample has an associated duplicate sample, the maximum concentration for each analyte was used as the detected concentration for that sample. In cases where both of the duplicate samples were recorded as Less Than (LT), then one half of the highest detection limit (of the two samples) was used as the concentration for that sample.

TENTATIVELY IDENTIFIED COMPOUNDS (TICs): Compounds that were designated as being of unknown identity were not evaluated further as chemicals of potential concern in the quantitative risk assessment.

LT & NON DETECT (ND) VALUES: Any analyte determined to be less than (LT) the Certified Reporting Limit (CRL) in all samples associated with a given environmental media were not considered to be chemicals of potential concern for the environmental media. Any analyte with an ND value associated with it was not quantifiable. These values were not considered to have been positively detected on the site. Analyte results designated as LTs or NDs were regarded as not detected in the environmental media sampled.

ANALYTES FOUND BY MORE THAN ONE METHOD: In isolated cases where a particular compound was analyzed under more than one method for a given sample, the preferred analytical method was used. The preferred analytical method was selected based on an evaluation of which method most accurately analyzed the individual compound or type of compounds.

BLANK CONTAMINATION: The following procedures were followed for evaluating method blank contamination (samples qualified as "B"):

- Method blank data were compared to the associated field sample results by sampling phase.

- In instances where the maximum detected concentration for common laboratory contaminants was less than ten times the concentration detected in all associated blank samples, the analyte was considered to not be of concern for the site. For chemicals other than common laboratory contaminants that appeared in blank samples, the criterion was five times the concentration detected in all associated blank samples.

REANALYZED\RESAMPLED DATA: In any case where an analyte was reanalyzed as a result of an error with the original analysis, the reanalyzed result was substituted for the original data. In any case where an analyte was resampled in the absence of error associated with the original data, the resampled data was treated as independent data.

GREATER THAN (GT) VALUES: Any concentration assigned a GT value was detected above the laboratory maximum certified concentration. The value associated with the GT qualifier was used as the detected concentration.

6.2.2 Evaluation of Data Quality

The following guidelines were used in evaluating data and identifying chemicals of potential concern:

- All available groundwater data from Phase I and II of the RFI were compiled and sorted by location (Appendix K);

- The appropriateness of data for the purposes of the risk assessment was evaluated based on flagging codes (in accordance with U.S. EPA Guidance for Data Usability in Risk Assessment, U.S. EPA, 1992a; and the HHEM, U.S. EPA, 1989b). Qualified data were included or excluded from further evaluation in accordance with the guidance. Table 6-2 provides a summary of pertinent data qualifiers and their interpretation for use in the risk assessment. Since the data had been validated prior to risk evaluations, any confirmed analysis was used in the risk assessment.

- Site and background results were used to determine the arithmetic mean, 95 percent upper confidence limit (UCL), range of detected concentrations (minimum and maximum), and frequency of detection for each of the detected chemicals. The 95 percent UCL was only calculated for instances in which there were at least three groundwater samples (and a chemical was detected in at least one of the three or more samples). If less than three samples were collected for a constituent within an area, then the maximum detected chemical concentration was employed for use in the selection/evaluation of chemicals of potential concern, and a 95 percent UCL was not calculated. The data were log normalized and U.S. EPA guidelines for calculating the 95 percent UCL were followed (U.S. EPA, 1992b, the calculation of the 95 percent UCL is discussed further in Section 6.3.3.1 and in Appendix K.). In cases where duplicate samples were collected, the maximum concentration of the two samples was utilized as the sample concentration. It should be noted that use of U.S. EPA's methodology for calculating the concentration term (specifically using the H-statistic) can result in likely spuriously high 95 percent UCL values where small sample sizes occur.

In accordance with EPA guidance (U.S. EPA, 1989a), one half of the certified reporting limit was employed as the sample concentration for non-detect results for both site-specific and background results. The tables in Appendix K which provide media- and sample-specific results for each detected chemical also provide this summary information. These results are presented for both the LBAD-specific areas of potential concern, and background.

6.2.3 Selection of Chemicals of Potential Concern

Screening methods were then employed to further refine the list of chemicals to be carried through the risk assessment. The end result was the development of a set of chemicals of potential concern worthy of further study in the risk assessment.

The following steps were performed to select the chemicals of concern.

- The site was divided into northern and southern portions and the maximum concentration for each area was compiled in Table 6-3.

- Maximum chemical concentrations for metals detected on-site were compared to two times the associated arithmetic average background concentration as per U.S. EPA, Region IV Guidelines (U.S. EPA, 1991). This comparison is presented in Table 6-4. Chemical-specific MCLs were also added to this table to make sure that chemicals were not removed from further consideration based on background levels that were above MCLs. The site-specific 95 percent UCL or maximum detected concentrations (whichever value is lower) for both LBAD groundwater areas are presented in Appendix K. This appendix also presents the average and two times the average background concentrations for Facility-specific groundwater samples. Because many of the metals detected in groundwater are naturally occurring, concentrations of metals in site samples were compared with background levels to determine whether the detected levels were elevated above naturally occurring levels. Chemicals identified as not significantly greater than background (i.e., the maximum detected concentration was within two times the mean background value) were excluded from further evaluation. The resulting chemical-specific concentrations for chemicals above background concentrations is presented in Table 6-5.

- All organics detected in groundwater were retained for further evaluation.

- U.S. EPA guidelines for risk assessment allow for an evaluation of media-specific frequencies of detection. In any case where a given chemical is detected infrequently in a large dataset for a given medium, that chemical can potentially be noted as a candidate for exclusion. For example, if a chemical is detected in less than 5% of the samples in a particular medium from which at least 20 samples were obtained; and was not detected in any site-related samples from any other medium; the exposure potential would be considered to be low and the chemical would be considered as a candidate for elimination. However, as a conservative measure, chemicals were not rejected as chemicals of potential concern based solely on frequency of detection.

6.2.3.1 Chemicals Never Detected

A multitude of analyses were performed for the different SWMUs/Areas of Concern on-site. The sampling and analysis was performed with consideration of appropriate QA/QC procedures to obtain data which would be representative of the chemical concentrations in the environmental media. The data were collected in a manner that would characterize site conditions with an appropriate degree of confidence in the reliability and validity. Therefore, in cases where chemicals were never detected in a given data set (northern or southern), these chemicals were not evaluated further as chemicals of potential concern for that area.

6.2.3.2 Chemicals Detected at Least Once

The site and background data results were analyzed further to determine which chemicals were detected in at least one sample in each of the areas of potential concern. Such chemicals were considered to be "detected" and represented the initial list of chemicals of potential concern which could be examined further for inclusion in the risk assessment. Tables which provide the sample-specific results for chemicals detected at the LBAD are presented in Appendix K.

6.2.3.3 Essential Nutrients

Chemicals which are considered to be essential nutrients are typically toxic only at very high doses. As a conservative measure, chemicals which are considered to be essential nutrients (calcium, chromium, copper, iron, magnesium, manganese, potassium, selenium, sodium, and zinc) were retained as chemicals of potential concern. However, a comparison of the concentrations detected on-site to U.S. DA Recommended Daily Average intake (RDA) of the essential nutrients was performed in Appendix P. The results of the comparisons were utilized to evaluate the results of the Risk Characterization.

6.2.3.4 Chemicals of Concern

Based on the procedures just described, Table 6-5 presents the chemicals of concern for both LBAD groundwater areas. As described previously, the chemicals of concern in groundwater were selected with consideration of data qualifiers, frequency of detection, comparison to background concentrations, and essential nutrient status. Although no chemicals were removed from further evaluation based only on frequency of detection or essential nutrient status, these factors will be considered in the evaluation of chemicals of potential concern.

6.3 EXPOSURE ASSESSMENT

This section presents an assessment of exposures that are relevant for the LBAD and the surrounding area. It consists of an evaluation of exposure pathways, exposure routes, exposed populations, estimated concentrations of chemicals at exposure points, and estimated intakes of chemicals for exposed populations.

The site conceptual model presented in Figure 6-4 summarizes the processes by which site chemicals of potential concern may be expected to impact potentially exposed populations. Both the current land use for the LBAD area and possible future land use scenarios are considered. The text which follows explains in detail each step of the process.

6.3.1 Characterization of the Exposure Setting

The exposure assessment includes an examination of the physical setting of the LBAD as well as an identification of potential human receptors in the LBAD vicinity.

6.3.1.1 Physical Setting

The physical setting at the LBAD is further characterized by consideration of the site-specific and regional climate, topography, geology, and hydrogeology. Much of the detail presented in Section 3.0 is repeated in this section to facilitate review of the baseline risk assessment.

Climate

The climate of the LBAD area can generally be characterized as continental with a large diurnal temperature range. Average seasonal temperatures are 35° F for winter, 62° F for spring, 50° F for fall, and 74° F for summer. The prevailing wind direction is south throughout most of the year but changing to a southwesterly direction in February, March, April and July.

Average precipitation for the LBAD area is evenly distributed throughout winter, spring, and summer, with about 12 inches recorded for each of these seasons. The fall season averages about 8.5 inches. Average annual precipitation is 45.68 inches.

Soils, Site Topography, and Drainage

The soils at the LBAD are comprised of three types; made or urban land, alluvial soils along streams, and limestone and shale-derived upland soils.

Made land (Md) is a term that describes any area where more than 20 inches of clayey fill material has been placed as a cover over native soils. At the LBAD, areas of Md include either side of the unnamed tributary along Ware Road, and throughout the southern area of the property. Urban land is land where the top layers have been removed. These soils are reddish-brown, clayey, soil which is slowly to moderately permeable. Most of the southern section of the area, where building development has occurred, contains this soil type.

Alluvial soils include the Lindside, Melvin, and Newark. Lindside Silt Loam (Ld) has moderate permeability and high moisture-supplying capacity. Lindside soils occur along the northernmost reach of the unnamed tributary along Ware Road and along the tributary that follows Briar Hill Road. The Melvin silt loam (Mt) is very friable loam to silty clay loam. The poorly drained soil occurs in a small lobe beneath the golf course pond. The Newark silt loam (Ne) is poorly drained and is a very friable to non-friable silt loam. It grades into a silty clay at around 18 to 48 inches below the ground surface. The Ne is found along the unnamed tributary up-elevation of the made land along Ware Road and is a lobe along a tributary off Briar Hill Road.

The remaining upland soils formed from limestone and calcareous shale include the Loradale Series, the Lowell Series, the Maury Series and the Mercer Series. The Loradale, in the northern section of the site near Burma Road, is a dark brown, very friable silt loam that grades downward into a brown silty clay loam, friable to firm to a mottled yellowish-brown and pale-brown, very plastic clay.

The Lowell Series is located at the end of Burma Road and is characterized as well to moderately well-drained soils on gently rolling uplands. Some areas having this soil have been severely eroded and the surface soil mixed with subsoil within the upper six inches.

The Maury Series exists in the northern section of the site and is characterized by nearly level to strongly sloping, well-drained soils on uplands formed mostly in phosphatic limestone but partly in a mantle of silt. There are areas of eroded Maury silt loam in which some of the substrate has been worked into the upper 6 inches of the soil. These areas are located near the water tower and on the north side of the tributary that parallels the former airstrip.

The Mercer Series is a nearly level to sloping, deep, moderately well-drained soil with a fragipan consisting of Mercer silt loam and an eroded Mercer silt loam. Mercer silt loam begins as a very friable, dark grayish-brown soil which down grades to a yellowish-brown very plastic clay. This soil occurs along Briar Hill Road north of the main gate, in the vicinity of the Commanding Officer's quarters, and north of the former airstrip. The eroded Mercer silt loam occurs in the northernmost extent of the unnamed tributary along Ware Road.

Regional Geology

The site is located near the crest of the Cincinnati Arch, a broad, low structural feature whose long axis extends generally northward from Tennessee through central Kentucky and western Ohio into southern Michigan.

Flat-lying rocks of Ordovician age, consisting chiefly of alternating beds of limestone and shale underlie the LBAD Facility.

Site-Specific Geology

The beds of limestone and shale underlying the Facility belong to the Lexington Limestone. The Lexington Limestone includes four members; the upper tongue of the Tanglewood Limestone, the Millersburg Limestone, The Tanglewood Member, and the Grier Limestone Member. All members are exposed at the surface on LBAD property. The rocks underlying most of the site property consist of the Millersburg Limestone. Additional information on site geology can be found in Section 3.2.

Regional Hydrogeology

As discussed in Section 3.2, the LBAD Facility is in the east-central part of the Inner Bluegrass Karst Region. Several investigations of the Inner Bluegrass Karst Region showed that dissolution and well yield are greatest beneath topographically low areas. The depths of solutional openings and productive wells is limited to about 80 feet. Poorly soluble units such as argillaceous limestone and shale, inhibit the development of solutional openings in rocks that underlie them.

Several studies have reported that the direction of groundwater flow was controlled by the topography and the dip of the rocks. It was also discovered that well yield is related to both topography and stratigraphy.

About 50 groundwater basins with areas up to 5.8 square miles have been identified. Within the basins, groundwater flow occurs within a dendritic conduit system reaching depths of about 100 feet. In interbasin areas, some conduits have breached poorly permeable beds and water may descend almost vertically to deeper conduits. However, evidence shows that the groundwater flow system at LBAD does not have large conduits and the water table generally replicates the surface water drainage. Groundwater discharges locally into streams and there appears to be little or no interbasin movement of water.

Site-Specific Hydrogeology

Groundwater is encountered at the bedrock/regolith interface or in the fractured section just below this interface. Three hydrologic zones exist at the LBAD. An upper bedrock zone was identified above 990 feet elevation and was described as relatively transmissive and unconsolidated. The middle bedrock zone is between 990 and 940 feet, and described as less transmissive and relatively tight. The lower bedrock zone is very transmissive and capable of yields of several hundred gallons per minute.

Evidence supports the existence of a groundwater divide in the area of the New Landfill. Groundwater as well as surface water on the north side of the divide flows north to Hutchinson Creek. Water on the south side of the divide flows south to a tributary of Elkhorn Creek. A surface water and groundwater divide exists in the middle of the Facility, running northeast to southwest. The water on the northwest side of the divide moves toward a relatively small tributary. Water to the southeast side of the divide flows directly into a larger tributary which flows into Elkhorn Creek. The potentiometric surface conforms to topography with steeper gradients near the divide, and lower gradients near the streams.

Groundwater discharge is into the local stream system and may occur in areas where the streams intersect solutional openings in the rocks.

Most of the streams are intermittent and flow only during and shortly after precipitation occurs. The larger streams at the Facility, into which the smaller streams drain, are believed to be perennial. For a more detailed description of site-specific hydrogeology, refer to Section 3.6.

6.3.1.2 Potentially Exposed Human Populations

Human receptors exist in the vicinity of the LBAD Facility. Area residents live near the LBAD; work on the LBAD; and have access to visit or trespass on the LBAD premises. Thus, these potential receptors may be subject to exposure to site-related chemicals of potential concern via contact with contaminated surface water, sediment, soil, ambient air, or wildlife. These potential exposures are summarized in conjunction with the results of this groundwater report in Appendix R. The general land use, demography, and groundwater use are described as follows to further characterize these potentially exposed human receptors.

Land Use

According to available zoning information, the LBAD Facility premises are designated for light industrial and general rural land uses (see Figure 6-2). The LBAD Facility is zoned primarily as general rural except for the south/southwest section which is zoned light industrial. The surrounding land use is primarily zoned general rural with some heavy industrial, light industrial, and retail trade. Currently, the northern portion of the site is utilized by the Kentucky National Guard for maneuver training. National Guard activities are planned for future use of the site, also. In addition, government subcontractors currently utilize the portions of the LBAD site for light manufacturing.

Demography

According to the 1990 U.S. Census, 8,276 people reside in the area surrounding the LBAD. As of October 6, 1994 there were 700 people employed at the LBAD as civilians or military personnel as manufacturing workers or office staff.

Groundwater Use

Potable water for the LBAD is supplied by the Kentucky-American Water Company. The Kentucky-American Water Company receives 75 percent of its water from the Kentucky River at the Kentucky River Station located off Evans Mill Road, 12 miles southeast of downtown Lexington. The other 25 percent of its water source is supplied from Jacobsen Reservoir at the Richmond Road Station located a little east of the Kentucky River Station.

There are four water supply wells located near the southern boundary of the base which have been used as a backup water supply in the past. The four wells are capable of providing a combined total of 800 gallons per minute. Three of the four wells were accessible for sampling during the groundwater investigation of the southern portion of the LBAD site. Results of the sampling and analysis for the three wells (W008WS0176, W01WSO1150, and W09WS01150) are provided in Appendix K. Chemicals detected were primarily naturally occurring inorganics, benzene (detected below Kentucky Domestic Water Criterion), and DDT (detected above Kentucky Domestic Water Criterion).

The main water-bearing formation in the area of the LBAD facility is the Lexington Limestone Formation. A drainage divide exists along the northern edge of the facility. On the north side of this divide, groundwater flow is in a northerly direction toward tributaries of Hutchison Creek. On the south side of the divide, groundwater flows to any of several intermittent tributaries of North Elkhorn Creek. The tributaries are not suitable for swimming or fishing because of the intermittent behavior, but do provide habitats for certain aquatic plants and animal species.

Potable water for the majority of the surrounding area, within a one mile radius, is also serviced by the Kentucky-American Water Company. In June of 1994, Sverdrup Environmental, Inc. (SVE) conducted a door-to-door well survey within a one mile radius of LBAD (refer to Appendix I). Information concerning potable water source was obtained from 112 residences out of a total of 120 residences. Information could not be obtained from eight of the residences due to no response from the resident or no occupancy at the location. The Kentucky-American Water Company was the source of water for 108 of the 112 residences. The other four residences are supplied through cisterns.

Twenty residents reported having wells on their property. Four of the twenty residents have wells that are active. There are a total of five active wells, three of which supply water to livestock, one supplies water to a geothermal heating system, and one supplies water to a batching operation.

In addition, SVE conducted a water usage search within a four mile radius of LBAD based on water supply maps provided by the Kentucky-American Water Company and the Boonesborough Water Association (BWA). Based on a review of the available maps and conversations with Kentucky-American Water Company and BWA, it was determined that wells or springs are not used as potable water sources within the four mile radius.

6.3.2 Identification of Exposure Pathways

Exposure pathway assumptions for hazardous waste sites vary on a site-by-site basis, according to conditions which are known to exist in the vicinity of the site. The scenarios herein described have been developed to characterize population activities specific to the LBAD which may lead to exposures to site-related chemicals of potential concern. Although the scenarios are intended to portray the maximally exposed human receptors, emphasis is placed on selecting exposure assumptions which are reasonable, and physically and conceptually feasible.

6.3.2.1 Areas of Contamination

As described in Section 6.1.2.2, the areas of potential contamination have been divided into two distinctly different groundwater areas referred to as the northern and southern portions of LBAD. Table 6-1 lists the various SWMUs/Areas of Concern associated with each designated groundwater area. The wells on site were installed to investigate potential migration from these SWMUs/Areas of Concern into groundwater.

6.3.2.2 Chemical Fate and Transport

The sources of chemical release for the LBAD are described in Section 6.3 of this report. This section presents a thorough evaluation of how the chemicals present in these sources may be released to the environment and transported to a point where they could potentially impact a given population group. The evaluation of a chemical release and transport mechanism here does not necessarily mean that a complete exposure pathway related to that mechanism exists. This is, rather, an intermediate step in the determination of the complete exposure pathways for the LBAD.

The chemicals of potential concern in groundwater include volatile organic compounds, semivolatile organic compounds, and metals. As can be seen in the site conceptual model (Figure 6-4), these chemicals may be released to surface water through groundwater recharge to seeps, creeks, streams, etc.

6.3.2.3 Human Activity Patterns

Exposure pathways describe the movement of chemicals from sources to locations (exposure points) where exposed populations (receptors) come in contact with the chemicals. This movement usually involves release of chemicals from the source to an intermediate environmental transport medium between source and receptor point. Exposure routes describe the modes of contact with, and intake of, environmental media and chemicals at exposure points. The first two elements of an exposure pathway have been addressed previously and in other sections of this report. The following discussion focuses on an evaluation of exposure points and routes of exposure, so that the determination can be made as to what, if any, pathways of exposure exist.

6.3.2.4 Exposure Points

Exposure points are the environmental media which serve as the potential vehicle for contact between site-related chemicals and receptors. Since groundwater is the only medium evaluated in this report, exposure to groundwater used for domestic purposes is the only point of exposure.

6.3.2.5 Potentially Complete Exposure Pathways

In order for an exposure pathway to be considered complete, three factors must be present simultaneously. Namely, there must be a source or release of chemicals; a receptor; and a transport vehicle or mechanism by which the receptor can be exposed to the chemical. The description of exposure pathways possible for the LBAD SWMUs and Areas of Concern is organized by current and future land use considerations. The site conceptual model in Figure 6-4 provides a presentation of the matrix of potential routes of exposure which were considered in evaluating the LBAD. This evaluation of exposure pathways is based on the groundwater data collected during Phase I and II of the RFI.

A detailed accounting of the methods, equations, and parameter values utilized in the calculation of exposure estimates for existing and future human receptor populations is provided in Appendix P. The determination of the potential exposures associated with chemicals of potential concern in groundwater at the LBAD Facility was performed on an area-specific basis. Potentially exposed populations and exposure routes were determined based on the future use designation of that particular area. Because of the large area encompassed by the LBAD, each SWMU and Area of Concern was evaluated as an individual exposure area for media other than groundwater. However, groundwater exposure was analyzed independent of these smaller areas. Therefore, while groundwater risk/hazard results are associated with either the northern or southern portion of LBAD, the other media have risk/hazard results associated with an individual SWMU. Finally, the area-specific risk/hazard results are added to the results of the smaller areas within the main larger areas in order to derive risk/hazard values with all media included. The compilation of results from this groundwater report and the previous RFI (U.S. AEC, 1994) have been presented in Appendix R in order to assess potential risks and hazards across all media. The types of activities performed previously in the different facility areas have varied historically across the site. Such variety in potential site land uses will likely continue into the future (based on the presence of existing buildings, the golf course, etc.). This approach also allows for the quantification of area-specific exposures, hazards, and risks which can be addressed individually if remedial measures are required.

Existing Human Receptor Population Exposures

Figures 6-2 and 6-5 show the land use categories/zoning designations for the LBAD. Two primary land use designations exist for the LBAD, namely light industrial and general rural. Site activities are currently consistent or were historically consistent with commercial/occupational or residential/recreational open space use. The LBAD is scheduled for closure in 1995. The worker population on-site is decreasing in anticipation of the closure activities. There are some base personnel who live on-site. However, groundwater exposure for existing occupational and residential receptors is assumed not to occur. Potable water for the LBAD is supplied by the Kentucky-American Water Company. On-site water supply wells, if used, function as a water source for the steam heating system. Currently there are 4 wells; one has a broken pump; two are connected but the pipe is broken; and the last one is operating, but not in use. Existing exposure to groundwater will not be included as a pathway of concern.

At present, Avon community residences are located on the southeast boundary of the LBAD. However, these homes are not located directly in or on areas which have been identified as contaminated or known to have been subjected to past site dumping activities. Therefore, these existing receptor populations must enter into the immediate vicinity of the contaminated areas during such activities as working, trespassing, or other activities which involve visits to the LBAD. As with the existing on-site LBAD residents, the off-site residents' exposure to groundwater at LBAD would be non-existent.

Future Use/Residential Human Receptor Population Exposures

The land use designations for the LBAD premises are presented in Figures 6-2 and 6-5. The current land use categories for the sites are light industrial and general rural. It is expected that the future land use at the LBAD will follow a similar trend. As noted in Section 6.3.1.2, the redevelopment plan for the LBAD indicates that areas currently zoned for general rural use are proposed to be utilized for a regional park, while an industrial park is planned for the LBAD areas zoned for industrial use.

Exposure scenarios for the areas zoned general rural could include farming or residential development. Although such areas are proposed for the development of a regional park, the hypothetical residential scenario provides a conservative approach to evaluating potential future receptor exposures in the vicinity. Because the areas zoned for general land use are not currently developed with existing structures and buildings, the possibility exists that the area could be utilized for residential purposes. The exposure scenarios for the area zoned light industry would most likely be limited to occupational exposures. In the unlikely event that future land use plans for the currently light-industrial area would be changed to incorporate a residential development, many changes would need to be made. The light industrial areas are characterized by a number of pre-existing buildings and structures which would serve as possible obstacles (necessitating costly removal or demolition) for other land uses such as residential or agricultural use. In addition, zoning in the light-industrial area would have to be changed to a classification similar to the surrounding "general rural" classification. However, as a conservative measure, a hypothetical future residential scenario will be evaluated for both groundwater areas, regardless of current zoning and property use. In addition, the more reasonable future occupational scenario will also be included for both groundwater areas. The future use scenario assumes that no remedial action will be implemented at the site.

Residential Scenario

Residential exposure to groundwater will occur in the future if groundwater wells are installed and utilized as water supply sources. The routes of exposure under this scenario would be ingestion, inhalation of vapors while showering, and dermal contact while showering. It is assumed that the residential exposure to groundwater would be the same for a farming family.

The receptors examined under the future residential development scenario are adults and children. It is assumed as a conservative measure that these receptors will reside directly on-site and derive their drinking water from a groundwater well installed on-site. However, the likelihood of future residential water supply wells being installed on site is minimal since public water supply is readily available to the area. In addition, the amount of available groundwater in the northern section of the site would be insufficient to support a residential well.

The potential exposure to receptors is examined from the perspective of a future resident who lives on-site for a total of 30 years. Adult and child subchronic exposures for a five-year exposure period were also evaluated. The exposure assumptions will be made that each of these receptors will shower once each day for 350 days each year. Assuming 350 days/year accounts for approximately two weeks spent away from the residence each year. In addition, it is assumed that an adult will ingest two liters of water each day for the same time period, and a child will ingest one liter each day.

Occupational Scenario

Even in a very conservative scenario, future occupational exposure to groundwater would be limited to ingestion. As a more likely alternative scenario to the residential scenario, this occupational exposure route was evaluated for both the northern and southern portions of the site. The primary receptor examined under the future commercial use scenario is an on-site adult worker aged 18 years or older. As with the future residential scenario, groundwater exposures in the occupational scenario are not likely to occur in association with on site groundwater use. The LBAD facility is supplied with potable water from the Kentucky-American Water Company. The four water supply wells located on the base are used as a backup water supply for steam heating the facility. It is most likely that any future drinking water used at this facility would continue to be supplied from off site. However, as a conservative measure, on site groundwater use will be evaluated for a 25 year long term and a 5 year short term worker ingesting one liter per day for 250 days/year.

6.3.2.6 Summary of Pathways Selected for Quantification

The following pathways were evaluated quantitatively in the baseline risk assessment:

- Ingestion of groundwater.
- Inhalation of groundwater while showering, residential scenario only.
- Dermal contact with groundwater while showering, residential scenario only.

As indicated in the site conceptual model in Figure 6-4 the primary exposure pathways for existing and hypothetical future receptors at the LBAD also include other potential pathways such as: ingestion of different farm animals and produce; ingestion of, inhalation of, and dermal contact with chemicals in soils; dermal contact with sediment and surface water; and ingestion of wildlife (such as deer, rabbits, etc.). The evaluation of environmental media other than groundwater-related exposures were evaluated quantitatively in the baseline risk assessment submitted as part of the RFI dated April of 1994. Therefore, the groundwater is being evaluated as a separate operable unit in this report.

6.3.3 Quantification of Exposure

Estimates of exposure levels for each contaminant are required for quantitative risk characterization. The basic equation used to calculate human intake of an environmental contaminant is:

$$DI = C \times HIF$$

where:

DI = daily intake (mg of chemical per kg of body weight per day)
C = concentration of the chemical
HIF = human intake factor (units of medium per kg body weight per day)

Each intake variable in the above equation has a range of values. For Superfund exposure assessments, intake variable values for a given pathway are to be selected so that the combination of all intake variables result in an estimate of the reasonable maximum exposure (RME) for that pathway (U.S. EPA 1989a). The RME is defined as the maximum exposure that is reasonably expected to occur at or near a site. This section of the risk assessment presents a discussion of the determination of the two key variables just described, the exposure concentration and the human intake factors.

6.3.3.1 Calculation of Exposure Point Concentrations

The concentration term in the intake equation generally utilizes the arithmetic average of the concentration that is contacted over the exposure period. Because of the uncertainty associated with any estimate of exposure concentrations, the upper confidence limit [i.e., the 95 percent upper confidence limit (UCL)] or the maximum media-specific chemical concentration (whichever is lower) was used for this variable. Exposure point concentrations were derived using the methodology outlined in the U.S. EPA's HHEM, Supplemental Region IV Risk Assessment Guidance, and U.S. EPA's "Supplemental Guidance to RAGs: Calculating the Concentration Term" (U.S. EPA, 1989a; U.S. EPA, 1989b; U.S. EPA, 1992a). A description of the calculations utilized is provided in Appendix K. Standard statistical methods were used to calculate the upper confidence limit on the arithmetic mean. A log normal distribution was assumed for the data for the LBAD groundwater areas, with the exception of chemicals where only two data points were available. The maximum concentration detected was assumed to be the exposure point concentration when only two data values were available for a particular chemical. Chemical-specific exposure concentrations utilized in the risk assessment for quantification of exposure are provided in Table 6-5.

6.3.3.2 Calculation of Human Intake Factors

Derivation of human intake factors (HIFs) involves consideration of U.S. EPA guidance and an evaluation of site specific factors which influence human exposures. The major U.S. EPA guidance documents that provide information for deriving HIFs include the HHEM and HHEM supplement (U.S. EPA, 1989b; 1991a), the Superfund Exposure Assessment Manual (SEAM) (U.S. EPA, 1988b) and the Exposure Factors Handbook (EFH) (U.S. EPA, 1989c). The HHEM summarizes much of the information provided by the SEAM and the EFH and was used as the primary source for information used to derive HIFs for the LBAD risk assessment.

An important component of each HIF term is the average exposure time (AET), which gives the average time per day that exposure occurs, taking into consideration any necessary adjustments for less than continuous exposure. In general, this adjustment is described as follows:

The exposure duration is the number of years a person is exposed. The appropriate averaging time for use in this expression depends upon the length of time required for an adverse health effect to occur. The averaging time is assumed to be a lifetime (70 years) for exposures to chemicals associated with carcinogenic effects. An averaging time equal to the exposure duration is assumed for chronic exposure to noncarcinogens, as per HHEM and HHEM supplemental guidance (U.S. EPA, 1989a; 1991).

The exposure frequency term describes the fraction of the exposure duration during which exposure activity occurs. This may depend both on the nature of the activity (i.e., hours/day, days/week or weeks/year spent in an activity), and on seasonal variations that influence the source and potential exposure to the source. Other terms in the derivation of HIF values depend on the specific exposure routes being considered. The derivation of HIF values for each of these exposure scenarios is detailed in Appendix L. Exposure, frequencies, and durations for the existing and potential receptor populations will be defined for each exposure scenario to be evaluated quantitatively in the risk assessment.

6.3.3.3 Calculation of Average Daily Intake (DI)

As indicated above, the calculation of the average DI involves the multiplication of the media-specific chemical concentration by the HIF. The resulting DI provides an indication of the potential daily intake averaged over a lifetime (i.e., 70 years) for carcinogenic effects or an exposure period for noncarcinogenic effects. The DI then represents an estimate of the average daily exposure which may be associated with the distribution of the media-specific chemical concentrations detected at the LBAD.

6.3.3.4 Estimation of Lead Exposure

Lead exposure is typically measured by blood lead levels (μg lead/deciliter (dl) blood) in the scientific literature. Blood concentrations are associated with clinical signs of toxicity. Similarly lead exposure levels noted to be associated with toxic endpoints are reported in terms of blood lead levels. The U.S. EPA has developed a biokinetic uptake model for the personal computer which can be used to estimate blood lead levels in children from 0 to 84 months old (U.S. EPA, 1991e). Site-specific information (eg. site-specific lead concentrations in soil, air, house dust, and drinking water) can be incorporated into the model in addition to well documented default settings. The lead biokinetic uptake model was used to estimate the lead exposure which may be experienced by a child under existing and future residential scenarios. The parameter assumptions and results of the model are presented in Appendix M. In addition, as per KDEP's internal risk assessment guidance, lead was also evaluated using standard risk assessment exposure calculations.

6.4 TOXICITY ASSESSMENT

The toxicity assessment provides information relevant to the toxic potential of the chemicals of potential concern. These data are derived from laboratory research studies. U.S. EPA evaluates chemical-specific toxicity data to derive appropriate toxicity criteria or guidelines for the protection of human health. Toxicity factors have been derived for carcinogenic and noncarcinogenic (chronic and subchronic) endpoints.

6.4.1 Health Effects Criteria Classification and Criteria Development

A summary of the critical toxic effects associated with the chemicals of potential concern at the LBAD are provided in Table 6-6. The table was developed based on the U.S. EPA's Integrated Risk Information System (IRIS, 1994) and Health Effects Summary Tables (HEAST, 1994) databases. It is intended the summary will provide a general indication of the toxicity information which has been considered for the preparation of reference dose (RfD) values and cancer slope factors (SF) used in health effects/risk assessments. RfDs are chemical exposure levels which are expected to be without adverse health consequences over a lifetime of daily exposure. The cancer slope factors or unit risk estimates are characterized as upper-bound estimates. The true risk to humans, while not identifiable, is not likely to exceed the upper-bound estimate and in fact may be lower. U.S. EPA cancer classifications represent weight-of-evidence judgments of the likelihood that a chemical is a human or animal carcinogen. These toxicity data and recommended exposure estimates are subject to uncertainties and limitations. In many cases, recommended human exposure levels were extrapolated from animal effects data. In addition, when toxicity information was not available for all exposure routes, data from ingestion studies were used by U.S. EPA to derive an inhalation RfD or cancer slope factor, and vice versa (HEAST, 1994).

6.4.2 Health Effects Criteria for the Chemicals of Potential Concern

The toxicity values recommended by U.S. EPA for assessing the risks/hazards of oral, inhalation, and dermal exposure to the chemicals of potential concern are provided in Table 6-7. Dermal toxicity is assessed by utilizing oral toxicity values which have been adjusted for absorption efficiency. Appendix N provides a description of the sources utilized to determine the chemical-specific oral absorption factors required for deriving adjusted toxicity values for dermal exposure. These toxicity summary tables were developed primarily from the U.S. EPA's IRIS, and the HEAST bases (IRIS, 1994; HEAST, 1993). The IRIS toxicity printouts for the chemicals of concern are provided in Appendix Q.

According to the U.S. EPA's HHEM (U.S. EPA, 1989a), exposures to chemicals with noncarcinogenic effects are considered to be chronic if the exposure duration exceeds seven years or subchronic if the exposure duration is less than seven years. Subchronic RfDs for noncarcinogens should be used in the subchronic exposure and hazard calculations for chemicals with noncancer effects. However, per U.S. EPA Region IV Risk Assessment guidance, chronic toxicity values were used for the subchronic childhood exposure duration.

The potential toxicity of lead concentrations detected on-site was evaluated by two methods. The first method involved comparing blood lead levels predicted by the U.S. EPA lead biokinetic/uptake model (Appendix M) to the Center for Disease Control's recommendation that conditions associated with blood lead levels of 10 to 15 μg lead/dl blood be avoided as concentrations at this level may result in toxic effects. (ATSDR, 1988). The 10 to 15 μg lead/dl blood is considered to be a range within which adverse effects such as neurotoxicity can occur in young children. The Center for Disease Control (CDC) issued a revised statement on Childhood Lead Poisoning in 1991 (CDC, 1991). This statement identified a hierarchy of child blood lead levels and associated clinical and community actions. Child blood lead concentrations of 10 μg/dL should trigger community concern as to potential sources of exposure. Lead levels from 15-20 μg/dL may signal undue exposure and should stimulate appropriate community action. Children with blood levels between 20 and 49 μg/dL should be medically evaluated for appropriate intervention, and levels of over 49 μg/dL should be considered a medical Emergency. No distinction in the ranges have been made between children and adults for blood lead levels by U.S. EPA or for the purposes of the risk assessment. The second evaluation of lead was performed per KDEP internal risk assessment guidance (KDEP, 1994), where the toxicity values for lead reported in the U.S. EPA's 1986 HEAST were employed to evaluate lead using methods outlined in the U.S. EPA's HHEM (U.S. EPA, 1989a).

It should be noted that the U.S. EPA has not developed References Doses for inorganic lead. However, use of the previously reported 1986 HEAST values was recommended as appropriate by KDEP.

6.5 RISK CHARACTERIZATION

The risk characterization serves to provide a comparison of the exposure concentrations estimated in the exposure assessment and applicable toxicological or dose-response data developed in the toxicity assessment. The outcome of this comparison is used to determine whether the chemical concentrations detected in groundwater at the LBAD may be associated with adverse effects on the health of humans potentially exposed to site-related chemicals.

The risk characterization requires that the potential toxic effects associated with exposures to each of the chemicals of potential concern be combined across environmental media and exposure pathways. The feasibility of combining hazards and risks across exposure pathways involves a conceptualization of the potential activities which an individual receptor might reasonably engage in over the identified existing and future exposure periods. As described in the exposure assessment (Section 6.3), it is reasonable to assume that the existing and future adult and child receptors could be exposed to the chemicals of concern through direct contact or exposure to site soils, dusts/vapors, groundwater surface water, sediments, or fish. Thus, it is indeed reasonable to combine the hazards and risks across environmental media and exposure pathways. However, the focus of this report is to characterize the risks associated with groundwater. Therefore, groundwater-specific results have been evaluated separately from the other media. In addition, risk and hazard results across all evaluated media have also been presented in Appendix R.

The potential noncarcinogenic hazards and carcinogenic risks were evaluated quantitatively by comparing exposure estimates to toxicity values for all of the chemicals of concern. The U.S. EPA has not developed or approved reference dose or cancer slope factor values for lead. However, lead concentrations were evaluated using toxicity values published in the 1986 HEAST (per KDEP internal risk assessment guidelines) and using the U.S. EPA's lead biokinetic/uptake model described in Section 6.4 in conjunction with the toxicologic information for lead presented in the toxicity assessment (Section 6.5, Appendix M). The results of the uptake/biokinetic model risk characterization for the lead levels detected at the LBAD are described in this section in addition to the results of the risk characterization for the noncarcinogenic hazards and carcinogenic risks for the other chemicals of concern.

Evaluation of Noncarcinogenic Hazards

The risk of adverse noncarcinogenic effects from chemical exposure is expressed in terms of the Hazard Quotient (HQ). The HQ is the ratio of the estimated dose which a human receives to the estimated dose level believed to be safe, the RfD (as discussed in Section 6.5). This is calculated as follows:

$$HQ = DI/RfD$$

Where:

HQ = Hazard Quotient for Exposure
DI = Daily Intake
RfD = Reference Dose

Chemical-specific HQs are summed for environmental media and exposure pathways to derive the total Hazard Index (HI).

If the HI value is less than 1.0, it is believed the potential for noncarcinogenic injury is low. If the HI exceeds 1.0, some risk of noncarcinogenic effects may exist. However, because most RfD values are derived in a conservative fashion, an HI value greater than 1.0 does not imply that an adverse effect will necessarily occur. The evaluation of noncarcinogenic risks presented here is based on short-term (subchronic) exposure to the chemicals of potential concern. Subchronic hazards were evaluated in the case of future receptors exposed for less than seven years.

The available RfD values for the chemicals of potential concern are presented in Table 6-7. Using the previous equation, the DI values presented in Appendix O, and the RfD values presented in Table 6-7, an HI for each of the exposures considered in this risk assessment was calculated for each chemical of potential concern associated with that pathway. The results of these calculations are summarized in Tables 6-9 and 6-10. Detailed hazard calculations are also provided in Appendix O.

Evaluation of Carcinogenic Risks

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed for his or her entire lifetime will develop cancer. This value is calculated by multiplying the average daily intake over a lifetime (the CDI) by the CSF for the chemical:

$$\text{Cancer Risk} = 1 - \exp(-\text{CDI} \times \text{CSF})$$

In most cases (except when the product of CDI x CSF is larger than about 0.01), cancer risk may be estimated more simply as:

$$\text{Cancer Risk} = \text{CDI} \times \text{CSF}$$

Risk estimates are presented as excess cancer risk per unit of population. For example, a risk estimate of 1E-04 is equivalent to one excess occurrence of cancer per 10,000 individuals in a given population. Using the above equation and employing the DI values previously calculated (Appendix O), along with the CSF values (Table 6-7), cancer risks were calculated for chronic (lifetime) exposures which may occur at the LBAD. A summary of the results are presented in Tables 6-9 and 6-10. Detailed risk calculations are also provided in Appendix O.

It is important to note that the total carcinogenic risk estimates for each exposure pathway presented in Tables 6-9 and 6-10 represent the summation of the individual carcinogenic risk estimates calculated for each potentially carcinogenic chemical of concern. A total cancer risk for each of the LBAD SWMUs and Areas of Concern (determined by summing all of the individual pathway risks) is also presented.

The U.S. EPA has set risks on the order of 1.0E-04 to 1.0E-06 as the target range for acceptable risks at Superfund Sites and RCRA Hazardous Waste Management Facilities (U.S. EPA, 1991d; U.S. EPA, 1990a). According to OSWER Directive 9355.0-30 (April 22, 1991), the total site risk to an individual should not exceed 1.0E-04 for lifetime excess cancer risk. KDEP internal risk assessment guidelines recommend 1E-06 as the criterion risk level.

6.5.1 Potential Hazards and Risks Estimated for SWMUS and Areas of Concern

An overall summary of the results of the noncancer hazard and carcinogenic risk results for each of the SWMUs and Areas of concern evaluated quantitatively in the human health risk assessment is provided in Table 6-11.

6.5.1.1 Risk Characterization Results for the Northern Portion of LBAD

The Northern portion of LBAD was evaluated for hypothetical future residential and occupational exposure pathways. Long and short term potential adult and child exposures were evaluated for the residential scenario, and the occupational scenario was evaluated for long and short term adult exposure.

With respect to noncarcinogenic effects, the noncancer hazard was above unity for hypothetical future residential short- and long-term adult (hazard index of 16.6 and 63.1, respectively) and child (hazard index of 35.9) exposures. Potential ingestion of lead, manganese, sodium and thallium provided the primary contribution to the total hazard for the adult exposures. Ingestion of arsenic, lead, manganese and thallium were associated with the total hazard for the child exposures. Ingestion of manganese and thallium provided the majority of the hazard of 5.74 and 19.0 for the occupational short and long term receptors, respectively.

Arsenic and beryllium detected in groundwater were associated with carcinogenic risks on the order of 7E-05, 3E-04, and 2E-04 for future hypothetical residential short-term adult, long-term adult, and child exposures, respectively. The primary pathway contributing to the total risk was ingestion. However, dermal contact with beryllium in groundwater also contributed to a route-specific risk level for the adult long-term and child short-term exposures. Arsenic and beryllium were associated with the short and long term occupational ingestion risk levels of 3E-5 and 9E-5, respectively.

6.5.1.2 Risk Characterization Results for the Southern Portion of LBAD

The southern portion of LBAD was also evaluated for hypothetical future residential and occupational exposure pathways. Long and short term potential adult and child exposures were evaluated for the residential scenario and the occupational scenario was evaluated for long and short term adult exposure.

With respect to noncarcinogenic effects, the noncancer hazard was above unity for hypothetical future residential short- and long-term adult (hazard index of 56.1 and 86.0, respectively) and child (hazard index of 121) exposures. Potential ingestion of antimony, aluminum, manganese, and thallium and dermal contact with manganese provided the primary contribution to the total hazard for the adult exposures. Potential ingestion of antimony, lead, manganese, and thallium and dermal contact with manganese were associated with the total hazard for the child exposures. Ingestion of antimony, manganese, and thallium was the main contributor to the hazard levels of 19.3 and 29.8 for the short and long term occupational scenarios, respectively.

Vinyl chloride, beryllium and arsenic detected in groundwater were associated with carcinogenic risks on the order of 1E-04, 6E-04 and 3E-04 for future hypothetical residential short-term adult, long-term adult, and child exposures, respectively. The primary pathways contributing to the total northern portion risks were ingestion, followed by dermal contact and inhalation of chemicals in air. Ingestion of arsenic and beryllium in groundwater contributed the majority of the excess risk associated with occupational short and long term risk levels of 5E-5 and 2E-4, respectively.

These groundwater risk and hazard results were subsequently compiled with results from the other media described in the April 1994 RFI. In order to derive a SWMU-specific total risk/hazard value, this compilation is presented in Appendix R. The calculations in this appendix combine the area-specific groundwater results with each of the SWMUs associated with that area. This approach helps to derive exposure values based on the hydrology of the site, while addressing, on a SWMU-specific basis, media that could or already have impacted the groundwater.

6.5.2 Uptake/Biokinetic Model Risk Characterization for Lead

The lead biokinetic/uptake model (U.S. EPA, 1991) provides an estimate of blood lead levels which would be expected to occur in association with media-specific chemical concentrations. A description of the model, parameter values utilized in the model, and results of the model calculations are described in Appendix M. The lead biokinetic model provides an estimate of a child's total lead uptake from diet, ambient air (indoor/outdoor), drinking water, and soil. The model is then employed to predict blood lead levels (μg lead/dl) based upon the total lead uptake across all media. The model provides blood lead level estimates specific to the child receptor (aged zero to six years). Site-specific information can be included in the model to reflect conditions relative to lead levels in the soil, groundwater, and air identified at the LBAD. Otherwise, default values were utilized in the model. For the northern and southern portions of LBAD, site-specific lead levels in groundwater were used as parameter values in the model. Blood lead levels of 10-15 μg/dl are considered to constitute a criterion or "cause for concern range" as levels at which toxic effects might occur in children (U.S. EPA, 1988; U.S. EPA, 1991e). However, 10μg/dl will be considered the criterion blood level that will constitute a cause for concern for exposure to lead in children.

As described in Appendix M, the U.S. EPA Biokinetic Uptake Model was employed to evaluate the groundwater for the northern and southern portions of the facility. Use of the model indicated that the criterion value of 10 μg/dl blood lead level in more than five percent of the population was exceeded in the northern and southern portions of LBAD. It should be noted that the biokinetic uptake model calculates blood lead levels for children aged zero to six years of age. The potential exposure and the relative sensitivity to the toxicity of lead will likely be lower for the adult receptor compared to a residential child receptor. Similarly, the potential for exposure and the relative sensitivity to the toxicity of lead will likely be lower for the adult worker compared to a residential child receptor. The model was also run on a SWMU-specific basis for SWMUs that had soil lead concentrations above background.

This SWMU-specific analysis was done using lead concentrations in groundwater, soil, and modelled air concentrations. This analysis is presented in Appendix R.

6.6 UNCERTAINTIES IN THE BASELINE RISK ASSESSMENT

Uncertainties which may have an impact on the estimates of exposure, noncancer hazard, and carcinogenic risk are identified in a qualitative manner in this section. Such uncertainties encompass the general headings of environmental chemistry, sampling, and analysis; fate and transport modeling; exposure parameter estimation; and toxicological data.

6.6.1 Environmental Chemistry, Sampling, and Analysis

The environmental data collected from a site serve as the most important component of any investigation. A concerted effort was employed to collect and analyze the environmental sampling data for the site to ensure that an appropriate level of reliability and validity would be achieved in characterizing site conditions. However, a number of factors related to environmental chemistry, sampling, and analysis may introduce some level of variability into the overall results of the risk assessment.

With respect to the chemistry of environmental media and contaminants, the chemical properties associated with chemicals in environmental media may have a bearing on the concentrations reported for a particular chemical. The concentrations of volatile organic compounds may decrease between the time that initial sampling activities begin and the actual sample is collected (i.e., through volatilization when the sample media is first exposed to air). Such a decrease in concentration would potentially result in a decreased estimate of exposure, risk and/or hazard.

The selection of sampling points which ultimately comprise the exposure area for receptors can result in an over- or under-estimation of total exposure, hazard, and/or risk. It is difficult to sample every square foot of an area which is suspected to contain environmental contamination. Rather, screening methods were employed to identify areas of contamination. For the most part the resulting samples selected for laboratory analysis were comprised of skewed results with the trend being for positive results. These results were then considered to be representative of the exposure concentrations which occur throughout the entire exposure area. Many of the LBAD SWMUs and Areas of Concern are comprised of sites of significant areal extent. It was assumed that the samples collected and analyzed from the SWMUs and the Areas of Concern were characteristic of the entire SWMU or Area of Concern. The associated exposures, hazards, and/or risks for these data, in turn, may have been over- or underestimated because the potential for exposure to the positively detected compounds may or may not be as high as was assumed in the exposure assessment.

The analytical results for tentatively identified contaminants (TICs) provided an indication that additional chemicals (which were not considered in the identification of chemicals of concern) may be present in the SWMUs and Areas of Concern. The TICs represent potential detections of chemicals which are matched to possible chemical names or compositional identifiers by the analytical laboratory. However, the TICs are not reported by the analytical laboratory with the same level of QA/QC assurance as chemicals on the TAL or TCL. The chemical name or identifier associated with a TIC represents the laboratory's best guess as to the identity of the compound. In addition, toxicologic information is typically lacking for TICs. Therefore, they cannot be evaluated quantitatively in a risk assessment without assuming toxicity factors for chemicals with similar structure and activity or physical properties. Such an assumption could lead to an over- or underestimation of exposure, hazard, and/or risk. Because TICs were present, yet not evaluated quantitatively in the risk assessment for the LBAD SWMUs and Areas of Concern, the total exposure, hazard, and risk estimates are likely underestimated for the Facility. However, the impact of the addition of the TICs to the quantitative risk assessment cannot be estimated.

6.6.2 Fate and Transport Modeling

For chronic and lifetime exposures, the simplifying assumption that all concentration values will remain constant was employed in evaluating the chemicals of concern for the soil, surface water, and sediment. This is likely to result in an overestimate of exposure for chemicals which biodegrade over time.

Chemical concentrations in environmental media which were not sampled at the LBAD (i.e., volatilization from groundwater) were predicted using models. The models have been developed to provide conservative estimates of chemical concentrations in the environmental media. Therefore, a great deal of uncertainty is added to the exposure, hazard, and/or risk estimates by the use of models which may or may not provide accurate representations of the concentrations of the chemicals of concern in the environmental media.

6.6.3 Exposure Parameter Estimation

The exposure point concentrations for the chemicals of concern were assumed to be representative of the exposure levels for the entire exposure area in which a potential receptor might be exposed. The actual range of concentrations in the SWMUs and Areas of Concern might be higher or lower in reality. The sampling approach for the LBAD RFI sought to identify, sample, and analyze areas where the highest concentrations of chemicals were suspected to be located. Such an approach will likely skew the average daily intake toward the higher end of the distribution of potential exposure levels.

The frequency of detection of chemicals in the environmental media sampled for the LBAD SWMUs and Areas of Concern was not used to eliminate chemicals from further study in the risk assessment unless the chemicals were naturally occurring analytes of low toxic potential. In many cases chemicals of concern were characterized by a low frequency of detection and provided the primary contribution to the overall risk or hazard. The potential for exposure across the entire exposure area would also be expected to be decreased for infrequently detected chemicals.

No site-specific data were available on activity patterns on-site and off-site, so assumed values for duration, frequency and degree of contact with environmental media are quite uncertain. The values selected are believed to be conservative (i.e., leading to an overestimation of dose).

Dermal uptake of chemicals from groundwater is especially difficult to estimate because this depends on the solubility characteristics of the chemical and the circumstances of exposure. The absorption values employed to estimate dermal uptake are highly uncertain, but are almost certainly conservative (i.e., leading to an overestimate of dose).

While infrequency of detection was not use as the single criterion for not evaluating an analyte of concern, it does have a significant bearing on exposure potential. If an infrequently detected chemical truly occurs infrequently and only in a localized area, then the hazard and risk may be overestimated because the frequency of receptor contact with the chemical will be similarly limited. The actual average daily intake may be much lower if the receptor is only exposed to high chemical concentrations for a very short period of time and lower concentrations for the majority of the exposure period. On the other hand, exposures, hazards, and risks could be underestimated if higher chemical concentrations exist in environmental media and the exposure to the site areas having the higher chemical levels is greater than the exposure period assumed in the exposure assessment.

Use of the 95 percent UCL or maximum chemical concentration for an environmental medium may result in an over- or underestimate of exposure, hazard, and risk if the true chemical concentrations for the medium are not accurately represented by the samples collected from the SWMU or Area of Concern. As noted in Section 6.6.1, screening methods were employed to select sampling locations where the highest levels of chemicals might occur.

6.6.4 Toxicological Data

The tasks of identifying and quantifying human health risks from chemicals in environmental media are often subject to a number of uncertainties related to toxicological information. The most important of these relating to the LBAD are summarized as follows:

- The toxicity factors which have been developed by U.S. EPA for some of the chemicals of potential concern may be overly conservative. Arsenic toxicity factors have been qualified by U.S. EPA as potentially overestimating potential risks by one or two orders of magnitude (U.S. EPA, 1988).

- Extrapolation of effects observed in animals to effects in humans is uncertain, because of potential physiological and metabolic differences. To account for this, an uncertainty factor of ten is usually used to make this extrapolation when deriving toxicity factors. In many cases, this will result in a conservative estimate of the risk to humans.

- There is considerable debate and uncertainty regarding the best way to estimate the SF for carcinogenic chemicals. To be conservative, the U.S. EPA calculates the upper 95% confidence limit of the slope at low dose, and this is employed as the SF. That is, actual slope factors could be lower, but are unlikely to be higher.

- When humans are exposed to more than one chemical in a medium, it is normally assumed that the adverse effects of the different chemicals are additive (U.S. EPA, 1989a). However, in some cases it is possible that synergistic or antagonistic interactions may occur. Although there are not data to suggest that synergistic or antagonistic interactions occur between the chemicals of potential concern at this site, this is nevertheless a source of uncertainty in the risk assessment.

- As noted in Section 6.6.1, the lack of appropriate toxicity values for many of the TICs provides an additional contribution to the overall uncertainty of the hazard and risk estimation process. Hazards and risks are likely under-estimated, but the magnitude of the underestimation may or may not be significant (i.e., depending on the relative toxic potential of the TICs compared to the identified chemicals of concern).

These uncertainties need to be considered when evaluating the results of this risk assessment and when making risk management decisions for the LBAD.

6.7 SUMMARY AND CONCLUSIONS

The baseline risk assessment centered upon the determination of the groundwater exposure concentrations, exposure pathways, exposure estimates, and relative noncancer hazard and carcinogenic risk of metals, semivolatile organic compounds and volatile organic compounds. These chemicals were selected as chemicals of potential concern at the LBAD based primarily on their concentration relative to background. The chemicals were evaluated quantitatively in the Risk Assessment for the entire base (divided into two hydrogeologically separate sections. In order to derive risk/hazard totals across all media, these groundwater results were subsequently compiled with the results from the other media. The following is a summary of these results.

6.7.1 Summary of Groundwater

The results provided in Table 6-11 provide the associated risk/hazard results for both the northern and southern portions of LBAD. These results are based on the conservative approach of evaluating groundwater concentrations throughout the two large portions of the base (northern or southern). This approach utilizes the 95% UCL or maximum throughout the area and assumes that all groundwater exposure is at that concentration.

Metals in groundwater in the northern portion of LBAD contributed to carcinogenic risk levels on the order of 7E-5, 3E-4, and 2E-4 for the future hypothetical residential short-term adult, long-term adult, and child exposures, respectively. The short-term and long-term future occupational exposures resulted in risks of 3E-5 and 9E-5, respectively. With respect to noncarcinogenic effects, short-term adult, long-term adult, and child hazard levels of 16.6, 63.1, and 35.9, respectively, were also a result of exposure to metals in groundwater. Likewise, hazard levels of 5.74 and 19.0 were associated with short-term and long-term occupational exposure to metals in groundwater.

Carcinogenic risk levels in the southern portion of LBAD were associated with exposure to vinyl chloride and metals in groundwater. The future hypothetical residential short-term adult, long-term adult and child risk values were 1E-4, 6E-4, and 3E-4, respectively. The short-term and long-term future occupational risk values were 5E-5 and 2E-4, respectively. The noncarcinogenic hazard values were 56.1, 86.0, and 121 for the future hypothetical residential short-term adult, long-term adult, and child, respectively. similarly, the short-term and long-term occupational exposures were associated with hazard levels of 19.3 and 29.8, respectively. The noncarcinogenic values were primarily a result of exposure to metals in groundwater.

Although groundwater within the two distinct portions of LBAD was evaluated to derive one exposure concentration for each area, it is important to also consider the factors that suggest contamination is more isolated. The data below describes more thoroughly the data variability within each of the two areas.

NORTHERN PORTION					
Chemicals of Concern Associated with Excess Risk/Hazard	Frequency of Detection	Range		95% UCL	Exposure Concentration
		Minimum µg/l	Maximum µg/l		
Arsenic	3/6	ND	8.78	19.3	8.78
Lead	5/7	ND	62.7	352	62.7
Manganese	7/7	34.5	1700	30,560	1700
Sodium	7/7	55,000	9.8E+6	2.4E+8	9.8E+6
Thallium	1/7	ND	189	119	119

SOUTHERN PORTION					
Chemicals of Concern Associated with Excess Risk/Hazard	Frequency of Detection	Range		95% UCL	Exposure Concentration
		Minimum µg/l	Maximum µg/l		
Vinyl Chloride	2/44	ND	150	8.70	8.70
Aluminum	37/40	ND	350,000	124,704	124,704
Antimony	3/41	ND	217	38.5	38.5
Arsenic	5/37	ND	25	2.88	2.88
Beryllium	10/41	ND	110	5.77	5.77
Lead	18/40	ND	470	41.9	41.9
Manganese	39/40	ND	65,000	8461	8461
Thallium	3/41	ND	437	79.1	79.1

These data tables, taken from Appendix K, indicate that a number of chemicals contributing to excess risk and/or hazard actually were detected infrequently, in very few wells. In addition, the lack of sufficient groundwater for sampling in the northern portion of LBAD presents more uncertainty when calculating the exposure concentration. Consequently, the lack of statistical confidence in the northern portion data resulted in 95% UCL concentrations that were usually much higher than the maximums. This statistical short-fall can result in an over-estimation of risks and/or hazards by defaulting to the maximum detected concentrations being used as exposure concentrations. In conclusion, the fact that many of the chemicals listed above were rarely detected suggests that actual risks/hazards may be lower than those actually calculated due to infrequent exposure.

As detailed in Sections 6.6, the total hazard and risk estimates may be over- or underestimated due to a number of uncertainties or confounding factors which are inherent in the risk assessment process. The factors include: the conservatism of the toxicity factors utilized for the chemicals of concern; the use of models to estimate chemical concentrations in environmental media which were not sampled and analyzed during the RFI; the conservatism of the methodology used to evaluate dermal uptake and toxicity, the nutrient status of the chemicals of concern associated with unacceptable hazards and/or risks; and the conservatism of assuming additivity of effect or toxic potential for noncarcinogenic chemicals. In many cases the chemicals which provided the primary contribution to the overall hazard or risk were detected infrequently in the environmental media. However, in order to provide a conservative estimate of potential exposure, such chemicals were analyzed in the quantitative risk assessment as if the detected concentration was indicative of the entire exposure area for the SWMU or Area of Concern. In addition, exposure levels were estimated using conservative assumptions regarding the potential receptor groups and exposure parameter values in order to determine whether site conditions could be associated with unacceptable hazards and risks. All of these factors should be considered when making risk management and potential remedial decisions for the LBAD groundwater.

6.7.2 Summary of All Media

Subsequently, to the derivation of the groundwater risk/hazard, the groundwater results were added to the corresponding 36 SWMUs that were evaluated in the April 1994 RFI. These results are compiled and presented in Appendix R. As described in Table 7.3 of the LBAD RFI, only 36 SWMUs and Areas of Concern were analyzed quantitatively because in 24 of the 50 LBAD SWMUs and Areas of Concern, the following factors were present:

- Environmental media were not sampled which could be evaluated quantitatively (wipe samples and concrete chip samples could not be evaluated quantitatively).
- No chemicals of potential concern were found above detection limits and/or background concentrations in the environmental media sampled;
- No complete exposure pathways were identifiable for the media of concern and the applicable existing or future receptors.

Exposures to the chemicals of potential concern in groundwater were investigated for human receptor populations identifiable for the LBAD under a future use scenario because there is no existing route of exposure to groundwater. Two receptor groups were identified for the evaluation of hypothetical future land use scenarios: a future worker, and future adult and child residents. Applicable future exposure scenarios for the receptor's were identified based on current land use designations for the LBAD areas. The land use designations for the LBAD are general rural and industrial. It is expected that these land use designations will continue into the future. Potential future scenario exposures for each of these receptors were quantified in the exposure assessment to present a range of exposures. However, it is not expected that all areas of the site will be utilized for residential purposes in the future. Conservative assumptions were employed in the characterization of potential exposure such that the resulting exposure estimates would err on the side of over-, rather than under-estimation of exposure, hazard, and/or risk.

The exposure assessment estimates were in turn, evaluated with respect to U.S. EPA-approved toxicity factors for the chemicals of potential concern to arrive at the risk characterization results. The resulting total noncancer hazard indices and carcinogenic risk estimates were compared to applicable criteria for acceptable U.S. EPA hazard (unity) and risk levels (1.0E-04 to 1.0E-06 being the range for potentially requiring site remediation). Since both the northern and southern portions of LBAD exceed acceptable risk and hazard levels, each well will be evaluated in the Corrective Measures Study (CMS) to determine potential remediation strategies. The compilation of these groundwater results are combined with the previous analysis of the other media in Appendix R in order to derive risk and hazard totals across all media.

The fact that the hazard index exceeds a value of 1.0 does not guarantee that an adverse noncancer effect in association with exposure to the chemicals of concern will occur in a human. Similarly, the evaluation of the noncancer hazards of the chemicals of potential concern involved a summation of all of the hazard quotients for all of the chemicals of potential concern. Such an approach may be overly conservative in that an additive relationship is assumed for the toxic potential of the chemicals and exposure pathways. However, the mechanism for toxicity for exposure to a group of chemicals of concern, across exposure pathways, may not be additive. Furthermore, the chemicals and pathways may have different target organs for toxic effects.

In the previous RFI, the U.S. EPA's lead biokinetic/uptake model was utilized to evaluate SWMUs/Areas of Concern where lead was detected in soil above background concentrations. Appendix R presents blood lead levels associated with soil lead levels, groundwater lead levels, and associated modelled air concentrations for the 17 SWMUs which have lead in soils above background concentrations. U.S. EPA recommends the use of 500 to 1000 ppm lead in soil as the preliminary remediation goal to be used in scoping remedial investigations and feasibility studies for Superfund Soil lead cleanups; and as the soil lead action level for RCRA corrective action (U.S. EPA 1988c). The 500 ppm value was derived to be protective of health of children (aged 6 months to 7 years). U.S. EPA recommends that where the UBK model identifies a greater than 5% probability that a child's blood levels may exceed 10 μg/dl (or that greater than 5% of potentially exposed children may experience blood lead levels greater than 10 μg/dl), remedial action is generally recommended (U.S. EPA 1988c).

Exceedances of the blood lead level criterion of 10 μg/dl (and also 5% probability that a child's blood level will exceed 10 μg/dl) occurred in four SWMUs and Areas of Concern, namely Building 63, SWMU 10, SWMU 12, and TPSA. For Building 63, a soil lead concentration of 1300 mg/kg resulted in a maximum predicted blood lead concentration of approximately 32 μg/dl. For SWMU 10, the soil lead concentration of 1800 mg/kg resulted in a maximum predicted blood lead level of approximately 40 μg/dl. For SWMU 12, 1430 mg/kg in soil resulted in a maximum predicted blood lead level of approximately 32 μg/dl. For the Telephone Pole Storage Area, the soil lead concentration of 1300 mg/kg resulted in the maximum predicted blood lead level of about 32 μg/dl.

A summary listing of the scenarios in the two groundwater areas and the associated comparison to acceptable hazards (i.e., 1.0) and risks (1E-04 to 1E-06) is provided in Table 6-44.

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TABLE 6-1
SWMUs/AREAS OF CONCERN WITH ASSOCIATED GROUNDWATER AREA
LEXINGTON-BLUEGRASS ARMY DEPOT

SWMU 4 (OLD LANDFILL)	SOUTHERN PORTION
SWMU 2,5,6, AND 7 (INDUSTRIAL AND SANITARY WASTE DISPOSAL LAND)	SOUTHERN PORTION
SWMU 1 (NEW LANDFILL)	NORTHERN PORTION
AREA A (SEPTIC TANK)	SOUTHERN PORTION
AREA B (DRAINAGE PATH NEAR WATER TOWER)	SOUTHERN PORTION
AREA C	NORTHERN PORTION
SWMU 3 (INDUSTRIAL WASTE LAGOONS)	SOUTHERN PORTION
SWMU 24 (SCRAP WOOD PILE/FIRE TRAINING AREA)	SOUTHERN PORTION
BUILDING 135	SOUTHERN PORTION
BUILDING 147	SOUTHERN PORTION
BUILDING 3	SOUTHERN PORTION
BUILDING 10	SOUTHERN PORTION
BUILDING 19	SOUTHERN PORTION
BUILDING 64	SOUTHERN PORTION
BUILDING 63	SOUTHERN PORTION
BUILDING 130	SOUTHERN PORTION
BUILDING 140 AND 141	SOUTHERN PORTION
SWMU 23 (BUILDING 4,5,135,139)	SOUTHERN PORTION
SWMU 18 AND 19 (SUMP BEHIND BUILDING 139)	SOUTHERN PORTION
SWMU 16,17, AND 30 (WASTEWATER TREATMENT)	SOUTHERN PORTION
SWMU 9 (BUILDING 27)	SOUTHERN PORTION
BUILDING 42	SOUTHERN PORTION
SWMU 20 (BUILDING 9 AND 46)	SOUTHERN PORTION
SWMU 25 (PCB STORAGE AREAS/BUILDING 8)	SOUTHERN PORTION
SWMU 11 (BUILDING 40)	SOUTHERN PORTION
COAL PILE RUNOFF/HEATING PLANT AREA	SOUTHERN PORTION
SWMU 10 (INDUSTRIAL WASTEWATER TREATMENT AND SAND DRYING BEDS/BUILDING 124	SOUTHERN PORTION
BUILDING 303	NORTHERN PORTION
OPEN STORAGE AND SHELTER AREAS	SOUTHERN PORTION
SWMU 12 (DRMO SPILL)	SOUTHERN PORTION
TRANSFORMER SPILL NEAR BUILDING 224	SOUTHERN PORTION
FACILITY-WIDE ACTIONS (STREAMS)	SOUTHERN PORTION
SWMU 22 (VEHICLE WASHRACK I)	SOUTHERN PORTION
AREA OF CONCERN 2 (CALCIUM HYDRATE STORAGE AREA)	NORTHERN PORTION
GOLF COURSE	NORTHERN PORTION
TELEPHONE POLE STORAGE AREA	SOUTHERN PORTION

TABLE 6-2
DATA EVALUATED IN THE BASELINE RISK ASSESSMENT
LEXINGTON-BLUEGRASS ARMY DEPOT

Qualifiers	Qualifier Definition	Use in Baseline Risk Assessment
B	Analyte found in blank as well as sample	Data will be utilized in the risk assessment with possible qualification
C	Analysis was confirmed	Data will be utilized in the risk assessment
D	Duplicate sample or test name.	Data will be utilized in the risk assessment
E	Element run with background correction.	Data will be utilized in the risk assessment
F	Sample filtered before analysis.	Data will be utilized in the risk assessment
G	Reported results affected by interferences or high background.	Data will be utilized in the risk assessment
H	Out of control but data accepted due to high recoveries.	Data will be utilized in the risk assessment
I	Out of control, data rejected due to low recoveries.	Data will be utilized if not rejected during validation in the risk assessment
J	Missed holding time; acceptable based on holding time study.	Data will be utilized in the risk assessment
K	Missed holding times for extraction and preparation.	Data will be utilized in the risk assessment
L	Missed holding time for analysis.	Data will be utilized in the risk assessment
M	Duplicate (high) spike analysis not within control limits.	Data will be utilized in the risk assessment
N	Low spike recovery is not within control limits.	Data will be utilized in the risk assessment
P	Results less than CRL but greater than COD.	Data will be utilized in the risk assessment
Q	Surrogate recovery markedly different from historical data.	Data will be utilized in the risk assessment
R	Analyte required for reporting purposes but not currently certified.	Data will be utilized in the risk assessment
S	Results based on internal standard.	Data will be utilized in the risk assessment
T	Analyzed for but not detected.	Data will be utilized in the risk assessment as if the data had been reported as a less than value
U	Analysis is unconfirmed.	Unsuitable for use in risk assessment calculations
V	Sample subjected to unusual storage conditions.	Data will be utilized in the risk assessment
W	Single analyte required from a multi-analyte method.	Data will be utilized in the risk assessment
X	Analyte recovery outside of certified range but within acceptable limits	Data will be utilized in the risk assessment

Note: Samples for VOCs and SVOCs in which holding times were grosly exceededby the laboratory were recollected and reanalyzed. All other confirmed data were considered usable for the project.

TABLE 6-3 MAXIMUM CONCENTRATIONS DETECTED IN THE NORTHERN AND SOUTHERN PORTIONS OF LBAD

ANALYTE	MAXIMUM CONCENTRATION NORTHERN PORTION ug/L	MAXIMUM CONCENTRATION SOUTHERN PORTION ug/L
Acetone	100	240
Benzene	2.8	33
Chloromethane	4.4	ND
Bis(2-ethylhexyl)phthalate	ND	13
Carbon tetrachloride	ND	1.1
1,1-Dichloroethane	ND	22
1,2-Dichloroethenes	ND	34
2,4-Dimethylphenol	ND	20.5
1,3-Dimethylbenzene	1.3	16
alpha-Endosulfan	ND	0.5
Ethylbenzene	ND	7.7
Methyl isobutyl ketone	ND	5.3
Phenol	ND	17
Tetrachloroethene	ND	1.1
Toluene	3.7	69
Trichloroethene	ND	6.6
Vinyl chloride	ND	150
Xylenes	ND	110
alpha-BHC	ND	0.003
delta-BHC	ND	0.015
DDT	ND	0.017
Lindane	ND	0.006
Aluminum	24300	350000
Antimony	ND	217
Arsenic	8.78	25
Barium	570	1870
Beryllium	3.1	110
Boron	535	2420
Cadmium	ND	417
Calcium	1700000	17000000
Chromium	47.1	448
Cobalt	ND	211
Copper	36.2	257
Iron	53400	342000
Lead	62.7	470
Magnesium	920000	980000
Manganese	1700	65000
Mercury	0.105	1.54
Molybdenum	ND	58.8
Nickel	49.7	499
Potassium	154000	125000
Sodium	9800000	5600000
Tellurium	ND	211
Thallium	189	437
Tin	ND	102
Vanadium	42.2	523
Zinc	111	1900

ND - Not Detected

TABLE 6-4 BACKGROUND COMPARISON OF INORGANIC COMPOUNDS IN GROUNDWATER AT LBAD

ANALYTE	MAXIMUM CONCENTRATION NORTHERN PORTION	MAXIMUM CONCENTRATION SOUTHERN PORTION	BACKGROUND CONCENTRATIONS	MCL (a)
	ug/L	ug/L	ug/L	ug/L
Aluminum	24300	350000	7830	200 (b)
Antimony	ND	217	ND	6
Arsenic	8.78	25	3.525	50
Barium	570	1870	432	2000
Beryllium	3.1	110	1.67	4
Boron	535	2420	ND	NL
Cadmium	ND	417	ND	5
Calcium	1700000	17000000	171300	NL
Chromium	47.1	448	ND	100
Cobalt	ND	211	ND	NL
Copper	36.2	257	109.4	1300 (d)
Iron	53400	342000	6150	300 (b)
Lead	62.7	470	19.11	15 (d)
Magnesium	920000	980000	55600	NL
Manganese	1700	65000	169.3	50 (b)
Mercury	0.105	1.54	ND	2
Molybdenum	ND	58.8	ND	NL
Nickel	49.7	499	ND	100
Potassium	154000	125000	12980	NL
Sodium	9800000	5600000	120000	NL
Tellurium	ND	211	ND	NL
Thallium	189	437	ND	2
Tin	ND	102	ND	NL
Vanadium	42.2	523	ND	NL
Zinc	111	1900	188.6	5000 (b)

ND – Not Detected

Shaded areas indicate values below background levels for that chemical

(a) MCL – Maximum Contaminant Level; (b) SMCL – Secondary Maximum Contaminant Level (c) MCLG – Maximum Contaminant Level Goal (d) Action Level

MCL, SMCL, MCLG and Action Level Source: USEPA. May 1995. Drinking Water Regulations and Health Advisories. Office of Water. Washington, D.C.

TABLE 6–5 EXPOSURE CONCENTRATIONS ASSOCIATED WITH CHEMICALS OF CONCERN IN GROUNDWATER

ANALYTE	EXPOSURE CONCENTRATION NORTHERN PORTION ug/L	EXPOSURE CONCENTRATION SOUTHERN PORTION ug/L
Acetone	100.00	30.90
Benzene	2.19	1.27
Chloromethane	2.69	ND
Bis(2–ethylhexyl)phthalate	ND	4.22
Carbon tetrachloride	ND	0.53
1,1–Dichloroethane	ND	0.94
1,2–Dichloroethenes	ND	3.20
2,4–Dimethylphenol	ND	3.41
1,3–Dimethylbenzene	1.30	2.55
alpha–Endosulfan	ND	0.0034
Ethylbenzene	ND	1.40
Methyl isobutyl ketone	ND	0.83
Phenol	ND	1.56
Tetrachloroethene	ND	0.53
Toluene	3.70	5.68
Trichloroethene	ND	0.72
Vinyl chloride	ND	8.70
Xylenes	ND	5.80
alpha–BHC	ND	0.0030
delta–BHC	ND	0.0019
DDT	ND	0.0077
Lindane	ND	0.0018
Aluminum	24300.00	124704.12
Antimony	ND	38.53
Arsenic	8.78	2.88
Barium	570.00	398.42
Beryllium	3.09	5.77
Boron	535.00	908.77
Cadmium	ND	10.20
Calcium	1700000.00	1024896.79
Chromium	47.10	68.41
Cobalt	ND	25.58
Copper	ND	37.89
Iron	53400.00	176723.49
Lead	62.70	41.85
Magnesium	920000.00	137653.87
Manganese	1700.00	8461.44
Mercury	0.074	0.12
Molybdenum	ND	29.98
Nickel	48.71	54.66
Potassium	154000.00	21553.77
Sodium	9800000.00	823094.61
Tellurium	ND	73.82
Thallium	118.64	79.09
Tin	ND	48.49
Vanadium	35.89	53.36
Zinc	ND	437.30

ND – Not detected above detection limits

Table 6−6 Summary of Critical Health Effects for Chemicals of Potential Concern at LBAD

	ANALYTE	NONCARCINOGENIC EFFECTS		CARCINOGENIC EFFECTS (2)	
		ORAL	INHALATION	ORAL	INHALATION
SEMIVOLATILES	Bis(2−ethylhexyl)phthalate	incr. relative liver weight	NA	liver (group B2)	NA (group B2)
	2,4−Dimethylphenol	nervous system effects blood alterations	NA	NA	NA
	Phenol	fetotoxicity	NA	NA	NA
VOLATILES	Acetone	liver, kidney increase weight; nephrotoxicity	NA	NA (group D)	NA (group D)
	Benzene				
	Carbon tetrachloride	liver lesions	liver lesions	liver tumors (group B2)	liver tumors (group B2)
	1,1−Dichloroethane	NA	kidney damage	NA	NA
	1,2−Dichloroethenes	liver lesions	NA	NA	NA
	Bromomethane	forestomach epithelium hyperplasia	NA	NA	NA
	Chloromethane	NA	NA	NA	NA
	Ethylbenzene	increased liver, kidney weight liver, kidney lesions	increased liver, kidney weight liver, kidney lesions	NA NA	NA NA
	Methyl isobutyl ketone	liver, kidney effects	increased liver weight, kidney effects	NA NA	NA NA
	Tetrachloroethene	hepatoxicity	NA	NA (group C−B2)	NA (group C−B2)
	Toluene	change in liver, kidney weights	CNS effects, eyes & nose irritation	NA	NA
	Trichloroethene	NA	NA	liver (group B2)	lung (group B2)
	Vinyl chloride	NA	NA	lung, liver (group A)	liver (group A)
	Xylenes	CNS hyperactivity, decreased body weight	NA	NA	NA
PESTICIDES	alpha BHC	NA	NA	liver (group B2)	liver (group B2)
	delta BHC	NA	NA	NA	NA
	4,4'−DDT	liver lesions	NA	liver (group B2)	liver (group B2)
	Endosulfan	kidney toxicity, kidney lesions	NA	NA	NA
	Lindane	liver, kidney toxicity	NA	liver tumors (group B2 − C)	NA
INORGANICS	Aluminum	NA	NA	NA	NA
	Antimony	reduced lifespan altered blood chem.	respiratory effects	NA	NA
	Arsenic	keratosis hyperpigmentation	NA	skin (group A)	respiratory tract (group A)
	Barium	incr. blood pressure	fetoxicity	inconclusive (group D)	inconclusive (group D)
	Beryllium	NOAEL	NOAEL	total tumors (group B2)	lung tumors (group B2)
	Boron	testes lesions	bronchitis	NA	NA
	Cadmium	renal toxicity	cancer	NA	respiratory tumors (group B2)
	Calcium	NA	NA	NA	NA
	Chloride				
	Chromium	hepatotoxicity	nasal mucosa atrophy	ND	lung tumors (group A)
	Cobalt	NA	NA	NA	NA
	Copper	local GI irritation	ND	NA	NA
	Cyanide				
	Fluoride				
	Iron	NA	NA	NA	NA

Table 6–6 Summary of Critical Health Effects for Chemicals of Potential Concern at LBAD (cont'd)

	ANALYTE	NONCARCINOGENIC EFFECTS		CARCINOGENIC EFFECTS (2)	
		ORAL	INHALATION	ORAL	INHALATION
INORGANICS (cont.)	Lead	central nervous toxicity	central nervous toxicity	NA (group B2)	NA (group B2)
	Lithium				
	Magnesium	NA	NA	NA	NA
	Manganese	central nervous system	respiratory symptoms, psychomotor disturb.	NA	NA
	Mercury	kidney effects	neurotoxicity	NA	NA
	Molybdenum	increased uric acid, pain, swelling in joints decreased blood copper levels	NA	NA	NA
	Nickel	decr. body weight	respiratory effects	NA	respiratory system (group A)
	Potassium	NA	NA	NA	NA
	Sodium	NA	NA	NA	NA
	Tellurium	NA	NA	NA	NA
	Thallium	incr. SGOT & serum LDH levels, alopecia	NA	NA	NA
	Tin	liver, kidney	NA	NA	NA
	Vanadium	NA	NA	NA	NA
	Zinc	anemia	anemia	NA	NA

(1) Source: Annual FY–1992 and FY–1994 Health Effects Assessment Summary Tables

(2) U.S. EPA Weight of Evidence for Carcinogens:

Group A, Human Carcinogen
Group B, Probable Human Carcinogen
Group C, Possible Human Carcinogen
Group D, Not Classifiable
Group E, Evidence of Noncarcinogenicity

NA=Not Applicable, ND=Not Determined

NOAEL – No observed adverse effect level

TABLE 6-7
TOXICITY VALUES FOR CHEMICALS OF CONCERN IN GROUNDWATER
LEXINGTON BLUEGRASS ARMY DEPOT

	NONCARCINOGENIC RfDs						CANCER SLOPE FACTORS		
	ORAL RfD (MG/KG/DAY)		ADJUSTED ORAL (DERMAL) (MG/KG/DAY) (a)		INHALATION RfD (MG/KG/DAY)		ORAL SLOPE FACTOR (MG/KG/DAY)-1	ADJUSTED ORAL (DERMAL) SLOPE FACTOR (b) (MG/KG/DAY)-1	INHALATION SLOPE FACTOR (MG/KG/DAY)-1 (b)
CHEMICAL	SUBCHRONIC	CHRONIC	SUBCHRONIC	CHRONIC	SUBCHRONIC	CHRONIC			
Acetone	1E+00	1E-01	1E+00	1E-01	NA	NA	NA	NA	NA
Benzene	NA	3E-04	NA	3E-04	NA	2E-03	2.9E-02	3.2E-02	2.9E-02
Carbon tetrachloride	2E-03	7E-04	2E-03	6E-04	2E-02	NA	1.3E-01	1.5E-01	5.3E-02
Chloromethane	NA	NA	NA	NA	NA	NA	1.3E-02	1.6E-02	6.3E-03
1,1-Dichloroethane	1E+00	1E-01	1E+00	1E-01	1E+00	1E-01	NA	NA	NA
mixed-1,2-Dichloroethene	9E-03	9E-03	8E-03	8E-03	NA	NA	NA	NA	NA
1,3-Dimethylbenzene	NA	2E+00	NA	2E+00	NA	NA	NA	NA	NA
Ethylbenzene	1E-01	1E-01	9E-02	9E-02	3E-01	3E-01	NA	NA	NA
Methyl isobutyl ketone	8E-01	8E-02	6E-01	6E-02	2E-01	2E-02	NA	NA	NA
Tetrachloroethene	1E-01	1E-02	1E-01	1E-02	NA	NA	5.2E-02	5.2E-02	2.0E-03
Toluene	2E+00	2E-01	2E+00	2E-01	3E-01	1E-01	NA	NA	NA
Trichloroethene	NA	NA	NA	NA	NA	1E-01	1.1E-02	1.1E-02	6.0E-03
Vinyl chloride	NA	NA	NA	NA	NA	NA	1.9E+00	2.4E+00	3.0E-01
Xylenes	NA	2E+00	NA	2E+00	NA	9E-02	NA	NA	NA
alpha-BHC	NA	NA	NA	NA	NA	NA	6.3E+00	7.0E+00	6.3E+00
delta-BHC	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	2E-02	NA	5E-03	1E-01	NA	1.4E-02	5.6E-02	NA
2,4-Dimethylphenol	2E-01	2E-02	1E-01	1E-02	NA	NA	NA	NA	NA
DDT	5E-04	5E-04	5E-04	5E-04	NA	NA	3.4E-01	3.8E-01	3.4E-01
Endosulfan	6E-03	6E-03	5E-03	5E-03	NA	NA	NA	NA	NA
Lindane	3E-03	3E-04	3E-03	3E-04	NA	NA	1.3E+00	1.3E+00	NA
Phenol	6E-01	6E-01	5E-01	5E-01	NA	NA	NA	NA	NA
Aluminum	NA	1E+00	NA	2E-01	NA	NA	NA	NA	NA
Antimony	4E-04	4E-04	2E-04	2E-04	NA	NA	NA	NA	NA
Arsenic	3E-04	3E-04	3E-04	3E-04	NA	NA	1.5E+00	1.6E+00	5.0E+01
Barium	7E-02	7E-02	4E-03	4E-03	1E-03	1E-04	NA	NA	NA
Beryllium	5E-03	5E-03	5E-04	5E-04	NA	NA	4.3E+00	4.3E+01	8.4E+00
Boron	9E-02	9E-02	9E-02	9E-02	NA	NA	NA	NA	NA
Cadmium (water)	NA	5E-04	NA	4E-05	NA	NA	NA	NA	6.3E+00
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium III	1E+00	1E+00	3E-02	3E-02	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	4E-02	NA	4E-02	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead(c)	1E-03	1E-03	7E-04	7E-04	4E-04	4E-04	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese (water)	5E-03	5E-03	2E-04	2E-04	NA	NA	NA	NA	NA

TABLE 6–7
TOXICITY VALUES FOR CHEMICALS OF CONCERN IN GROUNDWATER
LEXINGTON BLUEGRASS ARMY DEPOT

	NONCARCINOGENIC RfDs						CANCER SLOPE FACTORS		
	ORAL RfD (MG/KG/DAY)		ADJUSTED ORAL (DERMAL) (MG/KG/DAY) (a)		INHALATION RfD (MG/KG/DAY)		ORAL SLOPE FACTOR (MG/KG/DAY)−1	ADJUSTED ORAL (DERMAL) SLOPE FACTOR (b) (MG/KG/DAY)−1	INHALATION SLOPE FACTOR (MG/KG/DAY)−1 (b)
CHEMICAL	SUBCHRONIC	CHRONIC	SUBCHRONIC	CHRONIC	SUBCHRONIC	CHRONIC			
Mercury	3E−04	3E−04	4E−05	4E−05	9E−05	9E−05	NA	NA	NA
Molybdenum	5E−03	5E−03	1E−03	1E−03	NA	NA	NA	NA	NA
Nickel	2E−02	2E−02	2E−03	2E−03	NA	NA	NA	NA	NA
Potassium	NA	5E+01	NA	1E+01	NA	NA	NA	NA	NA
Sodium	NA	3E+01	NA	7E+00	NA	NA	NA	NA	NA
Tellurium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	8E−04	8E−05	8E−05	8E−06	NA	NA	NA	NA	NA
Tin	6E−01	6E−01	2E−02	2E−02	NA	NA	NA	NA	NA
Vanadium	7E−03	7E−03	7E−05	7E−05	NA	NA	NA	NA	NA
Zinc	3E−01	3E−01	9E−02	9E−02	NA	NA	NA	NA	NA

*Sources: U.S. EPA, Integrated Risk Information System (IRIS) database accessed July 1994.
U.S. EPA Health Effects Assessment Tables (HEAST), Annual FY−1994 edition(Heast, 1994).

**NA = Not Available

(a) Adjusted oral toxicity values used for calculation of dermal hazards.
Adjustment of an administered to an absorbed dose RfD:
(Administered RfD) x (Oral Absorption Factor) = Absorbed Dose RfD.

(b) Adjusted oral toxicity values used for calculation of dermal risks.
Adjustment of an administered to an absorbed dose CSF:
(Administered CSF)−1 / (Oral Absorption Factor) = Absorbed Dose CSF
Oral absorption factors from chemical−specific Toxicological Profiles, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service.

(c) The toxictiy values for lead were taken from the 1986 edition of HEAST per KDEP

Table 6-8 Applicable or Relevant and Appropriate Requirements for Chemicals of Concern in Groundwater at LBAD

Chemicals Detected in LBAD Groundwater	EPA Maximum Contaminant Levels (ug/L) (a)	Kentucky Water Quality Criteria Water Supply Source Criteria (ug/L) (b)
1,1-Dichloroethane	NA	NA
1,2-Dichloroethenes	70	NA
1,3-Dimethylbenzene	NA	NA
2,4-Dimethylphenol	NA	3090
Acetone	NA	NA
alpha-BHC	NA	NA
alpha-Endosulfan	NA	74
Benzene	5.0	1.2
Bis(2-ethylhexyl)phthalate	6.0	15000
Carbon tetrachloride	5.0	0.4
Chloromethane	NA	NA
DDT	NA	0.000024
delta-BHC	NA	NA
Ethylbenzene	700	3100
Lindane	0.2	0.019
Methyl isobutyl ketone	NA	NA
Phenol	NA	3500
Tetrachloroethene	5.0	0.8
Toluene	1000	14300
Trichloroethene	5.0	2.7
Vinyl chloride	2.0	2.0
Xylenes	10000	NA
Aluminum	50-200**	NA
Antimony	6	146
Arsenic	50	NA
Barium	2000	1000
Beryllium	4	6.8
Boron	NA	NA
Cadmium	5	10
Calcium	NA	NA
Chromium (III)	100 (Total)	33000; 50(Total)
Cobalt	NA	NA
Copper	1300 *	1000
Iron	300**	NA
Lead	15 *	50
Magnesium	NA	NA
Manganese	50**	50
Mercury	2	0.144
Molybdenum	NA	NA
Nickel	100	610
Potassium	NA	NA
Sodium	NA	NA
Tellurium	NA	NA
Thallium	2	13
Tin	NA	NA
Vanadium	NA	NA
Zinc	5000**	NA

(a) Drinking Water Regulations and Advisories. Office of Water, U.S. EPA. May 1994
(b) Kentucky Division of Water, Administrative Regulations 401 KAR Chapter 5
Kentucky Natural Resources and Environmental Protection Cabinet Department for Envrionmental Protection. August 24, 1994.
NA – Not Available
* – Action Level
** – Indcates the value is a secondary maximum contaminant level (SMCL)

TABLE 6-9
SUMMARY OF RISK AND HAZARD CALCULATIONS
FOR THE NORTHERN PORTION OF LBAD
LEXINGTON-BLUEGRASS ARMY DEPOT

Future Adult Residential – Short Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	7.26E-05	1.61E+01
	Dermal	6.80E-07	4.92E-01
	Inhalation	1.85E-07	2.84E-04
Total		7.35E-05	1.66E+01

Future Adult Residential – Long Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	3.11E-04	6.19E+01
	Dermal	2.91E-06	1.21E+00
	Inhalation	7.93E-07	3.05E-02
Total		3.15E-04	6.31E+01

Future Child Residential – Short Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	1.59E-04	3.51E+01
	Dermal	1.12E-06	8.08E-01
	Inhalation	8.09E-07	1.24E-03
Total		1.61E-04	3.59E+01

Future Adult Worker – Short Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	2.59E-05	5.74E+00
Total		2.59E-05	5.74E+00

Future Adult Worker – Long Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	9.26E-05	1.90E+01
Total		9.26E-05	1.90E+01

TABLE 6-10
SUMMARY OF RISK AND HAZARD CALCULATIONS FOR THE SOUTHERN PORTION OF LBAD
LEXINGTON-BLUEGRASS ARMY DEPOT

Future Adult Residential – Short Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	1.30E-04	5.41E+01
	Dermal	2.01E-06	2.02E+00
	Inhalation	6.17E-06	1.38E-03
Total		1.38E-04	5.61E+01

Future Adult Residential – Long Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	5.59E-04	8.35E+01
	Dermal	8.61E-06	2.50E+00
	Inhalation	2.65E-05	2.14E-02
Total		5.94E-04	8.60E+01

Future Child Residential – Short Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	2.85E-04	1.18E+02
	Dermal	3.30E-06	3.31E+00
	Inhalation	2.70E-05	6.02E-03
Total		3.15E-04	1.21E+02

Future Adult Worker – Short Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	4.66E-05	1.93E+01
Total		4.66E-05	1.93E+01

Future Adult Worker – Long Term

Matrix	Route	Risk	Hazard
Groundwater	Ingestion	1.66E-04	2.98E+01
Total		1.66E-04	2.98E+01

TABLE 6-1
SUMMARY OF RISK CHARACT
LEXINGTON-BLUEGRAS

STUDY AREA	RESULTS FROM RFI TABLE #	RECEPTOR	TOTAL RISK			MEDIA ASSOC W. EXCESS	EXPOSURE ROUTE CAUSING EXCESS
			>1.0E-06	>1.0E-05	>1.0E-04		
NORTHERN PORTION	9	FUT RES AD-ST	YES	YES (7E-5)	NO	GROUNDWATER	INGESTION
		FUT RES AD-LT	YES	YES	YES (3E-4)	GROUNDWATER	INGESTION/DERM
		FUT RES CH	YES	YES	YES (2E-4)	GROUNDWATER	INGESTION/DERM
		FUT WORK AD-ST	YES	YES (3E-5)	NO	GROUNDWATER	INGESTION
		FUT WORK AD-LT	YES	YES (9E-5)	YES	GROUNDWATER	INGESTION
SOUTHERN PORTION	10	FUT RES AD-ST	YES	YES	YES (1E-4)	GROUNDWATER	INGEST/DERM/INH
		FUT RES AD-LT	YES	YES	YES (6E-4)	GROUNDWATER	INGEST/DERM/INH
		FUT RES CH	YES	YES	YES (3E-4)	GROUNDWATER	INGEST/DERM/INH
		FUT WORK AD-ST	YES	YES (5E-5)	NO	GROUNDWATER	INGESTION
		FUT WORK AD-LT	YES	YES	YES (2E-4)	GROUNDWATER	INGESTION

①

LE 6-11
ARACTERIZATION RESULTS
EGRASS ARMY DEPOT

URE NG S	CHEMICALS ASSOC WITH EXCESS	TOTAL HAZARD > 1.0	MEDIA ASSOC W. EXCESS	EXPOSURE ROUTE CAUSING EXCESS	CHEMICALS ASSOC WITH EXCESS
N	arsenic, beryllium	YES (16 6)	GROUNDWATER	INGESTION	lead, manganese.thallium
N/DERMAL	arsenic, beryllium/beryllium	YES (63.1)	GROUNDWATER	INGESTION/DERMAL	lead, manganese.thallium sodium/thallium
N/DERMAL	arsenic, beryllium/beryllium	YES (35.9)	GROUNDWATER	INGESTION	arsenic, lead, manganese, thallium
N	arsenic, beryllium	YES (5.74)	GROUNDWATER	INGESTION	manganese, thallium
N	arsenic, beryllium	YES (19.0)	GROUNDWATER	INGESTION	manganese, thallium
ERM/INHAL	vinyl chloride, arsenic, beryllium/ beryllium/vinyl chloride	YES (56.1)	GROUNDWATER	INGESTION/DERMAL	antimony, manganese, thallium/manganese
ERM/INHAL	vinyl chloride, arsenic, beryllium/ vinyl chloride, beryllium/vinyl chloride	YES (86.0)	GROUNDWATER	INGESTION/DERMAL	antimony, manganese. aluminum.thallium/ manganese
ERM/INHAL	vinyl chloride, arsenic, beryllium/ vinyl chloride.beryllium/vinyl chloride	YES (121)	GROUNDWATER	INGESTION/DERMAL	antimony, lead, manganese. thallium/manganese
N	vinyl chloride, arsenic, beryllium	YES (19.3)	GROUNDWATER	INGESTION	antimony, manganese. thallium
N	vinyl chloride, arsenic, beryllium	YES (29.8)	GROUNDWATER	INGESTION	antimony, manganese. aluminum.thallium

②

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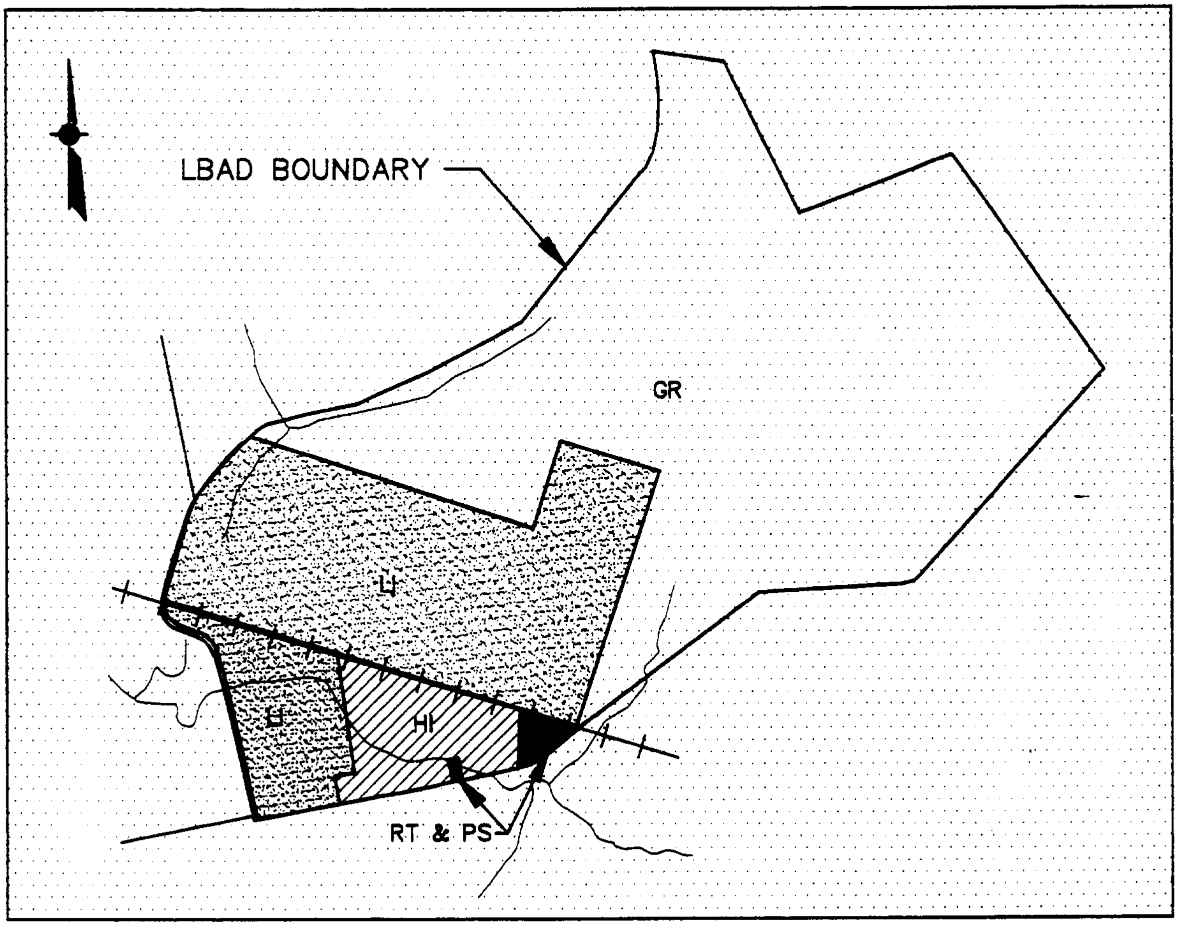
LEXINGTON-BLUEGRASS ARMY DEPOT

FACILITY SITE MAP

LEXINGTON, KENTUCKY

Project number
012308

Figure
6-1



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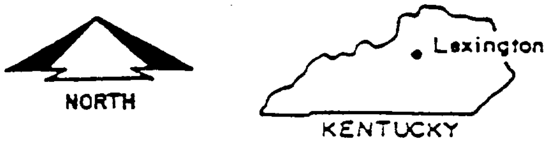
▩ **Retail Trade & Personal Services**
This category includes establishments for the retail sale of goods, prepared foods and drinks, or the provision of certain personal services. The intent of this category is to group together all establishments which operate in a store or store-like environment. These include hardware stores, general merchandise and food stores, automobile dealers and gasoline service stations, eating and drinking places and branch banks, beauty or barber shops, and shoe repair stores, etc. Professional service activities may also take place in these areas.

▦ **Light Industrial**
This land use category includes those establishments for the assembly of finished or semi-finished materials, food preparation, publishing, communication, construction materials, or any establishment or repair services which may present a moderate nuisance to adjacent properties. The activities included in this category are: light manufacturing, depots and terminals, communications, water supply, automotive repair shops, welding repair, animal services (other than veterinarians), construction materials and equipment yards, industrial laundries, etc.

▧ **Heavy Industrial**
This category includes establishments engaged in manufacturing involving the transformation of a material from its raw form to a finished or semi-finished product, and establishments with high potential nuisance factors such as noise, odor, vibrations, etc. These activities include heavy manufacturing, fuel and power production, waste disposal, meat packing and slaughter houses, lumber milling, chemical and petroleum storage and bulk sales, material salvage yards and mining.

░ **General Rural**
This land use category includes primarily agricultural land uses to preserve and promote the rural character of the Rural Service Area by discouraging urban development except for large tract residential subdivisions and the Rural Activity Centers.



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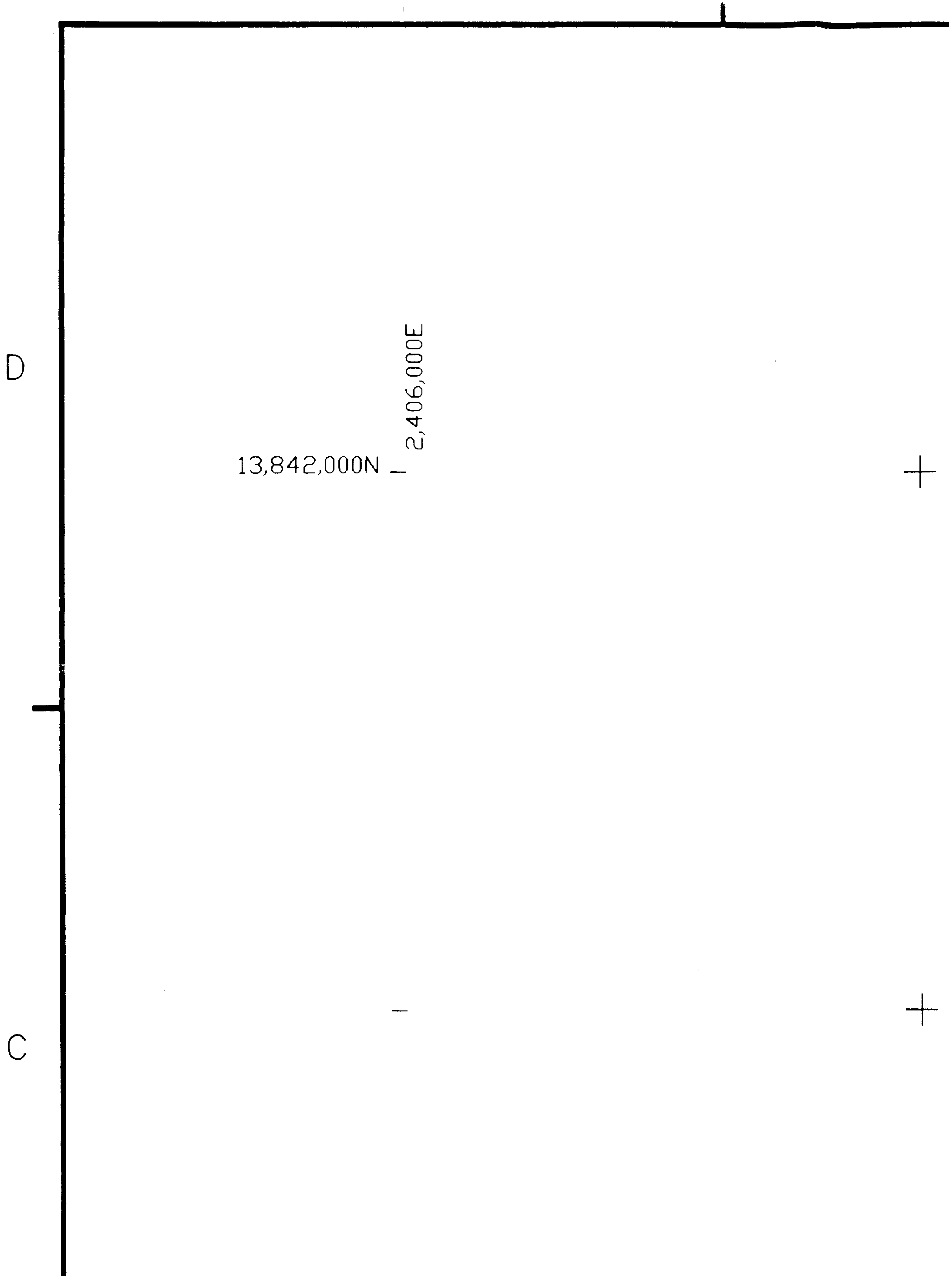
LEXINGTON–BLUEGRASS ARMY DEPOT
POTENTIAL FUTURE ZONING IN THE VICINITY OF LBAD
LEXINGTON, KENTUCKY

Project Number	012308
File Name	FIG7–4
Figure	6-2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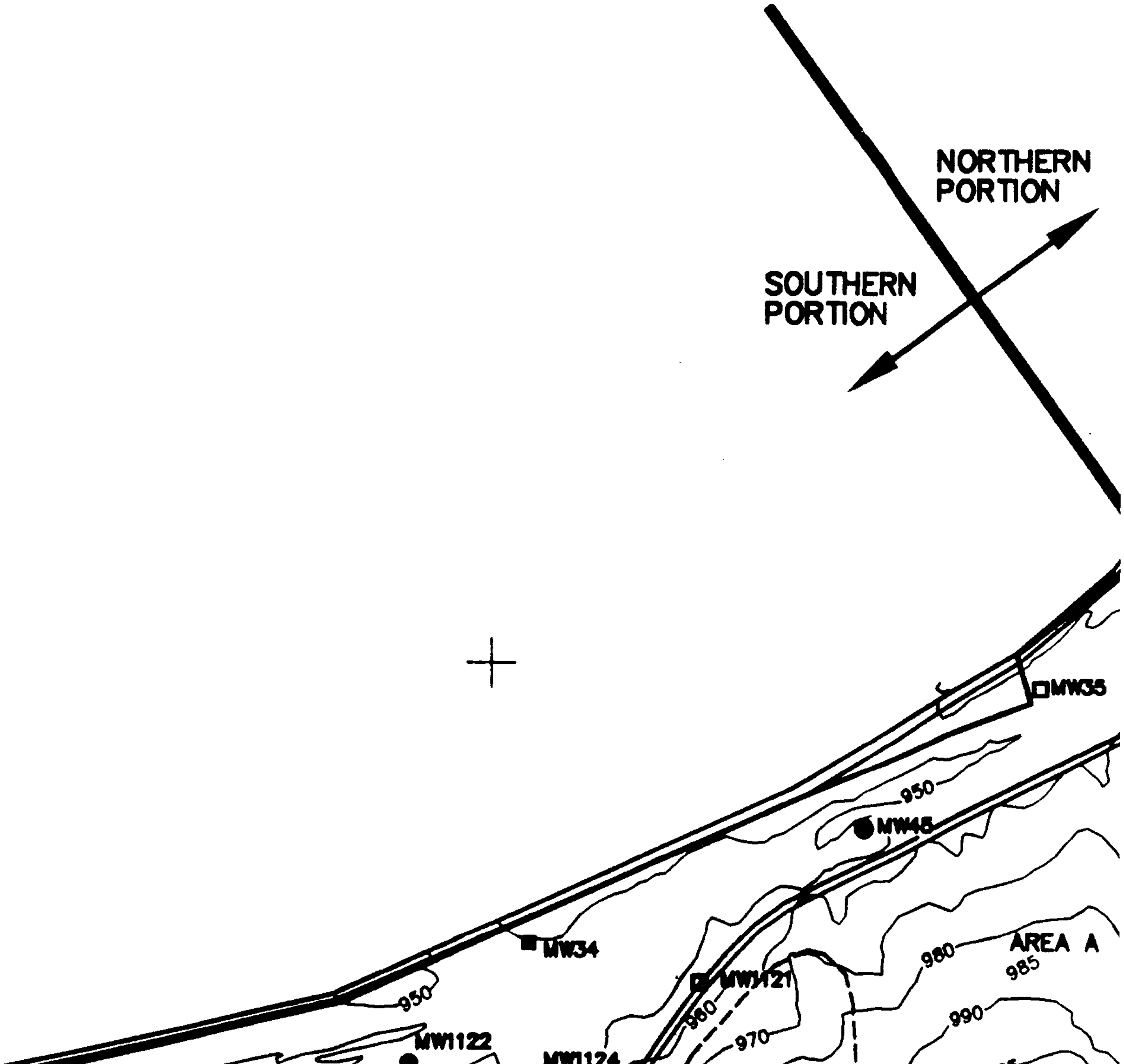
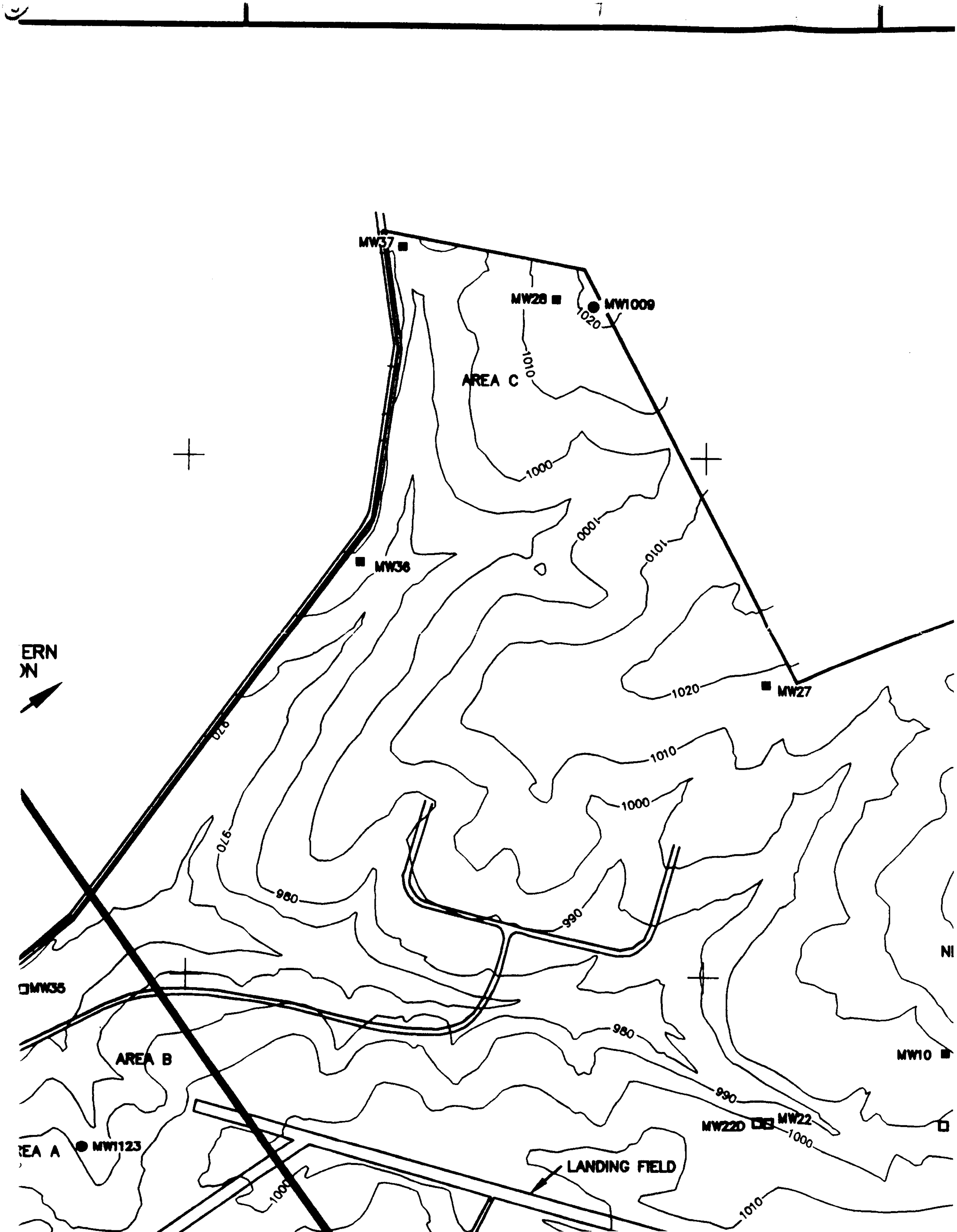
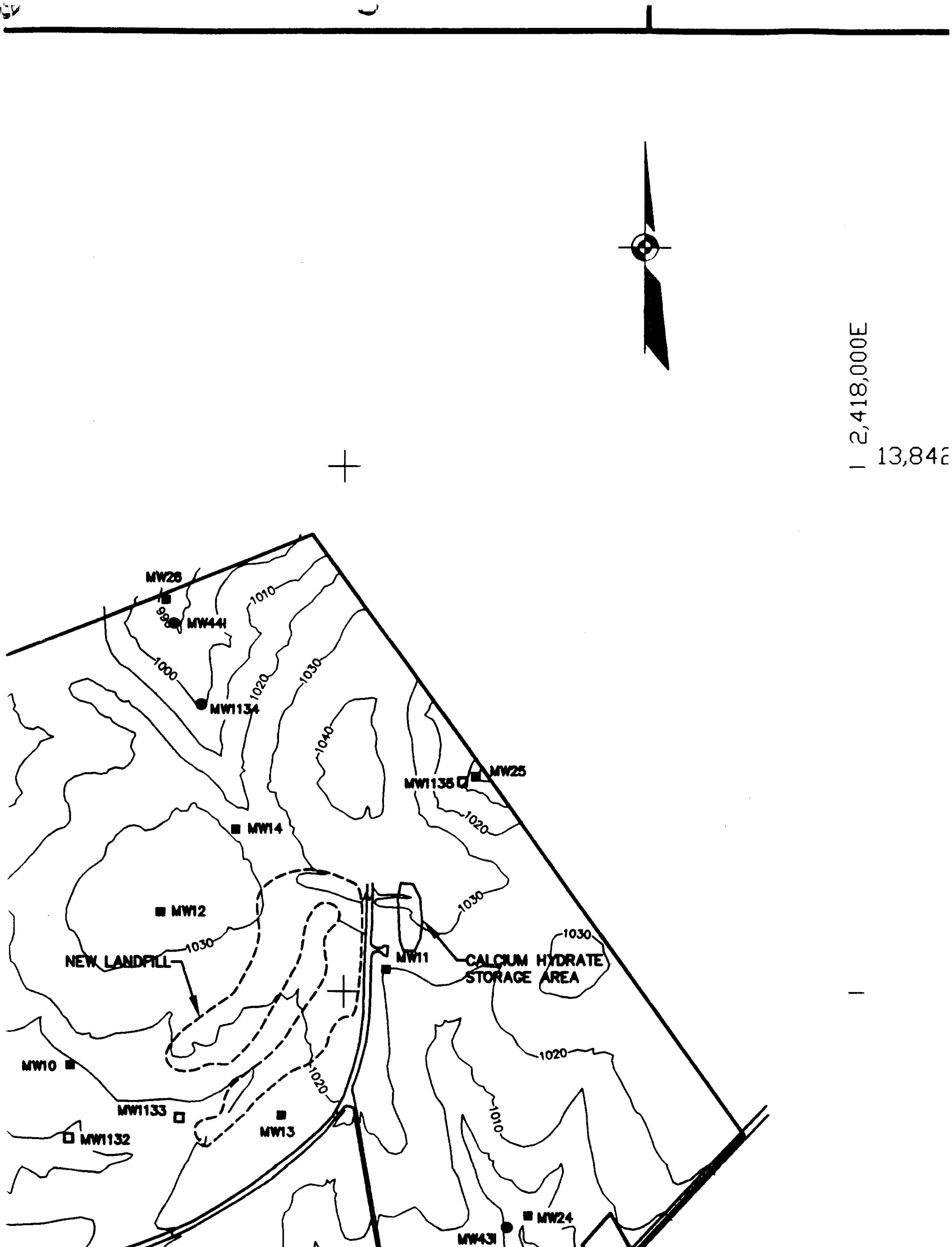
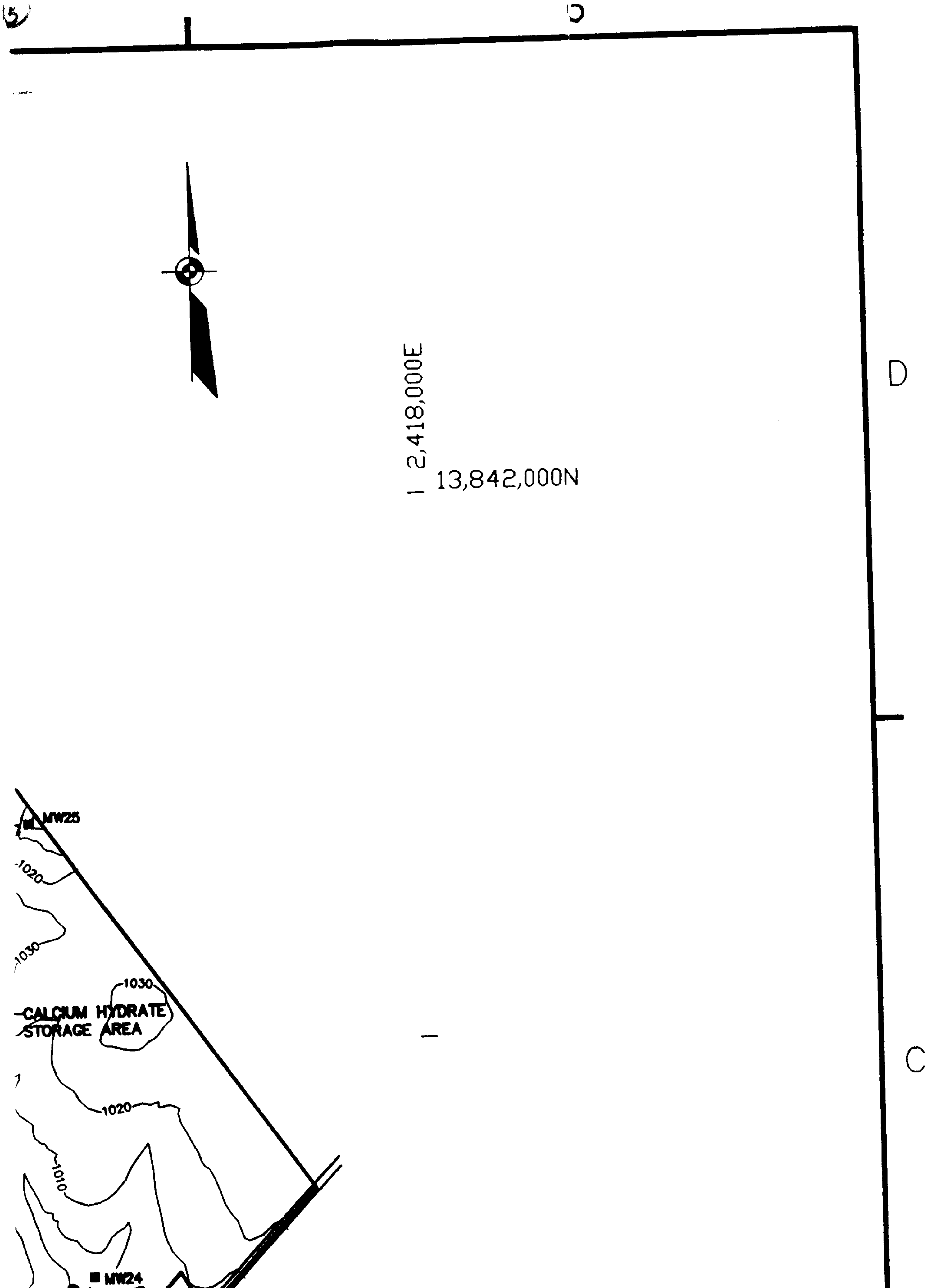

NORTHERN PORTION
SOUTHERN PORTION
MW35
950
MW45
MW34
AREA A
980
985
MW1121
950
960
990
970
MW1122
MW1124


7
MW37
MW28
MW1009
1020
1010
AREA C
1000
1000
1010
MW36
ERN
N
970
1020
MW27
1010
1000
970
980
990
MW35
980
AREA B
MW10
NI
990
MW22D
MW22
1000
EA A
MW1123
LANDING FIELD
1000
1010


2,418,000E
13,84
MW26
998
MW44I
1000
1010
1020
1030
MW1134
1040
MW1135
MW25
1020
MW14
MW12
1030
NEW LANDFILL
MW11
CALCIUM HYDRATE
STORAGE AREA
1030
1030
1020
MW10
1020
1010
MW1133
MW13
MW1132
MW24
MW43I


5
D
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2,418,000E
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MW25
1020
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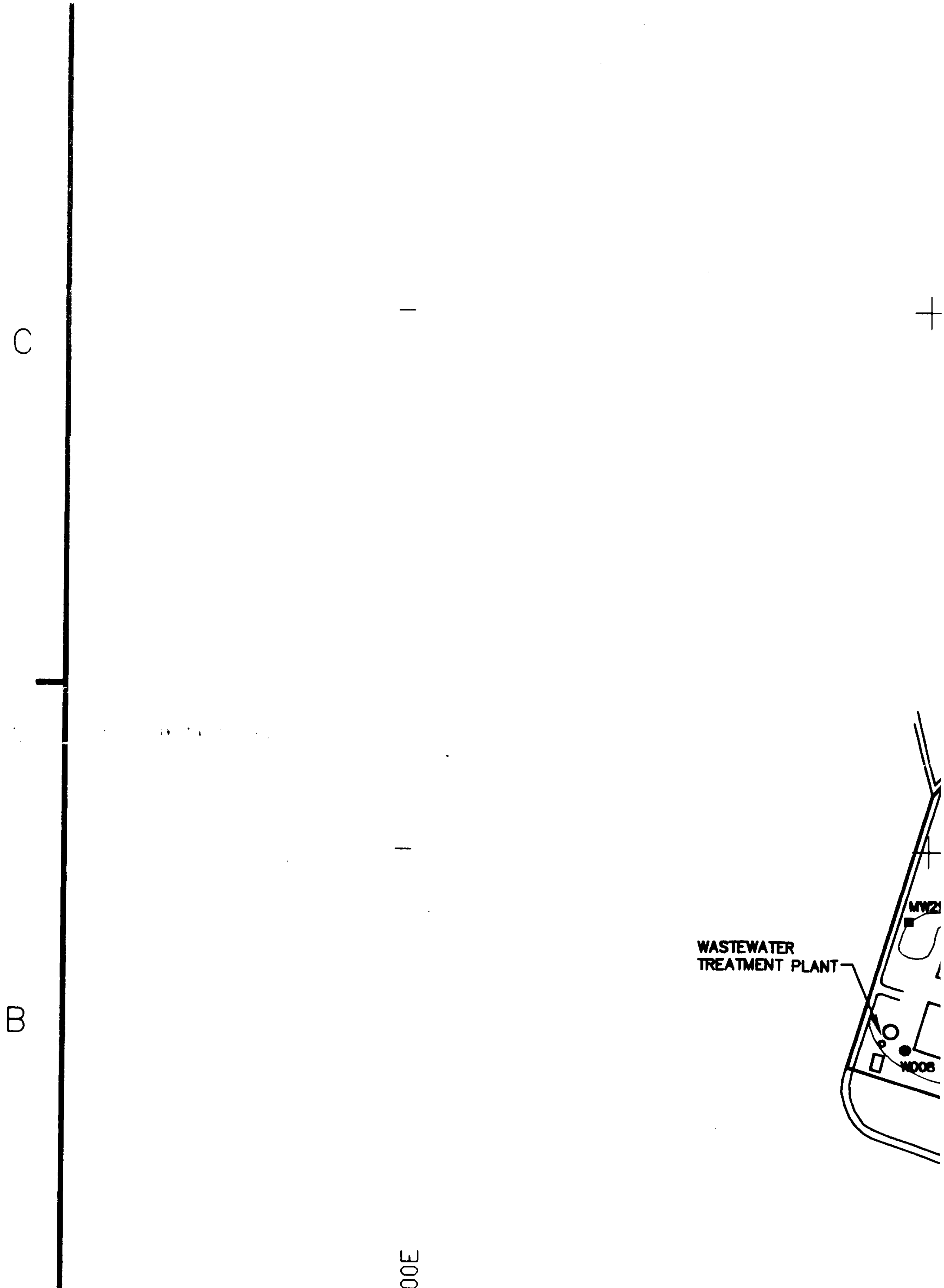
1030
CALCIUM HYDRATE
STORAGE AREA
1020
1010
MW24

(6)



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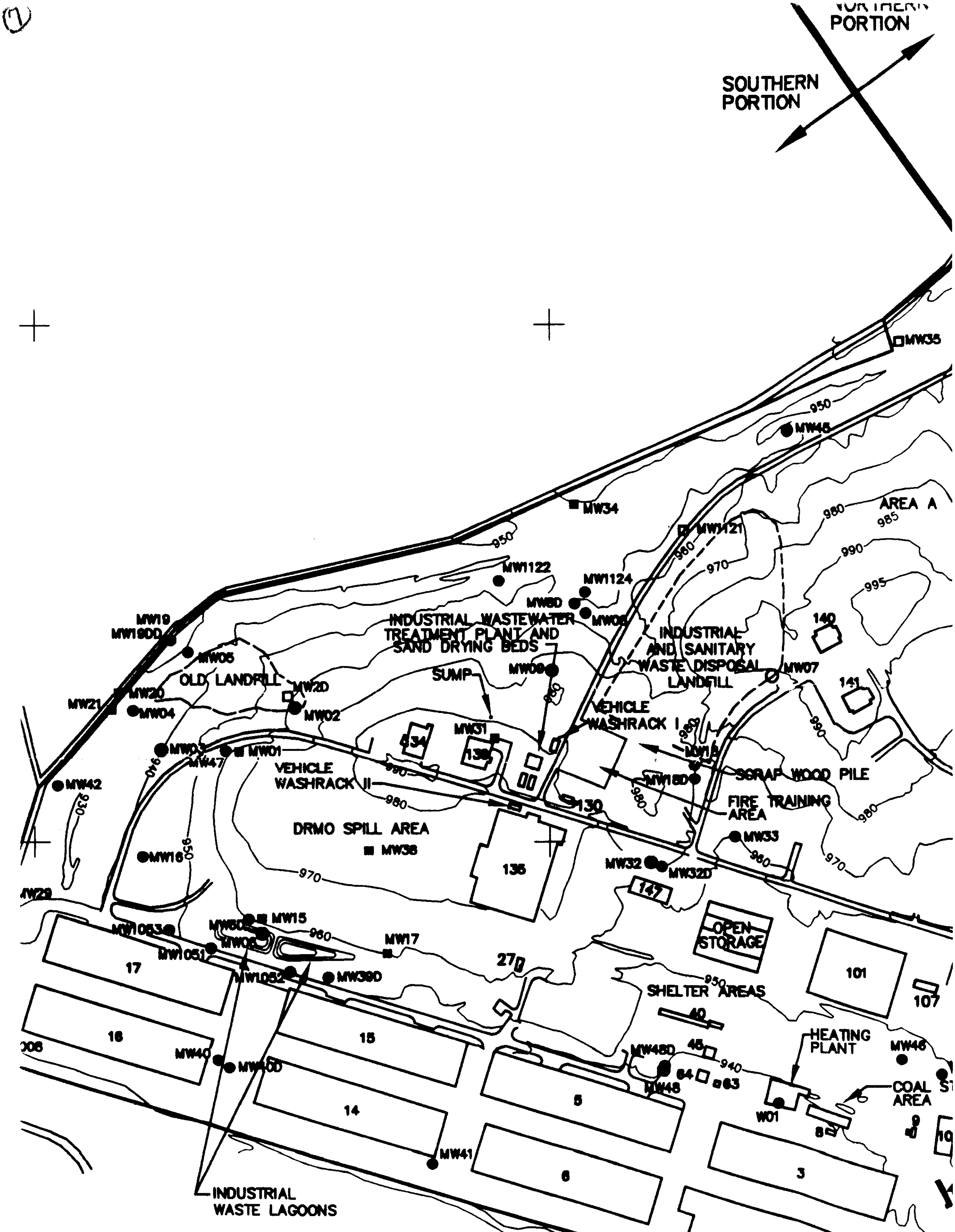
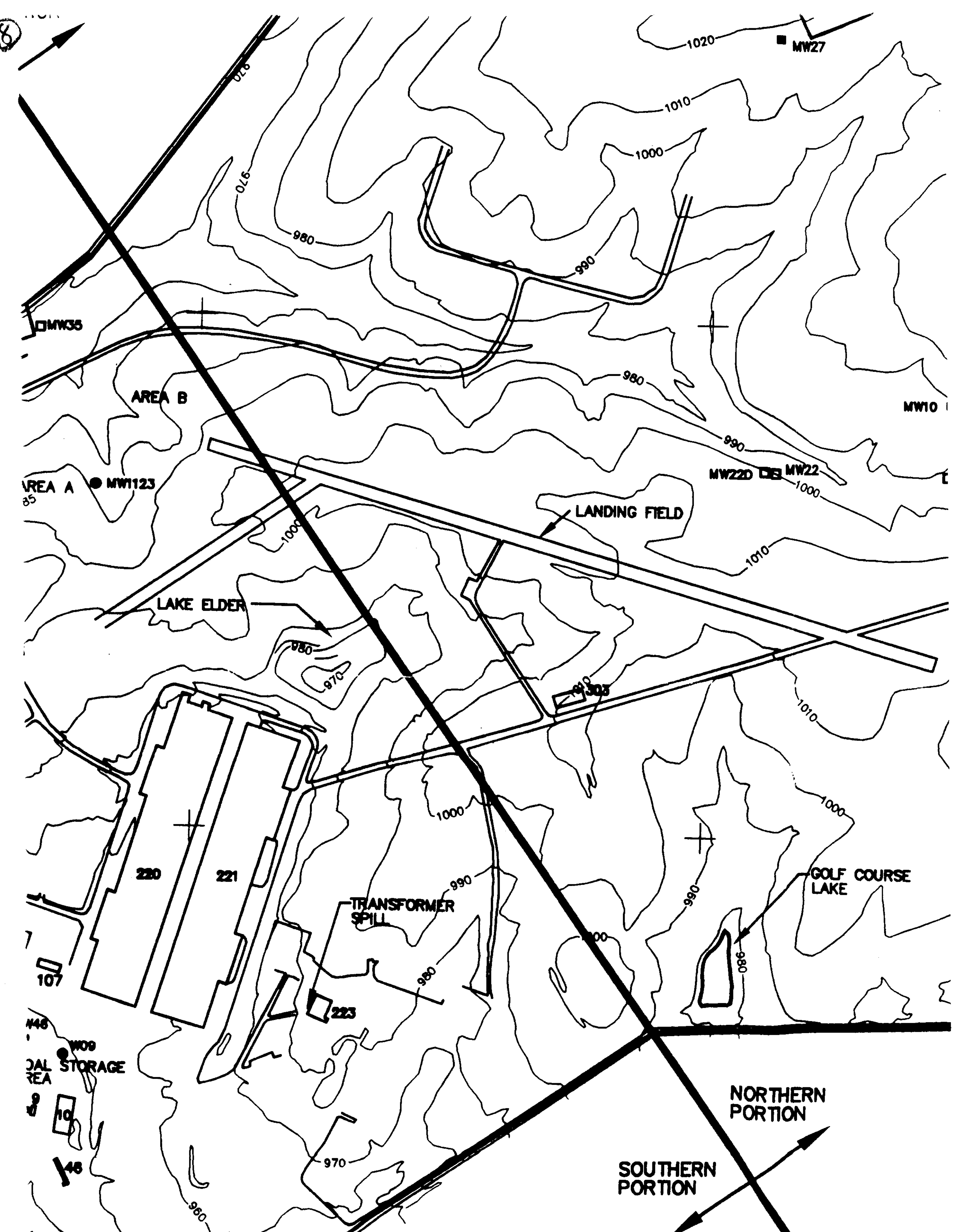

NORTHERN PORTION
SOUTHERN PORTION
MW35
950
MW45
AREA A
980
985
990
995
MW34
MW1121
980
970
950
MW1122
MW1124
MW6D
MW06
INDUSTRIAL WASTEWATER TREATMENT PLANT AND SAND DRYING BEDS
INDUSTRIAL AND SANITARY WASTE DISPOSAL LANDFILL
140
141
MW07
MW19
MW19DD
MW05
OLD LANDFILL
MW2D
MW02
MW20
MW21
MW04
SUMP
MW09
960
VEHICLE WASHRACK I
MW31
134
138
MW18
MW18D
SCRAP WOOD PILE
FIRE TRAINING AREA
MW03
MW47
MW01
VEHICLE WASHRACK II
990
980
130
940
MW42
930
DRMO SPILL AREA
MW38
135
MW33
MW32
MW32D
970
MW16
950
MW29
147
OPEN STORAGE
101
107
MW1053
MW15
MW50S
MW08
MW1051
MW17
27
17
MW1052
MW39D
SHELTER AREAS
40
16
15
MW40
MW40D
HEATING PLANT
MW46
45
MW48D
940
64
63
MW48
W01
COAL AREA
9
8
14
5
006
MW41
6
3
INDUSTRIAL WASTE LAGOONS


8
970
1020
MW27
1010
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980
990
MW35
AREA B
980
MW10
990
MW22D
MW22
1000
AREA A
85
MW1123
LANDING FIELD
1000
1010
LAKE ELDER
980
970
303
1010
220
221
1000
1000
GOLF COURSE
LAKE
990
990
TRANSFORMER
SPILL
1000
980
980
107
223
W46
W09
OAL STORAGE
REA
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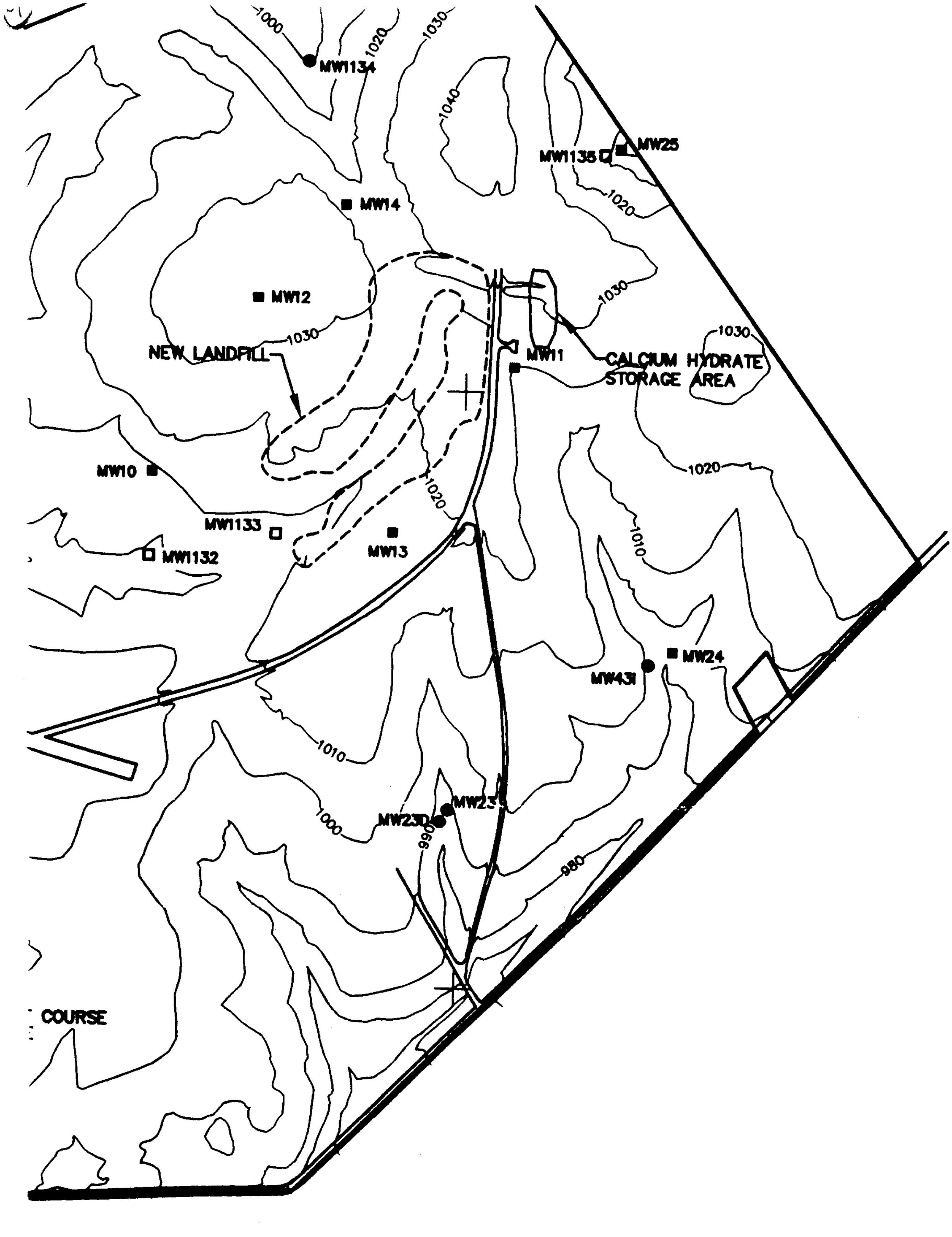
10
46
970
960
NORTHERN
PORTION
SOUTHERN
PORTION


1000
1020
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MW1134
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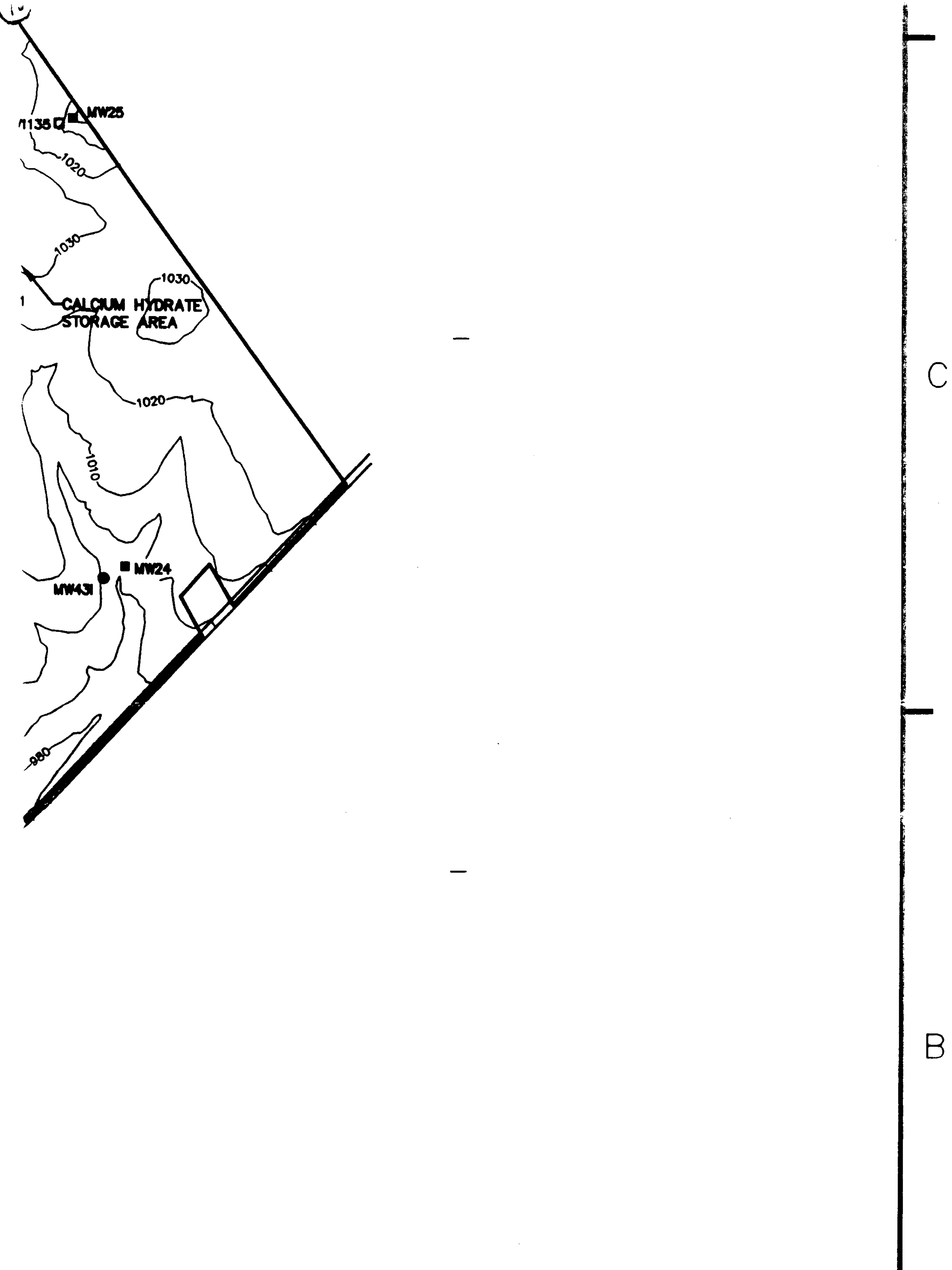
MW25
MW1135
1020
MW14
MW12
1030
NEW LANDFILL
MW11
1030
CALCIUM HYDRATE STORAGE AREA
1030
1020
MW10
1020
MW1133
MW13
MW1132
1010
MW24
MW431
1010
MW23
MW23D
1000
990
980
COURSE


MW25
1135
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CALCIUM HYDRATE
STORAGE AREA
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MW24
MW431
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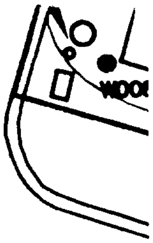


2,406,000E

13,836,000N

LEGEND

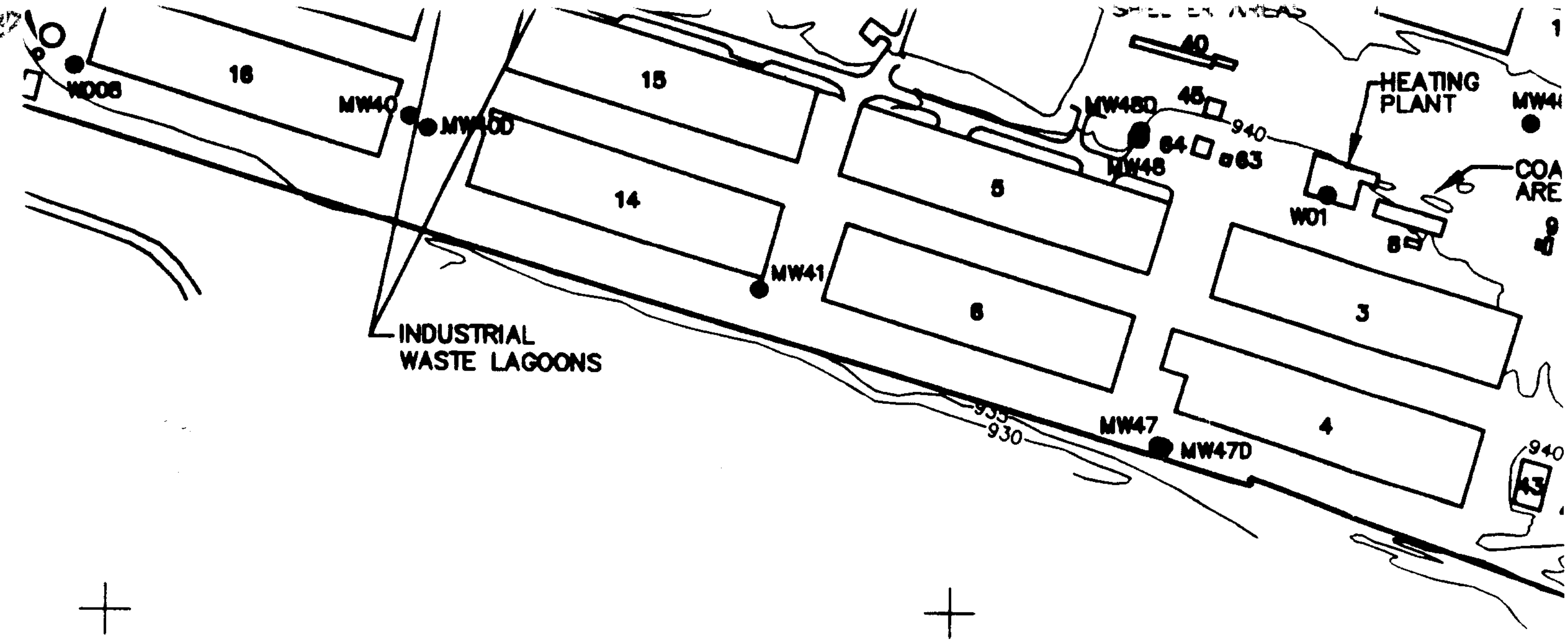
■	DRY HOLES (NO SAMPLING DATA)
□	EXISTING WELLS DRY AT TIME OF SAMPLING (NO SAMPLING DATA)
●	GROUNDWATER SAMPLING LOCATIONS USED IN RISK ASSESSMENT
○	BACKGROUND WELLS

A

NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION

REVISIONS

1



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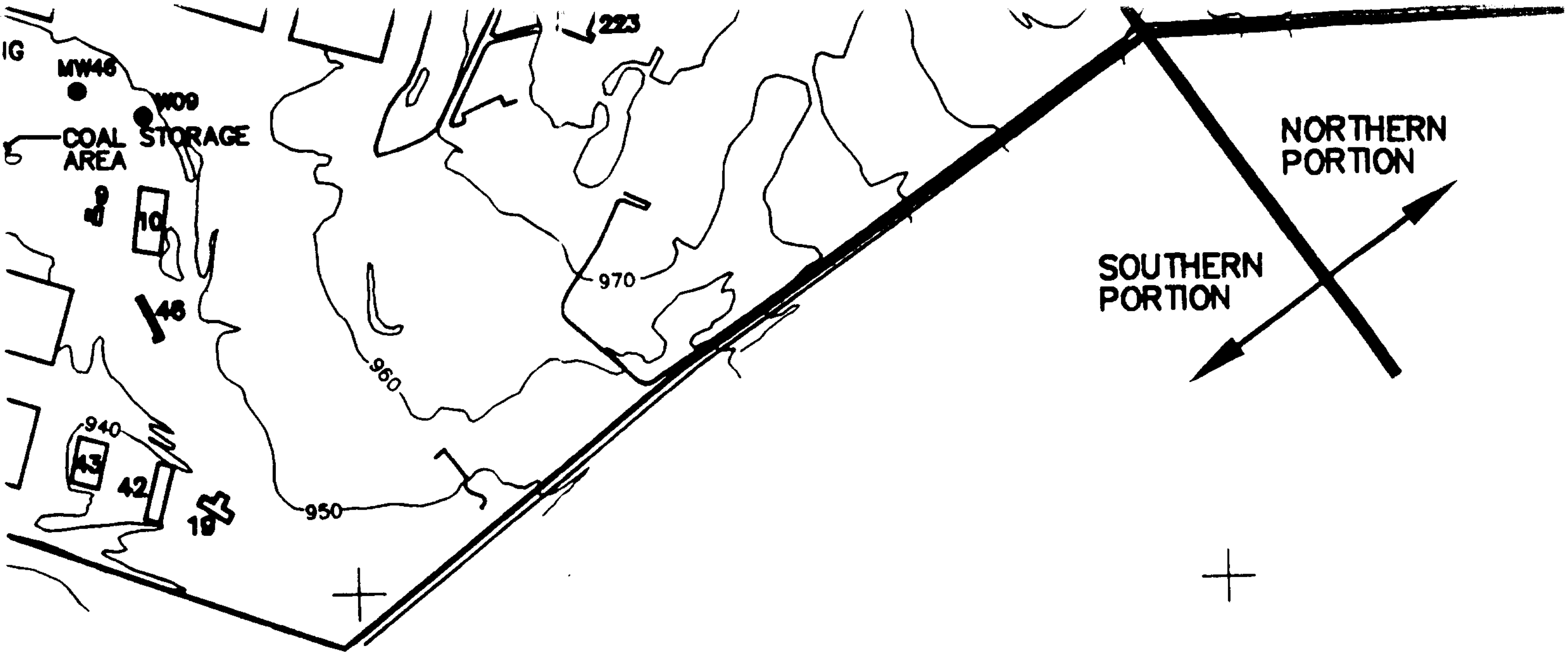

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UNLESS OTHERWISE NOTED OR CHANGED

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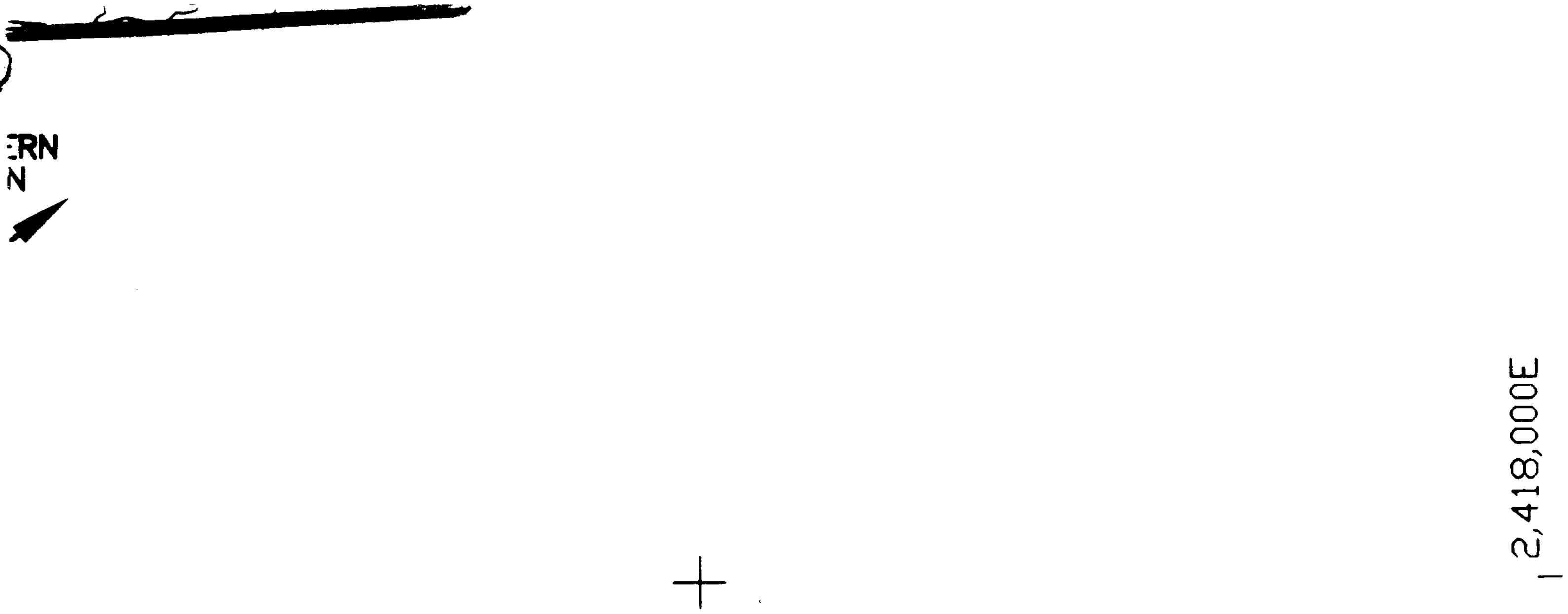

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OR CHANGED BY REPRODUCTION

LEXINGTON BLUEGRASS ARMY DEPOT

NORTHERN AND SOUTHERN GROUNDWA
PORTIONS OF LBAD

LEXINGTON, KENTUCKY

(12)

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A

NGTON BLUEGRASS ARMY DEPOT

AND SOUTHERN GROUNDWATER
PORTIONS OF LBAD

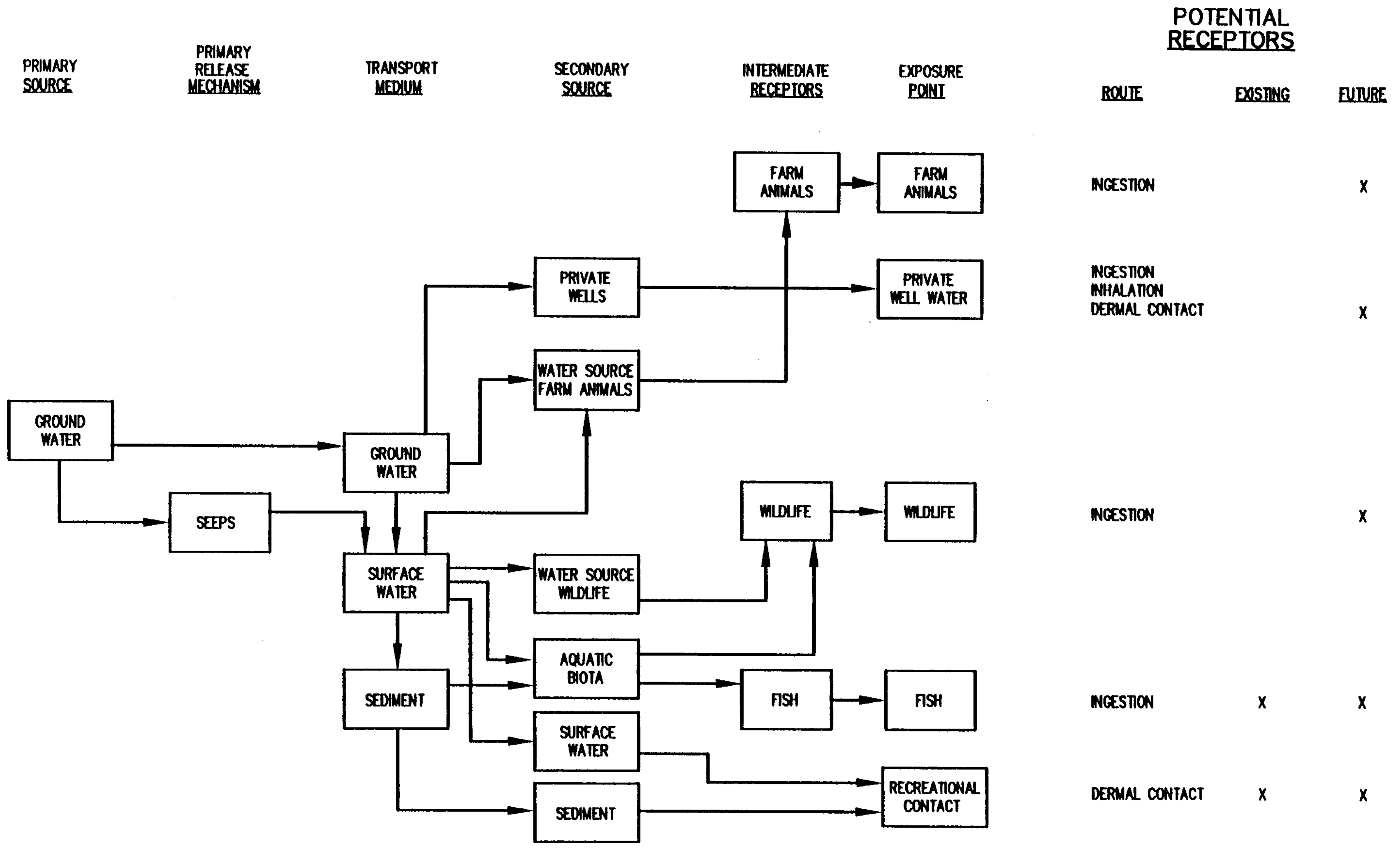
LEXINGTON, KENTUCKY

JOB 012308

FILE NO. 308-6-3

FIGURE 6-3

6



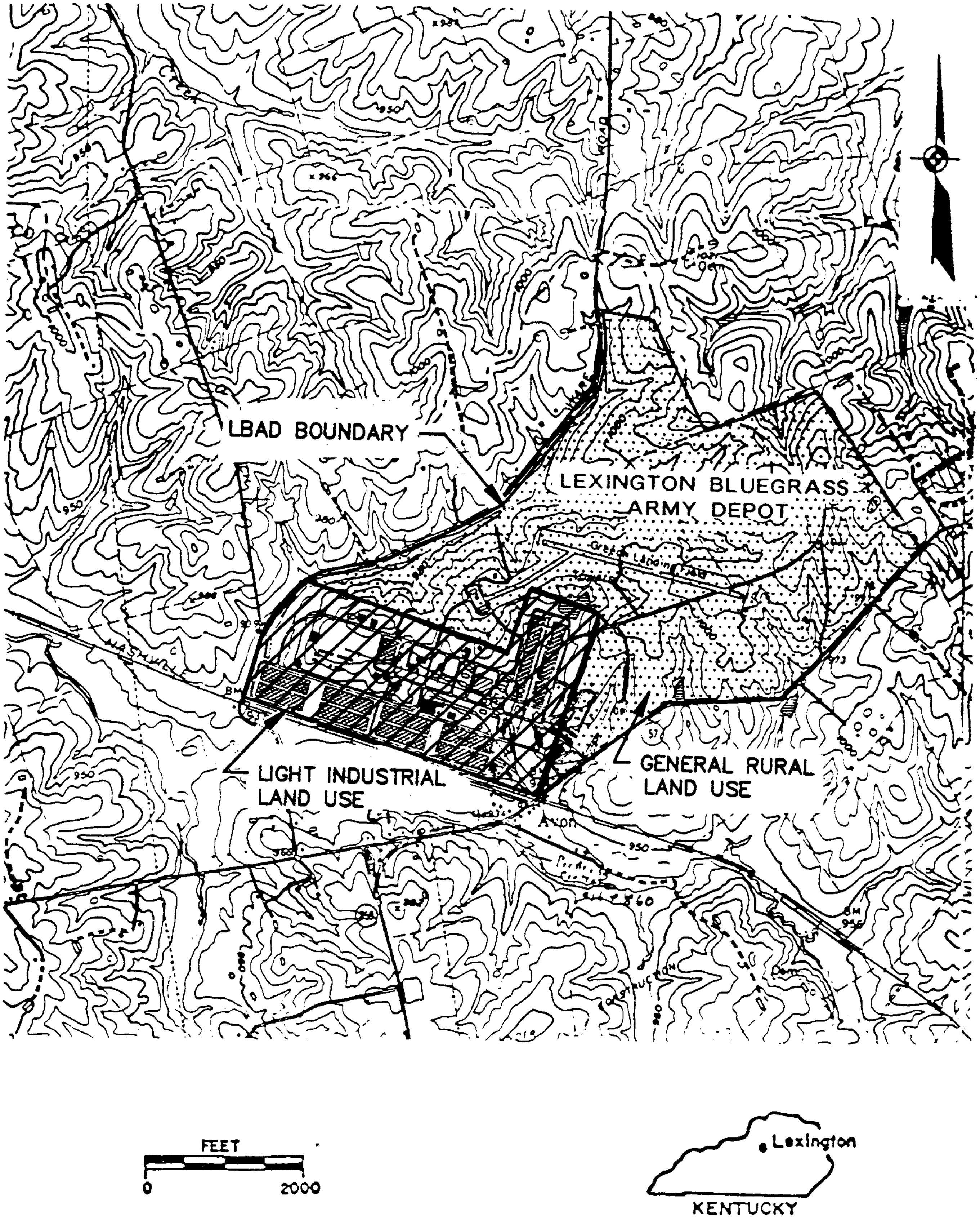
Metcalf & Eddy

LEXINGTON BLUEGRASS ARMY DEPOT
CONCEPTUAL MODEL OF SOURCES, TRANSPORT MEDIA AND POTENTIAL RECEPTORS
LEXINGTON, KENTUCKY

Project Number 012308

File Name 308–6–4

Figure 6–4



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Metcalf & Eddy

LEXINGTON-BLUEGRASS ARMY DEPOT

DETAIL OF LBAD ZONING/LAND USE DESIGNATIONS

LEXINGTON, KENTUCKY

Project number
012308

Figure
6-5

7.0 SUMMARY AND CONCLUSIONS

The objective of the groundwater RFI at the LBAD was to identify the nature and extent of contamination and potential human health risk as it relates to past and present activities undertaken at specific areas of the facility. This objective was accomplished by installing and sampling monitoring wells across the site.

7.1 NATURE AND EXTENT OF CONTAMINATION

This section will present brief discussions on the constituents detected at each area and the extent of contamination. Contamination was determined when contaminant concentrations exceeded site-specific background concentrations or ARARs such as MCLs. Groundwater results from the areas investigated as part of the base-wide study are presented below.

Old Landfill

Constituents present above MCLs and/or background at this landfill include 20 inorganics and five organics. The extent of contamination extends to the western edge of the landfill to MW19 and MW19DD. It appears that no organic contamination is present to the west of these wells. Groundwater flow from this area extends to the west of the landfill into the tributary of North Elkhorn Creek.

New Landfill

Constituents present above MCLs and/or background at this landfill include 14 inorganics and two organics. The extent of contamination in this area appears to be isolated to the east of the landfill at MW43I. There is no organic contamination present at MW23 and MW23D, which are located to the southeast. Groundwater direction in this area flows to the southeast.

Industrial and Sanitary Waste Landfill

Constituents present above MCLs and/or background at this landfill include 17 inorganics and nine organics. The extent of contamination in this area appears to extend to the west of the landfill and to the southeast of the landfill toward MW47, which is located on the property boundary. Groundwater in the area of the Industrial and Sanitary Landfill, flows radially to the west, south, and southeast.

Industrial Waste Lagoons

Constituents present above MCLs and/or background at this landfill include 17 inorganics and seven organics. The extent of contamination in this area appears to be localized to the lagoon area. Wells located south of the lagoon do not indicate that contamination has migrated to those points. Groundwater from this area flows south into a creek located off site, south of LBAD.

Area B

Constituents present above MCLs and/or background at this landfill include 14 inorganics and two organics. The extent of contamination in this area appears to be localized to the area. The groundwater in this area flows to the west into the tributary of North Elkhorn Creek. However, the source of the groundwater contamination is difficult to establish based on groundwater flow and the location of known potential contaminant sources.

Area C

Constituents present above MCLs and/or background at this landfill include 11 inorganics and two organics. The extent of contamination in this area appears to be localized to the area. The groundwater in this area flows to the west into the tributary of North Elkhorn Creek. However, the source of the groundwater contamination is difficult to established based on groundwater flow and the location of known potential contaminant sources.

7.2 RISK ASSESSMENT

After evaluation of the constituents present at each area above MCLs and/or background, a baseline risk assessment was performed and chemicals of concern derived.

The baseline risk assessment for human health at the LBAD centered upon the determination of the groundwater related exposure concentrations, exposure pathways, exposure estimates, and relative noncancer hazard and carcinogenic risk of chemicals of concern which included metals, semivolatile organic compounds, and volatile organic compounds. The chemicals of concern were selected primarily on the basis of a single detection of a chemical in the groundwater samples collected from the LBAD. The results of the assessment conducted on the other media (USAEC, 1994) are presented in Appendix

R of this report in conjunction with the results of this report. Naturally occurring inorganic (primarily metals) analytes were compared to site-specific background concentrations and removed from further study in the risk assessment if the site-specific concentrations were lower than background levels.

The human health risk assessment was developed by segregating the analytical results according to a physical/hydrogeological divide at the facility, resulting in data which represented the Northern and Southern portions of the LBAD. Therefore, two data sets (representing the northern and southern portions of the facility) were constructed for quantitative evaluation in the risk assessment. Chemicals detected in groundwater did not remain within the geographical/surficial boundaries of the RFI SWMUs and other areas. The north-south division of the data allowed for the characterization of potential exposure to groundwater using site-specific information with regard to groundwater flow direction, yield, depth to groundwater, and potential chemical migration pathways in groundwater.

The chemicals evaluated in the baseline risk assessment had the following characteristics: sufficient environmental and chemical data; at least one chemical detection above certified reporting limits in groundwater; and a potentially complete exposure pathway (i.e., where a selected chemical, a receptor, and a transport medium between the source and the receptor were all present).

Current and future land-use exposure scenarios were examined in the exposure assessment. No current land-use scenarios were identifiable for the groundwater pathway. Groundwater is not currently utilized on-site. In addition, area residents utilize supplied water for the most part. However, there are some private wells in the site vicinity, but none of them are used for drinking water. Any current off-site exposures would be encompassed in the conservative assessment performed for potential future case receptors.

The future land-use scenario considered three potential receptor groups: a hypothetical future worker and hypothetical future adult and child residents. SWMUs and other areas where such potential exposures might feasibly occur were identified based on the land use designations for the LBAD and surrounding vicinity (i.e., general rural and light industry). These land use designations will likely continue into the future. However, all receptors were evaluated for potential exposures to groundwater concentrations regardless of the current and planned future zoning/site use.

Potential future scenario exposure estimates were quantified for the receptor groups in the exposure assessment. Conservative assumptions were employed in the characterization of potential exposures such that the resulting exposure estimates would err on the side of over-estimation, rather than under-estimation of exposure, hazard, and/or risk. Potential exposure pathways included: ingestion of groundwater, dermal contact with groundwater, and inhalation of groundwater during showering. Exposure concentrations for the chemicals of concern were based on the 95 percent upper confidence limit (UCL) or maximum sampling result (whichever was lower) from the north and south groundwater wells investigated.

The toxicity assessment identified toxicity values (RfDs and CSFs) and critical toxic effects for the chemicals selected for evaluation. Exposure concentrations which exceed the toxicity values may be associated with the development of adverse health effects.

The risk characterization was performed to evaluate the exposure levels estimated in the exposure assessment relative to the toxicity values identified in the toxicity assessment. The potential for noncarcinogenic effects was evaluated by comparing the estimated exposure levels to the toxicity values. The ratio of the comparison of the exposure level to the noncancer toxicity value is a hazard quotient. The chemical-specific hazard quotients were summed across all chemicals of concern and/or exposure pathways for each SWMU or area investigated to determine the total hazard index for the area. U.S. EPA requirements stipulate that a noncancer hazard index of 1.0 not be exceeded to demonstrate that site conditions are not associated with unacceptable human health effects (U.S. EPA, 1991d). Estimated hazard indices were found to be greater than unity for the following cases.

AREA OF INVESTIGATION	**CHEMICALS CONTRIBUTING TO HAZARD INDEX >1.0**
NORTHERN LBAD GROUNDWATER	Arsenic, Lead, Manganese, Thallium, Sodium
SOUTHERN LBAD GROUNDWATER	Antimony, Manganese, Thallium, Aluminum

The potential for carcinogenic effects was evaluated in the risk characterization as the probability that an individual will develop cancer over a lifetime of exposure to the selected chemicals, i.e., carcinogenic risk. The U.S. EPA's National Contingency Plan (NCP) requires that the lifetime cancer risk at hazardous waste sites should fall within the range of 1 in 10,000 (1E-04) to 1 in 1,000,000 (1E-06). KDEP requires that 1E-06 be utilized as the target for acceptable risk.

The risk estimates for the groundwater areas investigated at LBAD exceeded the criterion of 1E-06 for the following cases:

AREA OF INVESTIGATION	CHEMICALS CONTRIBUTING TO CARCINOGENIC RISK >1E-06
NORTHERN LBAD GROUNDWATER	Arsenic, Beryllium
SOUTHERN LBAD GROUNDWATER	Vinyl Chloride, Arsenic, Beryllium

The total noncancer hazard indices and risk estimates were within acceptable limits for all of the other chemicals investigated in the baseline human health risk assessment for the LBAD.

The results of the human health baseline risk assessment were tempered by a consideration of a number of uncertainties in the risk assessment process. Such uncertainties may have an impact on the risk management and remedial decisions which are to be made for the LBAD. These uncertainties included the following considerations: conservatism of the exposure concentrations and exposure estimation assumptions; lack of site-specific exposure parameter values; uncertainties in toxicity values; lack of consideration of synergistic/antagonistic effects of chemicals; and lack of measured air concentrations for the chemicals of concern.

The chemicals which provided the primary contribution to the total hazard or risk were metals (arsenic, beryllium, lead, manganese, and thallium) concentrations which may actually reflect the natural variability of metals in groundwater. Also, it was assumed that receptors would be exposed to the higher metal concentrations in groundwater, without further filtration or treatment, for the extended period of exposure, thereby overestimating total exposure, hazard and risk. Furthermore, conservative modeling to predict air and dermal uptake concentrations were used in place of actual sampling/characterization of these media and exposure mechanisms; this methodology may have resulted in an overestimate of potential exposure, hazard and risk. Risk management decisions for the LBAD must include a thorough evaluation of these uncertainties in the course of determining the extent of remediation which will be required for the groundwater areas where total hazard indices or risk were higher than acceptable hazard and risk levels.

7.3 CONCLUSIONS

The chemicals of concern for this RFI are those chemicals which were detected in the LBAD site groundwater above background concentrations which present an unacceptable risk to human health or exceed Federal U.S. EPA or State of Kentucky cleanup standards, standards of control, or other potentially relevant criteria/guidelines for human health and/or environmental protection[1]. These chemicals of concern will be the focus of the remedial alternatives evaluation for the LBAD groundwater in the Corrective Measures Study (CMS) portion of this report. Specifically, these chemicals include benzene, vinyl chloride, aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, sodium thallium, and zinc.

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[1] The only noted exceptions to this definition are DDT, bis(2-ethylhexyl)phthalate, carbon tetrachloride, tetrachloroethene, and trichloroethene. DDT was detected in only 3 out of 42 groundwater samples at concentrations which were generally consistent with background concentrations. Bis(2-ethylhexyl)phthalate, carbon tetrachloride, and tetrachloroethene were detected in only 1 out of 44 samples at concentrations which were close to or below USEPA MCLs and the State of Kentucky Water Supply Source Criteria Values. Trichloroethene was detected slightly above the USEPA MCL and the State of Kentucky Water Supply Source Criteria Value for trichloroethane in only 1 out of 44 samples. The results of the risk assessment for the LBAD groundwater determined that the detected concentrations of all these chemicals did not present an unacceptable risk to human health.

8.0 CORRECTIVE MEASURES STUDY

8.1 APPROACH

The Corrective Measures Study (CMS) portion of this RFI/CMS report presents evaluations of remedial alternatives for chemicals of concern which have been identified in the groundwater at the Lexington Facility of Bluegrass Army Depot (LBAD) in Lexington, Kentucky. Chemicals of concern are defined in this CMS as chemicals detected in the site groundwater which present an unacceptable risk to human health or exceed Federal U.S. EPA or State of Kentucky cleanup standards, standards of control, or other potentially relevant criteria/guidelines for human health and/or environmental protection[1]. Table 8-1 provides a complete list of the chemicals of concern identified in the LBAD groundwater. This CMS has been prepared in accordance with U.S. EPA guidance as provided in the document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (U.S. EPA, 1988).

The purpose of the CMS is to identify and evaluate remedial action alternatives which will reduce the human health and environmental risks associated with chemicals of concern in the LBAD groundwater. These alternatives would involve restrictions on groundwater use, removal, and/or direct treatment of the LBAD groundwater. In preparing the CMS, cleanup goals were developed for the chemicals of concern in the LBAD groundwater. These cleanup goals represent the concentrations to which the chemicals of concern should be reduced in order to achieve acceptable human health and/or environmental risks and to provide compliance with regulatory requirements. In accordance with U.S. EPA guidance (U.S. EPA, 1988), the cleanup goals and Applicable or Relevant and Appropriate Requirements (ARARs) were used to develop remedial action objectives for the contaminants of concern in the LBAD groundwater. General response actions were then developed for the contaminants of concern to satisfy the remedial action objectives. Remedial technologies/alternatives applicable to each general response action were then identified and screened to select those considered most appropriate for incorporation into a set of remedial action alternatives.

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[1] The only noted exceptions to this definition are DDT, bis(2-ethylhexyl)phthalate, carbon tetrachloride, tetrachloroethene, and trichloroethene. DDT was detected in only 3 out of 42 groundwater samples at concentrations which were generally consistent with background concentrations. Bis(2-ethylhexyl)phthalate, carbon tetrachloride, and tetrachloroethene were detected in only 1 out of 44 samples at concentrations which were close to or below USEPA MCLs and the State of Kentucky Water Supply Source Criteria Values. Trichloroethene was detected slightly above the USEPA MCL and the State of Kentucky Water Supply Source Criteria Value for trichloroethane in only 1 out of 44 samples. The results of the risk assessment for the LBAD groundwater determined that the detected concentrations of all these chemicals did not present an unacceptable risk to human health.

It should be noted that the remedial alternative evaluations presented in this report do not address the potential need for containment, treatment, removal, and/or monitoring of contaminants in the LBAD soil, sediment, or surface water. These environmental media were the subject of evaluation in a separate Corrective Measures Study report which was recently prepared for the U.S. Army (USAEC, June 1994). This report should be referred to for a detailed evaluation of remedial action alternatives for the contaminants of concern identified in the LBAD soil, sediment, and surface water.

The CMS portion of this report, following this introductory section, is divided into three sections. Each of the three sections presents an integral step in the CMS evaluation process for remedial alternative development, screening, and evaluation. These sections/steps are:

Section 9.0	Identification and Initial Screening of Technologies
Section 10.0	Development and Screening of Remedial Action Alternatives
Section 11.0	Detailed Analysis of Alternatives

8.2 BACKGROUND INFORMATION

8.2.1 LBAD Description and History

LBAD is located in Fayette County, Kentucky, in the town of Avon, approximately 10 miles east of Lexington (Figure 8-1). The Depot encompasses 782 acres which were acquired through the purchase of seven tracts of farm land. The Lexington Facility was established as a signal depot authorized by Department of War General Order No. 6 dated June 25, 1941. In December 1988, the Lexington Facility was identified for closure by the Defense Secretary's Commission on Base Realignment and Closure (BRAC). Section 1.0 of this RFI/CMS report should be referred to for a more detailed description of the LBAD facility and the facility history.

8.2.2 Summary of RFI Findings

The objective of the groundwater RFI was to identify the nature and extent of contamination as it relates to past and present activities at specific areas of the facility.

Three phases of the RFI were conducted at LBAD. The first phase began in October 1991, when 11 new wells were installed. Phase II commenced in July 1992 with the installation of an additional 24 monitoring wells and the RFI was completed in September 1993 when four more wells were installed. A total of 39 monitoring wells were installed over the course of the RFI.

Prior to the RFI, 11 monitoring wells were installed at LBAD in 1981 as part of an Environmental Survey.

During the RFI, samples were collected from the monitoring wells and analyzed for Target Compound List volatiles, semivolatiles, pesticides, TAL metals, and cyanide. As discussed in Section 8.1, the LBAD groundwater analysis results were evaluated to establish which of the detected constituents are considered chemicals of concern. Table 8.1 provides a list of these chemicals of concern.

8.2.3 Chemical Fate and Transport Summary

The fate and transport of chemical constituents in the LBAD groundwater is a function of the persistence and migration pathways for each chemical. Persistence generally refers to the amount of time a chemical compound resides in the environment before its chemical structure is altered or the residence time of a chemical within a specific environmental media (i.e., soil, groundwater, surface water, etc). Migration refers to how a constituent may be transported within or between environmental media. The fate and transport discussion presented in this section provides a brief summary of the persistence and potential migration pathways for the contaminant groups (i.e., volatile organic compounds and metals) which have been identified as contaminants of concern in the LBAD groundwater. A more detailed fate and transport discussion for the chemicals in the LBAD groundwater is presented in Section 5.4 of this report.

Organic Compounds

Volatile organic compounds (VOCs) have been identified as chemicals of concern in the LBAD groundwater (i.e., vinyl chloride and benzene). VOCs are generally characterized by rapid volatilization, low adsorption to soil, and varying degrees of solubility and biodegradability. With respect to solubility, vinyl chloride and benzene are only slightly soluble in water. With respect to biodegradability, chlorinated VOCs (vinyl chloride, in this case) tend to biodegrade very slowly, whereas the benzene is more amenable to biodegradation.

The principle route of VOC migration in the LBAD groundwater is expected to be lateral and vertical migration through the soils and within saturated fractures, joints, and bedding planes of the bedrock.

Vinyl chloride and benzene, which are not very soluble in water and have a lower density than water, are expected to migrate coincident with the top of the water table.

Metals

Metals have been identified as chemicals of concern in the LBAD groundwater. The presence, physical state, and concentrations of metals in groundwater are determined by chemical processes, physical processes, and environmental conditions. The fact that metals occur naturally at various concentrations in the environment is a factor which must be considered when evaluating the persistence and migration pathways of these elements. Furthermore, the chemical and physical processes of solubility, hydrolysis, sorption, oxidation-reduction, and complexation will also have a direct impact on the persistence and migration of metals in the LBAD groundwater. All of these factors serve to complicate the fate and transport evaluation for metals in the site groundwater to the extent that a very accurate and detailed evaluation could not be performed without a significant expenditure of time and effort. However, it can be generalized that the overall persistence of metal contaminants in groundwater is relatively high. Furthermore, it is anticipated that dissolved metals in groundwater would migrate coincident with groundwater flow and, depending on particle density and shape, the migration of undissolved metals would also be controlled by the presence, orientation, and geometry of fracture points in the bedrock aquifer.

8.2.4 Baseline Risk Assessment Summary

A risk assessment was performed to evaluate the possibility of human health effects in receptors potentially subject to exposure to chemicals detected in the LBAD groundwater. The risk assessment was conducted in accordance with applicable U.S. EPA and Kentucky Department of Environmental Protection (KDEP) guidelines concerning the performance of risk assessments. The risk assessment is comprised of an identification of chemicals of concern, an exposure assessment, a toxicity assessment, and a risk characterization. Conservative assumptions were employed to provide estimates of exposures, risks, and hazards which would likely result in over-estimates rather than under-estimates of the true risks and hazards for the receptor populations.

The identification of risk-based chemicals of concern was based primarily on the criterion of a single detection of a chemical in any of the samples obtained from the site for organic and non-naturally occurring inorganic compounds. For naturally occurring inorganic analytes, the maximum or 95 percent upper confidence level (UCL), whichever was lower, was compared to background levels. If the inorganic chemical concentration was higher than background concentrations, the chemical was retained as a chemical of concern. Therefore, the process for selecting risk-based chemicals of concern was conservative in that chemicals were included regardless of their frequency of detection, essential nutrient status, or relative toxic potential. The analytical results of groundwater samples indicated the presence of volatile organic compounds, semivolatile organic compounds and metals. Many of these chemicals were detected infrequently and at low concentrations.

Exposure consists of contact with a chemical or physical agent. An exposure assessment is performed to estimate the amount of a chemical available at a bodily exchange area, such as the lungs, gastrointestinal tract, or skin, over a specified time period. An exposure assessment was performed to determine whether the chemical concentrations in the groundwater would result in a daily intake level or dose which could be associated with an adverse health effect. The LBAD has downsized in anticipation of closure in 1995. The LBAD and surrounding area are zoned for general rural or industrial use. It is expected that the present land use designations will continue into the future. With respect to current land use, no receptor population groups were identifiable. Two hypothetical future land use receptor groups were identified: potential future workers and potential future residents.

Potential exposure pathways evaluated for these receptors included: ingestion of groundwater, dermal contact with groundwater, and inhalation of groundwater during showering. Exposure concentrations for the chemicals evaluated were based on the sampling results from either the northern or southern groundwater wells.

The potential for exposure to a chemical to result in an adverse health effect, and the chemical concentration at which such an effect might occur, are evaluated in the toxicity assessment of the chemicals of concern. A toxicity assessment was performed to determine appropriate toxicity values for the risk-based chemicals of concern at the LBAD. In addition, the toxicity assessment identifies the critical toxic effects for these chemicals of concern. The toxicity values represent the exposure levels which are expected to be without adverse noncancer health consequences, or which would be protective against excess cancer risk. Exposure concentrations which exceed the toxicity values may, therefore, be associated with an adverse health effect.

A risk characterization was conducted for the chemicals selected for evaluation in which the exposure levels calculated in the exposure assessment were evaluated with respect to the toxicity values identified in the toxicity assessment.

In a risk characterization, the potential for noncarcinogenic effects is evaluated by comparing the exposure level estimates to the toxicity values. The result of the comparison of the exposure level to the noncancer toxicity value is termed a hazard quotient. Chemical-specific hazard quotients summed across all chemicals of concern and/or exposure pathways are called hazard indices. U.S. EPA requirements stipulate that a noncancer hazard index of 1.0 (or unity) not be exceeded to demonstrate that site conditions are not associated with unacceptable human health effects (U.S. EPA, 1991d). Estimated hazard indices exceeded unity in both the northern and southern groundwater wells at the LBAD. The primary chemicals contributing to the excess hazard were: (1) arsenic, lead, manganese, and thallium in the northern LBAD area; and (2) antimony, manganese, and thallium in the southern LBAD area.

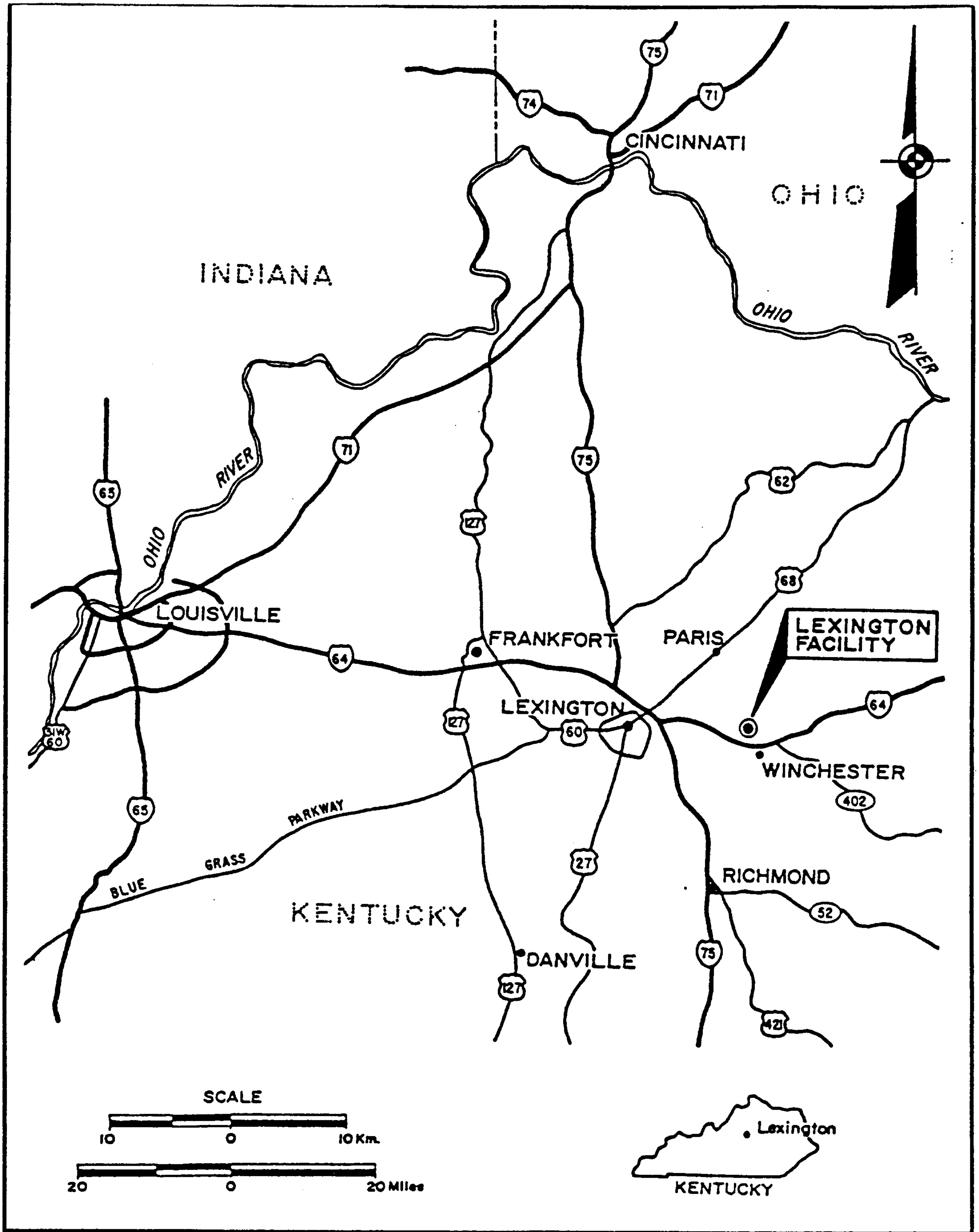
The potential for carcinogenic effects is evaluated in the risk characterization by determining the probability that an individual will develop cancer over a lifetime of exposure to the risk-based chemicals of concern. This estimated probability for cancer development is described as the carcinogenic risk. For exposure to chemical carcinogens at sites where hazardous substances have been released, U.S. EPA's National Contingency Plan (NCP) requires that the lifetime cancer risk at a particular site should fall within the range of 1 in 10,000 (1.0E-04) and 1 in 1,000,000 (1.0E-06) depending on a number of factors including cost, technical feasibility and public acceptance (U.S. EPA, 1991d). Similarly, U.S. EPA's proposed guidance for corrective actions for SWMUs at Hazardous Waste Management Facilities recommends similar guidelines (U.S. EPA 1990a). This policy states that acceptable exposure levels are generally concentration levels that represent a cumulative excess upper bound lifetime cancer risk to an individual between 1.0E-04 and 1.0E-06. KDEP requires a level of 1.0E-06 for acceptable risk. The risk estimates for the LBAD were within this criterion range, with the following exceptions where risk exceeded 1.0E-06: (1) potential exposure to arsenic and beryllium in the northern area of the LBAD; and (2) potential exposure to arsenic, beryllium, and vinyl chloride in the southern area of the LBAD.

Uncertainties in the risk assessment process include: conservatism in the exposure concentrations and exposure estimation assumptions; lack of site-specific exposure parameter values; uncertainties in toxicity values; lack of consideration of synergistic/antagonistic effects of chemicals; and lack of measured air and fish dermal uptake concentrations for the chemicals found at the site. Such uncertainties may result in over- or under-estimation of risks and hazards. The approach taken in the risk assessment was one where conservative assumptions were employed to err on the side of over-estimating exposures, risks, and hazards. Risk management decisions for the LBAD should include a thorough evaluation of such uncertainties.

TABLE 8-1
CHEMICALS OF CONCERN IDENTIFIED IN THE LBAD GROUNDWATER

ORGANICS
- Benzene
- Vinyl Chloride

INORGANICS
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Thallium
- Zinc



M&E
Metcalf & Eddy

LEXINGTON-BLUEGRASS ARMY DEPOT

LOCATION MAP

LEXINGTON, KENTUCKY

Project Number
012308

Figure
8-1

9.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

9.1 INTRODUCTION

In this section, remedial technologies and process options are identified and screened for impacted groundwater at LBAD. Remedial action alternatives for impacted soil, sediment, and surface water at LBAD were evaluated in a separate CMS report which was recently prepared and submitted to the U.S. Army (USAEC, June 1994). Inherent in the evaluation of remedial action alternatives for these media, particularly impacted soil, is the treatment or containment of contaminants which may be a source of the LBAD groundwater contamination. To avoid a duplication of effort, these alternative evaluations are not repeated in this report. The June 1994 CMS report should be referred to for an evaluation of remedial alternatives for contaminated LBAD soil, sediment, and surface water.

The remedial technology identification and screening process for impacted LBAD groundwater presented in this section consists of the following four steps:

- Develop remedial action objectives that specify the groundwater chemicals of concern, exposure pathways, and preliminary remedial cleanup goals. These remedial action objectives are developed on the basis of requirements developed from identified Applicable or Relevant and Appropriate Requirements (ARARs) (when pertinent) and from risk-related factors for the groundwater.

- Develop general response actions which could be taken to satisfy the remedial action objectives for the impacted groundwater.

- To the extent practicable, identify areas of groundwater contamination for which general response actions may be required.

- Identify and screen technologies applicable to each general response action. The initial criterion for this screening is technical feasibility.

Technically implementable technologies are further screened based on effectiveness, implementability, and cost in Section 10.0. Technologies retained after the second screening process are then assembled into alternatives and evaluated in detail in Section 11.0.

9.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are media-specific goals for protecting human health and the environment. Remedial action objectives specify the chemicals of concern, exposure routes and receptors, and acceptable contaminant levels. Protectiveness may be achieved by reducing exposure (i.e., by prohibiting future use of groundwater) as well as by actually reducing contaminant levels through treatment. The derivation of remedial action objectives is dependent upon consideration of the chemicals of concern and receptors for which cleanup goals are required.

Remedial action objectives are often risk-based contaminant concentrations (cleanup goals) developed using information from the baseline risk assessment. According to the National Contingency Plan (NCP), the acceptable target range for cancer risk is 1 x 10^{-4} to 1 x 10^{-6} excess occurrences of cancer in an exposed population. Health risk-based cleanup goals for noncarcinogenic effects are also developed using hazard indices. The criteria for developing cleanup objectives at sites requiring remediation are the acceptable cancer risk range of 1 x 10^{-4} to 1 x 10^{-6} and the noncancer hazard criterion of unity. For ecological receptors, appropriate toxicity level information and ambient water quality criteria can be utilized to develop cleanup goals. In cases where an ARAR for a chemical represents an acceptable exposure level, the ARAR can be utilized as a remedial objective (U.S. EPA, 1991c), provided that total site risk/hazard remains within the acceptable limits. In addition, background conditions and detection limits (Certified Reporting Limits) which may feasibly be achieved using current analytical techniques are also considered in the selection of appropriate chemical-specific cleanup goals for the LBAD groundwater. The remedial action objectives may also be based on federal and state ARARs.

The risk-based cleanup goals, federal and state ARARs, background levels, and Certified Reporting Limits (CRLs) which are identifiable as potential remedial action objectives for the LBAD sites are presented in the following subsections.

9.2.1 Risk-Based Cleanup Goals

The elimination or minimization of threats to human health and the environment from groundwater contamination at LBAD requires addressing exposure pathways, receptor populations, and levels of exposure associated with the groundwater contaminants.

The remedial action objectives are determined with consideration of existing and potential future use of the LBAD site. The remedial cleanup goals for the on-site contaminated groundwater are based on minimizing human health and ecological risks/hazards due to direct contact, ingestion, and/or inhalation of the chemicals detected in contaminated groundwater. Criteria for acceptable noncancer hazard (i.e., 1.0) and carcinogenic risk (i.e., 1E-06) were exceeded in both the northern and southern groundwater wells at LBAD. The remedial objectives for areas where risk criteria were exceeded will include the reduction of the total site exposures, noncancer hazards, and carcinogenic risks to acceptable levels. For the northern and southern areas of LBAD, these objectives would be developed to include the following requirements from the standpoint of the protection of human health:

> Northern Area: Reduce the exposure to groundwater levels of arsenic, beryllium, lead, manganese, and thallium through the ingestion and/or dermal contact exposure pathways.
>
> Southern Area: Reduce the exposure to groundwater levels of antimony, arsenic, beryllium, lead, manganese, thallium, and vinyl chloride through the ingestion, dermal contact, and/or inhalation exposure pathways.

9.2.1.1 Human Health-Based Cleanup Goals

Cleanup goals were developed for the LBAD groundwater on a site- and receptor-specific basis. U.S. EPA's guidelines for the development of remedial goals (U.S. EPA, 1992a) were utilized to derive appropriate human health remedial objectives for the LBAD groundwater where either the total noncancer hazard index exceeded the criterion value of 1.0 and/or the total carcinogenic risk exceeded the lower end (1E-06) on the acceptable carcinogenic risk range (i.e, a 1E-06 to 1E-04 risk). As described in Section 8.2.4, the human health noncancer hazard and/or the carcinogenic risk criteria were exceeded in both the northern and southern areas of LBAD.

The LBAD property is divided into two zoning categories, namely for agricultural use or rural use and facility land use is expected to continue to be utilized for primarily occupational and/or residential or recreational use in the future. Therefore. remedial objectives were developed for both a hypothetical future resident or a future occupational receptor. It is expected that sites located in the open-space area zoned for agricultural use and in the built-up area zoned for rural activity would continue to be potentially associated with residential and occupational receptors, respectively, in the future. Therefore, for decision-making purposes, health-based remedial objectives were derived for both occupational and residential scenarios where total risk exceeded 1E-06 or noncancer hazard exceeded unity.

Remedial objectives were derived based on the exposure pathways which were found to provide the primary contribution to the total site risks or hazards in the baseline risk assessment. Both the approach and calculations used in development of these risk/hazard-based cleanup objectives are presented in detail in Appendix S of this document. A brief summary of the results are presented in the following subsections.

The target risk of 1.0E-04 to 1.0E-06 was utilized to derive the remedial objectives for each of the chemicals of concern in the sites where a 1.0E-06 total site risk was exceeded. Table 9-1 indicates the concentrations necessary in site groundwater to achieve the target risk levels for each carcinogenic chemical of concern identified in the baseline risk assessment as providing the primary contribution to the total site risk. The total site carcinogenic risk exceeded a level of 1E-06 in both the northern and southern LBAD areas. Risk-based cleanup goals were developed for the potential residential and occupational receptors and exposure pathways associated with the unacceptable risks.

The target hazard index level of 1.0 for chemicals was used to formulate target hazard levels for the LBAD areas where the total site noncancer hazard exceeded unity. The total noncancer index exceeded unity for both the north and south LBAD areas where health-based criteria were exceeded. Table 9-1 also includes the site groundwater concentrations necessary to achieve the targeted hazard levels for the residential and occupational receptors and exposure pathways for which hazard levels were found to be unacceptable in the baseline risk assessment.

Overall, the human health risk-based cleanup goals were developed using very conservative assumptions, which will likely be over- rather than under-protective of human health. Therefore, in the case where the maximum chemical concentration detected was below the risk-based cleanup level, the chemical was eliminated from further consideration or evaluation in the CMS as a chemical of concern.

9.2.1.2 Uncertainties Associated With the Development of Risk-Based Cleanup Goals

A number of uncertainties inherent in the risk assessment process are also applicable to the risk-based development of cleanup goals. These uncertainties are associated with the assumptions which are made regarding chemical concentrations, receptors, exposure, and the potential toxicity of the chemicals of concern. With respect to the human health-based cleanup goals, the following uncertainties should be noted:

- The assumption is made that the chemical concentrations detected at the LBAD sites are located in areas such that routine exposure can occur. If the chemical concentrations are not distributed equally across the exposure area, then the risk-based cleanup goals may be over- or underestimates of the concentrations which would be required to protect human health.

- The assumption is made that the receptor populations identified in the RFI risk assessment will be subject to exposure in the LBAD sites where total site hazards and risks exceeded acceptable levels. If such receptor populations do not utilize the LBAD sites as assumed in the risk assessment, the cleanup goals may be over- or underestimated. In general, in the Comprehensive Plan, the open-space area of LBAD is not zoned for residential use. Rather, plans call for the area to be used as a park or refuge. In sites where residential exposures were assumed, the risk-based cleanup levels may be overestimated compared to a recreational exposure scenario.

- Conservative assumptions regarding daily exposure were employed in the development of the human health-based cleanup goals. The exposure term was based on scenarios which include the possibility that exposure to soil would occur on a daily basis for a site resident or occupational receptor. However, such exposure might be lesser or greater in extent or frequency depending upon individual receptor variation. In general, the exposure assumptions utilized have been selected to err on the side of over-conservatism, such that actual exposure would be expected to be lesser in magnitude.

- The assumption of additivity of effect is utilized in human health risk assessments. However, chemicals may not interact and result in additive or compounded health effects when exposure to more than one chemical occurs. Thus, the chemicals identified as requiring remediation may not all require such action. However, in the absence of a more definitive method for identifying chemicals which may be associated with unacceptable health impacts, the more protective assumption of additivity is employed.

- The human health-based cleanup goals are derived using toxicity factors (i.e., noncancer reference doses and cancer slope factors). For many chemicals, these toxicity values are developed using laboratory animals and then extrapolating effects to humans. Uncertainty or safety factors are also included in the derivation of the toxicity factors to account for such species-species extrapolations, as well as for factors such as the mode of chemical administration, the overall quality of the study, the number of study subjects, etc. In addition, the studies from which the toxicity data are developed may not match the duration of the exposure (i.e., chronic, subchronic, or acute) for which the chemical is being evaluated in the baseline risk assessment or remedial objective identification arenas.

- The identification of risk-based chemicals of concern was based primarily on the criterion of a single detection of a chemical in any of the samples obtained from the site for organic and non-naturally occurring inorganic compounds. For naturally occurring inorganic analytes, the maximum was compared to background levels. If the inorganic chemical concentration was higher than background concentrations, the chemical was retained as a chemical of concern. Therefore, the process for selecting risk-based chemicals of concern was conservative in that chemicals were included regardless of their frequency of detection, essential nutrient status, or relative toxic potential. Consequently, the fact that rarely detected chemicals were carried through the risk assessment suggests that actual risks/hazards may be lower than those actually calculated due to infrequent exposure.

9.2.2 ARARs

ARARs for the impacted LBAD groundwater include cleanup standards, standards of control, and other enforceable federal, or state environmental protection requirements. These standards and requirements might specifically address a hazardous constituent, remedial action, location, or other circumstances at a RCRA site. Appendix T provides a preliminary list of potential ARARs for the LBAD groundwater.

ARARs are categorized as:

1. Chemical - specific requirements,
2. Action - specific requirements, or
3. Location - specific requirements.

Following the identification of chemicals of concern present at the site and any special location characteristics, the location- and chemical-specific ARARs may be identified. Action-specific ARARs are considered in the CMS during the development of remedial alternatives. Chemical-specific ARARs are values applied to site conditions to establish levels or concentrations of specific chemicals which may remain in or be discharged to the ambient environment. Federal and Commonwealth of Kentucky chemical-specific ARARs for constituents detected in the LBAD groundwater are provided in Table 9-2.

Federal Maximum Contaminant Levels (MCLs) and Kentucky Domestic Water Supply Criterion Values (KDWSC) are provided in Table 9-2 (if available) for the chemicals detected in the LBAD groundwater. The MCLs are promulgated by the Safe Drinking Water Act (SDWA), and are generally considered ARARs for water that is or could be used for drinking. MCLs do not necessarily represent *de minimis* risk concentrations. However, U.S. EPA has set MCLs based on a number of cost-benefit factors (i.e., toxicity, best developed available technology, etc.) The KDWSC values are also generally considered ARARs for water that could be used for drinking water in the State of Kentucky. Use of an MCL as an ARAR for the LBAD groundwater is considered to be conservative in light of the fact that the LBAD groundwater has not been utilized as a drinking water supply.

Federal Ambient Water Quality Criteria (AWQCs) and State of Kentucky Water Quality Criteria for protection of human health and aquatic life are also presented in Table 9-2. These criteria values are not legally enforceable standards, but are potentially relevant and appropriate to RCRA actions. The Federal AWQCs and Kentucky water quality criteria values may be used as ARARs in the event that treated LBAD groundwater is discharged to on-post streams or ponds. These values have been developed for human ingestion of both water and fish; human ingestion of fish; and the protection of freshwater aquatic organisms and warm water aquatic habitat.

Action- and location-specific ARARs are included in Appendix T. Action-specific ARARs are technology- or activity-based requirements which apply to actions taken at the site. Location-specific ARARs are restrictions placed on chemical concentrations or remedial activities due to their location. The more common location-specific ARARs pertain to protection of wetlands, flood plains, and siting criteria for hazardous and solid waste facilities.

9.2.3 Certified Reporting Limits

Before any analytical system is employed by a USATHAMA certified laboratory, sufficient spikes and blanks are analyzed in order to statistically establish the lowest sample concentration which may be reported. This concentration is called the Certified Reporting Limit (CRL).

The CRLs are laboratory-specific and are derived from the following assumptions:

- The relationship between the found concentration and target concentration is linear;
- The variance of the least squares linear regression line is homogeneous over the tested concentration range; and
- Found concentrations for a given target concentration are normally distributed.

CRLs are determined by using the USATHAMA program with 90-percent confidence limits. The CRL is associated with the entire method and reflects all sample preparation and measurement steps.

CRLs are included in this discussion to provide a point of comparison for the development of the cleanup concentrations for the LBAD groundwater. It would not be expected that cleanup levels would be set at concentrations which are below such reporting limits, if such levels could not be reliably determined by laboratory analytical procedures.

9.2.4 Background Concentrations

The background chemical concentrations for LBAD groundwater are presented in Table 9-3. Samples were collected at the LBAD which were upgradient of the LBAD sites or which were located in areas which were unaffected by site activities. As per U.S. EPA Region IV guidelines for risk assessments (U.S. EPA, 1991b), the background levels represent concentrations which are two times the average measured background concentrations detected for the LBAD. These data are provided as a point of comparison for the development of cleanup goals for the LBAD groundwater. It would not be expected that the cleanup goals for the sites would be lower than background concentrations.

9.2.5 Remedial Objectives for Groundwater

The culmination of the evaluation of human health-based cleanup goals, ARARs, CRLs, and background concentrations for the chemicals of concern in the LBAD groundwater is the summary presentation of chemical-specific cleanup goals. Table 9-4 presents each of these factors considered in the identification of the cleanup goals for the LBAD groundwater. These values represent potential cleanup goals which should be considered during the risk management decision-making process for the LBAD groundwater.

It should be noted that background concentrations must be considered when selecting the groundwater cleanup goals for all naturally occurring chemicals, particularly when the human health-based cleanup goal or ARAR concentrations are lower than the background concentrations. However, calculated PRGs that are higher than established MCLs would not be utilized instead of the more conservative MCLs. Remediation of site groundwater to levels which are cleaner than background conditions would be considered unreasonable. Similarly, CRL values should be considered in the selection of cleanup goals because it is not expected that cleanup levels would be set at concentrations which are below CRLs since these concentrations could not be reliably determined by laboratory analytical procedures.

9.3 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

General response actions are steps taken to satisfy remedial action objectives and characterize the range of remedial responses appropriate for impacted environmental media. As previously discussed, this CMS provides a focused evaluation of general response actions/remedial alternatives for impacted LBAD groundwater. General response actions for the impacted groundwater include no action, institutional controls, *in-situ* treatment, groundwater extraction and treatment, containment of soil contaminants which are a groundwater contaminant source, removal and treatment and/or disposal of impacted soils which are a groundwater contaminant source, and treatment and/or disposal of treatment residuals. These response actions were developed based on the LBAD groundwater remedial action objectives and other site-specific characteristics. The general response actions under consideration for the LBAD groundwater are described below.

No Action

No remediation work is performed and the site is left unchanged. Evaluation of this general response action is required by the NCP.

Institutional Controls

Minimal actions are performed. These actions may include legal controls, restrictions on future land use (e.g., deed restrictions), physical barriers to prevent public access to contaminated areas (e.g., fences), and long-term monitoring.

In-Situ Treatment

Remedial actions are performed using technologies which reduce groundwater contaminant concentrations via technologies which provide for the treatment of groundwater in-place (e.g., air sparging, biological treatment, treatment barriers, etc.).

Collection/Treatment/Discharge

Actions include collection of contaminated groundwater followed by treatment and discharge. Treatment options to be considered for the extracted groundwater include biological, chemical, physical, and thermal technologies.

Containment of Soil Contaminants Which Are a Groundwater Contaminant Source

A response action which would reduce the potential for soil contaminants to migrate and continue to act as a source of groundwater contamination. Containment actions would include capping and/or vertical barriers to prevent the migration of soil contaminants. As previously discussed, the June 1994 CMS report provides an evaluation of remedial action alternatives, including containment options, for contaminants in the LBAD soils. This separate CMS report should be referred to for an evaluation of containment options for the LBAD soil contaminants.

Removal and Treatment and/or Disposal of Soil Contaminants Which Are a Groundwater Contaminant Source

A response action which would prevent soil contaminants from acting as a future source of groundwater contamination. As previously discussed, the June 1994 CMS report provides an evaluation of remedial action alternatives, including treatment technologies and disposal options for contaminants in the LBAD soils. This separate CMS report should be referred to for an evaluation of treatment/disposal options for the LBAD soil contaminants.

9.4 DELINEATION OF CONTAMINATED GROUNDWATER AREAS

Based upon the results of the risk assessment and a comparison of the groundwater analytical results to ARARs and site background concentrations, areas of impacted groundwater have been identified at

LBAD. Figure 9-1 illustrates the LBAD well locations where chemicals of concern were identified and the respective concentrations of these chemicals.

9.5 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Based on the remedial action objectives and general response actions developed in Sections 9.2 and 9.3, a comprehensive list of remedial technologies for the impacted LBAD groundwater has been developed. As discussed in Section 9.3, the general response actions which entail containment, removal, or treatment of LBAD soil contaminants have already been addressed in a separate CMS report (USAEC, June 1994). This separate CMS report should be referred to for evaluations of these general response actions. These evaluations are not repeated in this report.

Table 9-5 identifies and screens technologies for the impacted LBAD groundwater. At this stage of the CMS process, the technologies are preliminarily screened to eliminate those which are not expected to achieve the remedial action objectives or are considered technically infeasible based on site-specific conditions or characteristics. The screening comments in Table 9-5 provide the specific rationale used to retain or eliminate a given technology. The following sections provide detailed descriptions of the technologies/remedial actions which were retained for the LBAD groundwater following the initial screening process.

9.5.1 No Action

The National Oil and Hazardous Substances Contingency Plan (NCP) requires that "no action" be considered during the feasibility study process to provide a baseline for comparing all other remedial actions. With no action, no efforts would be made to reduce the concentrations of contaminants in the LBAD groundwater; no steps would be taken to minimize exposure of contaminants to humans or the environment; and no attempt would be made to monitor the future migration of groundwater contaminants.

9.5.2 Institutional Controls/Groundwater Monitoring

Institutional controls are activities performed at a site which serve to restrict public access, prevent future site development and/or disposal activities, and/or monitor the future migration of site contaminants. These control measures provide some protection of human health and the environment by limiting the potential for future exposure to site contaminants. Restriction of public access may be accomplished with the use of warning signs and perimeter fencing. Future site development and/or disposal activities may be prevented by adding restrictive covenants to the property deed or enacting local ordinances. Monitoring of site contaminants may be accomplished with the periodic collection and analysis of environmental samples.

9.5.3 Collection, Treatment, and/or Discharge of Impacted Groundwater

9.5.3.1 Groundwater Collection

Extraction Wells

Extraction wells may be used to collect impacted groundwater prior to treatment. Extraction wells consist of a groundwater well, screened at the appropriate depth, which is equipped with a pump for the recovery of groundwater from the well. The groundwater collected from the well may then be treated on- or off-site and disposed of in accordance with regulatory requirements. An evaluation of the site-specific hydrogeologic conditions is necessary to determine the number of extraction wells, the spacing (distance) between wells, and a pumping rate which will facilitate control and capture of groundwater contaminants. A line of several extraction wells may be installed along the leading edge of a groundwater contaminant plume to prevent further migration of groundwater contaminants.

Interceptor Trenches

Interceptor trenches are subsurface drainage systems designed to collect or redirect the flow of groundwater. The systems typically consist of a below-grade zone of high permeability, such as perforated conduit and/or gravel, which are used to control, convey, and/or collect groundwater. Interceptor trenches are well-suited for the collection or control of shallow groundwater in strata with low or variable hydraulic conductivity. Interceptor trenches can also be installed to collect groundwater from significant depths, however, shoring, dewatering, and/or hard rock excavation requirements may present significant technical challenges and result in prohibitively high installation costs.

9.5.3.2 Groundwater Treatment

Air Stripping

Air stripping is a mass-transfer process used to remove volatile organic compounds (VOCs) from liquid waste streams by transferring them to the gas phase. Historically, packed towers equipped with air blowers have been used to transfer VOCs from a liquid stream to a gas stream. Most towers work on the principle of counter-current flow, whereby the water stream flows down through the tower packing while air flows upward and exits the top of the tower. More recently, shallow-tray aerator systems have been developed to treat liquid waste streams which contain VOCs. The shallow-tray systems operate by passing contaminated water through a series of perforated trays (frothing beds) while air is blown through the trays from below. Both packed towers and shallow trays have proven effective in removing VOCs from liquid waste streams.

Filtration

Filtration is a physical treatment process whereby suspended solid particles are removed from an aqueous stream. Depth filtration is one of the most common filtration methods. In depth filtration, liquid containing typically less than 100 parts per million (ppm) of suspended solid material is forced through a porous medium. The solids are then captured and retained inside the medium. The types of porous media available to capture suspended solid material include granular-media filters, screen filters with a precoat, and disposable cartridge filters.

Carbon Adsorption

Granular-activated-carbon adsorption is a proven technology which is widely used in the treatment of liquid hazardous waste streams. This technology is effective for removal of a broad range of organic contaminants. The process of adsorption onto activated carbon is implemented by allowing the liquid waste stream to come in direct contact with the carbon, usually by flow through one or a series of downflow, fixed-bed carbon units. The carbon units may be connected in parallel to provide increased hydraulic capacity.

During the carbon-adsorption treatment process, hazardous constituents are adsorbed via surface attraction to the internal pores of the carbon granules The molecular polarities of the contaminants are important in determining the effectiveness of carbon adsorption, as more polar substances are less effectively adsorbed by the carbon granules. Water, which is a polar molecule, is not adsorbed by carbon. Another factor to consider in determining the potential effectiveness of carbon adsorption is aqueous solubility. More hydrophobic (insoluble) substances are more readily adsorbed onto carbon than substances which are highly soluble.

When the micropore surfaces of the carbon become saturated with adsorbed substances, the carbon must be replaced with virgin or thermally regenerated carbon. The length of operating time before saturation is the most critical operating parameter for carbon-adsorption treatment and is a function of contaminant type and concentration. Spent carbon replacement/disposal or regeneration costs contribute significantly to the overall cost of this technology. Carbon adsorption is sometimes used in combination with other treatment technologies such as chemical treatment, filtration, or air stripping.

Precipitation

Chemical precipitation is a commonly used treatment process which transforms dissolved species in liquid waste streams into solid settleable particles of various compounds. The most common precipitation application is for the removal of metals from water. Other anionic species, such as phosphates, sulfates and fluoride, can also be removed by chemical precipitation.

This treatment process is initiated by adding a precipitating agent to the waste stream. This step is followed by rapid mixing to disperse the precipitating agent, then slow mixing to maximize contact between the contaminant and the precipitating agent. When large particles are not formed, such as in the precipitation of metals, polymers are added to cause flocculation of metal precipitates. Finally, the flocs are allowed to settle in a clarifier. The solids can then be removed by decantation, filtration or centrifugation. A large volume of sludge is generated from the precipitation/flocculation process, and the sludge ultimately requires disposal. If the sludge is to be land disposed, it may require treatment by a technology such as stabilization/solidification in order to meet land disposal restrictions (LDRs).

Ion Exchange

Ion exchange is a treatment technology where contaminants are removed from water through the exchange of nontoxic ions from an ion-exchange material. Ion-exchange materials are generally synthetic organics which contain ionic functional groups. The exchange material can consist of natural clays, zeolites, or (most commonly) synthetic resins. The synthetic resins can be tailored to selectively remove specific ions. Specific ion-exchange systems must be designed on a case-by-case basis. Ion exchange can be used to remove cationic and anionic elements of compounds, including: metals, halides, cyanides, nitrates, sulfonics, and phenols.

Reverse Osmosis

Reverse osmosis (RO) is an aqueous treatment technology designed to remove dissolved inorganic materials. In the RO treatment process, a liquid waste stream is passed through a semipermeable membrane under a pressure greater than the osmotic pressure caused by the dissolved contaminants in the water. Purified water passes through the membrane, and contaminants unable to pass through the membrane are retained in a concentrated solution behind the membrane. The concentrated waste stream is then disposed or treated further.

In treatment of hazardous-waste-contaminated streams, use of reverse osmosis would be primarily limited to polishing low-flow streams containing highly toxic contaminants. The main limitation to RO treatment is that organic matter and low-solubility salts can clog the membrane surface, thereby reducing the efficiency of the process. Wastewater must be pretreated to remove oxidizing materials such as iron and manganese salts, filter out particulates, adjust pH to a range of 4.0 to 7.5, and remove oil, grease, and other materials which may cause fouling of the membrane. Pretreatment of the wastewater stream could extend the life of the membrane. Contaminated water which contains high concentrations of some organics may dissolve the membrane, thus limiting its applications in such waste streams.

Ultraviolet (UV) Oxidation

This innovative technology uses UV radiation and ozone (O_3) or hydrogen peroxide (H_2O_2) to oxidize toxic organic compounds in water. Typical commercial systems consist of a reactor module, and an air compressor/ozone generator module or a hydrogen peroxide feed system. Portable systems permit on-site treatment of a wide variety of liquid wastes.

During the treatment process, influent to the UV Oxidation reactor is simultaneously exposed to UV radiation and ozone or hydrogen peroxide to oxidize the organic compounds. Off-gas from the reactor passes through an ozone-destruction unit, which reduces ozone levels before venting to the air ; this unit also destroys gaseous volatile organic compounds stripped off in the reactor. Effluent from the reactor is tested and analyzed before disposal.

This water-treatment technology is gaining considerable attention because, in contrast to air stripping or activated carbon treatment, the contaminants treated via UV oxidation are permanently destroyed and are not transferred to another media.

Incineration

With this thermal technology, contaminated site media are treated using high-temperature oxidation to destroy contaminants. Contaminants are degraded into products that include: CO_2, H_2O vapors, SO_2, NO_x, HCL gas, and ash. The hazardous products of the thermal destruction/incineration, such as particulates, SO_2, NO_x, HCL, and products of incomplete combustion, require air-pollution-control equipment to prevent release of undesirable substances into the atmosphere. Thermal destruction is applicable to destroying organic contaminants in liquids, gases, and solid waste streams. Thermal treatment is not effective in treating heavy-metal contaminants; however, some metals in the treatment stream may be volatilized during the incineration process.

9.5.3.3 Discharge/Disposal of Groundwater

Following treatment by any of the technologies described in Section 9.5.3.2 (except incineration), site waters would be discharged to either a local stream or a Publicly Owned Treatment Works (POTW).

Discharge to POTW

Treated site waters would be collected and discharged to on-site sanitary sewers which flow to the local POTW. Permission for this discharge option would have to be granted by the receiving POTW. Acceptance of the wastewaters would likely depend on the available capacity of the local POTW and the type and concentrations of residual contaminants present in the treated site water.

Discharge to Local Streams

Treated site waters would be collected and discharged to a stream located on or near the site. Off-site discharges would require a KPDES (Kentucky Pollution Discharge Elimination System) permit. It is likely that stringent discharge limitations (with regard to allowable quantity of toxic pollutants) would be associated with this discharge option. The following would have to be monitored to assure compliance: 1) the mass of each pollutant, 2) the volume of effluent, and 3) the frequency of discharge.

Table 9-1: Risk-Based Cleanup Goals for Residential Exposure to Chemicals in Groundwater at the Lexington-Bluegrass Army Depot

	Toxicity Information**				Risk-based Cleanup Goals					
	Carcinogenic		Noncarcinogenic		Oral Exposure		Inhalation Exposure		Oral and Inhalation Exposure	
CHEMICAL	SForal (mg/kg/day)-1	SFinh (mg/kg/day)-1	RFDoral (mg/kg/day)	RFDinh (mg/kg/day)	Carcin (mg/L)	Non-carc (mg/L)	Carcin (mg/L)	Non-carc (mg/L)	Carcin (mg/L)	Non-carc (mg/L)
Vinyl chloride	1.90E+00	3.00E-01	NA	NA	4.48E-05	NA	5.68E-05	NA	2.50E-05	NA
Antimony	NA	NA	4.00E-04	NA	NA	1.46E-02	NA	NA	NA	1.46E-02
Arsenic	1.80E+00	5.00E+01	3.00E-04	NA	4.73E-05	1.09E-02	NA	NA	4.73E-05	1.09E-02
Barium	NA	NA	7.00E-02	NA	NA	2.56E+00	NA	NA	NA	2.56E+00
Beryllium	4.30E+00	8.40E+00	5.00E-03	NA	1.98E-05	1.82E-01	NA	NA	1.98E-05	1.82E-01
Lead	NA	NA	1.40E-03	4.30E-04	NA	5.11E-02	NA	NA	NA	5.11E-02
Manganese (water)	NA	NA	5.00E-03	1.10E-04	NA	1.82E-01	NA	NA	NA	1.82E-01
Thallium	NA	NA	8.00E-05	NA	NA	2.92E-03	NA	NA	NA	2.92E-03

Risk-Based Cleanup Goals for Occupational Exposure to Chemicals in Groundwater at the Lexington-Bluegrass Army Depot

	Toxicity Information**				Risk-based Cleanup Goals	
	Carcinogenic		Noncarcinogenic		Oral Exposure	
CHEMICAL	SForal (mg/kg/day)-1	SFinh (mg/kg/day)-1	RFDoral (mg/kg/day)	RFDinh (mg/kg/day)	Carcin (mg/L)	Non-carc (mg/L)
Vinyl chloride	1.90E+00	3.00E-01	NA	NA	1.51E-04	NA
Antimony	NA	NA	4.00E-04	NA	NA	4.09E-02
Arsenic	1.80E+00	5.00E+01	3.00E-04	NA	1.59E-04	3.07E-02
Barium	NA	NA	7.00E-02	NA	NA	7.15E+00
Beryllium	4.30E+00	8.40E+00	5.00E-03	NA	6.65E-05	5.11E-01
Lead	NA	NA	1.40E-03	4.30E-04	NA	1.43E-01
Manganese (water)	NA	NA	5.00E-03	1.10E-04	NA	5.11E-01
Thallium	NA	NA	8.00E-05	NA	NA	8.18E-03

NA - Not Available

** Toxicity Information Sources: Integrated Risk Information System (IRIS, Accessed July, 1994); and Health Effects Assessment Summary Tables (1993)

TABLE 9-2
CHEMICAL-SPECIFIC POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR CHEMICALS DETECTED IN THE LBAD GROUNDWATER

Chemicals Detected in LBAD Groundwater	EPA Ambient Water Quality Criteria Human Health (Water and Fish Ingestion) (ug/L) I	EPA Ambient Water Quality Criteria Human Health (Fish Ingestion) (ug/L) II	EPA Ambient Water Quality Criteria Freshwater Aquatic Organisms Acute/Chronic (ug/L) III	EPA Maximum Contaminant Levels (ug/L) IV	Kentucky Water Quality Criteria		
					Domestic Water Supply Source Criteria (ug/L)	Warm Water Aquatic Habitat Acute/Chronic (a) (ug/L)	Human Health Protection from Consumption of Fish (ug/L)
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethenes	NA	NA	NA	70	NA	NA	NA
1,3-Dimethylbenzene	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	400	2296	212/21.2	NA	3090	NA	NA
Acetone	NA	NA	NA	NA	NA	NA	NA
alpha-BHC	NA	NA	NA	NA	NA	NA	NA
alpha-Endosulfan	NA	NA	NA	NA	74	NA	NA
Benzene	1.8	71.28	530/53	5	1.2	NA	71
Bis(2-ethylhexyl)phthalate	1.76	5.92	1110/0.3	6	15000	NA	NA
Carbon tetrachloride	0.254	4.42	3520/352	5	0.4	NA	6.94
Chloromethane	NA	NA	NA	NA	NA	NA	NA
DDT	NA	NA	NA	NA	0.000024	1.1/0.001	0.000024
delta-BHC	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	700	3100	NA	29000
Lindane	NA	NA	NA	0.2	0.019	2/0.080	NA
Methyl isobutyl ketone	NA	NA	NA	NA	NA	NA	NA
Phenol	300	4615385	1020/256	NA	3500	NA	NA
Tetrachloroethene	NA	NA	NA	5	0.8	NA	NA
Toluene	6764.8	201294	1750/175	1000	14300	NA	424000
Trichloroethene	NA	NA	NA	5	2.7	NA	NA
Vinyl chloride	NA	NA	NA	2	NA	NA	NA
Xylenes	NA	NA	NA	10000	NA	NA	NA

TABLE 9-2 (Cont'd)

Chemicals Detected in LBAD Groundwater	EPA Ambient Water Quality Criteria Human Health (Water and Fish Ingestion) (ug/L) I	EPA Ambient Water Quality Criteria Human Health (Fish Ingestion) (ug/L) II	EPA Ambient Water Quality Criteria Freshwater Aquatic Organisms Acute/Chronic (ug/L) III	EPA Maximum Contaminant Levels (ug/L) IV	Kentucky Water Quality Criteria		
					Domestic Water Supply Source Criteria (ug/L)	Warm Water Aquatic Acute/Chronic (a) (ug/L)	Human Health Protection from Consumption of Fish (ug/L)
Aluminum	NA	NA	750/8.7	50–200**	NA	NA	NA
Antimony	14	4308	1300/160	6	146	NA	45000
Arsenic	0.0175	0.14	360/190	50	NA	NA/50	NA
Barium	2000	NA	NA	2000	1000	NA	NA
Beryllium	0.0077	0.132	16/0.53	4	6.8	NA/11	0.117
Boron	NA	NA	NA/750	NA	NA	NA	NA
Cadmium	5	168	1.79/0.66	5	10	3.92/1.13	NA
Calcium	NA	NA	NA	NA	NA	NA	NA
Chromium (III)	33300	673077	984/117	100 (Total)	33000; 50(Total)	1736.5/207.0	670000
Cobalt	NA	NA	NA	NA	NA	NA	NA
Copper	1000	NA	9.2/6.5	1300 *	1000	17.7/11.8	NA
Iron	300	NA	NA/1	300**	NA	4.0/1.0	NA
Lead	50	NA	33.8/1.3	15 *	50	81.6/3.18	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA
Manganese	30	100	NA	50**	50	NA	NA
Mercury	0.151	0.153	2.4/0.012	2	0.144	2.4/0.012	0.146
Molybdenum	NA	NA	NA	NA	NA	NA	NA
Nickel	607	4584	789/87	100	610	1418.2/157.7	4600
Potassium	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA
Tellurium	NA	NA	NA	NA	NA	NA	NA
Thallium	13	48	140/4	2	13	NA	48
Tin	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA
Zinc	5000	NA	65/59	5000**	NA	NA	NA

(a) Where applicable, a water hardness concentration of 100 mg/l (as CaCO3) was used to calculate the criteria values.

NA – Not Available

* – Action Level

** – Indicates the value is a secondary maximum contaminant level (SMCL)

Note: Chemicals which are shaded have no State of Kentucky or USEPA criteria concentrations available.

TABLE 9-3
CONCENTRATIONS FOR CHEMICALS WHICH WERE DETECTED IN THE LBAD GROUNDWATER BACKGROUND SAMPLES

Chemical	Background Concentration (ug/L)
DDT	0.0275
Aluminum	7830
Arsenic	3.525
Barium	432
Beryllium	1.67
Calcium	171300
Copper	109.4
Iron	6150
Lead	19.11
Magnesium	55600
Manganese	169.3
Potassium	12980
Sodium	120000
Zinc	188.6

Note: Background concentrations presented are two times the average background concentrations detected on site as per USEPA Region IV guidance.

TABLE 9–4
SUMMARY OF POTENTIAL CHEMICAL–SPECIFIC CLEANUP GOALS FOR THE LBAD GROUNDWATER

Chemicals	Human Health–Based Cleanup Goals (ug/L)		ARARs					
	Residential Scenario (ug/L)	Occupational Scenario (ug/L)	EPA Ambient Water Quality Criteria (a, b) (ug/L)	EPA Maximum Contaminant Levels (ug/L)	Kentucky Ambient Water Quality Criteria (b, c) (ug/L)	Kentucky Domestic Water Supply Source Criteria (ug/L)	Certified Reporting Limits (CRLs) (ug/L)	Background Concentrations (ug/L)
1,2–Dichloroethenes	NA	NA	NA	5.0	NA	NA	5.0	NA
Benzene	NA	NA	1.8 – 530	5.0	1.2 – 71	NA	1	NA
Vinyl chloride	0.025	0.151	NA	2.0	NA	NA	12	NA
Aluminum	NA	NA	8.7 – 750	50–200**	NA	NA	112	7830
Antimony	14.6	40.9	14 – 4308	6	146 – 45000	146	60	ND
Arsenic	0.0473	0.159	0.0175 – 360	50	50	NA	2.35	3.525
Barium	2560	7150	2000	2000	1000	1000	2.82	432
Beryllium	0.0198	0.0665	0.0077 – 16	4	0.117 – 11	6.8	1.12	1.67
Cadmium	NA	NA	0.66 – 168	5	1.13 – 10	10	6.78	ND
Chromium (Total)	NA	NA	NA	100 (Total)	50 (Total)	50 (Total)	16.8	ND
Copper	NA	NA	6.5 – 1000	1300 *	11.8 – 1000	1000	18.8	109.4
Iron	NA	NA	1.0 – 300	300**	1.0 – 4.0	NA	77.5	6150
Lead	51.1	143	1.3 – 50	15 *	3.18 – 81.6	50	4.47	19.11
Manganese	182	511	30 – 100	50**	50	50	9.67	169.3
Mercury	NA	NA	0.012 – 2.4	2	0.012 – 2.4	0.144	0.1	ND
Nickel	NA	NA	87 – 4584	100	157.7 – 4600	610	32.1	ND
Thallium	2.92	8.18	4.0 – 140	2	13 – 48	13	125	ND
Zinc	NA	NA	59 – 5000	5000**	NA	NA	18	188.6

(a) EPA Ambient Water Quality Criteria include criteria values for human health (water and fish ingestion; fish ingestion only) and criteria values for freshwater aquatic organisms (acute and chronic).

(b) EPA and Kentucky Ambient Water Quality Criteria values (which were developed for surface water) may be considered applicable for treated groundwater that is discharged to on–site streams but may not apply to site groundwater that remains in the ground.

(c) Kentucky Ambient Water Quality Criteria include criteria values for human health protection from consumption of fish and criteria values for Warm Water Aquatic Habitat (acute and chronic).

NA – Not Available ND – Not Detected * –Action Level ** – Value is a secondary maximum contaminant level (SMCL)

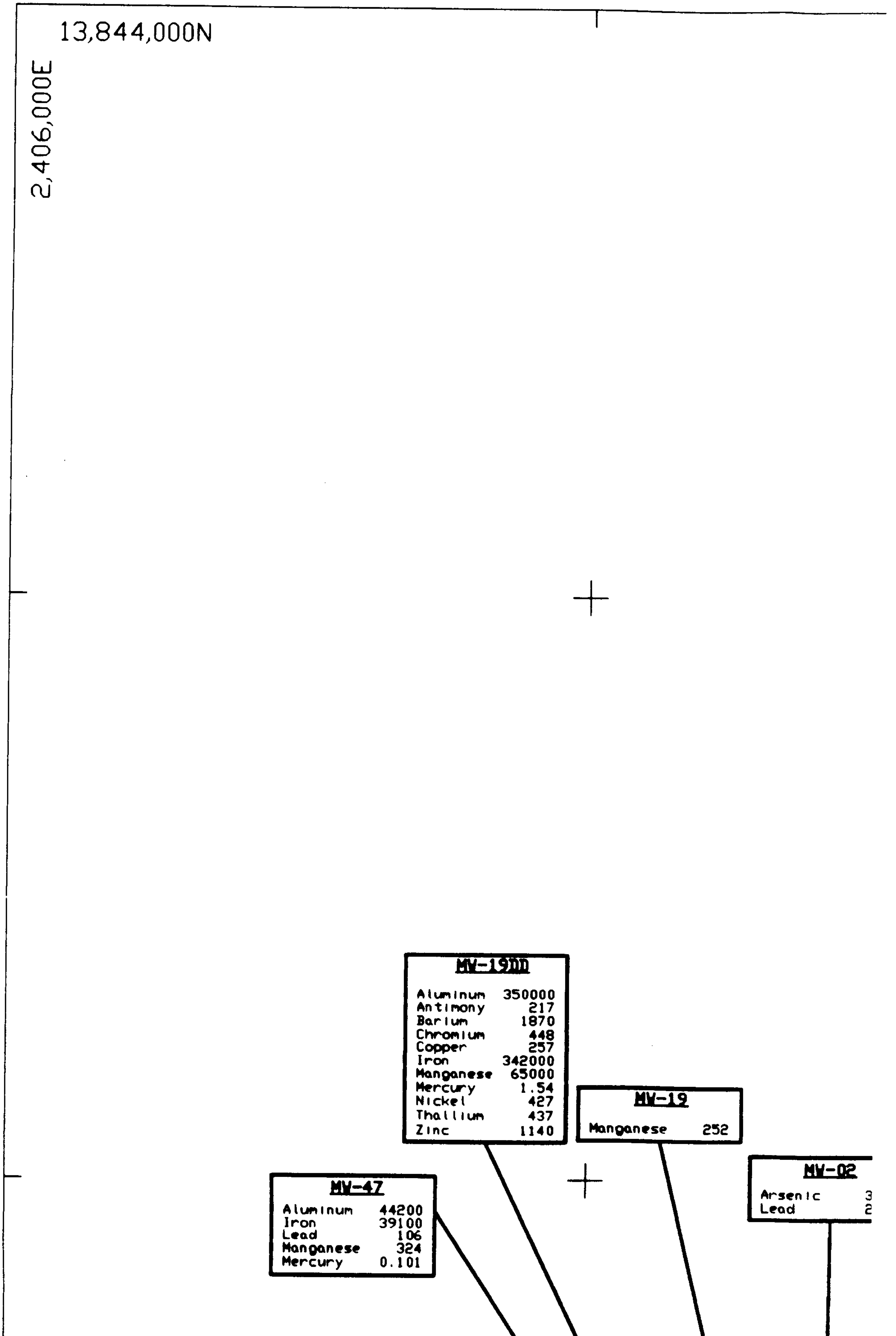
TABLE 9-5

Identification of Remedial Action Objectives and General Response Actions and Evaluation of Potential Remedial Action Technologies For Impacted LBAD Groundwater
Lexington, Kentucky

Environmental Media	Remedial Action Objectives	General Response Actions	Potential Remedial Action Technologies/Description	Retained For Further Analysis?	Screening Comments
Groundwater	For Human Health: Prevent exposure to carcinogenic groundwater contaminants which pose a cancer risk above the maximum level established for the LBAD site	No Action	No Action	Yes	Retained for evaluation in accordance with Subpart F requirements of the NCP. Provides a baseline upon which to compare and evaluate action alternatives
	Prevent exposure to groundwater which contains non-carcinogens at concentrations which exceed reference doses.	Institutional Controls	Long-Term Groundwater Monitoring Restrict Site Access/Deed Restrictions Prevent Future Dumping/Disposal	Yes Yes Yes	Institutional controls retained for analysis because they may help limit current and future exposure to contaminants
	Prevent exposure to groundwater contaminants which are present at concentrations above ARAR-established limits	Collection/Treatment/Discharge of Groundwater	Groundwater Collection:		
			Extraction Wells - A series of groundwater wells operated to extract contaminated groundwater prior to treatment.	Yes	Potentially applicable, however, there are some technical limitations associated with the use of extraction wells to collect groundwater from fractured bedrock
	For Environmental Protection: Prevent exposure of environmental receptors to contaminants in the groundwater		Steam-Enhanced Extraction - Injection wells installed and used to force steam through impacted soils above and below the water label to thermally enhance the vapor/liquid extraction process. Extraction wells are used to collect groundwater and recover steam/vaporized contaminants. Collected groundwater and vaporized contaminants are then treated with the chosen technologies.	No	This remedial action is not technically feasible for the recovery of contaminants in the fractured bedrock and overlying tight clays present at LBAD
			Interceptor Trenches - Trenches installed below the groundwater table and backfilled with highly permeable material(s) (i.e., gravel and perforated pipe) which facilitates the collection of groundwater. The interceptor trench would also include collection sumps and pumps to facilitate the recovery of groundwater from the trench	Yes	Potentially applicable, however, interceptor trenches may not be appropriate for the collection of groundwater in deep fractured bedrock due to cost and technical limitations associated with construction and installation.
			On-Site or Off-Site Groundwater Treatment:		
			Air Stripping - Mass transfer process in which volatile organic compounds in water are transferred to the gas phase.	Yes	Potentially applicable for treatment of volatile organic compounds in groundwater
			Filtration - Use of an appropriate filter or filtration device to remove particulates from a solution	Yes	Potentially applicable for the removal of particulates and insoluble inorganic contaminants in groundwater
			Carbon Adsorption - Adsorption of organic constituents by a surface attraction phenomenon whereby organic molecules are attracted to the internal pores of carbon granules	Yes	Potentially applicable for treatment of organic contaminants in groundwater.
			Precipitation - Physiochemical process whereby some or all of a substance in solution is transformed into a solid phase.	Yes	Potentially applicable for treatment of metal contaminants in groundwater.
			Ion Exchange - Removal of toxic ions from solution by exchange with relatively harmless ions held by the ion exchange material.	Yes	Potentially applicable for treatment of metal contaminants in groundwater
			Reverse Osmosis - Use of a membrane impermeable to inorganics to separate these contaminants and form a concentrated solution which will require further treatment prior to disposal.	Yes	Potentially applicable for treatment of metal contaminants in groundwater

TABLE 9-5 (Cont'd)

Environmental Media	Remedial Action Objectives	General Response Actions	Potential Remedial Action Technologies/Description	Further Analysis?	Screening Comments
Groundwater (cont'd)		Collection/Treatment/Discharge of Groundwater (cont'd)	On-Site or Off-Site Groundwater Treatment (cont'd):		
			Ultraviolet (UV) Oxidation - Decomposition of organic compounds by a strong oxidant, such as ozone or peroxide, while organic molecules are being excited by UV light.	Yes	Potentially applicable for treatment of metal contaminants in groundwater
			Incineration - High-temperature thermal destruction of organic compounds	Yes	A potentially applicable, yet costly, treatment technology for organic contaminants in groundwater
			Discharge/Disposal of Groundwater:		
			POTW - Discharge of treated or untreated groundwater to the local POTW.	Yes	A potential alternative for the discharge/disposal of treated groundwater.
			Local Streams - Discharge of treated groundwater to on-site streams in accordance with NPDES requirements.	Yes	A potential alternative for the discharge of treated groundwater.
			Deep Well Injection - Discharge of untreated groundwater into a deep well injection system.	No	The site aquifers are not suitable for the injection of impacted groundwater.
		In-Situ Treatment	In-Situ Bioremediation - Treatment of organic contaminants in groundwater through injection of the appropriate nutrients to enhance the biological degradation process.	No	This treatment approach is not considered technically feasible for contaminants in fractured bedrock.
			Air Sparging - Injection of air into the groundwater table to promote the volatilization of volatile organic compounds and promote the biological degradation of some other organic compounds in the groundwater	No	This treatment approach is not considered technically feasible for contaminants in fractured bedrock. Furthermore, the low-permeability clay soils above the water table will prevent effective control and capture of organic contaminants which are volatilized from the groundwater.



MV-19DD

Aluminum	350000
Antimony	217
Barium	1870
Chromium	448
Copper	257
Iron	342000
Manganese	65000
Mercury	1.54
Nickel	427
Thallium	437
Zinc	1140

MV-19

Manganese	252

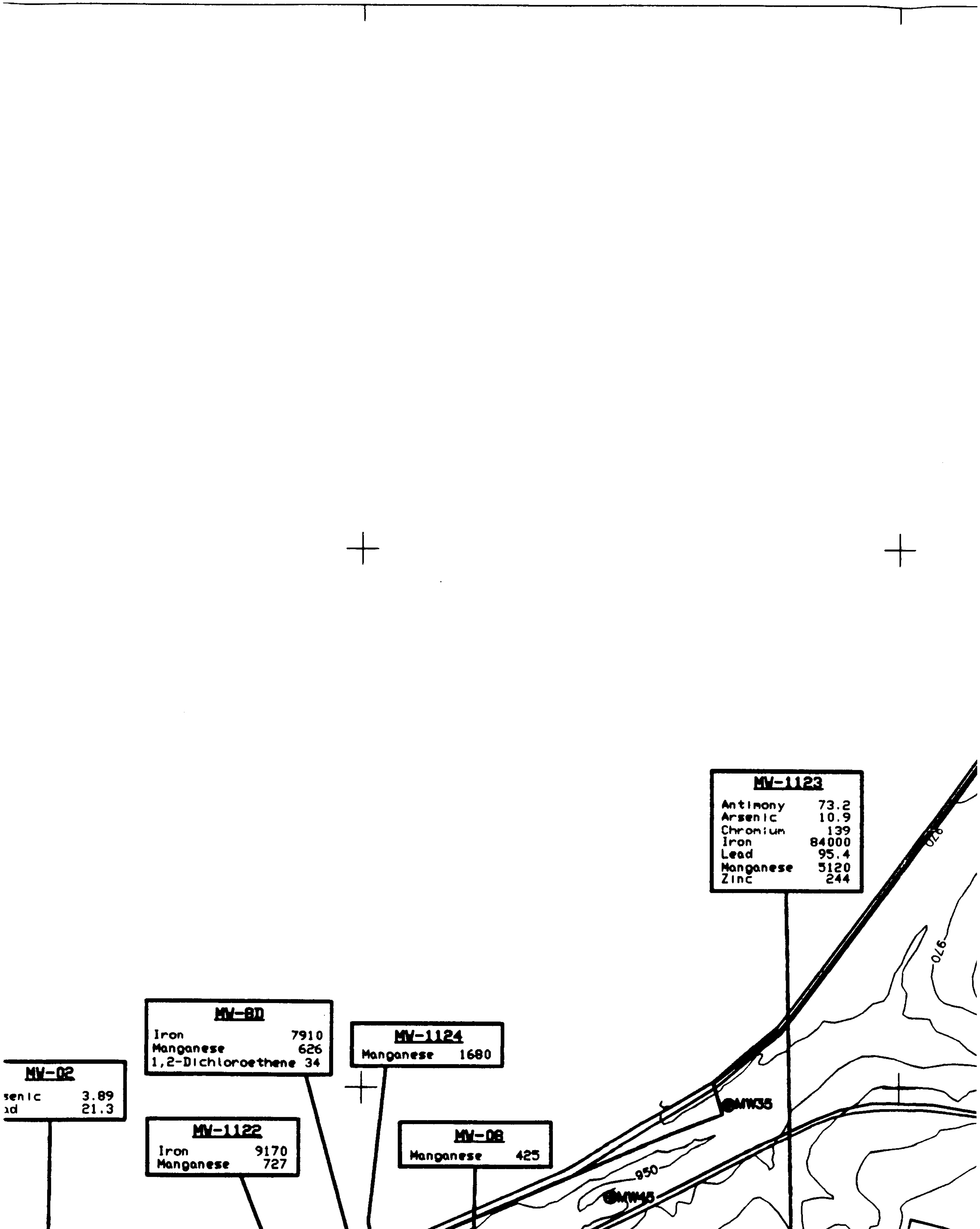
MV-47

Aluminum	44200
Iron	39100
Lead	106
Manganese	324
Mercury	0.101

MV-02

Arsenic	3
Lead	2

(2)



MW-1123

Antimony	73.2
Arsenic	10.9
Chromium	139
Iron	84000
Lead	95.4
Manganese	5120
Zinc	244

MW-8D

Iron	7910
Manganese	626
1,2-Dichloroethene	34

MW-1124

Manganese	1680

MW-02

senic	3.89
ad	21.3

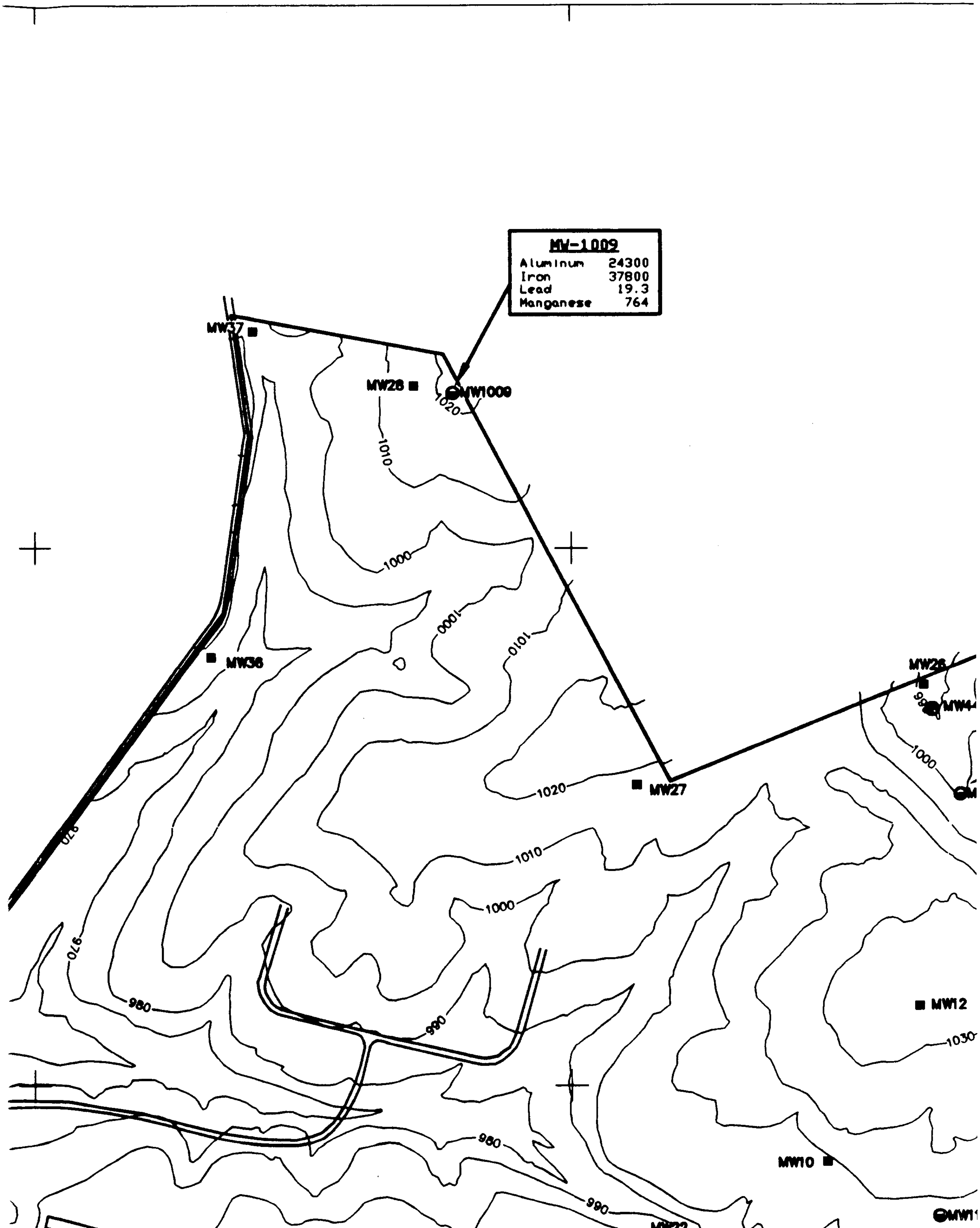
MW-1122

Iron	9170
Manganese	727

MW-08

Manganese	425

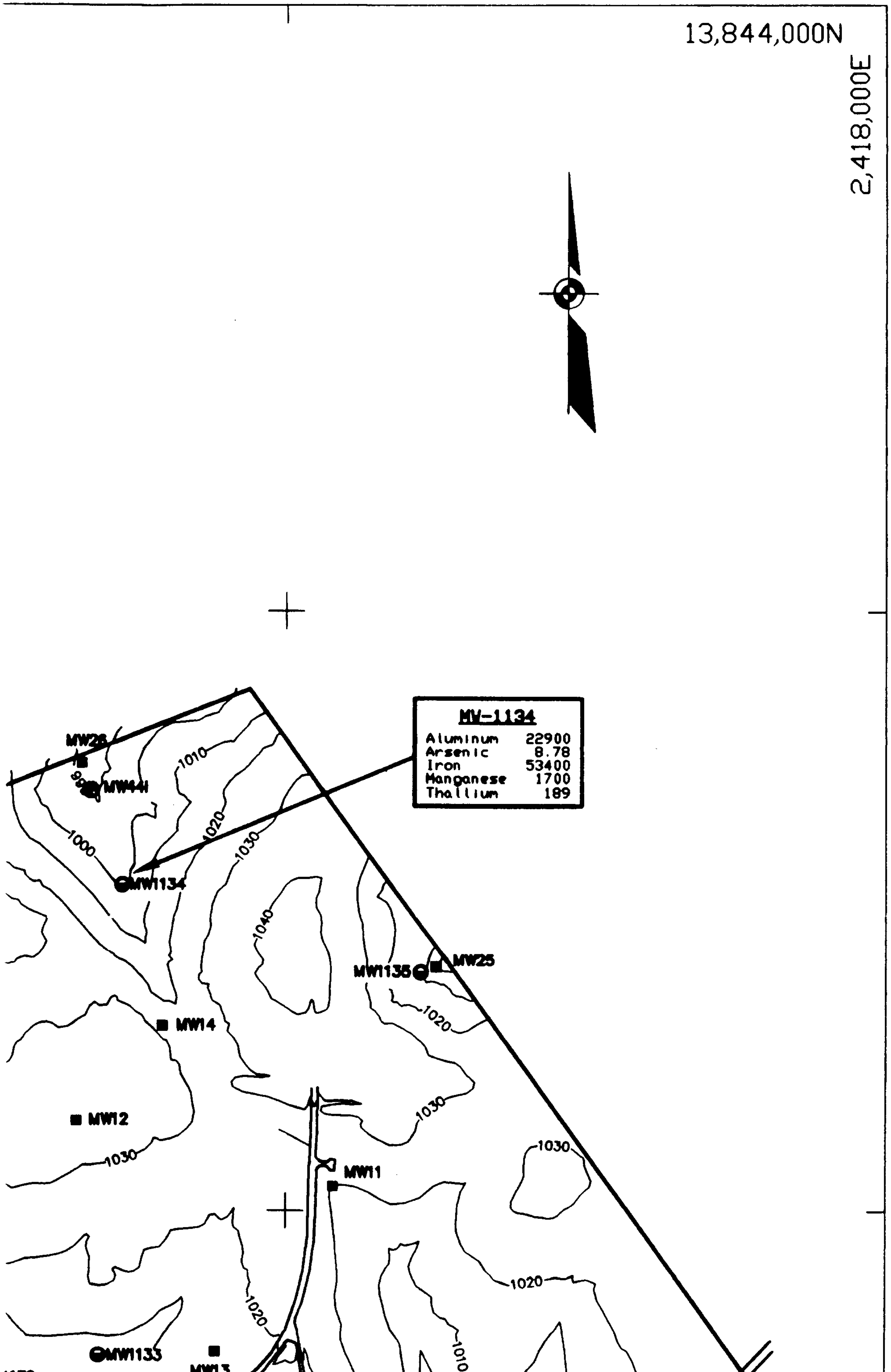
(3)



MV-1009

Aluminum	24300
Iron	37800
Lead	19.3
Manganese	764

4



MV-1134

Aluminum	22900
Arsenic	8.78
Iron	53400
Manganese	1700
Thallium	189

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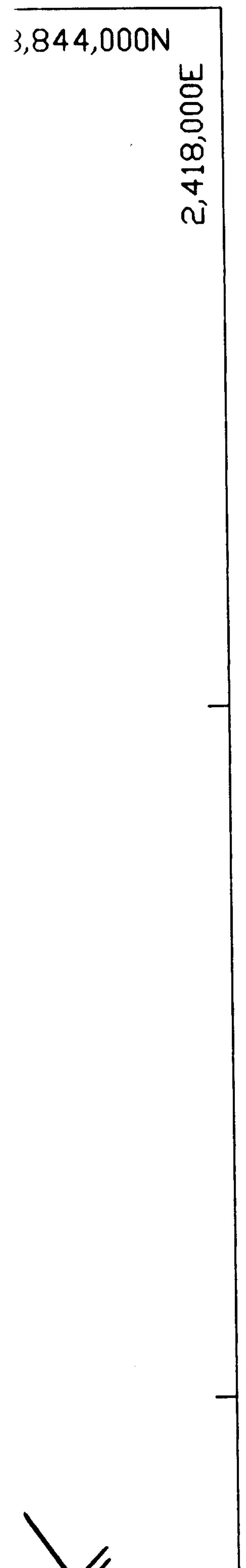

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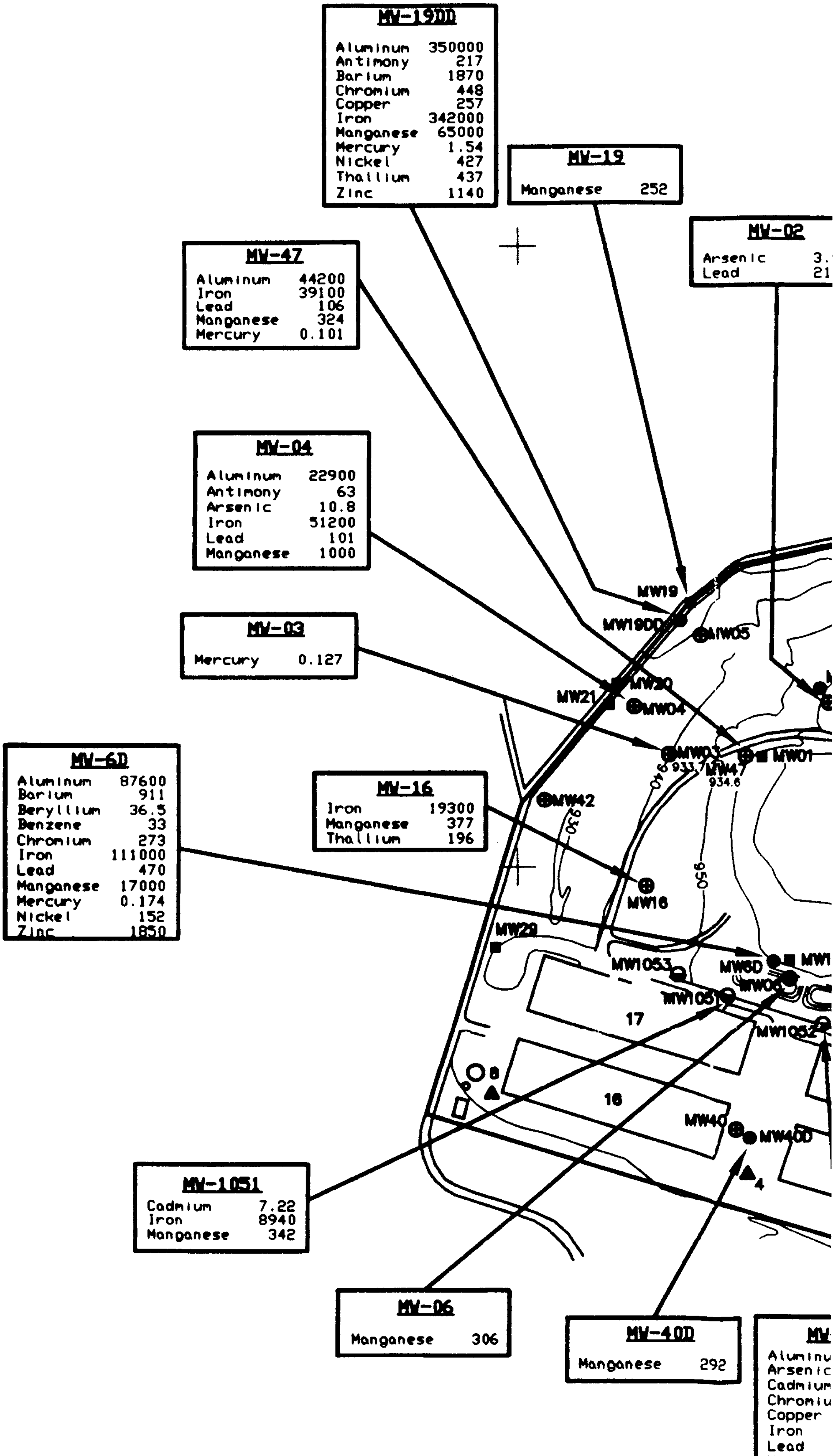


MW-19DD

Aluminum	350000
Antimony	217
Barium	1870
Chromium	448
Copper	257
Iron	342000
Manganese	65000
Mercury	1.54
Nickel	427
Thallium	437
Zinc	1140

MW-19

Manganese	252

MW-02

Arsenic	3.
Lead	21

MW-47

Aluminum	44200
Iron	39100
Lead	106
Manganese	324
Mercury	0.101

MW-04

Aluminum	22900
Antimony	63
Arsenic	10.8
Iron	51200
Lead	101
Manganese	1000

MW-03

Mercury	0.127

MW-6D

Aluminum	87600
Barium	911
Beryllium	36.5
Benzene	33
Chromium	273
Iron	111000
Lead	470
Manganese	17000
Mercury	0.174
Nickel	152
Zinc	1850

MW-16

Iron	19300
Manganese	377
Thallium	196

MW-1051

Cadmium	7.22
Iron	8940
Manganese	342

MW-06

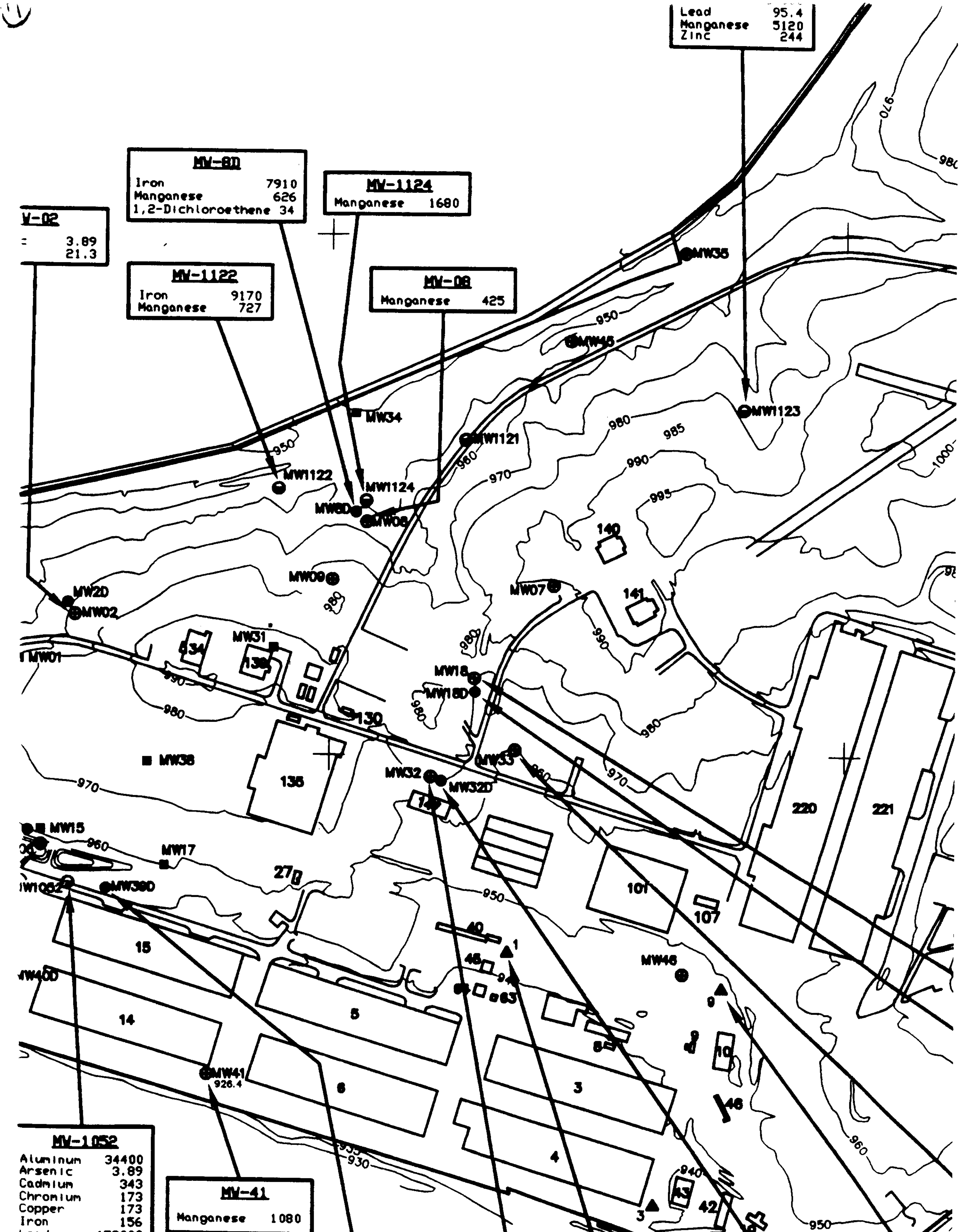
Manganese	306

MW-40D

Manganese	292

MW

Aluminu
Arsenic
Cadmium
Chromiu
Copper
Iron
Lead



Lead	95.4
Manganese	5120
Zinc	244

MV-8D

Iron	7910
Manganese	626
1,2-Dichloroethene	34

MV-1124

Manganese	1680

V-02

=	3.89
	21.3

MV-1122

Iron	9170
Manganese	727

MV-08

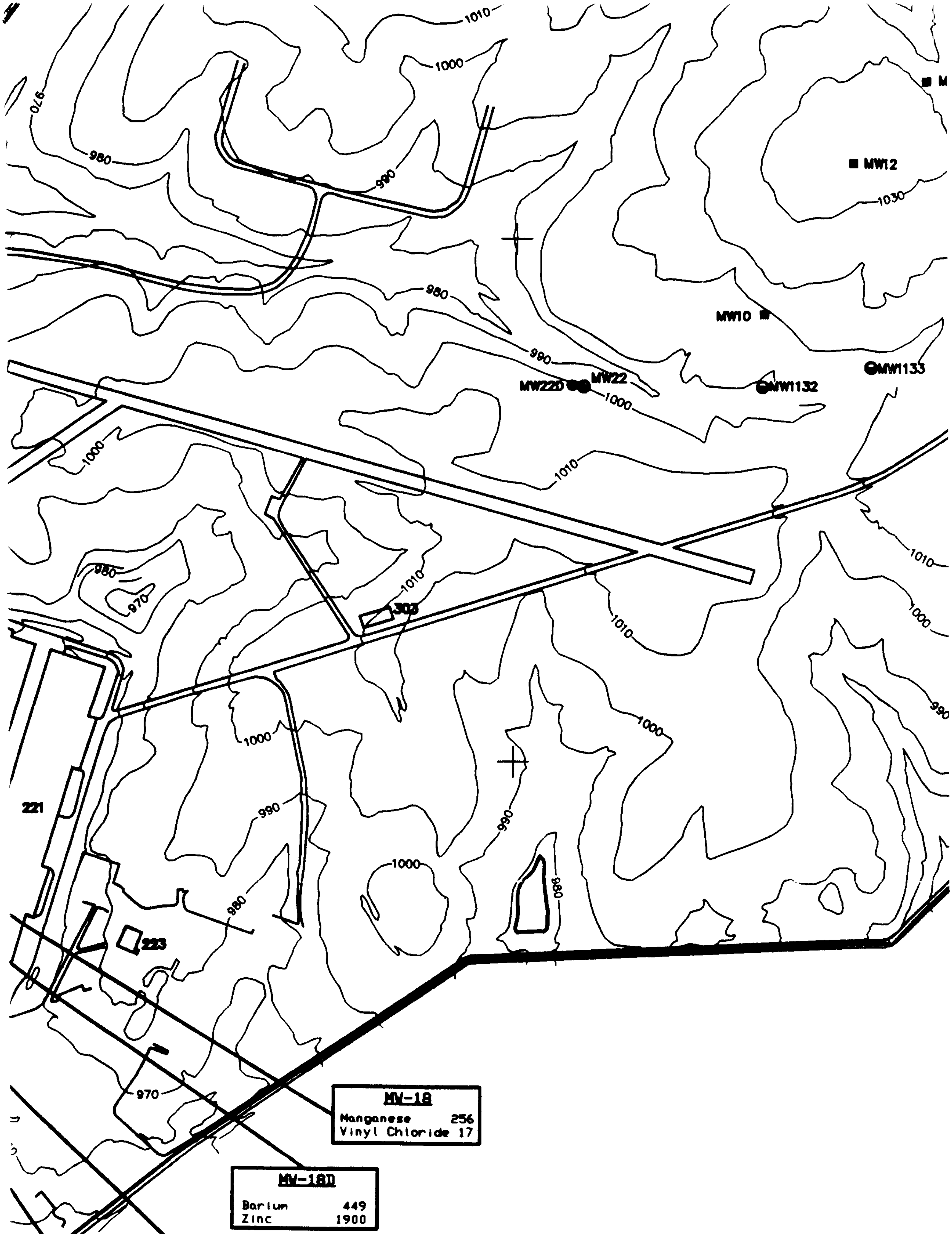
Manganese	425

MV-1052

Aluminum	34400
Arsenic	3.89
Cadmium	343
Chromium	173
Copper	173
Iron	156

MV-41

Manganese	1080

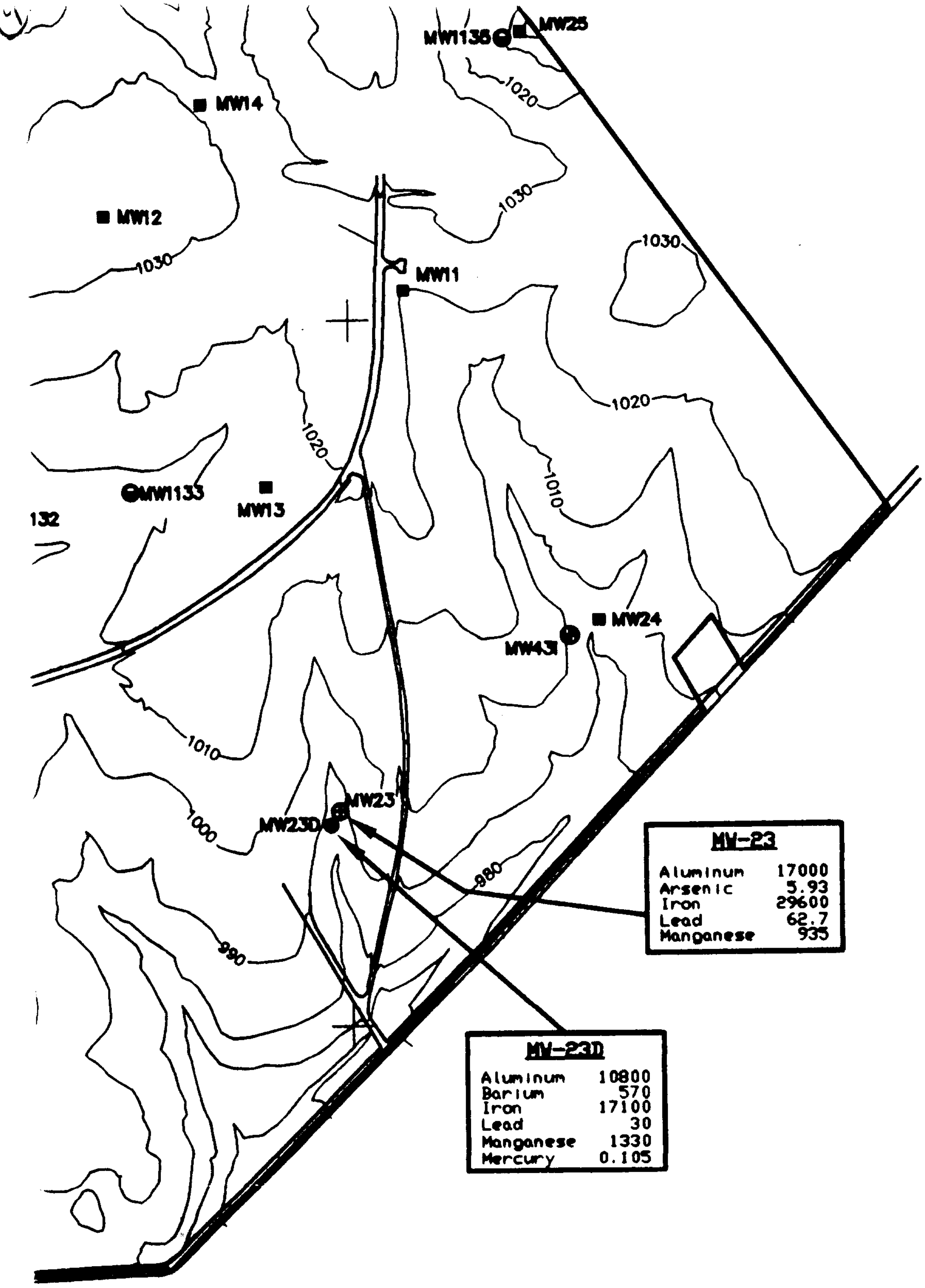


MW-18

Manganese	256
Vinyl Chloride	17

MW-18D

Barium	449
Zinc	1900

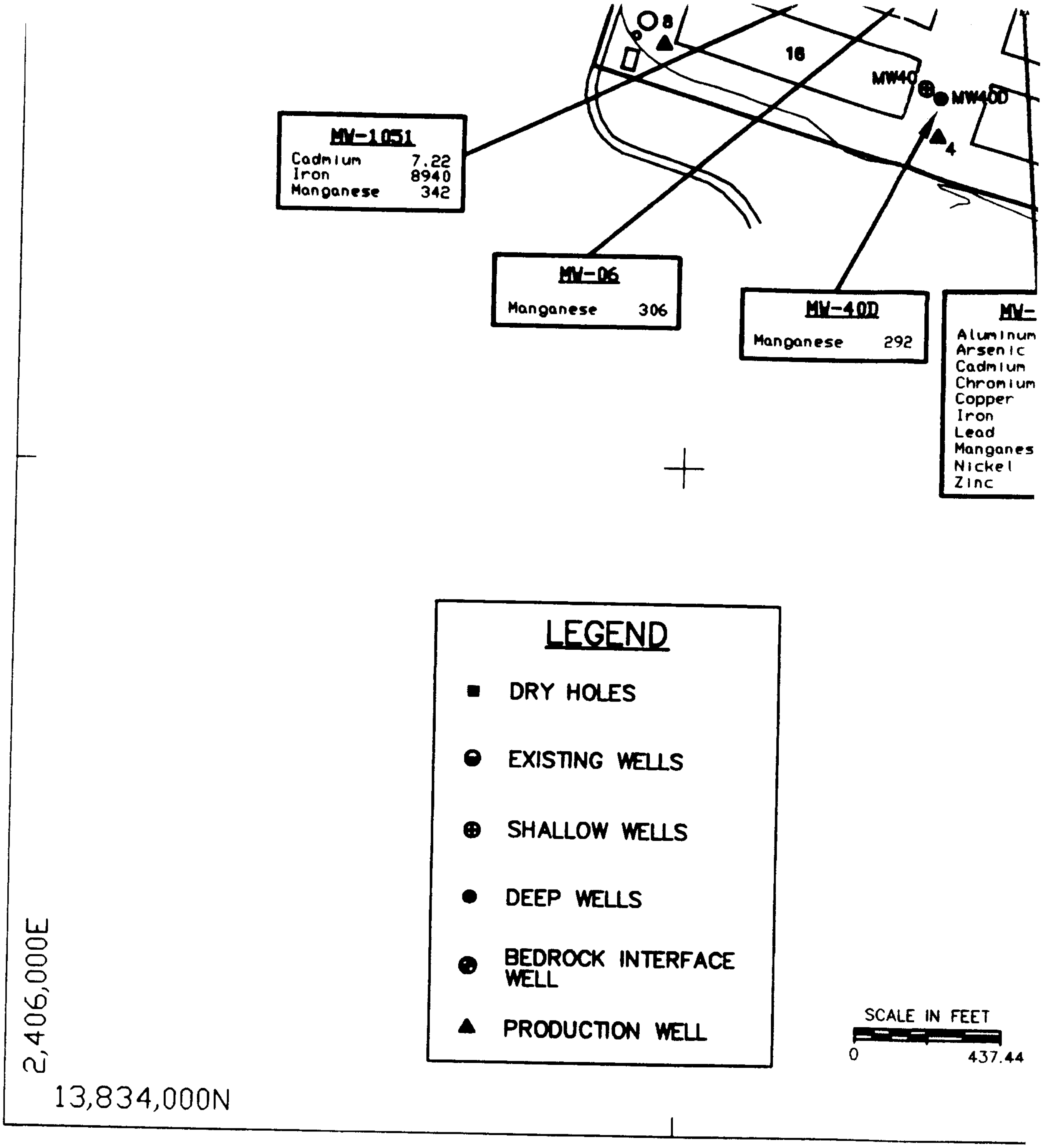


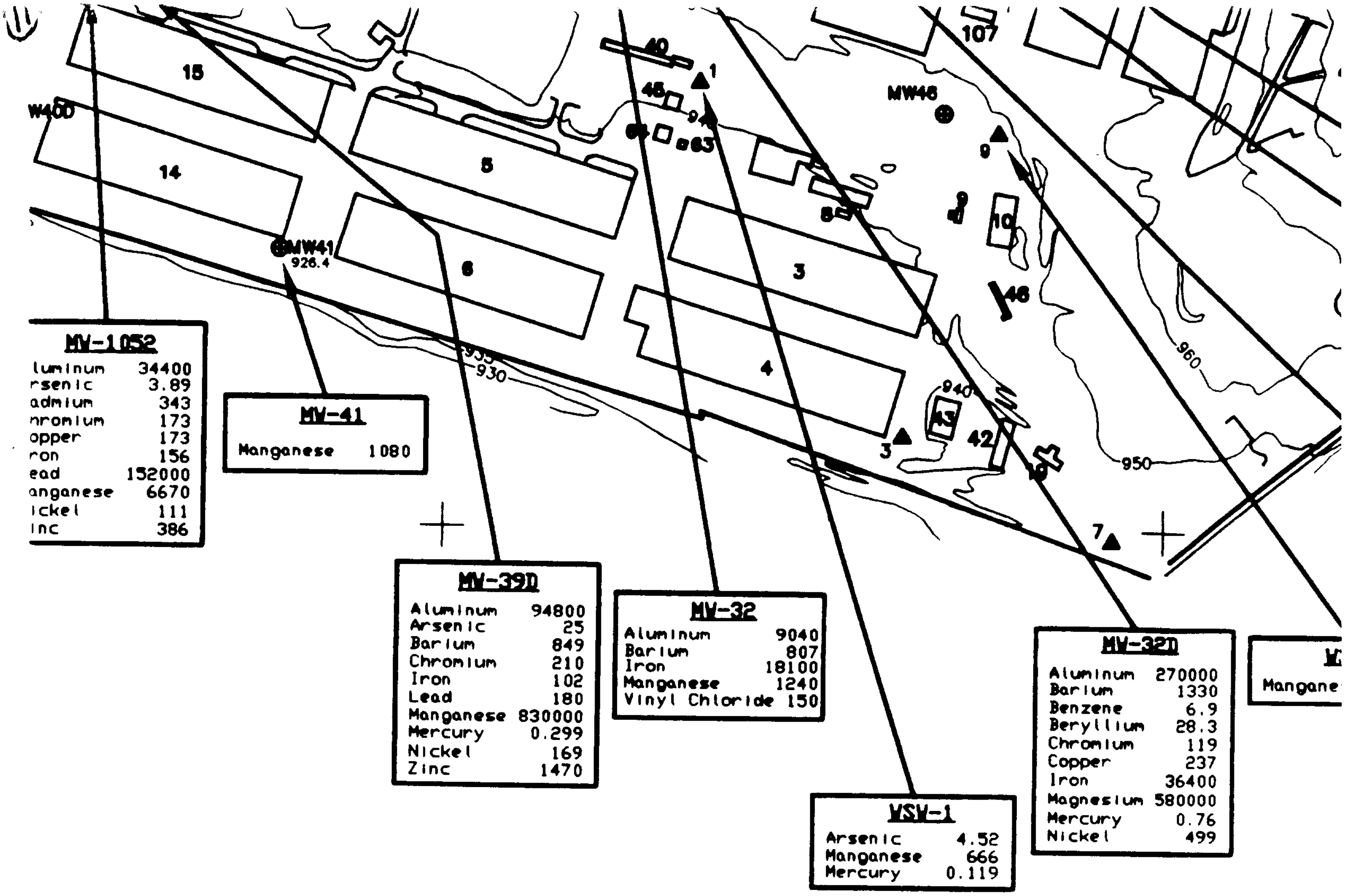
MW-23

Aluminum	17000
Arsenic	5.93
Iron	29600
Lead	62.7
Manganese	935

MW-23D

Aluminum	10800
Barium	570
Iron	17100
Lead	30
Manganese	1330
Mercury	0.105


8
16
MW40
MW40D
4
MV-1051
Cadmium 7.22
Iron 8940
Manganese 342
MV-06
Manganese 306
MV-40D
Manganese 292
MV-
Aluminum
Arsenic
Cadmium
Chromium
Copper
Iron
Lead
Manganes
Nickel
Zinc
LEGEND
■ DRY HOLES
EXISTING WELLS
⊕ SHALLOW WELLS
● DEEP WELLS
BEDROCK INTERFACE WELL
▲ PRODUCTION WELL
SCALE IN FEET
0
437.44
2,406,000E
13,834,000N



MW-1052

luminum	34400
rsenic	3.89
admium	343
hromium	173
opper	173
ron	156
ead	152000
anganese	6670
ickel	111
inc	386

MW-41

Manganese	1080

MW-39D

Aluminum	94800
Arsenic	25
Barium	849
Chromium	210
Iron	102
Lead	180
Manganese	830000
Mercury	0.299
Nickel	169
Zinc	1470

MW-32

Aluminum	9040
Barium	807
Iron	18100
Manganese	1240
Vinyl Chloride	150

WSW-1

Arsenic	4.52
Manganese	666
Mercury	0.119

MW-32D

Aluminum	270000
Barium	1330
Benzene	6.9
Beryllium	28.3
Chromium	119
Copper	237
Iron	36400
Magnesium	580000
Mercury	0.76
Nickel	499

Mangane

ET

437.44

NOTE: ALL CONCENTRATIONS IN ug/l

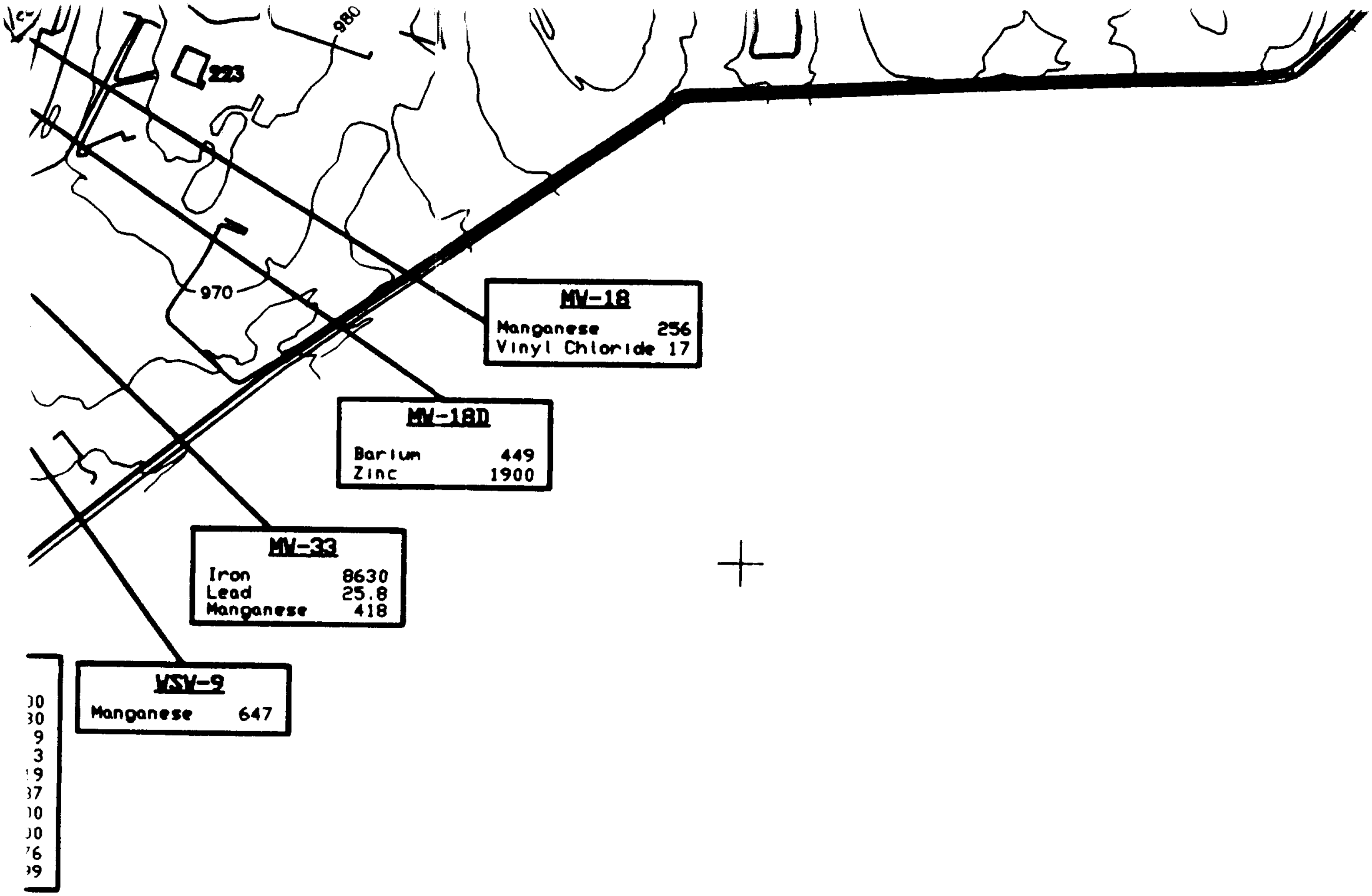


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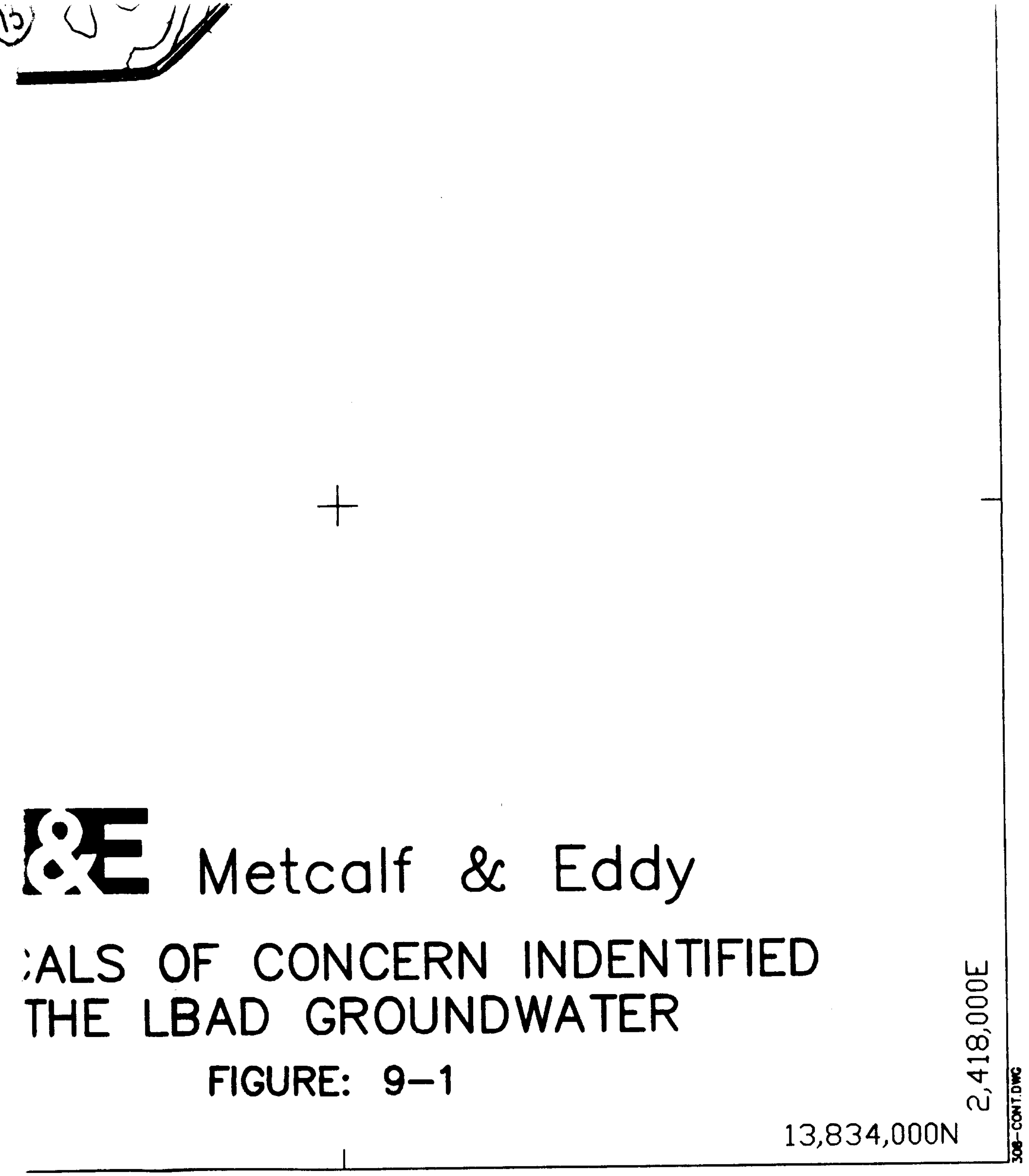
FIG



Metcalf & Eddy

ALS OF CONCERN INDENTIFIED
THE LBAD GROUNDWATER

FIGURE: 9-1

10.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

10.1 INTRODUCTION

Remedial action alternatives represent the various approaches which can be taken to achieve remediation of site contaminants. These alternatives are developed to provide a basis for the evaluation, comparison, and selection of a remedial action plan. In this section, remedial alternatives for the impacted LBAD groundwater are developed, evaluated, and screened against a common set of criteria. The alternatives which pass the screening process are then combined to form a set of alternatives which will be evaluated in detail in Section 11.0.

As noted throughout Section 9.0, the remedial action alternatives which are evaluated in this report do not address the contaminants in the LBAD soils which may be acting as a source of the LBAD groundwater contamination. An evaluation of contaminant, removal, and treatment alternatives for the impacted LBAD soils has already been addressed in a separate CMS report which was submitted to the U.S. Army in June, 1994 (USAEC, June 1994). Consequently, the LBAD groundwater remedial alternatives development and screening process in this section should be reviewed with the understanding that containment, removal, and treatment actions for the impacted LBAD soils, which may be a source of the LBAD groundwater, have been evaluated in a separate document which is currently under review by U.S. Army, U.S. EPA, and State of Kentucky representatives.

The preliminary list of potential remedial actions and technologies presented in Section 9.0 (Table 9-5) is the starting point from which remedial alternatives are developed. Table 10-1 summarizes the remedial actions and groundwater treatment technologies from Section 9.0 which were retained for further analysis. A review of Table 10-1 indicates that several treatment options for the impacted LBAD groundwater have been retained for further analysis. In Section 10.2, these treatment options are evaluated based on their anticipated effectiveness, implementability, and relative cost to select one or more options (or combination of options) considered most appropriate.

Following the screening of groundwater treatment options in Section 10.2, remedial alternatives are presented, evaluated, and screened in Section 10.3. Alternatives passing the screening process in Section 10.3 are then combined to provide a set of alternatives for the LBAD groundwater which are retained for detailed evaluation and analysis in Section 11.0. The three criteria against which the treatment options and remedial alternatives are evaluated in Sections 10.2 and 10.3, include effectiveness, implementability, and cost. Each of these criteria is composed of one or more factors as discussed below:

Effectiveness

- The potential effectiveness of process options in handling the estimated areas or volumes of impacted environmental media and meeting remediation goals, including ARARs.
- The potential impacts to human health and the environment during the construction and implementation phases.
- How proven and reliable the process is with respect to the contaminants and conditions at the site.

Implementability

- The technical feasibility of implementing a given remedial action at the site.
- The administrative feasibility of implementing a given remedial action, including the ability to obtain permits; the availability and capacity of off-site treatment, storage, and disposal facilities; and the availability of equipment and skilled workers to implement the technology.

Cost

- Determination of relative capital and O&M costs (i.e., high, medium, or low) based on engineering judgement.

It should be noted that the Superfund Amendments and Reauthorization Act of 1986 (SARA), under whose guidelines this CMS is being prepared, identifies some factors that must be considered during the alternatives evaluation and screening process. Statutory preference under SARA is given to alternatives that employ source control; offer permanent solutions; reduce toxicity, mobility, or volume of contaminants; and/or use an innovative treatment or resource recovery technology. Options discouraged under SARA include off-site disposal of wastes without treatment, and land disposal in general. SARA also requires that a no-action alternative be considered in the screening process.

The goal of the screening process in Section 10.3 is to reduce the number of candidate alternatives to be evaluated in detail. The most promising alternatives are those that are protective of human health and the environment and represent the best balance of the effectiveness, implementability, and cost criteria in light of SARA's statutory preferences. In applying the screening criteria, those alternatives determined to be inadequately protective of public health and the environment or to have serious obstacles to implementation are eliminated from further consideration. Cost is employed mainly to discriminate between alternatives offering similar levels of public-health/environmental protectiveness.

10.2 SCREENING OF TREATMENT OPTIONS FOR IMPACTED GROUNDWATER

Table 10-1 indicates that numerous treatment technologies are being considered for the LBAD groundwater. The purpose of this section is to review and evaluate these groundwater treatment technologies based on their effectiveness, implementability, and relative costs. The results of the evaluation are then used to determine which technologies, or combination of technologies, will be retained for incorporation into a set of remedial action alternatives for the impacted LBAD groundwater.

Metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, thallium, and zinc) and volatile organic constituents (benzene and vinyl chloride) have been identified as the chemicals of concern in the LBAD groundwater. Based on the results of the treatment option evaluations in Table 10-2, the following groundwater treatment technologies have been retained for further evaluation:

- Filtration
- Ion Exchange
- Air Stripping

As noted in Table 10-2, incineration, carbon adsorption, ultraviolet (UV) oxidation, precipitation, and reverse osmosis are the treatment options which were eliminated from further evaluation for the LBAD groundwater. Incineration treatment was eliminated from further consideration because treatment of water via incineration is a very energy intensive (and therefore very expensive) treatment option which provides no noteworthy advantages over air stripping treatment, which is much less expensive. Furthermore, incineration treatment may pose significant administrative difficulties based on the public's general opposition to incineration treatment.

Carbon adsorption was eliminated from further consideration because it is generally ineffective for the recovery of vinyl chloride, which is a chemical of concern in the LBAD groundwater. Furthermore, carbon adsorption treatment is considered less desirable than air stripping treatment because of the higher operating costs associated with the removal and replacement of spent carbon units. Operating costs are considered a significant evaluation factor because it is anticipated that treatment of the LBAD groundwater may be required over a period of several years.

UV oxidation is another treatment process for the organic contaminants in the LBAD groundwater which was eliminated from further consideration. UV oxidation is a relatively new treatment technology which, at this time, is not well-proven and has a higher capital cost when compared with air stripping treatment. Furthermore, the operating costs for UV oxidation treatment are expected to be higher than those associated with operation of an air stripper due to the costs associated with the ozone-source chemicals.

Precipitation and reverse osmosis are two treatment technologies which were eliminated from further consideration for the treatment of metals in the LBAD groundwater. Precipitation was eliminated because the sludge material generated as a result of the precipitation treatment process will require additional treatment and disposal. The quantity of residual sludge material is expected to be significantly greater than the amount of residuals which result from filtration or ion exchange treatment. Furthermore, the one-step filtration and ion exchange treatment systems are easier to install and maintain when compared with a precipitation treatment system which involves several steps (mixing, flocculation, separation/sedimentation). Finally, reverse osmosis was eliminated as a treatment technology for metals in the LBAD groundwater because this technology is not well-proven or widely used for the treatment of hazardous wastes. Furthermore, reverse osmosis units are considered highly subject to chemical attack, fouling, and plugging.

10.3 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, the results of the identification and initial screening of technologies presented in Section 9.5 and the results of the treatment-option-screening process in Section 10.2 are used to develop a list of alternatives for the impacted LBAD groundwater. Table 10-3 provides a list of the four remedial alternatives developed for the LBAD groundwater. Table 10-3 also includes an evaluation of these four alternatives based on their anticipated effectiveness, implementability, and relative costs. Based on this evaluation, the following three remedial alternatives have been retained for the LBAD groundwater:

Alternative I - No Action
Alternative II - Institutional Controls/Long-Term Monitoring
Alternative III - Groundwater Treatment

As presented and explained in Table 10-3, remedial Alternative IV was eliminated from further consideration. Alternative IV was identical to Alternative III with the noted exception that an interceptor trench was proposed for groundwater collection as opposed to the extraction wells which are included under Alternative III. As discussed in Table 10-3, extraction wells are preferred over the interceptor trench approach for the collection of groundwater because the extraction wells can be installed at a much lower cost and the interceptor trench does not provide any noteworthy advantages over the extraction wells.

Based on the results of the alternative development and screening process, the three alternatives noted above will be the subject of a detailed analysis and evaluation in Section 11.0.

TABLE 10-1

LIST OF LBAD GROUNDWATER REMEDIAL ACTIONS AND TECHNOLOGIES WHICH HAVE BEEN RETAINED FOR FURTHER EVALUATION

No Action

Institutional Controls/Long-Term Monitoring

Collection Via Extraction Wells or Interceptor Trenches
Followed by On-Site or Off Site Treatment
Using One or More Technologies:

- Air Stripping
- Filtration
- Precipitation
- Ion Exchange
- Reverse Osmosis
- Carbon Adsorption
- Ultraviolet (UV) Oxidation
- Incineration

Table 10-2
Evaluation of Treatment Options for Impacted LBAD Groundwater
Lexington, Kentucky

Treatment Option	Applicable Contaminants	Technology Evaluation			Retained for Further Analysis?	Comments
		Effectiveness	Implementability	Relative Cost		
Filtration	Undissolved Metals	This technology could handle the anticipated volume of impacted groundwater generated during site remediation activities. Filtration is a proven treatment technology for the removal of undissolved metals from solution. The concentrations of dissolved and undissolved metals in the groundwater must be established before the effectiveness of this treatment technology can be fully evaluated. Site workers would wear the appropriate personal protective equipment to limit exposure during remediation activities.	Technically feasible treatment option. This technology will not remove dissolved metals from solution. Filtration equipment and skilled workers are readily available to implement this technology. Implementation of this treatment technology is considered administratively feasible. This treatment technology will not remove organic constituents from the LBAD groundwater.	Low	Yes	A proven technology for removal of undissolved metals from solution. This technology may be used in combination with ion exchange treatment if both dissolved and undissolved heavy metals require removal from the LBAD groundwater.
Incineration	Organics	This technology could handle the anticipated volume of impacted groundwater generated during site remediation activities. Incineration is a proven technology for removal of organic contaminants from liquid waste streams. Impacts to human health and environment could be controlled with appropriate air pollution control equipment and by ensuring that site workers wear the appropriate personal protective equipment during site remediation activities	Technically feasible treatment option. Incineration units and skilled workers are available for on-site treatment. Some administrative difficulties may be associated with the implementation of this treatment technology based on the public's general opposition to treatment via incineration. This technology will not thermally destroy metals contaminants in the site groundwater.	High	No	Treatment of water by incineration is very energy intensive, and therefore very expensive. Furthermore, public opposition to treatment via incineration can complicate the administrative aspects associated with the implementation of this treatment technology.
Carbon Adsorption	Organics	This technology could handle the anticipated volume of impacted groundwater generated during site remediation. Carbon adsorption is an effective and reliable method for removing most organic contaminants from water. However, carbon adsorption is generally ineffective for the recovery of vinyl chloride. Site workers would wear the appropriate personal protective equipment to limit exposure during site remediation activities.	Technically feasible treatment option. Spent carbon units will require regeneration at an off-site facility prior to reuse. Carbon units are available for on-site treatment. This treatment technology will may remove some of the metal contaminants in the LBAD groundwater. Implementation of this treatment option is considered administratively feasible.	Moderate to High	No	Although carbon adsorption is a proven treatment process for the removal of most organic contaminants, it is generally ineffective for the removal of vinyl chloride. Furthermore, long-term treatment requirements for the impacted LBAD groundwater may require significant quantities of carbon, thereby increasing operating costs and O&M requirements.
Ultraviolet (UV) Oxidation	Organics	This technology could handle the anticipated volume of impacted groundwater generated during site remediation. UV oxidation is a relatively new and innovative technology for treatment of contaminated water. Site workers would wear the appropriate personal protective equipment to limit exposure during remediation activities.	This innovative treatment technology is expected to be technically feasible. UV oxidation treatment units are reportedly available for on-site treatment. This treatment technology will not remove metals from the LBAD groundwater. Implementation of this treatment option is considered administratively feasible.	Moderate to High	No	A promising and innovative treatment technology. However, this treatment technology has been eliminated from further consideration based on the fact that it is generally not well-proven and has a significantly higher capital cost when compared with air stripping.
Air Stripping	Volatile Organics	This technology could handle the anticipated volume of impacted groundwater generated during site remediation activities. Air stripping is a proven technology for removing volatile organic contaminants from liquid waste streams. Impacts to human health and the environment could be controlled with the appropriate air pollution control equipment and ensuring that site workers wear the appropriate personal protective equipment during site remediation activities.	Technically feasible treatment option. The air stream which exits the stripper unit may require some additional treatment (e.g., carbon adsorption or thermal oxidation) prior to discharge to the atmosphere. This treatment technology will not treat or remove the metal contaminants in the LBAD grondwater.	Moderate	Yes	An effective treatment process for the removal of volatile organic constituents from groundwater. Pretreatment of the groundwater for metals removal prior to air stripping may be necessary to prevent fouling of the air stripper during operation.
Precipitation	Metals	This technology could handle the anticipated volume of impacted groundwater generated during remediation. This is a proven treatment process for removal of metal contaminants from liquid waste streams. Site workers would wear the appropriate personal protective equipment to limit exposure during remediation activities.	This is a non-selective treatment process which will precipitate compounds other than those targeted for removal and generate potentially significant quantities of sludge which will require further treatment and/or disposal. This treatment technology will not remove organic constituents from the LBAD groundwater. Implementation of this treatment option is considered administratively feasible.	Moderate	No	This treatment technology will generate sludge material which will require further treatment and/or disposal. The ion exchange and/or filtration technologies are preferred over precipitation because smaller volumes of treatment residuals will be generated and the one-step treatment systems for these technologies are easier to install and maintain.
Ion Exchange	Metals	This technology could handle the anticipated volume of impacted groundwater generated during site remediation. Ion exchange is a proven treatment option for the removal of dissolved metals from solution. The concentrations of dissolved and undissolved metals in the LBAD groundwater must be established before the effectiveness of this treatment technology can be fully evaluated. Site workers would wear the appropriate personal protective equipment to limit exposure during remediation activities.	Technically feasible treatment option. Any suspended solids (including undissolved metals) in solution will require filtration prior to treatment with this technology. Used ion exchange units will require regeneration at an off-site facility prior to reuse. Ion exchange equipment and skilled workers are readily available to implement this technology. Implementation of this treatment technology is considered administratively feasible. This treatment technology will not remove organic constituents from the LBAD groundwater.	Low to Moderate	Yes	A proven technolgy for the removal of dissolved metals from solution. This technology may be used in combination with filtration if both dissolved and undissolved metals require removal from the LBAD groundwater.

Table 10–2 (cont'd)

Treatment Option	Applicable Site Contaminants	Technology Evaluation			Retained for Further Analysis?	Comments
		Effectiveness	Implementability	Relative Cost		
Reverse Osmosis	Metals	This technology could handle the anticipated volume of impacted groundwater generated during site remediation. Reverse osmosis has not been widely used for the treatment of hazardous wastes. Site workers would wear the appropriate personal protective equipment to limit exposure during remediation activities.	Technically feasible treatment option. However, reverse osmosis units are highly subject to chemical attack, fouling, and plugging if the feed waste stream is not properly pretreated. The equipment and materials required to implement this process on–site are readily available.	Low to Moderate	No	Not a well–proven technology for the removal of inorganic contaminants from a hazardous waste stream. Reverse osmosis units are also highly subject to chemical attack, fouling, and plugging.

Table 10-3
Evaluation of Remedial Alternatives Developed for Impacted LBAD Groundwater
Lexington, Kentucky

		Alternative Evaluation				
	Alternative	Effectiveness	Implementability	Relative Cost	Retained For Further Analysis?	Comments
I	No Action	No remedial action performed; therefore, no construction or implementation-related impacts to human health and the environment are anticipated. Remediation goals would not be achieved.	No technical feasibility considerations apply to the no-action alternative. Administratively, this alternative is expected to to be difficult to implement because the no-action plan will not prevent exposure to surface water contaminants or reduce contaminant concentrations.	None	Yes	Retained for analysis in accordance with Subpart F of the NCP Provides a baseline upon which to compare and evaluate acti alternatives.
II	Institutional Controls - Groundwater Monitoring; Restrict Site Access/Deed Restrictions, and Prevent Future Dumping/Disposal Activities and Prevent Future Use of Groundwater	Limited remedial actions are expected to result in minimal implementation-related impacts to human health and the environment. The appropriate PPE and health and safety equipment would be used to limit exposure to contaminants during sampling. No provisions for treatment of groundwater or soils which are a suspected source of groundwater contamination are included with this alternative.	Technically feasible. Administratively, this alternative may be difficult to implement because treatment of contaminants is not provided for.	Low	Yes	Retained for futher analysis because preventing future use of site groundwater will prevent groundwater contaminants from presenting a future exposure risk, provided groundwater moni toring results continue to indicate that groundwater contamina are not migrating off-site.
III	Collection of Groundwater Via Extraction Wells, Groundwater Treatment Via Air Stripping, Filtration and Ion Exchange, Discharge of Treated Water to the POTW or On-Site Streams	This alternative is expected to provide for effective collection and treatment of impacted LBAD groundwater. Remediation goals would be achieved. The potential for site workers to be exposed to site contaminants during construction and implementation activities could be controlled by ensuring that site workers wear the appropriate PPE and are properly trained.	Technically feasible. Administratively, approval of the POTW to discharge treated water or permits (NPDES, KPDES) to discharge the treated water to an on-site stream will be necessary. The equipment and labor needed to implement this alternative is available. On-site treatment of groundwater is preferred over off-site treatment because the cost to transport and treat the water off-site is expected to be significantly higher than the cost of on-site treatment. Furthermore, the availability of off-site treatment facilities which can provide the prescribed treatment is uncertain.	Moderate	Yes	An effective and implementable approach to remediate the impacted LBAD groundwater.
IV	Collection of Groundwater Via an Interceptor Trench, Groundwater Treatment Via Air Stripping, Filtration and Ion Exchange; Discharge of Treated Water to the POTW or On-Site Streams	The effectiveness issues associated with this alternative would be identical to the alternative discussed above with the noted exception that an interceptor trench would collect significantly more groundwater, thereby requiring a larger treatment system.	The implementability issues associated with this alternative would be similar to the alternative above, with the noted exception that the interceptor trench would be significantly more excpensive and technically difficult to install and operate when compared with extraction wells. Furthermore, pumping test results indicate that a single extraction well pumped at a rate of 5 to 10 gallons per minute would create a radius of influence which is large enough to capture the groundwater contaminants. Alternatively, the interceptor trench would collect much more water, some of which is not expected to be contaminated. The interceptor trench does not provide any noteworthy advantages when compared with the use of extraction wells.	Moderate to High	No	Eliminated from further consideration based on the noted advantages which an extraction well has over an interceptor trench.

11.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

11.1 INTRODUCTION

The remedial alternatives for the LBAD groundwater which were retained from the Section 10.0 screening process for detailed analysis in Section 11.0 are presented below:

Alternative I	-	No Action
Alternative II	-	Institutional Controls/Long-Term Monitoring
Alternative III	-	Groundwater Treatment

To select the most appropriate remedial alternative for the LBAD groundwater, the candidate alternatives are evaluated and compared in terms of the following nine criteria:

- Overall Protection of Human Health and the Environment -- Involves an assessment based on a composite of factors addressed under other evaluation criteria, including long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

- Compliance with ARARs -- Assesses the compliance of an alternative with all chemical-specific, action-specific, and location-specific ARARs. Listings of potential ARARs for the LBAD groundwater are presented in Appendix T.

- Long-Term Effectiveness and Permanence -- Examines the protection of human health and the environment after construction and implementation of the remedial alternative. This criterion addresses the long-term adequacy, reliability, and permanence of the remedial alternative and the magnitude of the risk posed by treatment residuals and/or untreated wastes.

- Reduction of Toxicity, Mobility, and Volume Through Treatment -- Examines the extent to which the remedial alternative achieves the statutory preference for remedial actions which permanently and significantly reduce the toxicity, mobility, and volume of contaminants.

- Short-Term Effectiveness -- Examines the protection of the community, worker health, and environment during construction and implementation of the remedial alternative.

This criterion also evaluates the time required to implement the alternative and achieve remedial action objectives.

- Implementability -- Considers the technical and administrative feasibility of each alternative, as well as availability of required resources. Factors considered in assessing this criterion include: construction, reliability, operation, and maintenance of the remedial alternative; potential problems which may be encountered during the implementation of an alternative; required approvals and permits from regulatory agencies; availability of required off-site treatment or disposal services; and availability of necessary equipment, materials, and personnel.

- Cost -- Involves development and evaluation of the capital cost of construction, equipment, land, buildings, engineering services, and project administration, and operation and maintenance (O&M) costs of labor, spare parts, materials, utilities, and administration. In addition, the present worth of annualized costs associated with each alternative are calculated using an annual discount rate of 5 percent before taxes and after inflation. Costs are then compared on a common, present-worth basis in terms of 1994 dollars. The level of detail employed in developing these estimates is considered appropriate for making choices between alternatives, but the estimates are not intended for use in budgetary planning.

- State Acceptance -- Identifies the State's apparent preference or concerns about the alternatives.

- Community Acceptance -- Identifies the community's apparent preferences or concerns about the alternatives.

The following sections provide detailed and comparative analyses of the remedial alternatives for the impacted LBAD groundwater. These analyses will assist in the selection of a preferred alternative for the LBAD groundwater which represents the best balance of the nine evaluation criteria.

As noted throughout Section 9.0, the remedial action alternatives which are evaluated in this report do not address the contaminants in the LBAD soils which may be acting as a source of the LBAD groundwater contamination. An evaluation of contaminant removal and treatment alternatives for the impacted LBAD soils has already been addressed in a separate CMS report which was submitted to the U.S. Army in June, 1994 (USAEC, June 1994). Consequently, the LBAD groundwater remedial alternatives presented in this section should be reviewed with the understanding that containment, removal, and treatment actions for the impacted LBAD soils which may be a source of the LBAD groundwater have been evaluated in a separate document which is currently review by U.S. Army, U.S. EPA, and State of Kentucky representatives.

11.2 ALTERNATIVES ANALYSIS

11.2.1 Alternative I - No Action

11.2.1.1 Description

Under this alternative, no remedial actions would be performed to remediate the LBAD groundwater. No efforts would be undertaken to contain, remove, monitor, or treat the groundwater contaminants. Evaluation of the no-action alternative provides a baseline against which action alternatives can be compared and evaluated.

11.2.1.2 Overall Protection of Human Health and the Environment

The no-action alternative is not considered to provide adequate overall protection of human health and the environment because of the anticipated adverse long-term impacts and failure to meet ARARs.

11.2.1.3 Compliance with ARARs

With the noted exception of possible natural biological degradation of groundwater contaminants, the no-action alternative does not provide for any reduction in contaminant concentrations. Consequently, violations of Federal MCLs and State action levels for groundwater contaminants are expected to continue, and reduction of contaminant concentrations to cleanup goal levels (see Section 9.2) may not be achieved under the no-action scenario.

11.2.1.4 Long-Term Effectiveness and Permanence

The no-action alternative is considered to provide inadequate long-term effectiveness and permanence. Based on the results of the risk assessment completed for the LBAD groundwater and the cleanup goals developed in Section 9.2 of this report, Alternative I will leave unacceptable concentrations of contaminants in the LBAD groundwater. None of the existing contaminant exposure pathways would be eliminated under the no-action scenario.

11.2.1.5 Reduction of Toxicity, Mobility, and Volume

Because site contaminants would not be treated under the no-action alternative, no reduction in contaminant toxicity, mobility, or volume would be achieved.

11.2.1.6 Short-term Effectiveness

The absence of remedial actions under the no-action alternative indicates that no short-term impacts to the community or the environment would occur during implementation.

11.2.1.7 Implementability

There are no construction-related implementation considerations associated with Alternative I. Administratively, the no-action alternative would be difficult to implement based on the continued Federal MCL and State of Kentucky Water Quality Criteria value exceedances and the human health risks associated with the existing groundwater contaminant concentrations. The administrative feasibility of Alternative I is further diminished by the availability of viable treatment alternatives.

11.2.1.8 Cost

No direct costs are associated with the no-action alternative. However, costs associated with future environmental liabilities could be substantial if no actions are performed to reduce the groundwater contaminant concentrations or eliminate contaminant exposure pathways.

11.2.1.9 State Acceptance

Due to failure to meet ARARs, State acceptance of the no-action alternative is not expected.

11.2.1.10 Community Acceptance

Community acceptance of the no-action alternative is not anticipated for the reason discussed above under State Acceptance.

11.2.2 Alternative II - Institutional Controls/Long-Term Monitoring

11.2.2.1 Description

Under Alternative II, the use of LBAD groundwater as a drinking water supply would be prohibited. Deed restrictions would be placed on the LBAD property to help ensure that the groundwater is not used as a drinking supply in the future. This alternative also includes the long-term monitoring of groundwater on- and off-base to determine the migration of the contaminant plume and concentrations of groundwater contaminants. If the groundwater monitoring results indicate that the contaminant concentrations are increasing significantly or the contaminant plume is migrating off-base, additional remedial actions which will facilitate a reduction in groundwater contaminant concentrations (i.e., extraction and treatment of groundwater) may be undertaken.

11.2.2.2 Overall Protection of Human Health and the Environment

The institutional controls alternative would provide protection of human health by eliminating the human exposure pathways associated with the drinking of impacted LBAD groundwater. However, due to the absence of any groundwater treatment actions under Alternative II, the potential for further migration of groundwater contaminants will continue if Alternative II is implemented.

11.2.2.3 Compliance With ARARs

Initially, Alternative II is not expected to comply with ARARs due to exceedances of Federal MCLs and State of Kentucky Water Quality Criteria for contaminants in the groundwater. However, prohibiting the future use of site groundwater as a drinking water source may render these ARARs inapplicable.

Furthermore, natural attenuation of the LBAD groundwater contaminants may result in the reduction of some groundwater contaminant concentrations (particularly organic constituents) to levels which will comply with these criteria. Continued monitoring of the site groundwater will help determine if future compliance with drinking water standards is achieved.

11.2.2.4 Long-Term Effectiveness and Permanence

The institutional controls alternative will provide a moderate degree of long-term effectiveness and permanence. No actions would be taken to reduce the LBAD groundwater contaminant concentrations under Alternative II; however, preventing the future use of site groundwater as a drinking water source should eliminate the human exposure pathway associated with the ingestion of site groundwater. Long-term monitoring of the groundwater will help evaluate the long-term effectiveness and permanence of this alternative.

11.2.2.5 Reduction of Toxicity, Mobility, and Volume Through Treatment

Site contaminants will not be treated under Alternative II; therefore, no reduction in contaminant toxicity, mobility, or volume will be achieved.

11.2.2.6 Short-Term Effectiveness

The remedial actions performed under Alternative II will not present any risks to the surrounding community or environment during implementation. Site workers would wear the appropriate PPE during groundwater sampling activities to reduce their potential for exposure to chemicals in the groundwater. For the purposes of this report, the time period over which the institutional controls will be implemented or enforced (groundwater monitoring and deed restrictions) is assumed to be 30 years.

11.2.2.7 Implementability

There are no construction-related impacts associated with the implementation of Alternative II. Administratively, the implementation of this alternative may be difficult based on statutory preferences for alternatives which provide for treatment of site contaminants and the fact that exceedances of drinking water standards for contaminant concentrations in the groundwater would continue.

11.2.2.8 Cost

Table 11-1 provides a breakdown of the costs associated with the implementation of Alternative II. The total net present worth cost to implement Alternative II, assuming groundwater monitoring activities would continue for 30 years, is estimated to be $388,940.

11.2.2.9 State Acceptance

This criterion will be addressed after the State of Kentucky's comments on this RFI/CMS report have been received.

11.2.2.10 Community Acceptance

This criterion will be addressed after community comments on the remedial alternatives presented in this RFI/CMS report have been received.

11.2.3 Alternative III - Groundwater Treatment

11.2.3.1 Description

Under Alternative III, impacted LBAD groundwater would be collected, treated to reduce the concentrations of organic and inorganic contaminants, and discharged to on-site streams or the local POTW. The proposed treatment process for the collected groundwater would include filtration and ion exchange to remove metals and air stripping to remove volatile organic contaminants. With respect to the two treatment technologies for metals, filtration is appropriate for the removal of undissolved metals and ion exchange is appropriate for the removal of dissolved metals. Presently, the relative amounts of dissolved and undissolved metals in the LBAD groundwater are unknown; therefore, Alternative II includes additional sampling of the LBAD groundwater as a part of the remedial design phase to determine the relative concentrations of dissolved and undissolved metals. In the event that the sample analysis results indicate the majority of the metals in the groundwater are dissolved, ion exchange technology may be used exclusively for metals removal. Alternatively, if the sample analysis results indicate that the majority of the metals are undissolved, the filtration technology may be used exclusively for metals removal.

With respect to the treatment of organic contaminants in the groundwater via air stripping, preliminary estimates of the organic concentrations in the air stream which exits the air stripper (see Appendix U) indicate that the organic concentrations will be well below levels which require treatment, based on State of Kentucky Air Quality Regulations. The air stripper off-gas will be monitored during operation of the treatment system to ensure that organic concentrations in the gas stream are consistent with these preliminary estimates, and the regulatory limits are not exceeded. If necessary, the air stripper could be equipped with a carbon adsorption unit or catalytic oxidation unit to reduce the concentrations of organics in the exit gas prior to discharge to the atmosphere.

Treatment residuals from the proposed groundwater treatment process would include solids collected in the filters; ion exchange units which have reached full capacity; the treated water; and, possibly, carbon adsorption units (in the event that treatment of the air stripper off-gas is necessary). Assuming that the collected filter solids are not classified as a hazardous waste (based on TCLP testing), the solids will be disposed of off-site at a solid waste landfill. The spent ion exchange units will be disposed of or recharged off-site in accordance with regulatory requirements. The treated water may be disposed of off-site at the local POTW or discharged directly to on-site streams. If carbon adsorption units are used, the units will be recharged off-site once they have reached full capacity.

Figure 11-1 presents the potential locations for the groundwater extraction wells and an estimated radius of influence for each well during pumping. The extraction well locations indicated on Figure 11-1 were preliminarily selected to facilitate recovery of impacted groundwater based on available analytical and hydrogeologic data for the site. It should be noted that the available hydrogeologic data are considered insufficient to definitively determine the optimal location and radius of influence for each extraction well. Additional investigations (e.g., pump tests) will be required during the remedial design phase of this project to establish the best location and the actual radius of influence for each well.

Under Alternative III, the pumps which are installed in the extraction wells for the recovery of groundwater would be controlled by water level switches. These switches will prevent the operation of the well pumps when the water level in the well falls below a preset elevation. Each of the five extraction wells will be connected to a separate treatment system. Based on available analytical results, all extracted groundwater will require treatment for the removal of metals. However, the groundwater collected from extraction wells EW-1 and EW-5 will not be treated for the removal of volatile organic compounds based on the absence of these compounds in the nearby wells. Therefore, the groundwater treatment systems for wells EW-1 and EW-5 will not include an air stripper.

All five treatment systems will include an equalization tank for the collection of extracted groundwater. Level switches in the equalization tanks will control the flow of water which exits the tanks and enters the treatment systems. These level switches will activate a transfer pump which transfers from the tank to the treatment system when the tank is almost full and deactivate the transfer pump when the tank is almost empty. This design will facilitate groundwater treatment in a batch mode operation at a consistent flow rate of 15 to 20 gallons per minute for each treatment system.

Alternative III will also include long-term monitoring of the LBAD groundwater to assist in the evaluation of the effectiveness of the groundwater treatment systems. All of the groundwater treatment systems will be designed to accommodate future alterations or expansions.

11.2.3.2 Overall Protection of Human Health and the Environment

The remedial actions performed under Alternative III would be designed to effectively control both short- and long-term impacts to human health and the environment. Treatment of the impacted LBAD groundwater via air stripping, filtration, and ion exchange should effectively reduce the concentrations of volatile organic and metal contaminants in the groundwater. The remedial actions proposed under this alternative are expected to meet all ARARs and offer a high level of overall protection of human health and the environment.

11.2.3.3 Compliance With ARARs

Treatment of the LBAD groundwater, as proposed under Alternative III, will reduce the concentrations of contaminants in the groundwater to levels which are below the cleanup goal concentrations specified in Section 9.2, thereby satisfying the ARARs for acceptable groundwater contaminant concentrations. Regulatory requirements for the discharge of treated groundwater to on-site streams or the local POTW will also be complied with under Alternative III. Furthermore, OSHA standards for hazardous waste and construction site workers will be complied with during the implementation of Alternative III.

11.2.3.4 Long-Term Effectiveness and Permanence

The remedial actions proposed under Alternative III will provide long-term protection of human health and the environment. The treatment technologies proposed for the LBAD groundwater under Alternative III are expected to permanently reduce the concentrations of groundwater contaminants, thereby eliminating the potential for future exposure to these contaminants. Residuals from the groundwater treatment process will be properly handled and disposed of to limit future human health and/or environmental risks which they may pose. After treatment activities have been completed, monitoring of the LBAD groundwater will continue. The long-term monitoring of the LBAD groundwater will facilitate future evaluations of the groundwater treatment efforts and assist in determining if chemicals of concern in the LBAD groundwater are maintained below their respective cleanup goal concentrations.

11.2.3.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

The treatment technologies proposed under Alternative III will reduce the toxicity and volume of contaminants in the LBAD groundwater. The combination of metals treatment via ion exchange and filtration and volatile organics treatment via air stripping will reduce the concentrations of these chemicals in the groundwater, thereby reducing the toxicity and volume of these constituents.

11.2.3.6 Short-Term Effectiveness

Remedial actions performed under Alternative III are expected to present little or no risks to the surrounding community during implementation. The relatively remote location of LBAD in relation to residential areas will help limit potential impacts or risks to the community during remedial activities. Access to the treatment system areas will be restricted to prevent public exposure to groundwater contaminants and treatment residuals.

Site workers could potentially be exposed to site contaminants during remediation activities. Potential impacts to site workers could be controlled with the use of the appropriate PPE and by ensuring that site workers have the required training and work experience.

The implementation of Alternative III is not expected to pose any significant environmental impacts. The exact time to implement this alternative will depend on weather conditions, the construction contractor's capabilities and experience, the availability of the required construction equipment, and the effectiveness and efficiency of the groundwater treatment system in reducing the concentrations of groundwater contaminants below the cleanup goal concentrations. Based on available site information, a period of 10 to 14 months should be sufficient to prepare remedial design specifications and install the groundwater treatment system. It is anticipated that the groundwater treatment system will be required to operate for several years before cleanup goals for the groundwater contaminants have been achieved.

11.2.3.7 Implementability

All of the groundwater treatment technologies proposed under Alternative III are well-developed and proven for the contaminants of concern in the LBAD groundwater. The required labor, equipment, and materials to implement this alternative are readily available. Coordination with the local POTW will be required if POTW discharge of treated water is performed under this alternative. A KPDES permit will be required if the treated water is discharged to on-site streams. The remediation contractor will have to coordinate the construction schedule with the appropriate Army officials. These officials will need to assist the contractor with site access arrangements and the location of access roads and storage areas for the construction and remediation equipment.

11.2.3.8 Cost

The cost estimate for Alternative III is based on the construction and simultaneous operation of five groundwater treatment systems at batch flow rates of 15 to 20 gallons per minute. The capital cost estimate was developed with the understanding that both filtration and ion exchange treatment for metals would be required, and that the treated water would be discharged on-site. The operation and maintenance costs for this alternative were developed with the understanding that the groundwater treatment systems would operate for 5 years and that groundwater monitoring would be performed for a period of 30 years. The cost estimates presented in this CMS are intended to provide a basis for making cost comparisons between alternatives and, as discussed in Section 10.1, were not developed with the level of detail required for their use in budget planning. Table 11-2 provides breakdown of the costs associated with Alternative III. The total estimated cost to implement Alternative III is $1,735,312.

11.2.3.9 State Acceptance

This criterion will be addressed after the State of Kentucky's comments on this RFI/CMS report have been received.

11.2.3.10 Community Acceptance

This criterion will be addressed after community comments on the remedial alternatives presented in this RFI/CMS report have been received.

11.3 Comparative Analysis of Alternatives

This section highlights and compares the relative strengths and weaknesses of Alternatives I, II, and III. Table 11-3 presents a summary of this comparison in terms of the nine evaluation criteria. The comparative-analysis discussion of the three alternatives for the LBAD groundwater is presented below.

Prior to proceeding with the comparative-analysis discussion, it is important to note that a complete and objective evaluation of remedial alternatives for the LBAD groundwater cannot be performed unless the remedies under consideration or selected for contaminants in the LBAD soils are also taken into account. Contaminants which have been identified in the LBAD soils are considered a source of the LBAD groundwater contamination. As previously discussed, a separate CMS report has been prepared which evaluates remedial action alternatives for contaminants in the LBAD soils (USAEC, June 1994). This document is currently under review by the U.S. Army, U.S. EPA, and the State of Kentucky. Dependent upon which remedial action alternatives are selected and ultimately implemented for the impacted soils, soil contaminants which are contributing to the LBAD groundwater contamination may be contained, removed, and/or treated; thereby facilitating future reductions in groundwater contaminant concentrations without direct treatment of the groundwater. This being the case, some additional support may be provided for the selection of the long-term monitoring alternative which does not include direct treatment of groundwater (Alternative II) when compared with the alternative which entails groundwater collection and treatment (Alternative III). Therefore, although treatment, containment, and removal actions for the LBAD soil contaminants are addressed in a separate report, the remedial action(s) chosen for the LBAD soil contaminants must be considered along with the comparative-analysis discussion presented below to ensure a complete and objective evaluation of remedial action alternatives for the LBAD groundwater.

11.3.1 Overall Protection of Human Health and the Environment

Alternative III is expected to provide the greatest amount of overall protection of human health and environment when compared with Alternatives I and II. Alternative III includes removal and treatment of the impacted LBAD groundwater and long-term monitoring of the site groundwater. Alternative II is considered less protective of human health and the environment because no treatment of the site groundwater is provided for, although long-term monitoring and restrictions on the future use of the site groundwater are included under Alternative II. Alternative I, the no-action alternative, will not provide any protection of human health and the environment.

11.3.2 Compliance With ARARs

Alternative I is not expected to comply with ARARs because no actions would be taken to reduce groundwater contaminant concentrations and achieve the prescribed cleanup goals for the LBAD groundwater. Furthermore, Alternative I does not include any provisions for the long-term monitoring of the LBAD groundwater to determine if the groundwater contaminant concentrations are increasing or decreasing above or below their respective cleanup goal concentrations.

Alternative II may not comply with ARARs because no actions would be taken to reduce the contaminant concentrations in the LBAD groundwater. However, Alternative II does include the use of deed restrictions to prevent the future use of LBAD groundwater as a drinking water source, thereby eliminating the human exposure pathway associated with the ingestion of groundwater contaminants. Elimination of the human exposure pathway is a critical element of Alternative II because, although no measures for the reduction of groundwater contaminant concentrations will be implemented under Alternative II, the cleanup goal concentrations for the site groundwater contaminants (which may be considered ARARs) are based on the existence of a human exposure pathway. Consequently, if the deed restrictions imposed under Alternative II were successfully implemented, the human exposure pathway would be eliminated and the cleanup goal concentrations would be rendered inapplicable.

Alternative III is expected to comply with ARARs because the site groundwater would be extracted and treated to reduce contaminant concentrations and achieve the established cleanup goals. OSHA standards for workers at hazardous waste sites will be followed during the on-site construction activities associated with the implementation of Alternative III.

11.3.3 Long-Term Effectiveness and Permanence

The no-action alternative offers no means to prevent current or future exposure to the LBAD groundwater contaminants, nor does it include treatment of the groundwater to reduce the contaminant concentrations. Therefore, the no-action alternative is not expected to provide any long-term effectiveness or permanence.

Alternative II will eliminate the human exposure pathway (i.e., consumption of impacted groundwater) if efforts to prevent future use of the LBAD groundwater as a source of drinking water are successful. Alternative II does not include any treatment of the groundwater to reduce the contaminant concentrations. Therefore, Alternative II is expected to provide a moderate level of long-term effectiveness and permanence.

The extraction and treatment of the impacted LBAD groundwater, as proposed under Alternative III, should permanently reduce the concentrations of groundwater contaminants below the cleanup goal levels. Long-term monitoring of the LBAD groundwater contaminant concentrations under Alternative III will help establish the effectiveness and permanence of the treatment remedy in reducing the contaminant concentration levels. Therefore, Alternative III is expected to provide a high level of long-term effectiveness and permanence.

11.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives I and II provide no treatment, and therefore achieve no reduction in contaminant toxicity, mobility, or volume.

Alternative III will reduce the toxicity and volume of the LBAD groundwater contaminants through treatment. Air stripping will reduce the concentrations of volatile organic constituents in the groundwater. Filtration and ion exchange treatment will reduce the concentrations of metals in the groundwater.

11.3.5 Short-Term Effectiveness

The no-action alternative will impose no short-term impacts during implementation because no remedial actions would be performed. Remedial actions performed under Alternative II, which include the imposition of deed restrictions and the long-term monitoring of site groundwater, are not expected to impose any short-term impacts on the nearby community or the environment. Furthermore, individuals responsible for the collection of groundwater samples will be properly trained and will wear the appropriate PPE during sample collection activities to control the potential for exposure to site groundwater contaminants.

Remedial actions performed under Alternative III would pose no significant community impacts because public access to the groundwater treatment system areas would be restricted. Site workers responsible for the installation and operation of the groundwater treatment system and the long-term monitoring of site groundwater will have the proper training and experience to implement this remedial action. Furthermore, site workers will don the appropriate PPE to control the potential for exposure to the groundwater contaminants. No significant environmental impacts are anticipated during the implementation of Alternative III.

Alternative II could be implemented in less than two months and Alternative III could be implemented in 10 to 14 months. For the purposes of this report, it is assumed that the long-term groundwater monitoring activities associated with Alternatives II and III would be performed four times a year for a period of 30 years.

11.3.6 Implementability

Alternatives I and II have no technical feasibility considerations. Alternative III is considered technically feasible based on the fact that the Alternative III treatment methods are well developed and proven for the treatment of the LBAD groundwater contaminants.

Alternatives I and II may be administratively difficult to implement based on the lack of any direct treatment of the site groundwater and continued MCL exceedances. Alternative III is considered administratively feasible. Coordination with the local POTW will be required if treated groundwater is discharged to the POTW under Alternative III. Coordination with the State of Kentucky for approval of a KPDES permit will be required if treated groundwater is discharged to on-site streams under Alternative III.

11.3.7 Cost

There is no cost associated with the implementation of Alternative I. The estimated cost to implement Alternative II is $388,940 and the estimated cost to implement Alternative III is $ 1,735,312.

11.3.8 State Acceptance

State acceptance of the groundwater remedial action alternatives will be addressed after the State of Kentucky's comments on these alternatives have been received.

11.3.9 Community Acceptance

Community acceptance of the groundwater remedial action alternatives will be addressed after the community's comments on these alternatives have been received.

TABLE 11-1
ALTERNATIVE II
(Institutional Controls/Long-Term Groundwater Monitoring)
Cost Estimate

ITEM	UNIT COST	UNITS	EST QTY	TOTAL COST
1. Administrative/Labor Costs to Implement and Enforce Deed Restrictions	$20,000	LS	1	$20,000
2. Quarterly Sampling and Analysis of Groundwater for TAL inorganics and TCL Volatile Organics	$500	SAMPLE	48	$24,000
Net Present Worth Cost to Perform Quarterly Sampling and Analysis of Groundwater Samples ($24,000/year for 30 years @ 5% cost inflation rate)				$368,940
TOTAL NET PRESENT WORTH COST FOR ALTERNATIVE II				**$388,940**

TABLE 11-2
ALTERNATIVE III COST ESTIMATE

CAPITAL COSTS	UNIT COST	UNITS	EST QTY	TOTAL COST
ITEM				
I PRELIMINARY ACTIVITIES				
1. Groundwater Sampling to Establish Relative Concentrations of Dissolved and Undissolved Metals	$250	SAMPLE	30	$7,500
2. Provide Power Supply to Each Treatment System Location	$5,000	LS	1	$5,000
3. Purchase and Construct Small Buildings/Sheds for Treatment Systems	$6,000	EACH	5	$30,000
SUBTOTAL (ITEM I)				$42,500
II GROUNDWATER EXTRACTION				
1. Construct/Install Open Hole Extraction Wells (Maximum Depth of 50 feet)	$5,000	EACH	5	$25,000
2. Purchase and Install Groundwater Pumps	$2,000	EACH	5	$10,000
3. Purchase and Install Miscellaneous Piping and Hoses	$4,000	LS	1	$4,000
4. Connect Pumping System to Existing Power Supply	$2,000	LS	1	$2,000
SUBTOTAL (ITEM II)				$41,000
III FILTRATION				
1. Purchase and Install Prefabricated Filtration Systems	$20,000	EACH	5	$100,000
2. Purchase and Install Control Panels To Operate Treatment Systems	$5,000	EACH	5	$25,000
3. Purchase and Install Filtration System Transfer Pumps	$1,000	EACH	10	$10,000
4. Purchase and Install Miscellaneous Piping, Fittings, Valves, Control Alarms, etc.	$15,000	LS	1	$15,000
5. Connect Filtration System to Existing Power Supply	$800	LS	1	$800
SUBTOTAL (ITEM III)				$150,800

TABLE 11-2 (Cont'd)

CAPITAL COSTS (Cont'd)	UNIT COST	UNITS	EST QTY	TOTAL COST
IV ION EXCHANGE				
1. Purchase and Install Ion Exchange Units	$35,000	EACH	5	$175,000
2. Purchase and Install System Pumps	$1,000	EACH	10	$10,000
3. Purchase and Install Miscellaneous Piping, Fittings, Valves, Control Alarms, etc.	$15,000	LS	1	$15,000
4. Connect Ion Exchange System to Existing Power Supply	$800	LS	1	$800
SUBTOTAL (ITEM IV)				$200,800
V AIR STRIPPING				
1. Purchase and Install Air Stripper Treatment Units	$25,000	EACH	3	$75,000
2. Purchase and Install Miscellaneous Piping, Fittings, Valves, Control Alarms, etc.	$10,000	LS	1	$10,000
3. Purchase and Install Transfer Pumps	$1,000	EACH	6	$6,000
SUBTOTAL (ITEM V)				$91,000
VI DISCHARGE TO SURFACE STREAMS				
1. Purchase and Install Discharge Piping or Collection Tanks (as appropriate)	$25,000	LS	1	$25,000
2. KPDES Permit Application Costs	$7,500	LS	1	$7,500
SUBTOTAL (ITEM VI)				$32,500
ALTERNATIVE III - SUBTOTAL CAPITAL COSTS				$558,600
25% CONTINGENCY				$139,650
TOTAL CONSTRUCTION COST				$698,250
25% FOR DESIGN, ENGINEERING AND CONST. MGMT.				$174,563
ALTERNATIVE III - TOTAL CAPITAL COST				**$872,813**

TABLE 11-2 (Cont'd)

ANNUAL OPERATION AND MAINTENANCE COSTS ITEM	UNIT COST	UNITS	EST QTY	TOTAL COST
1. Management and Disposal of Treatment Residuals	$50,000	LS	1	$50,000
2. Treatment System Operation and Maintenance (Including miscellaneaous equipment repairs/ parts replacement and chemical additives for ion exchange system operation)	$50,000	LS	1	$50,000
3. Electricity Costs	$0.10	KWH	50000	$5,000
4. Quarterly Sampling and Analysis of Treatment System Effluent for TAL Inorganics and TCL Volatile Organics	$500	SAMPLE	20	$10,000
5. Quarterly Sampling and Analysis of Groundwater for TAL inorganics and TCL Volatile Organics	$500	SAMPLE	48	$24,000
Annual O&M Subtotal Cost				$115,000
20% Contingency				$23,000
ALTERNATIVE III - ANNUAL O&M COST				**$138,000**
TOTAL O&M COST (NET PRESENT WORTH) ($138,000/year for 5 years @ 5% cost inflation rate, plus $24,000/year for an additional 25 years @ 5% for groundwater monitoring only)				$862,499
NET PRESENT WORTH COST FOR ALTERANTIVE III (Total Capital Cost + Net Present Worth O&M Cost)				**$1,735,312**

NOTE: Sources for unit costs include quotes from vendors, Means (1993), and M&E experience.

TABLE 11-3
SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE IMPACTED LBAD GROUNDWATER

Evaluation Criteria/Assessment Factors	Alternative I (No Action)	Alternative II (Institutional Controls/Long-Term Monitoring)	Alternative III (Groundwater Treatment)
Overall Protection of Human Health and the Environment	Provides no protection of human health and the environment.	Provides protection of human health by eliminating the ingestion pathway. Provides no protection of the environment.	Offers a high level of overall protection by reducing contaminant concentrations to prescribed cleanup levels and eliminating the human exposure pathways by preventing future consumption of groundwater until contaminant concentrations have been reduced to safe levels.
Compliance with ARARS	Fails to comply with several ARARs.	May not comply with ARARs.	Will comply with ARARs.
Long-Term Effectiveness:			
• Magnitude of Residual Risks	Provides no reduction in human health or environmental risks.	Should eliminate human health risks. Cleanup goals not achieved, although these goals may be inapplicable because the human exposure pathway would be eliminated.	Will achieve cleanup goals and eliminate future human health risks at the site.
• Adequacy of Control	Not Applicable	Not applicable	Groundwater will be treated with proven technologies for site contaminants.
• Reliability	Not Applicable	Not applicable	Methods employed are generally reliable.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction in contaminant toxicity, mobility, or volume due to lack of treatment.	No reduction in contaminant toxicity, mobility, or volume due to lack of treatment.	Reduction in contaminant toxicity and volume will be achieved.
Short-Term Effectiveness	No short-term impacts because no remedial actions performed.	Short-term impacts are minimal and could be controlled.	Short-term impacts relatively minimal and could be controlled. Estimated 10 to 14 months design and install treatment system.
Implementability:			
• Technical Feasibility	Not applicable.	Not applicable	Technically feasible alternative.
• Administrative Feasibility	Difficulties anticipated based on lack of direct groundwater treatment and the continued exceedances of drinking water standards	Difficulties possible based on lack of direct groundwater treatment and the continued exceedances of drinking water standards, although restrictions on future groundwater use would render these restrictions inapplicable.	Administratively feasible alternative.

TABLE 11-3
SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE IMPACTED LBAD GROUNDWATER

Evaluation Criteria/Assessment Factors	**Alternative I (No Action)**	**Alternative II (Institutional Controls/Long-Term Monitoring)**	**Alternative III (Groundwater Treatment)**
Cost	None	$388,940	$1,735,312
State Acceptance	To be addressed after State comments are received.	To be addressed after State comments are received.	To be addressed after State comments are received.
Community Acceptance	To be addressed after community comments are received.	To be addressed after community comments are received.	To be addressed after community comments are received.

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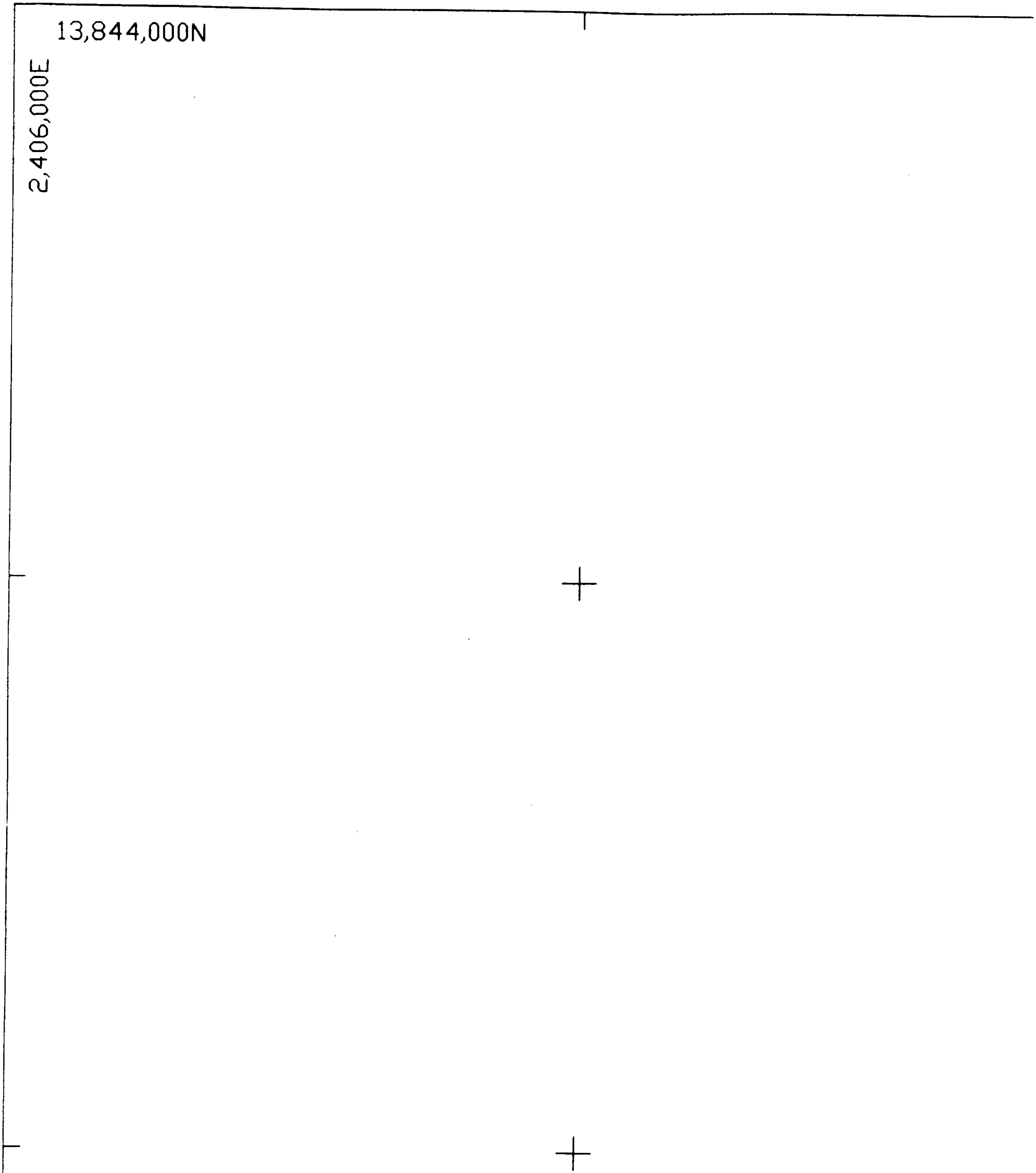

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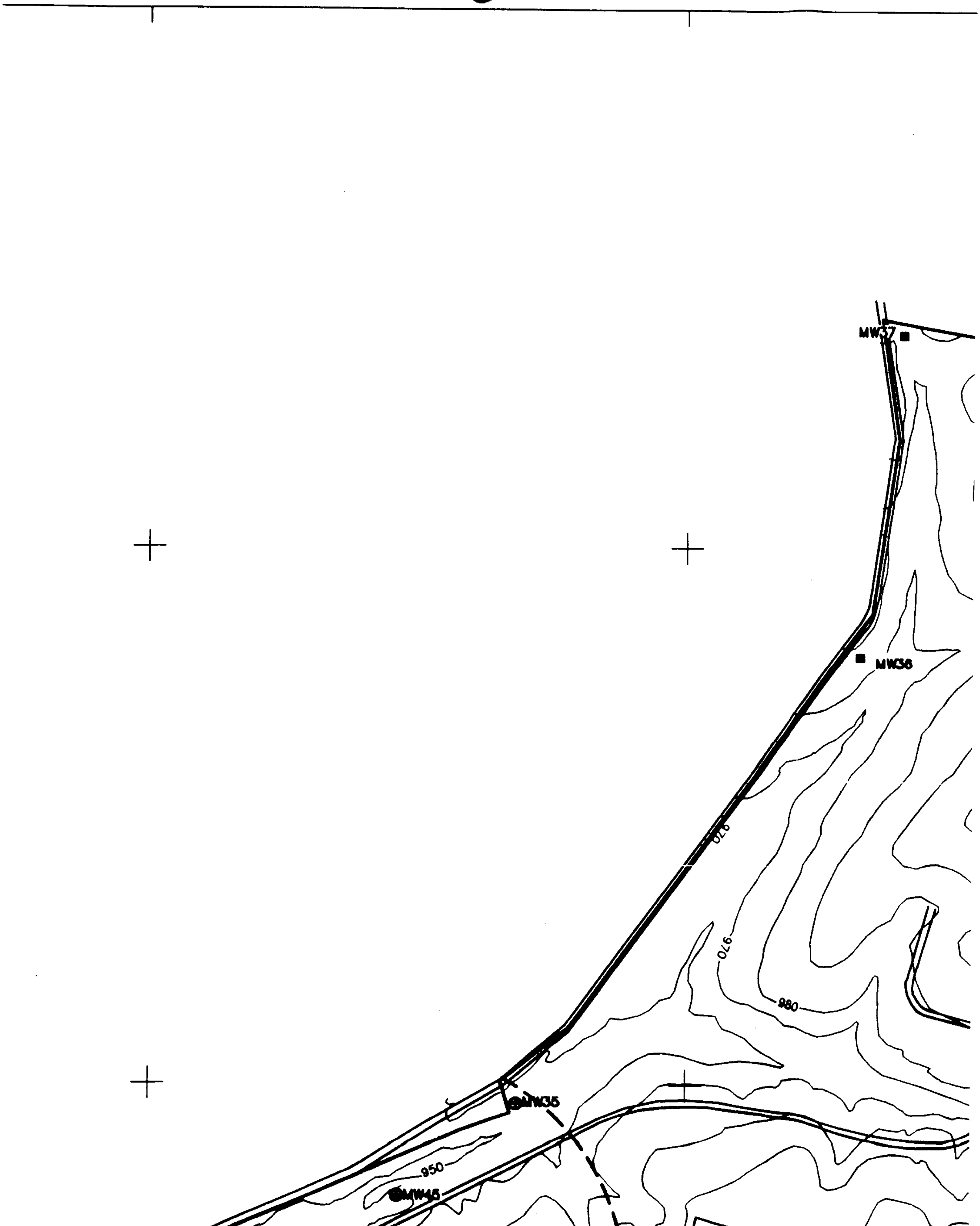

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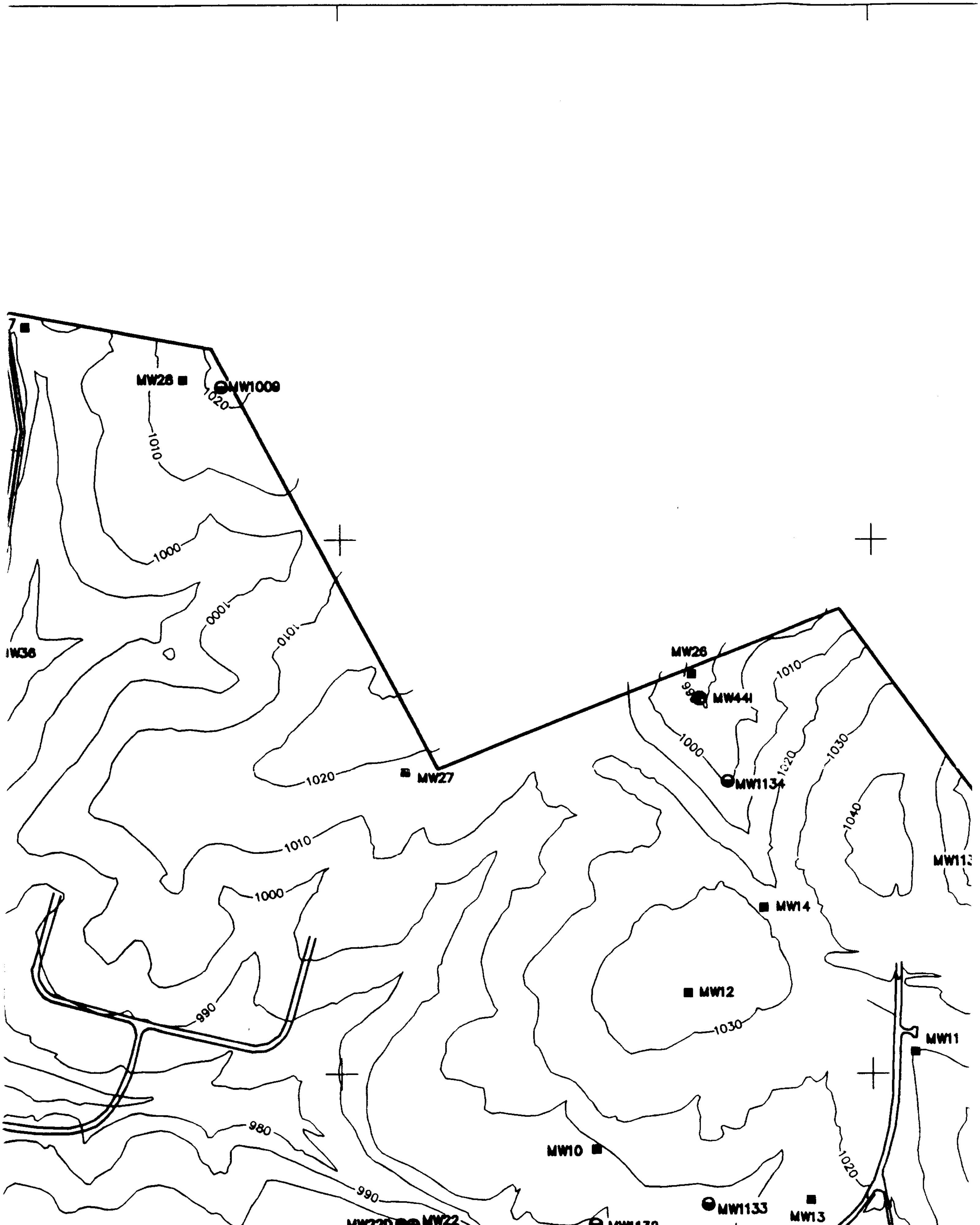
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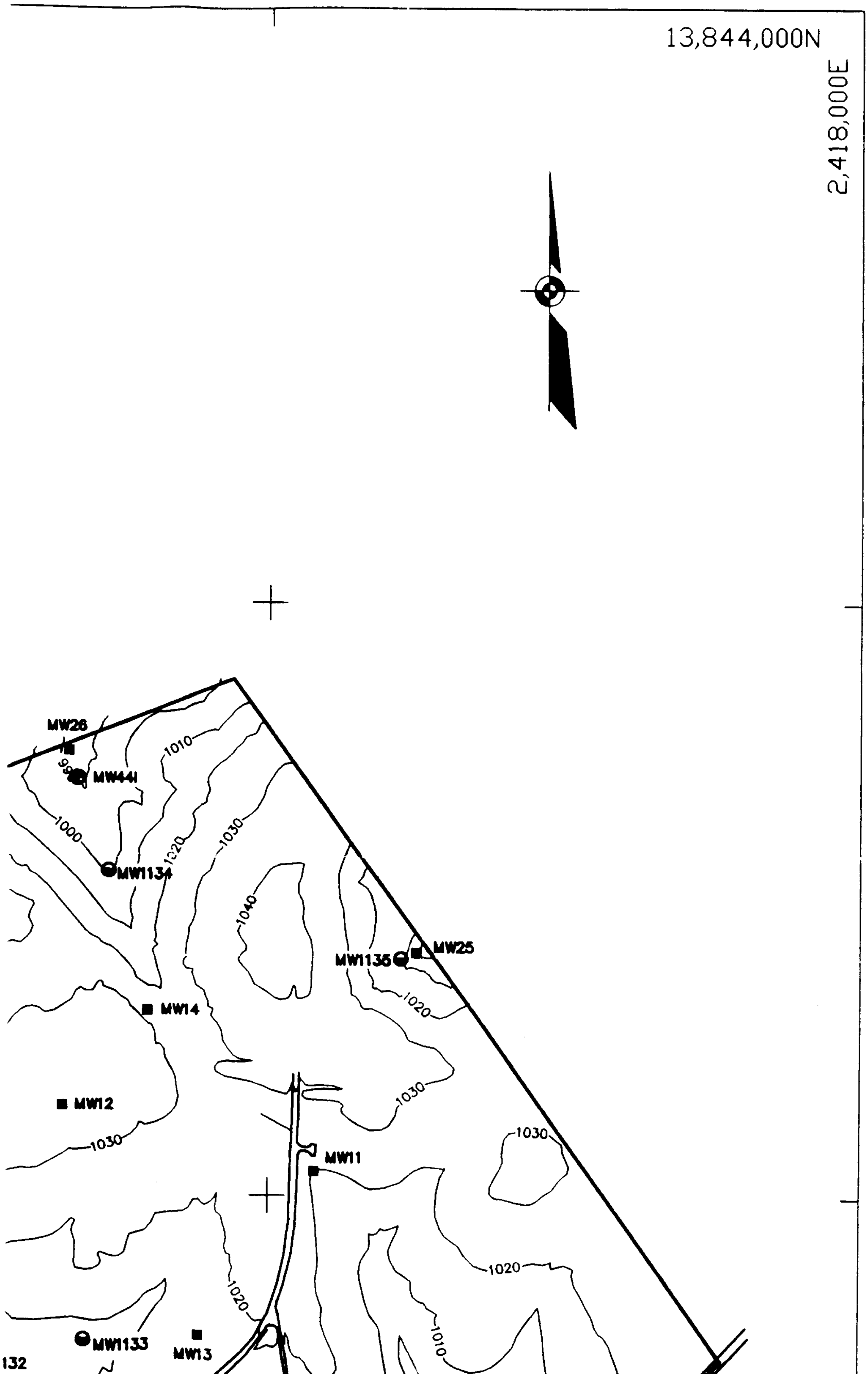
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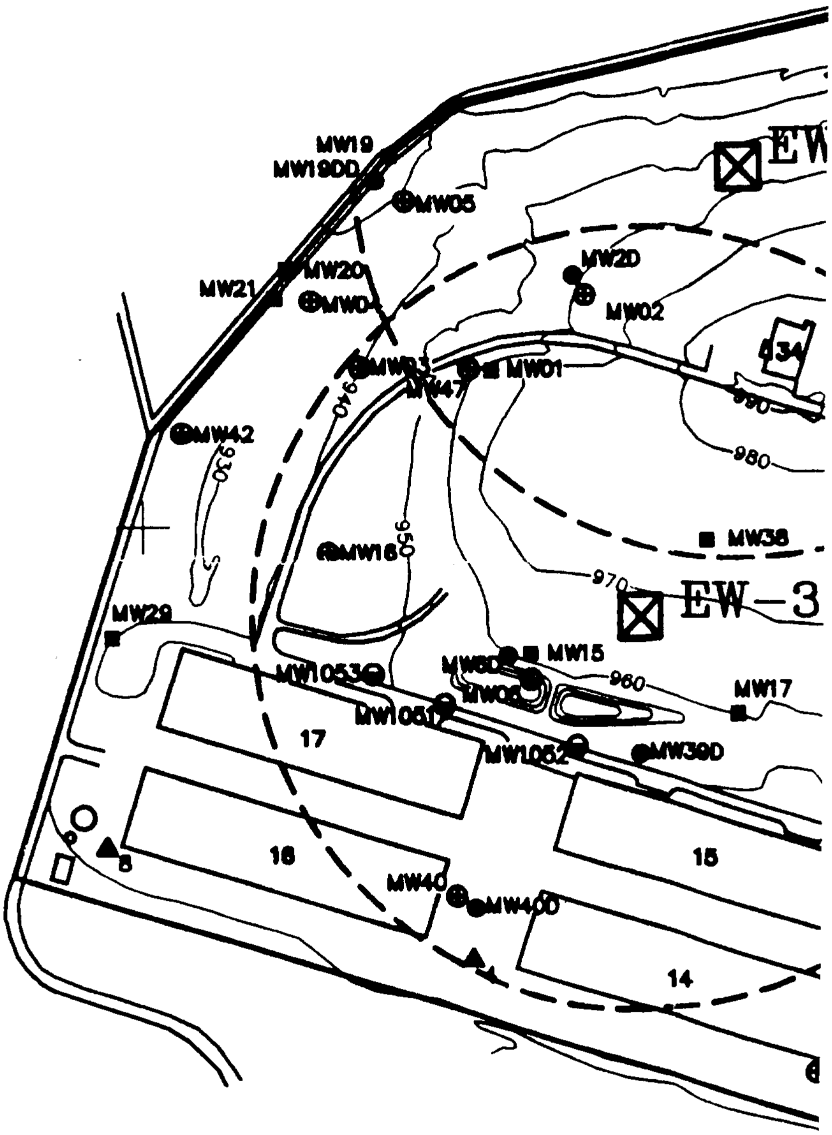
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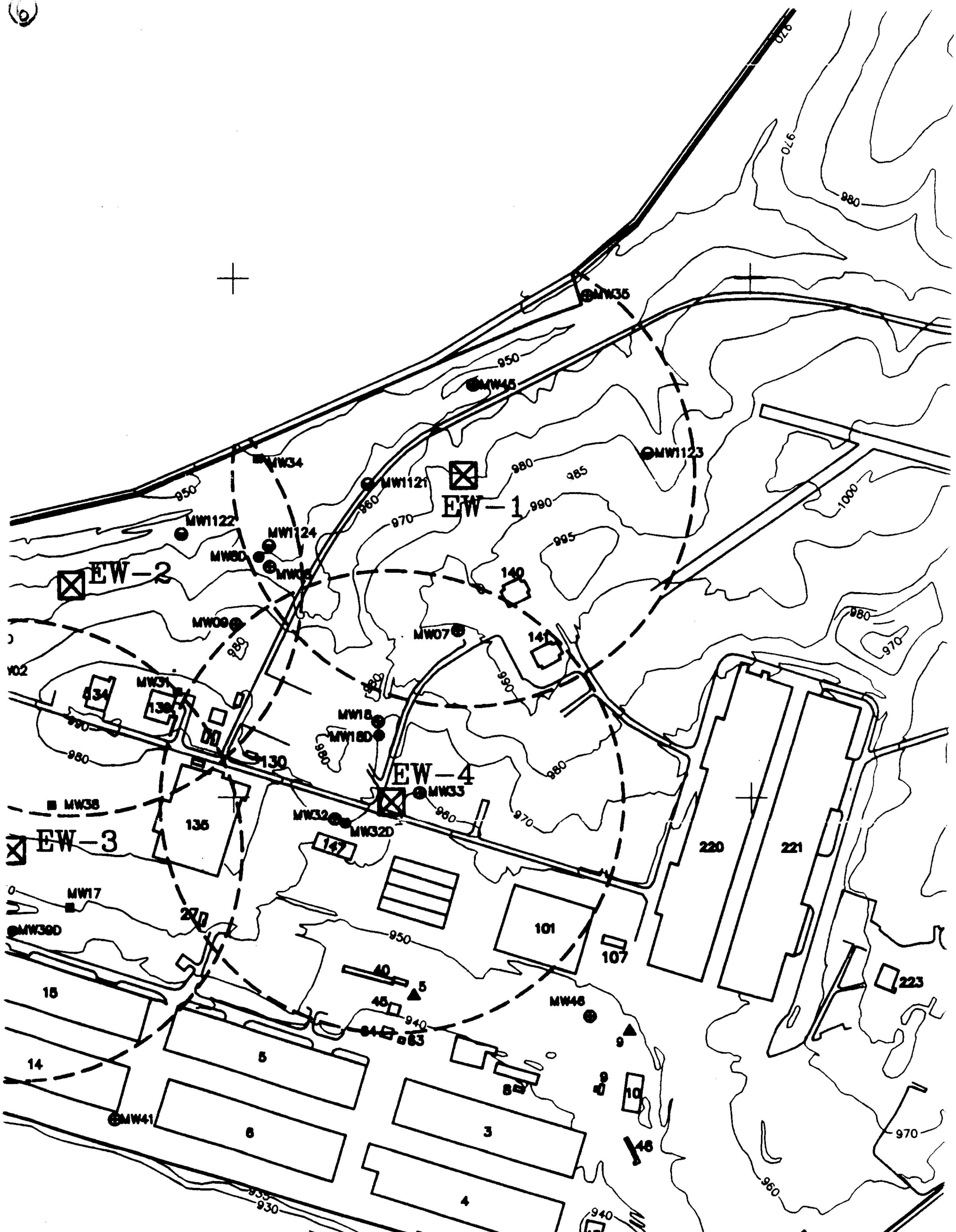
(6)



EW-1
EW-2
EW-3
EW-4
MW35
MW45
MW34
MW1121
MW1122
MW1123
MW1124
MW8D
MW08
MW09
MW07
MW31
MW18
MW18D
MW33
MW32
MW32D
MW38
MW17
MW39D
MW46
MW41
134
139
130
135
136
140
141
147
101
107
220
221
223
27
40
45
5
9
8
10
46
63
64
15
14
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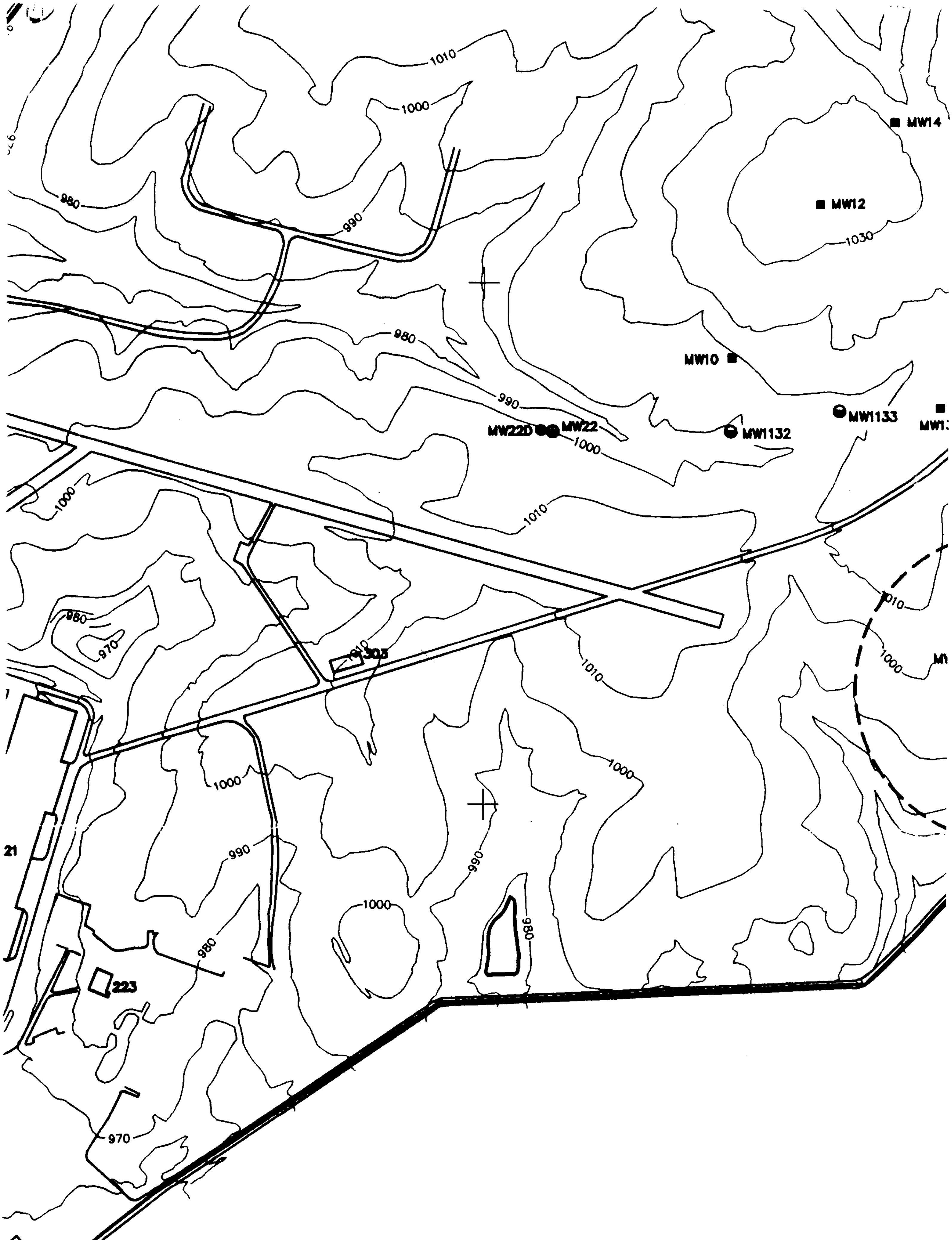
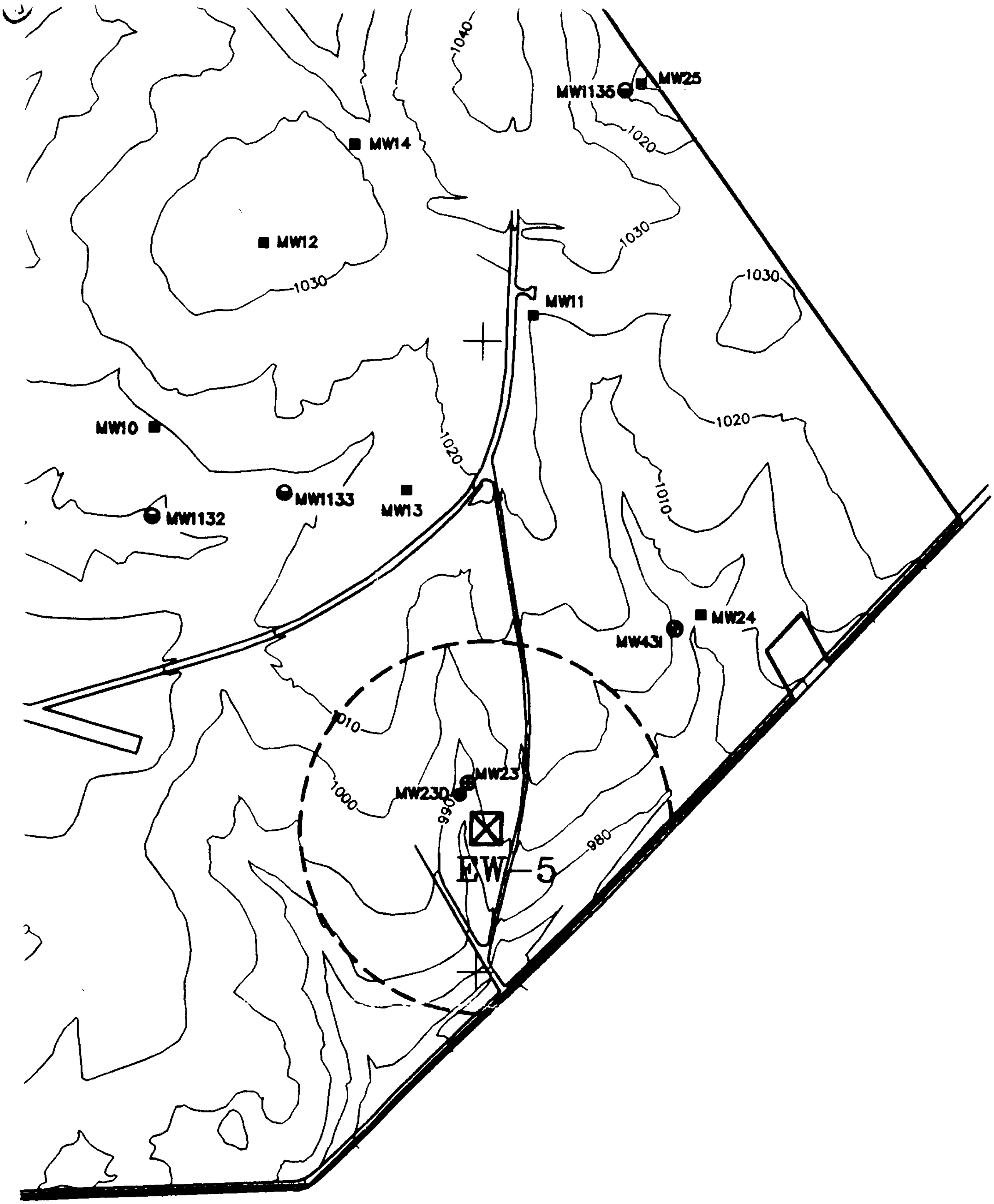
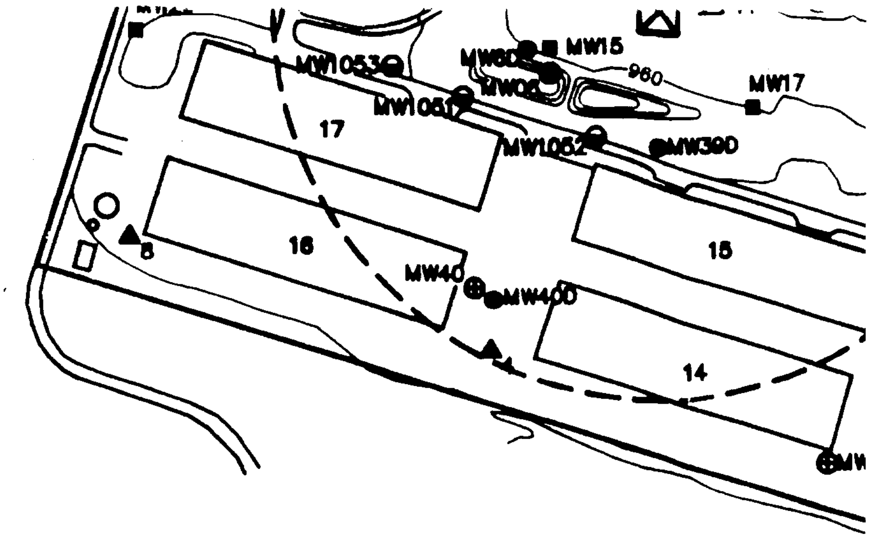
4
920
930
935
940
950
960
970
980
985
990
995
1000


1010
1000
980
990
980
990
1000
1010
1030
MW14
MW12
MW10
MW22D
MW22
MW1132
MW1133
1000
1010
980
970
303
1010
1000
1000
21
990
990
1000
980
980
223
970


1040
MW1135
MW25
1020
MW14
MW12
1030
1030
1030
MW11
MW10
1020
1020
MW1133
MW13
MW1132
1010
MW24
MW43I
1010
MW23
MW23D
1000
990
EW-5
980

(9)



LEGEND

- ☒ PROPOSED EXTRACTION WELL LOCATION
- ■ DRY HOLES
- ◒ EXISTING WELLS
- ⊕ SHALLOW WELLS
- ● DEEP WELLS
- ◉ BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL

SCALE IN FEET

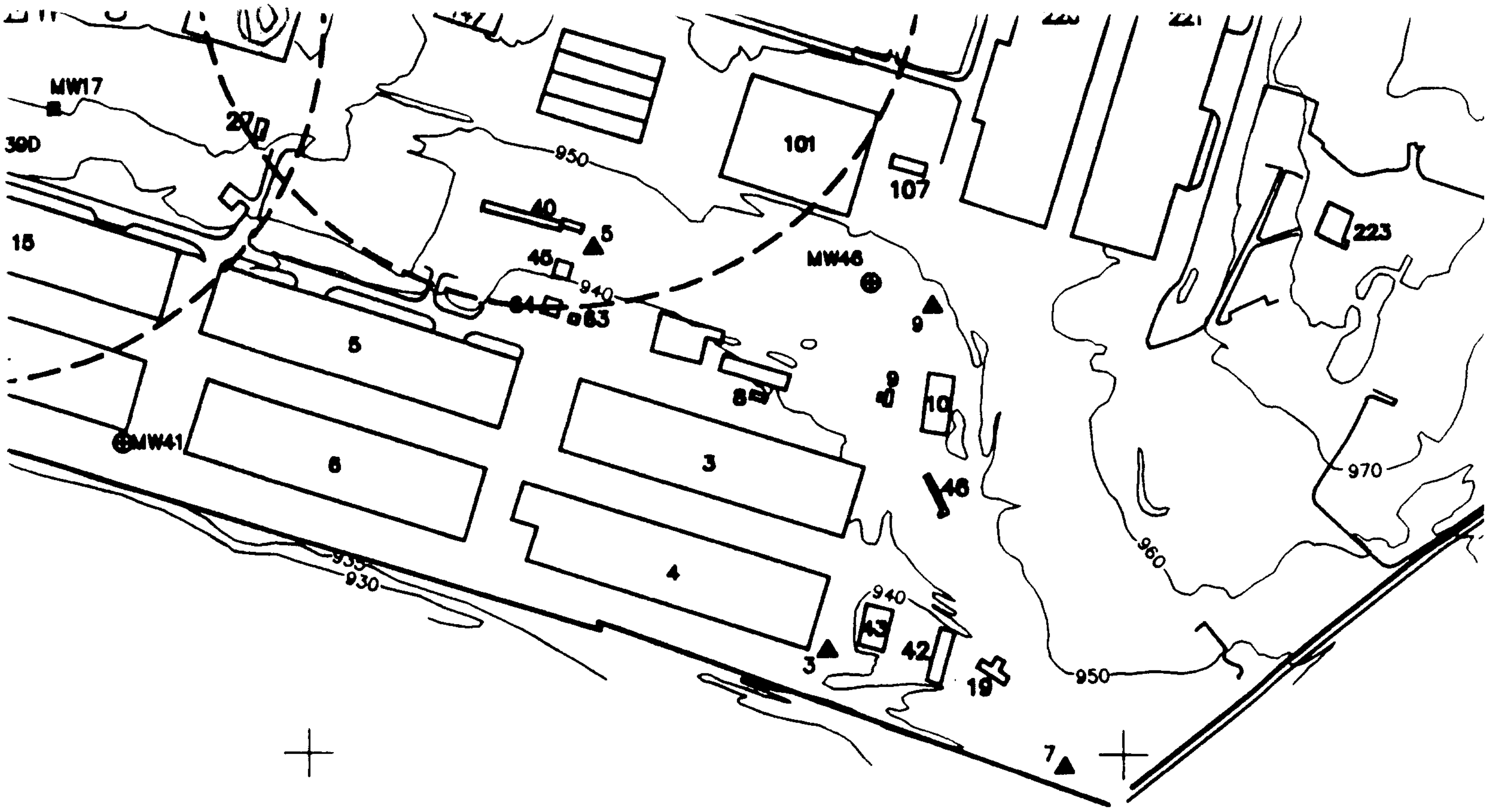
0 437.44

DASHED

NOTE:

2,406,000E

13,834,000N



DASHED LINES INDICATE ESTIMATED RADIAL ZONE OF INFLUENCE FOR EACH EXTRACTION WELL.

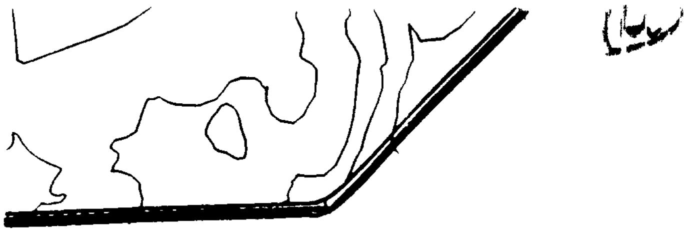
NOTE: PRELIMINARILY IT HAD BEEN DETERMINED BASED ON AVAILABLE ANALYTICAL DATA THAT THE TREATMENT SYSTEM FOR EW-2, EW-3, AND EW-4 WILL TREAT BOTH ORGANIC AND INORGANIC CONTAMINANTS AND THE TREATMENT SYSTEMS FOR EW-1 AND EW-5 WILL TREAT ONLY INORGANIC CONTAMINANTS.

M&E Metc

PROPOSED EXTRACTION
THE LBAD GROUNDWATER

FIGURE

SYSTEM
MENT



M&E Metcalf & Eddy

D EXTRACTION WELL LOCATIONS FOR
GROUNDWATER TREATMENT SYSTEMS

FIGURE 11-1

2,418,000E

13,834,000N

308-A.DWG

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APPENDIX A
SOIL BORING LOGS

PROJECT :

SITE LOCATION:

JOB NO.

LOCATION: SUMP BEHIND BUILDING 139

SHEET OF

BORING NO. 51819SO200

GROUND ELEV.

TOTAL DEP

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
		0-1	8"		8"-66%	10YR 4/6 dark yellow/brown 9:02 CL/CLM-Silty 15%			PLAS- MEDIUM COH- SOFT DENS - MEDIUM MOIS- MOIST NO BEDDING
70		2-3	12"		100	~~8:58~~ 9:09 2-3 10YR CL, CLAY SILT 5% 10YR 5/6 Yellowish brown LOW STIFF DENSE			MOIST NO BEDDING MOTTLED COLOR (FeO$_2$ Staining)
75		5-6	12"		100	9:25 CL SILT 5% 10YR 5/8 yellowish brown MEDIUM STIFF DENSE			MOIST NO BEDDING MOTTLED COLOR (FeO$_2$ Staining)
80									
85									
90									
95									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 51819SO200

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :
SITE LOCATION:
JOB NO.
SHEET
OF
BORING NO. 518195022
LOCATION:
GROUND ELEV.
TOTAL DEPTH

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
		0-1	12"		100%	1:25 Silt Clay ~5% 10 YR 3/6 ~~Low~~ dark yellow brown Low Soft Loose Moist No bedding Fill Material ?	
		2-3	12"		100%	1:32 Clay 10% Silt 10YR 6/6 brownish yellow Low Stiff Dense Moist Mottled No bedding FeO_2 Staining	
		5-6			100%	1:38 Clay 0% Silt 10YR 6/6 brownish yellow High Stiff Moist Mottled No bedding FeO_2 staining	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 518195022

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : BGAD
SITE LOCATION:
JOB NO. 007248
SHEET 1 OF
BORING NO. 12 S012
LOCATION: S0B350~~04~~ 12
GROUND ELEV.
TOTAL DEPTH
DRILL CONTRACTOR: LAW
ENG/GEO:
BEGUN :
DRILL RIG: CME 55
DRILLER: E. Flemming
FINISHED:
HOLE SIZE:
WEATHER: 39°F Clear Sky
GROUND WATER (DEPTH/ELEV.): /
DRILLING METHOD: HSA
DRILLING FLUID/SOURCE: None/HSA
TOP OF ROCK (DEPTH/ELEV.):

940

944

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	SS	0-1'	12"	3·6·6·8		DK. BROWN (7.5YR 3/3) Silty Clay (10%) (CL-ML) Dense, Dry, Low plasticity, trace sand. └ DAMP			
5	SS	2-3'		7·9·19·16		Yellow Brown (7.5YR 7/6) Clay w/ minor silt (<5%) (CL) Dense, Dry - Damp, Low - Med. plasticity, minor mottling, Reddish/Black oxide staining from small sand grains			
10	S	4-5'							
15									
20									
25									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: T. Smith

BORING NO.: S012

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : EBAD

SITE LOCATION: OLD LAGOONS - South Berm

JOB NO.

SHEET 1 OF 1

BORING NO. S003

LOCATION: S003 S003

GROUND ELEV.

TOTAL DEPTH 6'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING RATE (min/ft)	% RECOVERY or RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS			3		2": CLAY (EL), little silt & sand Dry-Damp, dk brown (5 YR 3/1)	
				3			
1335			11"	5			
				4		9": CLAY (CLS), sandy, trace silt, Dry-Damp brown w/ orange mottling (10YR 4/2 SAMPLED 0-1	
2				3			
			12"	4		12": CLAY (CL), little sand, plastic, Damp gray-brown (10YR 4/3). Sampled 2-3'	
1341				5			
				4			
4							
				5		17": CLAY (CLS), sandy, plastic, wet-saturated, 2.5Y 6/3 yellowish brown. Weathered limestone float is present Sampled 4-5'.	
1347			17"	10			
				10			
				50/3"			
6							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: Logged By J. Stratton

BORING NO.: S003

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. S0φ2
SITE LOCATION: OLD LAGOONS – SOUTH BERM	JOB NO.		
	LOCATION: SDφ3SOφ2	GROUND ELEV.	TOTAL DEPTH 6'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS	0-1'	6"	3 2 3 4		6" CLAY (CL), LITTLE SILT, TRACE SAND, dry orange brown 7.5YR 4/6 Sampled 0-1	
1048 2		2-3'	5"	4 5 5 5		5" CLAY (CL), little silt & sand, dry-damp ~~orange~~ brown 7.5YR 4/4.	
1056 4		4-5'	17"	3 5 11 19		12" - CLAY (CL), sandy, LITTLE SILT, DRY-DAMP Brown (7.5YR 4/4. 5" - CLAY (CL), DRY-DAMP 7.5 YR 7/2, weathered limestone gravel & pebbles. SAMPLED 4-5'.	
1139 ~~1130~~ 6							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: LOGGED BY J. STRAYTON

BORING NO.: S0φ2

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. S001

LOCATION: S003S001.

GROUND ELEV.

TOTAL DEPTH 5'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING RATE (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0939 0	SS			4		2" - CLAY (CL), SILTY, dk. BROWN (7.5YR3/4), dry-damp, TRACE SAND. 11" - CLAY (CL), little SAND, ~~orange brown~~ (7.5YR4/4 dry-damp, little silt. Silt ~~dec~~ DECREASES w/ depth SAMPLED 0-1'	
			13"	3			
				4			
				5			
0945 2				4		10" - CLAY (CL), some SAND, LITTLE SILT, GRAY mottled, 7.5YR6/6 - orange-brown; damp-dry. SAMPLED 2-3', low plastic	
				5			
			10"	6			
				5			
1004 1004'				3		15" - CLAY (CL), little sand, trace SILT, damp-dry, low plastic, brown 7.5YR4/4 SAMPLED 4-5' bgs.	
				4			
			15"	5			
				8			
6							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: Logged by J. Stratton

BORING NO.: S001

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION: BACKGROUND SOIL BORINGS E of Ancillary Range

JOB NO.

SHEET 1 OF 1

BORING NO. S013

LOCATION: BKGDS013

GROUND ELEV.

TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD
0	SS	0-1'		2	
1035				5	
			22"	5	
				7	
2				7	
		2-3'	18"	8	
1042				10	
				12	
4					

SAMPLE DESCRIPTION

12" - CLAY, Dark brown (CL), silty, little sand, damp; 7.5YR 4/2

10" - CLAY (CL), reddish brown, silty, damp 5YR 4/4

sampled 0-1'

18" - CLAY, reddish brown, trace silt, little sand, damp, 5YR 4/6

SAMPLED from 2-3'

EOB @ 4'

GRAPHIC LOG

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: S013

Metcalf & Eddy Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. S014

LOCATION: BKGDS014

GROUND ELEV.

TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS			2		6" - CLAY (CLM), SILTY, TOPSOIL, DK. ~~Brn~~ Brown, DAMP, 7.5YR 3/2	
		0-1'		3			
			17"	5			
1058				12		11" - CLAY (CL), LITTLE SILT, TRACE SAND, ORANGE BROWN, DAMP, 7.5YR 4/4 Sample collected 0-1'	
2							
			12			21" - CLAY (CLM), SILTY, TRACE SAND, ORANGE BROWN, DAMP ~~10~~ 7.5YR4/6	
		2-3'	10	21"			
1105			14				
			17			Sample collected 2-3'	
4							
						EOB @ 4'	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: Logged by Strayton

BORING NO.: S014

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LOAD		SHEET 1 OF 1	BORING NO. S025
SITE LOCATION:	JOB NO.		
	LOCATION: S004S025	GROUND ELEV.	TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	ST	0-1	24			6" - Topsoil - Clay, Channel - CLS, s~~andy~~ Black, dry 7.5YR 2/0	
		1-2				18" - Clay (CLS), sandy, hard/dense, ~~orange-brn~~ black organic ~~faint float~~ 10YR 6/4	
2		2-3				24" - Clay (CLS), sandy, dense, gray ~~brown~~ w/ orange mottling, black organic staining. 10YR 6/6	
0950		3-4	20"				
4							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: Logged by JDS.

BORING NO.: S025

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : CBAD		SHEET 1 OF 1	BORING NO. S032
SITE LOCATION:	JOB NO.		
	LOCATION: S604 S032	GROUND ELEV.	TOTAL DEPTH 4

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	S-1					8" - CLAY (CL), little sand & SILT, dry, dense, dk brown 10YR 3/2	
		0-1	23"	PUSH			
1435		1-2				16" - CLAY (CLS), sandy, dense, dry, orange brown 7.5YR 5/6	
2							
		2-3	19"	PUSH		19" - SAME	
		3-4					
4							

SAMPLE TYPES SS-SPLIT SPOON, ST-SHELBY TUBE R-ROCK CORE, O-OTHER	NOTES: Logged by J. Stratton	BORING NO.: S032

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : CSAD
SITE LOCATION:
JOB NO.
SHEET OF
BORING NO. S031
LOCATION: SQ045031
GROUND ELEV.
TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR PID	SAMPLE DESCRIPTION	GRAPHIC LOG
0	ST						
		0-1		PUSHED		WASTE MATERIALS - ASH, CINDERS, METAL WIRE.	
		1-2		TUBE			
2							
		2-3				NO SAMPLES, Refusal 2 Spoons	
		3-4					
4							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: LOGGED BY J. STRAYTON

BORING NO.: S031

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. S030
SITE LOCATION:	JOB NO.		
	LOCATION: S7104 S030	GROUND ELEV.	TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	S-1						
		0-1	24"			Fill material - ashes, metal, glass, wire cinders, concrete Some clay mixed in.	
		1-2					
2							
		2-3	12"			Same.	
		3-4					
4							

SAMPLE TYPES SS-SPLIT SPOON, ST-SHELBY TUBE R-ROCK CORE, O-OTHER	NOTES: Logged by J. Strayton	BORING NO.: S030

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
SHEET 1 OF 1
BORING NO. S029
LOCATION: ~~S0[illegible]~~ S029
GROUND ELEV.
TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS	0-1	12"	Push		12" - CLAY (CL), sandy, dry, brown 7.5YR4/2	
						3 spoons ~~pushed~~	
1572 2		1-2	12"	Push		12" - Clay (CL), little sand, dry, hard 10YR5/3	
1517		2-3				2" - Same	
		3-4				Refusal - Stone on Rock. NO Samples	
4							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: Logged by J. Strayton

BORING NO.: S029

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. S027
SITE LOCATION:	JOB NO.		
	LOCATION: SB99 S027	GROUND ELEV.	TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS/1					Fill - Ashes, clay soil, glass, metal, brick, cinders, wire - Black color	7.5YR2/0
		0-1					
		1-2		21"			
2		2-3		24"		Same HNU = 200ppm	
		3-4					
4							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: Logged By J. Strayton

BORING NO.: S027

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :
SITE LOCATION:
JOB NO.
SHEET / OF 1
BORING NO. 5028
LOCATION:
GROUND ELEV.
TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	ST	0-1 1-2	24			24"- Fill material - Ashes, cinders, clay tile, metal - wire, glass, scrap metals. Black 7.5YR 2/0.	
2		2-3 3-4	24			24" Same	
4							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES:

BORING NO.: 5028

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :
SITE LOCATION:
JOB NO.
SHEET 1 OF 1
BORING NO. S024
LOCATION: S0045024
GROUND ELEV.
TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	ST	0-1				CLAY (CL), TRACE SILT, little sand, brown dry-damp 10YR5/4 cl	
0845			48"				
		1-2				Topsoil 2" - CLAY (CL), little silt, dark brown, dry-damp 10YR4/4.	
2							
		2-3			18"	CLAY, (CLS), sandy, dry-damp, orange brown 10YR 4/6	
0852			48"				
		3-4			6"	CLAY (CLS), sandy, dry-damp, gray brown 10YR5/3	
4							

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, C-OTHER

NOTES: Logged by STRAYTON

BORING NO.: S024

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : BGAD		SHEET	BORING NO.
SITE LOCATION: A00 AS034	JOB NO. 007248	OF	5034
	LOCATION: Lexington, KY.	GROUND ELEV.	TOTAL DEPTH

0850
0855

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
	ST	1-2	30"			Yellowish Brown (7.5YR 7/4) Clay w/ minor silt (1%) (CL), grayish mottling from Clay, small-med sand pebbles w/ oxide staining, some lamination, oxide staining vertically, low-med plasticity, soft, dense, dry	
	ST	3-4	30"			Grayish Brown (10YR 4/2) clay w/ silt (1%) (CL) angular fragmented ls ranging from small-med., small sand pebbles w/ oxide staining, low plasticity, soft, dense, dry-moist	

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES:

BORING NO.: 5034

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : BGAD
SITE LOCATION: A00AS036
JOB NO. 007248
SHEET OF
BORING NO. 360TS036
LOCATION: Lexington, KY.
GROUND ELEV.
TOTAL DEPTH

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR MILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1034		SS	1-2'	24"		100	10YR 6/6 - brownish yellow, Clay with minor silt ~ 7% mottling present ~~Low~~ med. plasticity, cohesive, oxide staining present, dense, moist, moderate softness	
1041		SS	3-4'	15"		53	10YR 5/6 - Yellowish brown, clay with minor silt ~ 5%. Mottling present with oxide staining. Med. plasticity, soft, med. moisture, moderate softness, limestone gravels present.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: ~~360~~ 5036

Metcalf & Eddy, Inc. ENGINEERS GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. S015
SITE LOCATION:	JOB NO.		
	LOCATION: BLGD S015	GROUND ELEV.	TOTAL DEPTH 4'

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0		SS			2		6": CLAY (CLM) silty, dark brown, damp,	
					3		trace sand 7.5YR4/3	
1123			0-1'	15"	3		9": CLAY (CL), trace silt & sand, orange-brown,	
					5		damp 7.5YR4/6 SAMPLED 0-1'	
2					4			
			2-3'	22"	6		22": CLAY (CL), trace silt, little sand, orange-brown	
1127					9		damp, 7.5YR4/6	
					12			
4							SAMPLED 2-3'	

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES: Logged By Strayton	BORING NO.: S015

16

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : BGAD
SITE LOCATION:
JOB NO. 7249
SHEET OF
BORING NO. 5016
LOCATION: BBGD-5016
GROUND ELEV.
TOTAL DEPTH

1

1

[illegible]

[illegible]

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	[illegible] OR FID	SAMPLE DESCRIPTION	GRAPHIC LOG
	SS	0-1'	13"	1·3·6·9		Dk Brown (7.5 YR 4/4) Silty Clay (10%) (CLM) roots & grass, small patches of Oxide staining, v. low plasticity, stiff, dense, dry	
	SS	2-3'	22"	6·12·16·20		Yellow Brown (7.5 YR 7/8) Clay w/ minor silt (3%) (CLM), small-med. sand pebbles w/ oxide staining, minor mottling, low plasticity, stiff, dense, dry	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5016

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT : 3G A)

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. S017

LOCATION: BKGD S017

GROUND ELEV.

TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS	0-1	2			5" - CLAY (CLM), silty, trace sand, dk brown, damp, 7.5YR3/2	
			3	15"			
1452			5				
			5			10" - CLAY (CL), little sand, trace silt, lt brown damp 7.5YR4/6 Sampled 0-1'	
2	SS	2-3					
			10			18" CLAY (CL), trace sand, orange-brown, damp, so 7.5YR5/8	
1459			12	18"			
			16				
			19			Sampled 2-3'	
4							

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: LOGGED BY STRAYTON

BORING NO.: S017

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :
SITE LOCATION:
JOB NO.
SHEET 1 OF 1
BORING NO. S018
LOCATION: BILGD S018
GROUND ELEV.
TOTAL DEPTH 4'

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0	SS			2		6" - CLAY (CLM), SILTY, LITTLE SAND, damp, dark brown - TOPSOIL -, 10 YR 3/2	
				3			
1519		0-1'	18"	5			
				8		12" - CLAY (CLS), SANDY, TRACE SILT, damp orange brown - 10 YR 4/4 SAMPLED 0-1'	
2				9		18" - CLAY (CL), little sand, damp, gray mottled, orange-brown 7.5YR 5/8 SAMPLED 2-3'	
		2-3'	18"	10			
1527				14			
				17			
4							

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: Logged by J. Strayton

BORING NO.: S018

S007

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION: LAGOON AREAS (S003)

JOB NO.

SHEET 1 OF 1

BORING NO. S007

LOCATION: S003 S007

GROUND ELEV.

TOTAL DEPTH

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1413 HNu= 0ppm	SS	0-1'	12"	2·4·5·7		Dk. Brown (7.5YR 4/2) first 6", Reddish Brown (2.5YR 5/8) second 6"; first 6" Clay w/ majority being silt (10%) (CL-ML), roots + grass, small sand pebbles w/ reddish/black oxide staining, second 6" less silt than first 6" (5%) dry, dense, very low - low plasticity, dense	
1424 HNu= 0ppm	SS	2-3'	12"	[illegible]·4·12·15		Pale Yellow Brown (10YR 7/2) Clay w/ minor silt (5%) (CL-ML) small-med sand pebbles w/ oxide staining, minor mottling, laminae bedding, stiff, dense, dry - moist, low - med. plasticity	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: S007

5 5008

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :		SHEET OF	BORING NO. 5008
SITE LOCATION:	JOB NO.		
	LOCATION:	GROUND ELEV.	TOTAL DEPTH

1345
HNu=0ppm

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
	SS	0-1' SS	5"	4-24-28-50/3½		Pale Yellow Brown (7.5YR 6/6) ~~Cla~~ Silty Clay (40%) (CL-M), roots & grass, weathered limestone pebbles small-large, dry, stiff-hard, loose-dense, v. low plasticity	
		2-3'					

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES: Auger refusal at about 1 feet	BORING NO.: 5008

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. S009

LOCATION: S003S009

GROUND ELEV.

TOTAL DEPTH ~~4~~3'

1315
HNu=0PPM

1322
HNu=0PPM

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
	SS	0-1'	14"	2-4-5-6		Pale Yellow Brown (10YR 6/4) Clay w/ silt (5%) (CLM) small-med sand pebbles w/ oxide staining, small-med. angular rocks of limestone, roots & grass, low plasticity, stiff, dense, dry	
	SS	2-3'	2"	6-9-39-50/4		Pale Yellow Brown (10YR 8/4) Clay w/ silt (50%) (CLM) small-large rocks of limestone, reddish/black oxide staining vertically, minor mottling, laminar bedding, low plasticity, stiff, dense, dry, weathered shale bottom of spoon, some fossils in rocks	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: Auger refusal at about 2½ feet — T. Smith

BORING NO.: S009

Metcalf & Eddy Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : BGAD		SHEET 1 OF 1	BORING NO. S010
SITE LOCATION:	JOB NO. 007248		
	LOCATION: S0030S010	GROUND ELEV.	TOTAL DEPTH

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1244 HNu = 9ppm	SS	0-1'	13"	3-6-6-6		DK BROWN (7.5YR 7/3) Clay w/ silt (6%) (CL-ML), roots + grass present, small sand pebbles w/ oxide staining, low plasticity, stiff, dense, dry	
1249 HNu 5	SS	2-3	18"	4-7-8-11		Yellow BROWN (10 YR 5/3 and 10YR 4/6) Clay w/ minor silt (9%) (CL), small-med. sand grains w/ oxide staining, horizontal lamination, change in color sequence 10" = 10YR 5/3, 8" = 10YR 4/6, Med ~~stiff~~ plasticity, stiff, dense, moist - damp	
	SS	4-5					

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: Aug. T. Smith

BORING NO.: S010

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION:

JOB NO.

SHEET 1 OF

BORING NO. 518195023

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
		0-1	12"		100%	2:21 Clay Silt - 10% 10YR 5/8 yellowish brown	High Stiff Dense Moist		No bedding Mottled FeO_2 Staining
5		2-3	12"		0	2:30 POOR RECOVERY			ROCK IN SHOE
10		5-6	12"		75%	2:37 Clay Gravel - 25% 10YR 5/4 yellowish brown	Low Soft Loose Dry		No bedding Some gravels consisting of micritic LS - breccia fossil frags
15									
20									
25									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5023

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION: Avon, KY

JOB NO.

SHEET 1 OF

BORING NO. 5011

LOCATION: S003S017

GROUND ELEV.

TOTAL DEPTH 4'

DRILL CONTRACTOR: Law

ENG/GEO: Strayton

BEGUN 10:35

DRILL RIG: CME 55

DRILLER: E. Fleming

FINISHED: 1044

HOLE SIZE: 4"

WEATHER: Sunny, Cold (34°F)

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
~~1049~~		~~SS~~	~~0-1'~~		~~3·4·4·5~~		Dk. Brown (10YR 4/6) Silty Clay (20%) (CL some roots + grass, dry, dense, low plasticity, soft-stiff			
.035	~~5~~	SS	0-1' ~~2-4~~		9·12·13·11					
1044	10	SS	2-4		8·14·13·16					
1058	15			178"	3·6·7·10		Dk. Brown (10YR 3/3) Clay w/ Silt (5-20%) (C Minor mottling, small angular pebbles of limestone, reddish/black oxide staining vertically, dense, dry, low plasticity, stiff			
	20									
	25									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: T. Smith

BORING NO.: 8011

33

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : BGAD		SHEET OF	BORING NO. 5035
SITE LOCATION: A00AS035	JOB NO. 007248		
	LOCATION: Lexington, KY.	GROUND ELEV.	TOTAL DEPTH

T.S.
0931

0955

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
	SS	1-2'	26"			Tannish Brown (7.5YR 5/8) Clay w/ silt (3%) (CL-ML) small-med. sand pebbles w/ oxide staining, reddish/Black vertical staining, low plasticity, soft, dense, dry	
	SS	3-4'	30"			Tannish Brown (7.5YR 6/6) Clay w/ minor silt (1%) (CL), small sand pebbles w/ oxide staining, low plasticity, soft, dense, dr	

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.: 5035

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION:

JOB NO.

SHEET OF

BORING NO. S1819S021

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
		~~0-2~~ 0-1	~~24"~~		100	11:11 10 YR 5/6 Low plas. No bedding yellowish brown Soft silt, clm Loose Clay 15% Moist	
		2-3	12"		100	11:17 10YR 5/8 Stiff FeO2 yellowish brown Dense Mottled Clay ~~med~~ Moist 5% silt No bedding High	
		4-5 5-6	12"		100	11:22 10YR 5/8 High FeO2 yellowish brown Stiff Mottled Clay Dense Moist 5% silt No bedding	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: S021

7/14/92

ENGINEERS

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: S001

SHEET 1 OF 1

BORING NO. SX-39

GROUND ELEV.

TOTAL DEPTH 10.0 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNTS (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (PPM)	SAMPLE DESCRIPTION	GRAPHIC LOG
0955		SS	0-2	18	2599		10YR 4/3 brown clay, organics in top 3", soft, loose, slightly moist. little silt S001SX3900	
0958		SS	3-5	18"	8172017		7.5YR 5/8 orange clay, some silt ~~dry to~~ slightly moist, hard, low plasticity S001SX3903	
1002		SS	7-9	14"	102150/4		10YR 6/8 w/ grey mottling hard, mostly dry, low plasticity S001SX3907	

depth to bedrock = 10.0' bgs

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX-39

ENGINEERS

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: 5001

SHEET 1 OF 1

BORING NO. 5X38

GROUND ELEV.

TOTAL DEPTH 7.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (6" @ 140 lbs) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
0932		SS	0-2	22"	351114		10YR4/3 brown clay (CL), organics in top 8" soft, loose, slightly moist, little silt 50015X3500	
0935		SS	3-5	20	8121212		10YR 5/6 clay, stiff, slightly moist, some dark brown organic spots, low plasticity 54015X3803	

depth to bedrock = 7.0' bgs

F.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: 5X38

ENGINEERS

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. SX24
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 2,5,67	GROUND ELEV.	TOTAL DEPTH ~~b~~ 17.0'bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
0915		SS	0-2	18"	16 14 11 9		12" white gray clayey gravel 6" brown clay, little silt, slightly moist 10YR-6/6 (CL) S2567SX240	
0924		SS	3-5	18" ~~3-5~~	5 13 21 22		2.5Y 5/5 brown clay, firm, slightly moist, low plasticity (CL) S2567SX243	
0930		SS	7-9	18"	7 11 36 27		2.5Y 6/6 yellow brown clay, slightly moist firm, some organic brown spots, low to medium plasticity (CL) S2567SX247	

depth to bedrock = 17.0' bgs

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX24

7/28/92

ENGINEERS

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. 5X-35

LOCATION: Calcium hydrate A002 storage

GROUND ELEV.

TOTAL DEPTH 12.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1845		SS	1-3	18"	5 12 16	19	greybrown clay, fairly stiff, slightly moist, little silt, (CL) 10YR 4/3 ~~S25X 75X35~~ ~~A002SX3540~~ A002SX3501	
1852		SS	5-7	20"	8 19 26	35	10YR 5/3 same more burnt orange discoloration A002SX3505	
1858		SS	10-12	18"	13 28 50/3		10YR 5/4 clay (CL) ~~A002SX3510~~ A002SX3510 stiff slightly moist	

"depth to bedrock - 12.0'

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X-35

7/29/98

ENGINEERS LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. SX36

LOCATION: Calcium hydrate A002 Storage

GROUND ELEV.

TOTAL DEPTH 7.0 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1815		SS	1-3	24	5 13 21	29	orange brown clay, low plasticity, slightly moist, fairly stiff, some organic discoloration - dark brown A002SX3601 A002FD3601	collected dup
1822		SS	5-7	24	6 7 13 40		same, except moister + more discolorations due to organics A002SX3605	

7' depth to bedrock

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:
No sample (10-15')

BORING NO.: SX36

7/201

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: swmu 2,5,6,7

SHEET 1 OF 1

BORING NO. 5X31

GROUND ELEV.

TOTAL DEPTH 12.0 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
0855		SS	0-2	20	2458		2.5Y 4/3, brown clay, some m-grained sand, slightly loose, semi moist. 525675X310	
0959		SS	3-5	24"	2458		2.5Y 4/2 brown clay, little m-grained sand, moist, medium plasticity, semi soft (CL) 525675X313	
0905		SS	7-9	24"	591316		2.5Y 5/3, brown clay, stiff, slightly moist, some orange & grey discoloration, some dark brown organic spots. c-g sand & pebbles in bottom 4" 525675X317 52567FD317 depth to bedrock = 12.0' F.O.B.	collected dup.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X31

7/30/92
aw

ENGINEERS

PROJECT : LBAD			
SITE LOCATION:	JOB NO.	SHEET 1 OF 1	BORING NO. 5X45
	LOCATION: 5001	GROUND ELEV.	TOTAL DEPTH 12.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1310		SS	0-2	19"	1 7 8 10		4" 10YR 4/4 brown clay (CL), some silt, slightly moist, loose, organics 15" 10YR 4/6 clay, slighty moist fairly stiff, some dark organics, low plasticity 5001SX4500	
1315		SS	3-5	18'	6 9 12 13		same as 15" of (0-2') 5001SX4503	
1320		SS	7-9	24"	2 4 5 7		2.5Y 5/3 clay (CL), high plasticity moist, soft, some granules/pebbles 5001SX4507	

depth to bedrock = 12.0' bgs

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX 45

7/30/92

ENGINEERS

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: 5001

SHEET 1 OF 1

BORING NO. 5X44

GROUND ELEV.

TOTAL DEPTH 10.5bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT per 6 inches OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1235		SS	0-2	20"	3 10 16 14		10YR 4/3 clay (CL), some silt, soft, organics in top 4", low plasticity slightly moiste ~~some~~ little packing material on ≈16" from top 50015X4400	
1240		SS	3-5	12"	3433		2.5Y 5/2 clay (CL) firm, moist at bottom, few packing material at bottom 50015X4403	
1245		SS	7-9	24"	3 16 20 23		10YR 5/6 orange clay, some dark ~~brown~~ spots from organics, slightly moist, water in hole, little gray mottling, hard 50015X4407	
							depth to bedrock = 10.5bgs	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X44

7/30/

ENGINEERS

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X43
SITE LOCATION	JOB NO.		
	LOCATION: 5001	GROUND ELEV.	TOTAL DEPTH 5.5 bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1035	SS	0-2	24"	3 9 9 14		10YR 4/6, clay (CL) organics in top 3", slightly moist, slightly soft low plasticity, some dark brown organics spots 5001SX4300	
1038	SS	3-5	24"	5 12 15 18		same as 0-2' 5001SX4303	

depth to bedrock = 5.5' bgs

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X43

7/30/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: 5001

SHEET 1 OF 1

BORING NO. SX41

GROUND ELEV.

TOTAL DEPTH 6.5 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
084	2	SS	0-2	12"	3,4,9,10		10YR 6/60 clay, organics in top 2", slightly moist, low plasticity, (CL) 5001SX4100	
0900		SS	3-5	18"	6,9,13,4		10YR 5/6 clay, high plasticity moist to slightly moist, some dark brown organic spots (CL) 5001SX4103	

depth to bedrock = 6.5' bgs

E. O. B.

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: No sample (7-9')

BORING NO.: SX41

7/28/92 Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT: LBAD			SHEET 1 OF 1	BORING NO. SX-32
SITE LOCATION:	JOB NO.			
	LOCATION: SWMU 2, 5, 6, 7		GROUND ELEV.	TOTAL DEPTH 7.0' bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNTS (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0930	SS	0-2	16	3347		10YR 4/3, brown clay, moist, little silt, organics in top 3", low to medium plasticity S2567SX320	
0933	SS	3-5	22	5 13 16 14		2.5Y 3/2, brown clay, slightly moist, low plasticity, little silt stiff S2567SX323	
	~~SS~~	~~7-9~~				bedrock at 7' depth	
						F.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX32

7/28/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
LOCATION: A002 Calcium Hydrate Storage
SHEET 1 OF 1
BORING NO. 5X37
GROUND ELEV.
TOTAL DEPTH 5.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1633		SS	1-3	20	5 7 13 16		10YR5/6 clay, slightly moist slightly plastic, little silt, some organic discolorations - dark brown A002 5X3701	
1642		SS	5-7	4"	5 50/2		Same, no sample rock in shoe	

5.5 depth to bedrock

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sAmple (5-7'), (10-12')

BORING NO.: 5X37

7/29/92 Metcalf & Eddy, Inc. ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. 5X34

LOCATION: B046

GROUND ELEV.

TOTAL DEPTH 4.5'

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
0735		SS	0-2	18	781320		10YR 4/3 clay (CL), some gravel in top 4", organics in top 1", hard slightly moist B046SX3400	
0740		SS	3-5	14"	4750/4		10YR 5/6 clay (CL), moist some grey mottling, medium plasticity B046SX3403 B046FD3403	collect dup

depth to bedrock = 4.5'

E.aB.

SAMPLE TYPES
SS-SPLIT SPOON, ST-SHELBY TUBE
R-ROCK CORE, O-OTHER

NOTES: NO SAMple (7-9')

BORING NO.: 5X34

7/30/92

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: 5001 ~~golf course~~

SHEET 1 OF 1

BORING NO. 5X47

GROUND ELEV.

TOTAL DEPTH 6.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1435		SS	0-2	14"	3 12 0	13	7.5 YR 4/3 clay (CL), some organics in top 4", soft, loose, slightly moist, some silt 5001SX4700	
1442		SS	3-5	24	3 9 11	15	10YR 4/3 clay (CL), slightly moist stiff, low plasticity, some dark brown spots from organics 5001SX4703	

6.5' bgs – depth to bedrock

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9)

BORING NO.: 5X-47

7/30/92

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: 5001

SHEET 1 OF 1

BORING NO. SX46

GROUND ELEV.

TOTAL DEPTH 10.0 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1400		SS	0-2	18	5 10 13 1	9	~~10~~ 7.5YR 4/3 clay (CL) organics in top 3", soft/loose, some silt, slightly moist 5001SX4600	
1405		SS	3-5	0"	4 23-50/3		piece of wood in shoe No sample ~~5001SX400~~	
1410		SS	7-9	24	21162337		10YR 4/3, clay (CL) slightly moist stiff, low plasticity, some dark brown organic spots. 5001SX4607	

depth to bedrock = 10.0 'bgs

E.O.B.

Some trash (plastic, papers) in cuttings

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (3-5)

BORING NO.: SX46

1439

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ENGINEERS

GEOLOGIC LOG

7/28/92

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. SX30

LOCATION: SWMU 2,5,6,7

GROUND ELEV.

TOTAL DEPTH 8.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
0825		SS	0-2	5''	12 11		2.5Y 4/3 wet, silty clay (ML-CL) organics, soft No sample	
0828		SS	3-5	18	38915		2.5Y 3/2 brown clay (CL), moist medium plasticity, semi stiff some orange brown discoloration, little organic (dark brown) spots 52567SX303	
0832		SS	7-9	5''	3-50/1		10YR5/4 - brown clay (CL) stiff, moist, many organic staining NO SAMPLE	

depth to bedrock = 8.0'

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO SAMPLE (0-2), (7-9')

BORING NO.: SX30

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
SHEET 1 OF 1
BORING NO. SX-27A
LOCATION:
GROUND ELEV.
TOTAL DEPTH

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1000		SS	0-2	6"	3 19 13 17		10YR 4/4, brown clay, some organics throughout, [illegible] little silt, moist (CL) No sample	
1010		SS	3-5	2"	5 8 8 8		brown clay, moist, stiff, little silt. (CL) 2.5Y 4/2, little grey discoloration No sample	
115		SS	7-9	6"	5 11 25 27		piece of plastic in spoon No sample	

abandoned & moved to new location

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (0-2), (3-5)

BORING NO.: SX-27A

7/21/92

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X06
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 3	GROUND ELEV.	TOTAL DEPTH 11.0' bg

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1100		SS	0-2	12	4 10 11	11	brown clay, (CL), little silt, slightly hard, moist to slightly moist, medium dense, medium plasticity, organics in top 2" 10YR-4/4 S0035X0044	
1103		SS	3-5	24	2 7 12	18	dark to medium brown clay (CL), hard. slightly moist to moist, ~~very~~ medium plasticity, stiff, upper 12" 10YR-4/4, bottom 12" 10 YR-3/3 S0035X0043	
1108		SS	7-9	24	4 10 13	20	yellow brown clay (CL) hard. slightly moist to moist, very plasticity, stiff, much dark brown organic spots 2.5Y-6/4 S0035X0047	
							Bedrock at 11.0'	
							E.O.B.	

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.: 5X06

7/21/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. 5X02

LOCATION: SWMU 3

GROUND ELEV.

TOTAL DEPTH 1' bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1530	SS	0-2	8"	35 30/3		Rock & gravel from road	No sample collected
						bedrock at 1' depth	
						E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (0-1), (3-5), (7-9)

BORING NO.: 5X02

21/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. SX01
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 3	GROUND ELEV.	TOTAL DEPTH 5.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1557		SS	0-2	4"	5-14-16-11		mostly gravel, some brown dry clay No sample collected	
1602		SS	3-5	16"	3-5-13-32		brown clay, few granules & pebbles, slightly hard, slightly moist, low plasticity 10YR-3/3 (CL) 50035X0103	
							Depth to bedrock - 5.5'	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No Sample (0-1'), (7-9')

BORING NO.: SX01

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ENGINEERS

GEOLOGIC LOG

7/29/92

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. SX27
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 2,5,6,7	GROUND ELEV.	TOTAL DEPTH 8.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1330		SS	0-2	16	2 4 7 7		4" 10YR 4/6 brown clay - slightly moist, 12" 2.5Y 4/3 S2567SX270	organics in top 4", soft. (CL)
1334		SS	3-5	24"	4 9 11 10		2.5Y 5/4 clay, stiff, slightly moist, some grey mottling (CL) S2567SX273	
1340		SS	7-9	8"	12 50/5		2.5Y 6/0, grey clay, some brown discoloration, much gravel (limestone) angular. rock in shoe	no sample

depth to bedrock = 8.0'

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No SAmples (7-9)

BORING NO.: SX27

9/92 Metcalf & Eddy, Inc.
ENGINEERS

SHEET	BORING NO.
1 OF 1	SX50

PROJECT : LBAD

JOB NO.

GROUND ELEV.

TOTAL DEPTH 7.0 bgs

SITE LOCATION:

LOCATION: golfcourse

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR CUTTING TIME (min/ft)	% RECOVERY / RQD (%)	SAMPLE DESCRIPTION	GRAPHIC LOG
1302		SS	0-2	24	361010		10 YR 5/3, clay, slightly moist organics in top 3", little silt, mostly soft loose (CL) AOGCSX5004	
1305		SS	3-5	29	7131723		2.5 Y 6/2, clay, stiff, some orange mottling. low plasticity little silt (CL) AOGCSX5003 AOGCFD5003	collected dup.

depth to bedrock = 7.0 'bgs

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX50

1325 @ moving

7/29/92

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ENGINEERS

GEOLOGIC LOG

PROJECT: LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. 5X49

LOCATION: Golf Course

GROUND ELEV.

TOTAL DEPTH 11.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR CORING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1230		SS	0-2	14"	1455		10YR4/3 brown clay, slightly moist, little silt, loose/soft, organics in top 6" (CL) AOGCSX4900	
1233		SS	35	22"	9101418		10YR 5/6, clay, slightly moist Some dark brown organics, semi-stiff low plasticity (CL) AOGCSX4903	
1240		SS	79	24"	5203034		Same as (3-5') except stiff AOGCSX4907	
							11.5 depth to bedrock	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X49

7/29/92 ✓

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: B046

SHEET 1 OF 1

BORING NO. SX33

GROUND ELEV.

TOTAL DEPTH 6.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0809		SS	0-2	24"	2568		10YR 6/6 clay (CL), slightly moist muck dark brown organics, semi stiff B046SX3300	
0810		SS	3-5	14"	9142222		10YR 5/3 clay (CL) moist, soft, medium plasticity B046SX3303	

depth to bedrock = 6.0' bgs

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX33

7/22/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.:

LOCATION: SWMU 4

SHEET 1 OF 2

BORING NO. SX-16

GROUND ELEV.:

TOTAL DEPTH 7.5 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG Ludlow (click/min)
0943		SS	0-2	20	1019 1610		dark brown, coarse-grained sand, dry, loose, some gravel & brick fragments 5Y - 2.5/2 - No sample	36
16A								
0947		SS	3-5	12	66413		white paint-like substance in bottom of spoon - No sample will move location ≈ 30' North	84
1000		SS	0-2	16	41075		4" dark brown topsoil & sand w/organics 7" red brown 7.5YR 5/6 coarse-grained sand. fill material 5" gravel - rock fragments No sample	40
16B								
1004		SS	3-5	0	61279		spoon empty - no sample refusal at 4' (seems like piece of tire) will move again	0
1015		SS	0-2	22	481315		19" black coarse-grained sand, some gravel & pebbles, loose, slightly moist, (SW). little fines 3" 10YR 4/3, clay. some silt (CL). firm low plasticity S0045X1600	34

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX-16

7/22/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT: LBAD

SITE LOCATION:

JOB NO.:

SHEET 2 OF 2

BORING NO. SX-16

LOCATION: SWMU 4

GROUND ELEV.:

TOTAL DEPTH 7.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY (R) RQD	SAMPLE DESCRIPTION	GRAPHIC LOG Ludlow (click)/min
1022		SS	3-5	16	4 7 12 16		10YR - 5/4, yellow brown clay, fairly hard, slightly moist, some dark spots caused by organics S004SX1603	158c.
1320		SS	7-9	0	50/1		spoon empty - No sample	0
							bedrock at 7.5' depth	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX16

7/29/92
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Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
LOCATION: Golf Course
SHEET 1 OF 1
BORING NO. SX-53
GROUND ELEV.
TOTAL DEPTH 9.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1735		SS	0-2	17"	9 9 10 12		10YR 4/4 to 3/4 clay (CL) organics in top 7", soft, slightly moist medium plasticity AOGCSX5300	
1745		SS	3-5	24	6 13 17 20		10YR 5/6 clay (CL), hard, slightly moist, little gray mottling & dark brown organic AOGCSX5303	
1750		SS	7-9	14"	9 7 22 50/3		5Y 6/3, clay, lots of gravel, hard some brown mottling, mostly dry AOGCSX5307	
1800							depth to bedrock = 9.5'	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX-53

7/29/92

Metcalf & Eddy, Inc. ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X-52
SITE LOCATION:	JOB NO.		
	LOCATION: Golf Course	GROUND ELEV.	TOTAL DEPTH 11.0'bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT per 6 inches OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1655		SS	0-2	20	2455		10YR 5/3 clay (CL), slightly moist, organics in top 3", little silt, mostly soft, loose low plasticity AOGCSX5200	
1700		SS	3-5	19	5 12 18 27		7.5YR 5/6 clay (CL), slightly moist, hard, low plasticity, little silt AOGCSX5203	
1705		SS	7.9	18	6 20 31 40		10YR 6/6 clay (CL), some grey mottling, hard, slightly moist AOGCSX5207	

depth to bedrock = 11.0 bgs

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X-52

7/29/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT: LBAD		SHEET 1 OF 1	BORING NO. 5X51
SITE LOCATION:	JOB NO.		
	LOCATION: Golf Course	GROUND ELEV.	TOTAL DEPTH 9.5 'bgs.

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1355		SS	0-2	18"	3 4 6	10	10YR 5/3 Clay (CL), slightly moist, organics in top 3", little silt, mostly soft, semi-loose AOGCSX5100	
1359		SS	3-5	18	4 12 17	20	10 YR 5/6 clay (CL) slightly moist some dark brown spots caused by organics semi-stiff, low plasticity AOGC SX5103	
1405		SS	7-9	16"	8 17	50/5	same as 3-5 interval, except stiffer AOGC SX5107	

9.5' = depth to bedrock

E. O. B.

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.: 5X51

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Metcalf & Eddy, Inc.
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GEOLOGIC LOG

PROJECT: LBAD		SHEET 1 OF 1	BORING NO. 5X48
SITE LOCATION:	JOB NO.		
	LOCATION: Golf Course	GROUND ELEV.	TOTAL DEPTH 12.0'bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY (R) (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1422		SS	0-2	20	3579		10YR5/3 clay (CL), slightly moist, organics in top 3", little silt, mostly soft/loose AOGCSX4800	
1426		SS	3-5	18	6 1720 22		10YR5/6 clay (CL) slightly moist some dark brown organics spots, semi-stiff, low plasticity. AOGCSX4803	
1433		SS	7-9	22"	8 17 2532		same as (3-5') AOGCSX4807	

depth to bedrock = 12.0'bgs

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X48

7/29/92

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GEOLOGIC LOG

PROJECT: LBAD	SHEET 1 OF 1	BORING NO. 5X54	
SITE LOCATION:	JOB NO.		
LOCATION: Golf Course	GROUND ELEV.	TOTAL DEPTH 10.0 bgs	

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT per 6 inches OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1827		SS	0-2	24	4 4 10 13		10YR 4/4 to 3/4 clay (CL), organics in top 7", soft, slightly moist, medium plasticity AOGCSX5400	
1831		SS	3-5	24	9 12 20 33		10YR 5/6 clay (CL), hard, slightly moist, little grey mottling. ~~little~~ some dark brown spots caused by organics AOGCSX5403	
1840		SS	7-9	18	10 21 34 37		Same as 3-5 interval AOGCSX5407	
							depth to bedrock = 10.0'	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X54

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD	JOB NO.
SITE LOCATION:	LOCATION: 5001
SHEET 1 OF 1	BORING NO. SX40
GROUND ELEV.	TOTAL DEPTH 6.0 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0815		SS	0-2	14"	59179+		10YR 3/3 brown clay, organics in top 4", some silt, slightly moist, (CL) S0015X40.00	
0818		SS	3-5	24"	576013		2.5YR 6/3 clay stiff, slightly moist, high plasticity, (CL) S0015X4003	

depth to bedrock = 6.0'

E.O.B

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO sample (7-9')

BORING NO.: SX40

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JW

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD
SHEET 1 OF 1
BORING NO. 5X07
SITE LOCATION:
JOB NO.
LOCATION: SWMU 3
GROUND ELEV.
TOTAL DEPTH 2.5'bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR CORING TIME (min/ft)	% RECOVERY (R) (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1505	SS	0-2	20	2 9 13 15		brown clay (CL), dry, loose, medium plasticity, 10YR-4/3 50035X0700	
						Bedrock at 2.5' depth	
						E. O. B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (3-5'), (7-9')

BORING NO.: 5X07

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GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
LOCATION: SWMU -3
SHEET 1 OF 1
BORING NO. SX03
GROUND ELEV.
TOTAL DEPTH 9.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0785		SS	0-2	24	2 7 9 7		medium brown clay (CL), some silt, slightly moist, medium plasticity, stiff organics in top 2" 7.5YR-5/4 S0035X0300	
0803		SS	3-5	20	3 7 10	12	yellow brown clay (CL), some silt, slightly moist to moist, medium to high plasticity, some black organic dots, no odor, stiff (fairly) 10YR- 6/6 S0035X0303	
0815		SS	7-9	12"	17 34	50/3	grey to yellow brown clay (CL), moist some horizontal laminations, stiff, hard, some organics + rock fragments, 2.5Y-7/1 to 2.5Y-7/6 S0035X0307	

Rock at 9.5' depth

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SY03

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GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X04
SITE LOCATION:	JOB NO.		
	LOCATION: Swmu 3	GROUND ELEV.	TOTAL DEPTH 10.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
0835		SS	0-2	20"	6 10 12 11		brown, clayey silt, (ML), dry, loose organics in top 2" 7.5YR - 4/4 S4035X0400	
0895		SS	3-5	24	5 8 13 16		yellow brown clay (CL), some silt, few organic spots, low to medium plasticity, stiff (slightly), moist, semi-hard 2.5 Y - 6/6 S4035X0403	
0853		SS	7-9	23	5 14 21 32		yellow clay (CL), some silt, little grey mottling, few rock fragments, dense, hard 2.5 Y - 7/7 S0435X0407	
							Rock at 10.5'	
							E. O. B.	

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.: 5X04

7/22/92

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GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
LOCATION: SWMU 22
SHEET 1 OF 1
BORING NO. SX 22
GROUND ELEV.
TOTAL DEPTH 7.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1710		SS	0-2	16	10 7 14 16		yellow brown clay, some gravel, organics in top 3" (CL) 10YR 5/4, hard, slightly moist S0225X2200	
1715		SS	3-5	12"	17 9 35 50/5		yellowgrey clay. fill material hard, some gravel mostly dry 2.5Y 6/4 S0225X2203	
1730		SS	7-9	⊖	45 50/2		limestone rock frags NO SAMPLE e. o. b. = 7.5'	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX22

7/24/[illegible]

Metcalf & Eddy, Inc.
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PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X23
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 2,5,6,7	GROUND ELEV.	TOTAL DEPTH 16.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
0820		SS	0-2	15"	4101717		yellow-brown, 10YR-4/4 clay, some silt organics in top 3-4", moist, semi-stiff low to medium plasticity (CL) 52567SX230	
0825		SS	3-5	24"	691014		yellow brown, 10YR-5/5, clay, firm, moist, low to medium plasticity, some dark brown organic spots. (CL) 52567SX233	
0830		SS	7-9	12"	9 50/5		same except, some gravel 52567SX237	

depth to bedrock = 16'

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X23

7/24/92

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GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
LOCATION: SWMU 2,5,6,7
SHEET 1 OF 1
BORING NO. SX-26
GROUND ELEV.
TOTAL DEPTH 15.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1205		SS	0-2	8"	4 50/4		black c-g sand, some pebbles, moist, some silt organics in soil. (SM) 525675Y260	
1210		SS	3-5	12"	232268		dark grey clay (CL) 10YR-4/1, little silt, slightly moist, some wood pieces & splinters, some sand. 525675X263	
1215		SS	7-9	16	99814		top 8" greenish grey 5Y-5/6 bottom 8" grey 5Y-3/1 Clay, some glass & metal wire, soft. highly plastic, moist. 525675X267	
							depth to bedrock = 15.0' bgs E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX-26

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Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. SX28

LOCATION: SWMU 2,5,6,7

GROUND ELEV.

TOTAL DEPTH 7.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1525		SS	0-2	18	39111	7	brown clay, organics in top 8", slighty moist, soft/loose, low plasticity (CL) 52567SX280	
1536		SS	3-5	18"	61617	25	2.5Y 5/6 brown/orange clay (CL) slightly moist, some grey mottling, mostly stiff, low plasticity, organic discoloration 52567SX283	

depth to bedrock = 7.0' bgs

F.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX28

7/29/92

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GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. 5X29

LOCATION: SWMU 2,5,6,7

GROUND ELEV.

TOTAL DEPTH 11.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY (R) (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1440		SS	0-2	8"	42224	16	brown 2.5Y 3/2, clay (CL), some pebbles, soft organics in top 4" slightly moist 52567SX290	
1450		SS	3-5	20	7 12 13	15	2.5Y 5/6 brown/orange clay, slightly moist, mostly stiff, low plasticity, (CL) some grey mottling & organic discoloration 52567SX293	
1455		SS	7-9	22	7 13 28	39	Same, except hard, little to none grey mottling lots of organics 52567SX297	

depth to bedrock = 11.5 'bgs

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: 5X29

7/21/92

Metcalf & Eddy, Inc.
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GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: SWMU 4

SHEET 1 OF 1

BORING NO. SX 11

GROUND ELEV.

TOTAL DEPTH 5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
								Ludlow
1655		SS	0-2	16	7 15 19	33	yellow brown clay (CL), some silt, semi-hard, fairly dense, slightly moist 10YR-4/6, medium plasticity, organics, in top 3" 5004SX1100	74/min
1702		SS	3-5	16	7 13 22	50/1	yellow brown clay, semi-moist, dense, stiff, 10YR-5/8, medium plasticity 5404SX1103	58/min

Bedrock at 5' depth

E. O. B.

In borehole 164

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO SAMPLE (7-9)

BORING NO.: SX 11

7/21/92
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GEOLOGIC LOG

PROJECT :

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. SX13

LOCATION: SWMU 4

GROUND ELEV.

TOTAL DEPTH 3.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1744		SS	0-2	18	23 59		dark brown/grey clay (CL), slightly moist, soft, medium plasticity, fairly dense, 10YR-3/1 S004SX1300	ludlow 62/min
1750		SS	3-5	6	3 5 50/3		brown clay, some silt, (CL), moist to wet some f-g sand in bottom 2", very plastic dense 10YR-3/1 S004SX1303	—

3.5' depth to bedrock

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO SAMPLE (7-9)

BORING NO.: SX13

7/30/92

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GEOLOGIC LOG

M&E

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: 5001

SHEET 1 OF 1

BORING NO. SX42

GROUND ELEV.

TOTAL DEPTH 5.0' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1000		SS	0-2	20"	271114		10YR 5/6 orange brown clay 6" moist, slightly soft, organics in top 2" 10YR 4/3 14" - brown clay. some silt, soft/loose 5001SX4200	
1015		SS	3-5	12"	12730	50/1	10" same 3" rock fragments, limestone, angular 5001SX4203	

depth to bedrock = 5.0 bgs

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX-42

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PROJECT : LBAD

SITE LOCATION:

JOB NO.

SHEET 1 OF 1

BORING NO. SX 25

LOCATION: SWMU 2,5,6,7.

GROUND ELEV.

TOTAL DEPTH 19.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1118		SS	0-2	18	2 3 4 10		9" black cg sand, some silt, some pebbles, moist to almost wet. 9" dark grey clay, moist, medium plasticity, slightly stiff (CL) S2567SX250	
1122		SS	3-5	0	50/2		No recovery, wood in spoon	
1130		SS	7-9	0	18 18 11 13		No recovery, wood in spoon	

Depth to bedrock = 19.5

E.O.B.

cuttings from 9-19.5'
grey clay, medium plasticity
moist, little silt (CL)

water in hole!!

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO SAMPLE (3-5'), (7-9')

BORING NO.: SX25

21/92

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.:

SHEET 1 OF 1

BORING NO. 5X08

LOCATION: SWMU 3

GROUND ELEV.:

TOTAL DEPTH 5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1335		SS	0-2	22	5 10 13	15	brown clay (CL), some silt, some organics in top 3", slightly moist, firm, medium plasticity. 10YR-4/6 S4035X0800	
1340		SS	3-5	18	7 14 19	50/3	brown clay (CL), some silt, slightly moist fairly hard, medium plasticity 10YR-4/6 S4035X0803	

5' depth to bedrock

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No SAMPLE (7-9')

BORING NO.: 5X08

7/22/92
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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. SX-21
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU22	GROUND ELEV.	TOTAL DEPTH 9.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1755			0-2	16	18/29/12/14		Large Gravel fill, lower 12-14" yellow brown clay, some organics hard, 2.5Y-6/4, dry to slightly moist (CL) S0~~2~~22SX2100	
1804		SS	3-5	24	27 19 28 31		yellow brown clay, hard, dry to slightly moist, 2.5Y-6/4 (CL) S022SX2103	
1811		SS	7-9	24	17-30-50/4		yellowbrown clay, hard, some gravel slightly moist, 2.5Y-6/4 S022SX2107	
							E.O.B @ 9.5	

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.: SX-21

7/22/92
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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X19
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 4	GROUND ELEV.	TOTAL DEPTH 4.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1556	0-2	SS	0-2	20"	5 9 9 9		2.5Y 3/2 brown clay, slightly moist, fairly hard, little silt (CL) 5004SX1900	
1600		SS	3-5	6"	7 50/5		gravel + sluff No sample	
							4.5' depth to rock	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: no sample (3-5'), (7-9')

BORING NO.: 5X19

7/22/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. 5X20
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU-4	GROUND ELEV.	TOTAL DEPTH 5.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG Ludlow
1435		SS	0-2	15	581010		10YR 4/3 brown clay, some silt, ~~loose~~ dry medium density, some organics in top 3", stiff (CL) 5004SX2000	30
1440		SS	3-5	16	571113		2.5YR 4/3 brown clay, moist, stiff, medium plasticity (CL) 5004SX2003	40

5.5' = depth to bedrock

E.O.B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: 5X20

7/22/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: SWMU 4

SHEET 1 OF 1

BORING NO. SX 18

GROUND ELEV.

TOTAL DEPTH 3.5' bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1615	SS	0-2	19"	7 13 13 13		10YR 4/2 brown clay, some organics in top 3" Slightly moist, semi hard. (CL) S004SX1800 S004FD1800	collected duplicate (pounded 2 spoons)
	SS	0-2	24"	5 6 12 13			
1623	SS	3-5	0	50/5		No sample in spoon	
						depth to bedrock = 3.5'	
						E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (3-5), (7-9')

BORING NO.: SX 18

7/22/92

METCALF & EDDY, INC.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD		SHEET 1 OF 1	BORING NO. SX17
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU9	GROUND ELEV.	TOTAL DEPTH 7.5'bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG Ludlow
1342		SS	0-2	22	55 15 14		yellow brown clay, little silty, hard, dry to slightly moist, (CL) 10YR 4/6, some organics at top S009SX1700	40
1346		SS	3-5	22	6 6 18 19		same, except some dark brown spots from organics (CL) S009SX1703	44
1350		SS	7-9	6"	2150/3		little of same rock frags No sample collected	32
							Depth to bedrock = 7.5'	
							E.O.B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: SX17

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ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD
SITE LOCATION:
JOB NO.
LOCATION: SWMU 3
SHEET 1 OF 1
BORING NO. SX05
GROUND ELEV.
TOTAL DEPTH 10.5 bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1015		SS	0-2	14	3456		brown clay, (CL) some silt, slightly moist, organics in top 3", fairly dense, few pebbles 10YR-3/4 S0035X0500	
1025		SS	3-5	14	55711		light brown, silty clay, medium plastic fairly stiff, little orange mottling, moist (ML-CL) 7.5YR-6/4 S0035X0503	
1030		SS	7-9	24	6101934		yellow grey clay, (CL), little silt, hard, slightly moist, some grey mottling 2.5Y-7/3 to 2.5Y-7/0 S0035X0507	
							bedrock at 10.5' depth	
							E. O. B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.: SX05

7/21/92

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GEOLOGIC LOG

PROJECT: LBAD		SHEET 1 OF 1	BORING NO. SX 09
SITE LOCATION:	JOB NO.		
	LOCATION: SWMU 3	GROUND ELEV.	TOTAL DEPTH 4.5' bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR (RQD)	SAMPLE DESCRIPTION	GRAPHIC LOG
1355	SS	0-2	18	3378		brown clay, (CL), little silt, very slightly moist, soft, some organics in top 3" 10YR-3/3 S003SX0900	
1403	SS	3-5	16	71250/2		brown clay (CL), moist, semi-hard, stiff little silt, 10YR-4/3 Collected duplicate sample S003SX0903 S003FD0903	
						Rock at 4.5' depth	
						E. O. B.	

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO SAMPLE (7-9')

BORING NO.: SX 09

7/21/92

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT : LBAD

SITE LOCATION:

JOB NO.

LOCATION: SWMU 3

SHEET 1 OF 1

BORING NO. SX10

GROUND ELEV.

TOTAL DEPTH 4.5' bgs

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR CASING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	GRAPHIC LOG
1420		SS	0-2	24	3 10 17 18		brown clay (CL), dry, loose low to medium plasticity 10YR-4/4 S0035X1000	
1425		SS	3-5	12	9 38 50/1		brown clay, hard, slightly moist, stiff Medium plasticity 10YR-4/4 S0035X1003	

4.5' depth to bedrock

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: NO SAMPLE (7-9')

BORING NO.: SX10

7/21/92

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GEOLOGIC LOG

PROJECT : LBAD			SHEET 1 OF 1	BORING NO. 5X12
SITE LOCATION:	JOB NO.			
	LOCATION: Swmu4		GROUND ELEV.	TOTAL DEPTH 4'bgs

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY (R)	SAMPLE DESCRIPTION	GRAPHIC LOG Ludlow
1723	SS	0-2	16	2379		brown clay, (CL), semi-soft, slightly moist, little silt, fairly dense; low plasticity 10YR-3/2 5444SX1244	58/min
1725	SS	3-5	10	2-50/4		brown clay (CL), firm; slightly moist to moist, dense, low plasticity, 10YR-3/2 5444SX1243	47/min

Depth to bedrock = 4'

E. O. B.

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES: No sample (7-9')

BORING NO.: 5X12

APPENDIX B
CORE LOGS AND CORE PHOTOS

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ROCK CORING LO

BORING NO:

JECT: LBAD

EPTH ELOW ATUM EET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) RQD. REC 25 50 75 80	ROCK STRUCTURE
#1 -15.4"	8.65' = solution Fracture - Horizontal 9.0 = solution Fracture - 30° 9.1 = solution Cavity - 0.5" diameter 9.3 = " Fracture - 40° & 30° wavy. 9.4, 9.6, 9.8 = solution fractures - Horizontal 9.9 = Fracture 10° 10.1-10.3 Fracture solution Broken 10.4-10.5 Rubble 11.7, 11.3, 11.2 Horizontal 13.45 Horizontal 13.90 "		Run #1 8.0-15.4	2min/ft	100%	43%		Interbedded Shale
	Interbedded Clayey limestone with Clay shale, Clay up to 6" thick, 8-8.9 Biomicrite 8.9-11.7 Clay Shale + Interbedded LS 11.7-15.0 Clay Shale with L.S. Stringers up to 4" thick							

PROJECT NO. DO 7248

LOG

PAGE 1 OF 11

COR-1 New Landfill

ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
			TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
Interbedded Shale Clay w/LS Stringers	Top 3ft. Very weathered	Clay Shale - Soft LS - Hard							5"		Very Clayey, Top Portion Very weathered, Many breaks along bed planes, Difficult to tell from solution Mechanical with Depth Fractures Very High Shale Content

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ROCK CORIN

BORING N

PROJECT: LGAP

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 7
Run #2 15.4-25.3 9.9 Ft. run	15.55 Horizonal sol. 15.65 " " 15.80-16 " " Broken [illegible] " " [illegible] [illegible] 17.2 " 17.5 17.75 " " 18.3 " " 19.7 23.2 23.85 24.40 24.8 25.'		Run #2, 15.4'-25.3'	≈2'/min	100%	51%	
	15.4-'18.3' Interbedded Shale and Biomicrite Shale beds up to 6", Biomicrite upto 3" thick, Shale very limy 18.3'-21.65' Biomicrite with thin Shale beds upto 1" thick 21.65-25.3 Biomicrite, Very competent, high RQD						

PROJECT NO. 007248

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RING LOG

RING NO: COR-1 New Landfill

PAGE 2 OF 11

				DISCONTINUITIES								
RQD. REC (%) 50 75 80	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	REMARKS
	Interbedded shale and L.S. "Horizontal"	UNweathered	Hard			0°				≈ 1ft		Becoming more competent with depth. Fractures occur on shale/L.S. bed planes. Very difficult to determine [illegible] from Solution Fractures

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ROCK CORING LO

BORING NO:

OJECT: LBAD

EPTH ELOW ATUM EET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) RQD. REC 25 50 7580	ROCK STRUCTURE
#3, -26.8	Cored 1.5' due to barrel blockage. 25.5 - Solution Fracture 10° slickensides 25.8 - " " " Horizontal 26.2 - " " Horizontal/Vertical 26.5 - Brecciated 26.8 - Solution/Clay 10° Biomicrite with thin shale laminae, Max 3" apart. Very competent but fractured.		Run #3 25.3-26.8	≈2'/MIN	100%	30%		Interbedded L.S P
IN #4 .8-35.3	27.0 27.15 27.2 27.4 27.9 } Horizontal solution / rough 28.4 28.5 } Horizontal solution / undulatory 29.0 Rough solution 29.1 29.3 29.6 29.9 } Solution / undulatory 30.1 30.15 30.2 30.6 } solution rough 30.85 - sol. undulatory 31.0 - solution clean		Run #4 26.8-35.3	≈2'/MIN	100%	80%		Interbedded L.S P

PROJECT NO. 007248

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LOG

Cor-1 New Landfill

PAGE 3 OF 11

			DISCONTINUITIES								
ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	REMARKS
Interbedded L.S + shale.	None	Hard									Fractures occur on shale bedding. Difficult to determine mechanical from solution fractures
Interbedded L.S + shale/Nodular	None	Hard									Becoming more nodular, Fracturing along shale/L.S. interface. Difficult to determine mechanical from soln. Fractures.

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ROCK CORIN

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) RQD. REC 25 50 75
	31.4 - Solution / Undulatory / 5° 31.7 - Solution / Undulatory 31.[illegible] - " " / 5° 32.25 - " " 32.8 - solution 5° / 10° 33.0 - solution ~~Horizontal~~ / 5° rough 33.15 - Solution Horizontal / 10° 34.4 - " " clean 34.65 - " " undulatory 34.95 " " rough						
	26.8 - 27.4 Biomicrite 27.4 - 27.9 Clay shale w/ limestone nodules and limestone layers 27.9 - 31.8 Biomicrite with thin interbedded shale (Max 1" thick) 31.8 - 35.3 Shale w/ interbedded L.S. nodules up to 4" thick						
Run #5 35.3-45.1	35.5 Solution Fracture / shale stringers 35.7 Horizontal solution, rough 35.75 Horizontal (spin off) rough 37.1 Sol. Horizontal " 37.3 " " " 37.45 " " "		Run #5 35.3-45.1		100%	80%	

PROJECT NO. 007248

G LOG

PAGE 4 OF 11

O: COR-1 New LANDfill

	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
80				TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
	Interbedded Shale & LS. Nodular	None	Hard									Becoming More shaly, Hard to determine Mechanical from solution fractures.

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ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 7580	RQD.	REC
	37.7 Horizontal solution rough								
	37.9 " " clean								
	38.2 " " rough								
	39.4 " " "								
	41.0 " " smooth								
	41.8 " " rough								
	35.3 - 38.0 Clay shale with nodular limestone. Nodules up to 4", biomicrite, contacts undulatory								
	38.0 - 44.6 Clay shale, thinly bedded biomicrite L.S. Nodules up to 4" Prominent nodules at 38.4, 39.2, 39.6, 40.5, 41.0, 41.3,								
	44.6 - 44.9 Competent biomicrite some mud.								
	44.9 - 45.4 shale/no nodules								

PROJECT NO. 007248

NG LOG

PAGE 2 OF 11.

NO: COR-1 New LANDfill

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
75	80												

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ROCK CORING

BORING NO :

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 80 RQD. REC
Run #6 45.4-55.5	46.5 46.8 47.1 48.0 48.6 49.4 Solution Fractures - Undulatory 50.2 50.6 51.1 52.0 52.4 52.7 52.8 54.6 Solution Fractures - Undulatory Biomicrite with shale partings. Biomicrite Nodular. Higher % of L.S. than previous run.		Run #6 45.4-55.5	2'/min	100%	91%	
Run #7 55.5-65.5	56.5 - solution, Horizontal rough 56.85 - " " smooth 57.2 - " " " 58.7 - " " " 59.8 - " 62.8 - solution 5° semi-smooth 65° " " " Biomicrite & Biosparite with interbedded shale & mud. Nodular.		Run #7 55.5-65.5	2'/MIN	100%	84%	

PROJECT NO. 007248

ING LOG

PAGE 6 OF 11

S NO: COR-1, New Landfill

7580

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		L.S. - Shale interbedded nodular.	None	Hard									Pretty competent. Breaks along shale/L.S. interface; still ↑ % of shale.
		Limestone/interbedded shale, nodular	None	Hard									Becoming more Limestone & less shale. Breakage on shale partings.

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ROCK CORI

BORING

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 7
RUN #8 65.5-75.4	Mechanical breaks through out along shale partings. Very competent rock with few solution fractures. Limestone (Biosparite) some shale partings. less shale, more L.S., some stylolites - present. Becoming fewer with depth. 74.4' → Vuggy → filled with Micrite		RUN #8 65.5-75.4	2'/MIN.	100%	100%	
RUN #9 75.4-86.4	Mechanical breaks along shale partings, Many stylolites, Spary calcite, few fossils, Very competent, very little shale. Thin shale partings.		RUN #9 75.4-85.4	2'/MIN	100%	100%	
RUN #10 85.4-95.3	Mechanical breaks along shale partings. No apparent solution features. Sparite, few stylolites, Horizontal To undulatory Shale or Mud stringers. Very competent, very hard.		Run #10 85.4-95.3	2'/MIN	100%	100%	

PROJECT NO. 007248

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NG LOG

NO: COR-1, New Landfill

PAGE 2 OF 11

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Interbedded L.S & shale. Horizontal beds	None	Hard									No Water loss to date - COR-1
		Limestone with few Horizontal shale partings	None	Hard									Decreasing shale with depth.
		Limestone with Horizontal or undulating part of shale	None	Very Hard									Finer grained, less shale.

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ROCK CO

BORIN

PROJECT: 4BAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50
Run #11 95.3-105.3	Mechanical breaks along shale Partings. Biosparite, decrease in shale, shale parting up to 4" thick. Still undulatory to horizontal mud shale stringers. Partialy filled solution vug at 105.1.		Run #11 95.3-105.3	2"/min	100%	100%	
Run #12 105.3-115.3	Mechanical breaks along shale Partings. Biosparite, no fractures or pitty, Still very little shale. Very competent. Vugs replaced w/sparite at 110ft.		Run #12 105.3-115.3	2"/min	100%	100%	
Run #13 115.3-125.3	Mechanical Breaks along shale partings. Very competent. Biosparite, with increased shale up to 2" thick, 121.1-121.4 → vertical Fracture filled with micrite. Very competent.		Run #13 115.3-125.3	2"/min	100%	100%	

PROJECT NO. 007248

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CORING LOG

ORING NO: Cor-1 New Landfill

PAGE 8 OF 11.

REC & RQD (%) RQD. REC 50 75 80	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
				TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
	Horizontal to Undulatory limestone w/ shale stringers	NONE	Hard									
	Horizontal to undulatory limestone w/ shale stringers	None	Hard									
	Horizontal to Undulatory bedding.	NONE	Hard									

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ROCK

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC
Run#14 125.3-135.3	Mechanical breaks along shale Partings. Very competent. Increase in shale throughout. Biomicrite with shale partings. Shale very limy.		Run #14 125.3-135.3	2"/MIN	100%	100%	
Run #15 135.3-145.3	Mechanical breaks along shale partings. Very competent, Biosparite with ½ in shale partings. 143.3-143.7 → shale w/ limestone clasts. Increased shale content		Run #15 135.3-145.3	2"/MIN	100%	100%	

PROJECT NO. 007248

CORING LOG

PAGE 9 OF 11

BORING NO: COR-1 New LANDFill

GRAPHIC	REC & RQD (%) 25 50 75 80	RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
							TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
				Horizontal to Undulatory	None	Hard									
				Horizontal to Undulatory	None	Hard									

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Metcalf & Eddy

ROCK

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC
Run #16 195.3-155.6	~~Appears to be some minor fractures in upper 1 ft of run Maybe solution fracture~~. SH. Biosparite with shale mud lamine, some shale beds up to 2" thick. Less shale than previous run.		Run #16 145.3-155.6	2"/MIN	100%	~~98%~~ 100%	
Run #17 155.6-165.3	Some minor fractures i upper 1 ft of run. Maybe solution fractures. Biosparite with shale mud lamine. Higher shale content than previous run. Breakage along shale/L.S. interface		Run #17 155.6-165.3	2'/MIN	100%	98%	

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PROJECT NO. 007248

CORING LOG

BORING NO: COR-1 New LANDFill

PAGE 10 OF 11

REC & RQD (%)		ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
RQD.	REC				TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
5 50 75	80												
		Horizontal to Undulatory, interbedded	NONE	Hard									
		Undulatory to horizontal	None	Hard									

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Metcalf & Eddy

ROCK C

BC

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC 25
Run #18 165.3-175.3	Mechanical breakage at shale/L.S. interface. Biosparite with shale interbedded. Shaly = top 3 ft. Less shale = remainder of core. L.S. nodular.		Run #18 165.3-175.3	2'/MIN	100%	100%	
Run #19 175.3-185.3	Mechanical breakage on shale/L.S interface. Biosparite with interbedded shale. Very little shale. L.S. nodular. Cor-1 terminated at 185.3 ft.		Run #19 175.3-185.3	2'/MIN	100%	100%	

PROJECT NO. 007248

CORING LOG

PAGE 11 OF 11

BORING NO: COR-1, New Landfill

REC & RQD (%) RQD. REC 5 50 7580	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
				TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
	Undulatory-Horizontal Nodular	None	Hard									
	Nodular - Horizontal Undulatory	None	Hard									No water loss during drilling of COR-1

②

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Metcalf & Eddy

ROCK

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC 2
0-9'	clay, Brown silty						
Run #1 11.1-15' 936.74'ASL 1 ~~921.34'ASL~~	11.3 - Solution fracture 15° rough 11.3-11.6 - Core loss 11.9 - Solution Fracture - Rough 15° 12.1 - Solution Fracture - " " 12.2 - Horizontal Rough 12.7-12.9 - Core Loss 13.0-13.5 - Core Loss		Run #1 11.1-15.0 ft	.5 ft/min	72%	38%	
	Biosparite to 13.5 ft. Limestone nodules with micrite filly. Thin beds of shale interbedded between nodules. 1" shale bed at 14.0 ft. Presence of Vugs filled with Micrite or mud.						

PROJECT NO. 007248

CORING LOG

BORING NO: COR-2 ~~SIWL~~ ISWL

PAGE 2 OF 10

GRAPHIC	REC & RQD (%) RQD. REC 25 50 75 80	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular w/ interbedded shale laminae	Top 2.5 feet very weathered	hard	Core LOSS. 11.3-11.6		30°	Angular	rough + spin	None		11.3-11.6 .3 ~~ft~~	
					Core LOSS 12.7-12.9		30°	Angular	Spin off	None		12.7-12.9 .2 ~~ft~~	
					Core Loss 13.0-13.5		Horizontal		Rough-spin	None		13.0-13.5 .5 ~~ft~~	

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ROCK CC

BOR

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC 25
Run #2 15.0-24.9	Very few solution fractures. Interbedded L.S and shale. Higher shale content than previous run. Limestone - Biosparite, nodular. Very competent but breakage at shale lamina. L.S. Gray - 2YRN5 Shale - Very dark gray 2YRN3		Run #2 15.0-24.9	.7/min	100%	97%	
Run #3 24.9-34.7	No solution fractures present. Biosparite nodules separated by 1" shale beds. Shale muddy. Shale content higher than previous run. LS= 2YR N5 Sh= 2YR N3		Run #3 24.9-34.7	.7/min	100%	100%	
Run #4 34.7-44.8	No solution fractures present. Biosparite nodules separated by shale laminae. LS=2YRN5 Sh=2YRN3		Run #4 34.7-44.8	.7/min	100%	100%	

PROJECT NO. 007248

CORING LOG

PAGE 2 OF 10

BORING NO: COR-2 ISWL

GRAPHIC	REC & RQD (%) 25 50 75 80 RQD. REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Nodular & undulatory	None	Hard									LOSSING som water!
		Nodular to Horizontal	None	Hard									LOSSING 35-40: H_2O.

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ROCK C

BC

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC 25
RUN #5 44.8-54.8	No solution Fractures. Core becoming very ~~Vuggy~~ Vuggy from ≃ 47 ft. to 54.8'. Max. size 1/4 inch. ~~Vuggy~~ Vugs occur in highly fossilized zones. Biosparite with thin mud shale stringers, shale beds up to 0.5" thick. Less nodular than previous run.		Run #5 44.8-54.8	.6 ft/min	100%	100%	
RUN #6 54.8-64.9	No solution Fractures. Biosparite, Argillaceous bed from 53.4 – 56.3. Very fossiliferous w/ mud and L.S. mix. Hard to distinguish between laminae in this bed. Very few nodular beds throughout rest of core. Horizontal to undulatory bedding.		Run #6 54.8-64.9	0.6 ft/min	100%	100%	

PROJECT NO. 007248

CORING LOG

ORING NO: COR-2 ISWL

PAGE 3 OF 10

REC & RQD (%) RQD. REC 50 75 80	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	REMARKS
	Horizontal, nodular Vuggy	None	Hard									Vugs don't seem to be interconnected.
	Horizontal to Undulatory	None	Hard									Less vugs.

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ROCK

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)
Run #7 64.9-75.0	Few solution Fractures. Micrite at approximately 65 ft to 75 ft. Still some fossils. Laminated to thinly bedded. Increase in shale content. Shale lines. Nodular at ≈73 ft.		Run #7 64.9-75.0	.7 ft/min	100%	97%
Run #8 75-85 ft	Mechanical breaks along shale change from Micrite to Biosparite at 75.2, Becoming more nodular, Increase in shale content, beds up to 0.2 ft thick. ≈81 ft evidence of subaerial exposure = oxidized red-brown zone		Run #8 75-85 ft	.7 ft/min	100%	100%

PROJECT NO. 007248

CORING LOG

BORING NO: Cor-2 ISWL

PAGE 4 OF 10

GRAPHIC	REC & RQD (%) 25 50 75 80	RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
							TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
				Horizontal laminae, nodular	None	Hard									
				Horizontal & nodular	None	Hard									

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ROCK COR

BORING N

ECT: LBAD

TH OW UM ET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75	RQD.	REC
#9 -95.1	Very small vugs, No solution fractures. Biosparite with shale laminae, Becoming more nodular with depth. Shale also increasing with depth. Shale beds up to 0.1 ft. but increasing frequency.		Run #9 85-95.1 ft	1ft/min	100%	100%			
Run#10 95.1-105.1	Solution vug at 103.2 ft. No solution fractures. Biosparite - nodular to 103.5 ft. Changes to Micrite. Thin mud laminae. Less shale.		Run #10 95.1-105.1	1ft/min	100%	100%			

PROJECT NO. 007248

NG LOG

G NO: Cor-2 ISWL

PAGE 5 OF 10

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Nodular	None	Hard									

7580

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ROCK CORING

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75	RQD.	REC
Run#11 105.-114.9	Mechanical breaks, No solution fractures. Biomicrite with zones of sparite. Nodular structure but not as promnant. Some interbedded shale. Thin layers. up to 0.1 ft.		Run #11 105.1-114.9	1 ft/min	100%	100%			
Run#12 114.9-124.9	Mechanical breaks, No solution fractures. Biomicrite, nodular structure separated by thin Mud shale beds.		Run #12 114.9-124.9	1 ft/min	100%	100%			

PROJECT NO. 007248

RING LOG

IG NO: COR-2ISWL

PAGE 6 OF 10

				DISCONTINUITIES								
RQD. REC)) 7580	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	REMARKS
	Nodular to Laminar	None	Hard									
	Nodular	None	Hard									

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ROCK CORING

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75	RQD. REC
Run #13 124.9-134.8	No solution fractures. Nodular Biomicrite with small infequent zones of sparite. Nodules separated by mud & laminae. Clay shale beds up to 1" thick. Vuggy from 125-126'		Run #13 124.9-134.8	1ft/min	100%	100%		
Run #14 134.8-144.9	No solution fractures. Nodular, Biomicrite, with infequent sparite. Nodules separated by shale laminae, Shale beds towards end of Run, up to 0.2' thick.		Run #14 134.8-144.9	1ft/min	100%	100%		

PROJECT NO. 602248

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NG LOG

NO: COR-2 ISWh

PAGE 2 OF 10

7580

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Nodular + Horizontal	None	Hard									

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ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) RQD. REC 25 50 75 80
Run#15 144.9-154.9	No solution fractures. Nodular Biomicrite, Interbedded shale stringers. Vuggy throughout, No shale i excess of 1".		Run #15 144.9-154.9	1 ft/min	100%	100%	
Run #16 154.9-160.9	No solution fractures. Nodular biomicrite with interbedded shale. Some biosparite.		Run #16 154.9-160.9 ~~144.9-154.~~	1 ft/min	100%	100%	

PROJECT NO. 007248

ING LOG

G NO: CDC-~~3~~2 ISWL

PAGE 8 OF 10

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Nodular	None	Hard									

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ROCK CORIN

BORING N

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (In/In)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75	RQD.	REC
Run #17 160.9-165.9 #1	No solution fractures. Nodular Biomicrite with interbedded shale up to .25". Small Vugs.		Run #17 160.9-165.9	1 ft/ft	100%	100%			
Run #18 165.9-175.9 #2	No solution fractures. Nodular Biomicrite and biosparite separated by thin beds of shale up to ~~0.0 ft~~ 0.1 ft thick.		Run #18 165.9-175.9	1 ft/min	100%	100%			

PROJECT NO. 007248

ING LOG

NO: Cor-2A ISWL

PAGE 9 OF 10

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
75	80				TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Nodular Horizontal	None	Hard									

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ROCK COR

BORIN

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (% 25 50
Run #19 175.9-185.5 #3A	No solution Fractures. Nodular Limestone - biomicrite and Biosparite separated by up to ~~0.25~~ 0.3 'shale. decrease in shale content.		Run #19 175.9-185.5	1ft/min	100%	100%	
Run #20 185.5-195.5 #4A	No solution Fractures. Nodular Biomicrite & Biosparite, separated by 0.25' shale decrease in shale content.		Run 20 185.5-195.5	1ft/min	100%	100%	
Run #21 195.5-200.5 #5A	No solution fractures. Biomicrite, small nodular, Biosparite interbed, separated by up to 0.125 'shale. Shale content decreasing.		Run #21 195.5-200.5	1ft/min	100%	100%	

PROJECT NO. 007248

ING LOG

NO: COR-2A ISWL

PAGE 10 OF 10

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Nodular	None	Hard									
		Nodular to Horizontal	None	Hard									2500 gal of H_2O were used durig drillg. 60% ≈ 1500 gal. were lost down hole.

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ROCK CORIN

BORING NO

PROJECT: LBAD

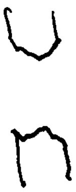
DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75	RQD.	REC
0-7.5	Silty Clay (CLS) ~~B~~ Med, stiff, Dense, Moist, Dark yellow brown 10YR 4/3								
~~75~~ Run#1 7.5-16.9 Cont.'g #2	7.5-7.7 rubble 7.85 ~~8~~ rough, solution Horizontal 7.9-8.1 core loss 8.4 - 45°\30° Solution 8.7 Horizontal, solution, rough 9.0 " " " 9.25 " " " 9.3-9.50 Core Loss 9.65 - solution, 45°/45° 10.00 solution 30° 10.25 solution 10°/30° 10.75 rubble 11.2 Horizontal sol. 11.40-11.70 core loss 11.9 Horizontal sol, rough 12.4 Horizontal " " 14.1 " " " 15.5 " " " 16.4 " " "		Run #1 7.5-16.9	2'/min	92%	36%			

PROJECT NO. 007248

ING LOG

PAGE 2 OF 5.

NO: COR-3 OLD LANDFILL

					DISCONTINUITIES								
RQD.	REC 7580	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	REMARKS
		Horizontal bed.	Heavy	Hard	Core loss 7.9-8.1		Horizontal/ spin off	Horizontal	rough/spin	None			
					Core loss 9.3-9.5		Horizontal/ spin off	Horizontal	rough/spin	None			
					Core loss 11.4-11.7		Horizontal/ spin	Horizontal	rough/spin	None			

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ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 80	RQD.	REC
RUN #1 Cont.	Biosparite with thin shale laminae occur every 2-4".								
Run #2 16.9-26.8	17.75 Horizontal - rough 18.05 " " 18.55 45°/35° 20.0 Horizontal - rough 19.5-21.5 Biosparite nodules separated by shale beds up to .4 ft. 21.5-23.1 Biosparite horizonal bed 23.1-25 Shale up to .4 feet/biosparite		Run #2 16.9-26.8	2ft/Min	100%	97%			
Run #3 26.8-36.8	27.75 Horizontal rough 28.1 " " 28.5 " " 29.7 " " 30.5 Rubble 31.2 30° smooth 33.0 horizontal smooth 34.0 " " Biosparite, semi-nodular, thin laminae of shale. Large Vug = .05' at 30 ft.		Run #3 26.8-36.8	2ft/min	100%	~~100%~~ 84%			

PROJECT NO. 007248

NG LOG

NO: COR-3 OLD LANDFILL

PAGE 2 OF 5.

'580

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Nodular	None	Hard									
		Semi-Nodular	None	Hard									

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ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 7580 RQD. REC
Run #4 36.8-46.8	45.4 Horizontal Rough 45.7 15°/5° rough 46.1 Horizontal rough 46.5 " "		Run# 36.8-46.8 4	2ft/min	100%	93 ~~100~~ %	
	Biospaite, interbedded shale up to 1inch to 38 ft. Biomicrite to 42 ft to 44 ft Biomicrite to 45 ft remainder biosparite. Very Vuggy.						
Run #5 46.8-56.8	~~B~~ No solution fractures. Biosparite interbedded with shale up to [illegible] 0.1 ft. Very Vuggy from 46.8 - 49 ft. Biomicrite from 49.0-52		Run #5 46.8-56.8	2ft/min	100%	100%	

PROJECT NO. 00 7248

ING LOG

G NO: Cor-3 Old Landfill

PAGE 3 OF 5

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		semi-nodular to Horizontal	None	Hard									
		semi-nodular to Horizontal	None	Hard									

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ROCK CORING

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 8 RQD. REC
Run #6 56.8-66.8	No solution fractures. Biomicrite with interbedded shale beds. 65-65.3 shale 65.3-65.6 Shaly biomicrite 65.6-65.85 shale remainder biomicrite with interbedded thin shale.		Run #6 56.8-66.8	2 ft/min	100%	100%	
Run #7 66.8-68.8	No solution fractures. Interbedded shale and biomicrite to 67.8 ft. Biosparite interbedded with shale. up to 1 inch thick to 68.8		Run #7 66.8-68.8	2 ft/min	100%	100%	
Run #8 68.8-76.8	No solution fractures - Interbedded shale and biosparite, Shale up to .3 ft. Biosparite nodular. 75-75.25 ft = thin brown shale beds showing subaerial exposure. Similar to brown beds found in COR-2		Run #8 68.8-76.8	2 ft/min	100%	100%	

PROJECT NO. 007248

ING LOG

G NO: Cor-3 Old Landfill

PAGE 4 OF 5

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7580

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Horizontal - semi nodular	None	Hard									Recovery only $\simeq$40% of Drilling H_2O. Has been the case from top of boring
		Horizontal to semi nodular	None	Hard									
		Horizontal to Nodular	None	Hard									

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ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 80 RQD. REC
Run # 9 76.8-86.8	No solution fractures. Nodular biomicrite with interbedded shale. Shale becoming finer. Primary mud laminae.		Run # 9 76.8-86.8	2 ft/min	100%	100%	
Run #10 86.8-96.8	No solution fractures. Nodular biomicrite and shale to 89.5. 86.8-96.8 Nodular biosparite with interbedded shale. Shale up to 0.1 ft.		Run #10 86.8-96.8	2 ft/min	100%	100%	
Run #11 96.8-106.8	No solution fractures. Nodular biosparite up to 97.4 with interbedded shale. Biomicrite to 98.5. Biomicrite / Biosparite alternating ≃6", interbedded shale. Shale up to 0.1 ft decreasing with depth.		Run #11 96.8-106.8	2 ft/MIN	100%	100%	

PROJECT NO. 00 8248

ING LOG

G NO: Cor-3 Old Landfill

PAGE 5 OF 5

RQD. REC 7580	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
				TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
	Nodular to Horizontal	None	Hard									
	Nodular to Horizontal	None	Hard									
	Nodular to Horizontal	None	Hard									used 2400 gal. of H_2O. 40% retined. Lost ≈ Lost 1440 gal.

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ROCK CORING

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75	RQD.	REC
0-6.2 Silty CLAY (CLM), Lt Brown, Med ~~Sti~~	Silty CLAY (CLM) Light Brown, 10YR6/4 Medium, Stiff, Dense, Moist, FeO2 Staining								
Run #1 6.2-11.4	Entire run fractured & broken. 0.5-1.5 Core Loss Interbedded micrite and shale. Shale is very clayey. Entire run very Fractured, and brecciated		Run #1 6.2-11.4 ft	2ft/min	81%	0%			
Run #2 11.4-13.8	Many Horizontal fractures, Rubbly, Horizontal Pieces up to .35', rough edges. Interbedded biomicrite, shale, & clay. Shale up to .2ft. High shale content		Run #2 11.4-13.8	2ft/min	100%	0%			

PROJECT NO.

ING LOG

G NO: COR-4 Waste Lagoons

PAGE 2 OF 6

) 7580

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Horizontal bedding	Very weathered	Shale - Very soft & clay; LS Hard	Core loss 0.5-1.5		Horizontal, ~~[illegible]~~ open off	rough, open	rough	None	0.3 ft		Difficult to determine solution fractures from mechanical fractures.
		Horizontal	L stone	Shaly & clay soft to Hard Micrite - Hard									Difficult to determine solution fractures from mechanical fractures.

LOGGED BY

2

Metcalf & Eddy

ROCK CORING

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75
Run #3 13.8-23.8	14.2 Horizontal, solution-rough 14.6 5° " " 15.1-15.2 Rubble 15.4 5° rough Biomicrite with interbedded shale beds, Biomicrite beds up to 0.5 ft. Shale beds up to 0.2 ft. Very Vuggy, Vugs replaced with spar.		Run #3 13.8-23.8	2ft/min	98%	72%	
Run #4 23.8-33.8	23.9 horizontal rough 24.0 " " 24.4 " " 24.8 " " 25.1 " " 25.5 " " Interbedded Biomicrite and shale. Very little shale, thin stringers. up to ~~0.05 ft.~~ 0.1 ft. Vuggy.		Run #4 23.8-33.8	2ft/min	100%	84%	

PROJECT NO. ____________

ING LOG

G NO: COR-4 Waste Lagoons

PAGE 2 OF 6

7580

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Horizontal to semi-Vuggy	None	Hard									Vugs appear to not be interconnected.
		Horizontal	None	Hard									

LOGGED BY ______________________

M&E
Metcalf & Eddy

ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 80 RQD. REC.
Run #5 33.8-43.8	34.8—35.1 Horizontal fractures-rough 35.5 " " "						
	34.8-35.1 Clay 37.0-39 Shaly 40.6-42.6 shaly 41.3 .3ft clay shale Biosparite with shale interbedded with biomicrite up to 0.9 ft. Very shaly.		Run #5 33.8-43.8	2 ft/min	100%	96%	
Run#6 43.8-53.8	No solution fractures. Biomicrite with interbedded shale. Becoming shaly at 45.4, Large Vug at 48.8 ft. replaced with ~~&~~ sparite. Shale c̄ thin beds.		Run #6 43.8-53.8	2 ft/min.	100%	100%	

PROJECT NO.

ING LOG

G NO: Cor-4 Waste Lagoon

PAGE 3 OF 6

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (in)	SPACING	
		Horizontal	None	Hard - L.S. Soft - Clay									
		Horizontal to semi-~~[illegible]~~ nodular	None	Hard									

LOGGED BY ____________________

2

M&E
Metcalf & Eddy

ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 8 RQD. REC
Run#7 53.8-63.8	No solution fractures. Interbedded shale and biomicrite, shale up to 0.1 ft. Run becoming more shaly.		Run #7 53.8-63.8	2ft/min	100%	100%	
Run#8 63.8-73.8	Solution fractures. Interbedded biomicrite and shale. Mechanical or Solution Horizontal fractures from 66.0 to 66.2 ft Rubble from 63.2-63.5. Very vuggy.		Run #7 63.8-73.8	2ft/min	100%	68%?	
Run#9 73.8-83.6	78.0-78.2 Vertical fracture Interbedded micrite with thin shale laminae up to .05 ft. 80.6-83.6 Very shaly		Run #9 73.8-83.6	2ft/min	100%	96%	

PROJECT NO. ______

1

ING LOG

NO: *Cor-4 Waste Lagoon*

PAGE *4* OF *6*

					DISCONTINUITIES								
RQD. 7580	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	REMARKS
		Horizontal	None	Hard									
		Horizontal	None	Hard									Difficult to determine solution fractures from mechanical fractures.
		Horizontal	None	Hard									

LOGGED BY

2

Metcalf & Eddy

ROCK CORING

BORING NO:

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - (ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) RQD. REC 25 50 75 80
Run #10 83.6-93.6	No solution fractures. Nodular biomicrite interbedded with shale. Becoming more shaley, 85.3 ~~85.~~ filled Vertical fracture. Some pyrite xtal. Shale up to 0.15 ft. 92.3-92.4 brown shale laminae similar to previous runs, indicates sub-aerial exposure. Vuggy		Run #10 83.6-93.6	2 ft/min	100%	100%	
Run #11 93.6 to 103.6	98.5 - 98.65 Vertical fracture smooth 101.9 - 102.5 " " " incl. Nodular biomicrite interbedded shale, Shale up to .02 ft.		Run #11 93.6-103.6	.25 ft/min	100%	100%	

PROJECT NO.

ING LOG

G NO: Cor-4 Waste Lagoons

PAGE 5 OF 6

RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		Horizontal to ~~[illegible]~~ nodular	None	Hard									
		Horizontal to nodular	None	Hard									Drilling rate has slowed way down to .25 ft/min

LOGGED BY ____________________

2

Metcalf & Eddy

ROCK CORIN

BORING NO

PROJECT: LBAD

DEPTH BELOW DATUM (FEET)	DESCRIPTION	GRAPHIC LOG	RUN NUMBER - (depth interval - ft.)	PENETRATION RATE (min/ft.)	RECOVERY (in/in)	CUM. RQD (IN/IN)	GRAPHIC REC & RQD (%) 25 50 75 8 RQD. REC
Run#12 103.6-113.6	No solution Fractures, Nodular biomicrite interbedded with shale. shale up to .05 ft thick.		Run #12 103.6-113.6	.25 ft / min	100 %	100 %	
Run #13 113.6-123.6	No solution fractures. Nodular biomicrite interbedded with shale. Shale up to 0.2 ft. Shale content increasing.		Run #13 113.6-123.6	.25 ft/min	100%	100%	
Run 14 123.6-133.6	No solution fractures. Interbedded shale up to .5 ft, Less Nodular biomicrite		Run 14 123.6-133.6	1 ft/50 min	100%	100 %	

PROJECT NO.

1

ING LOG

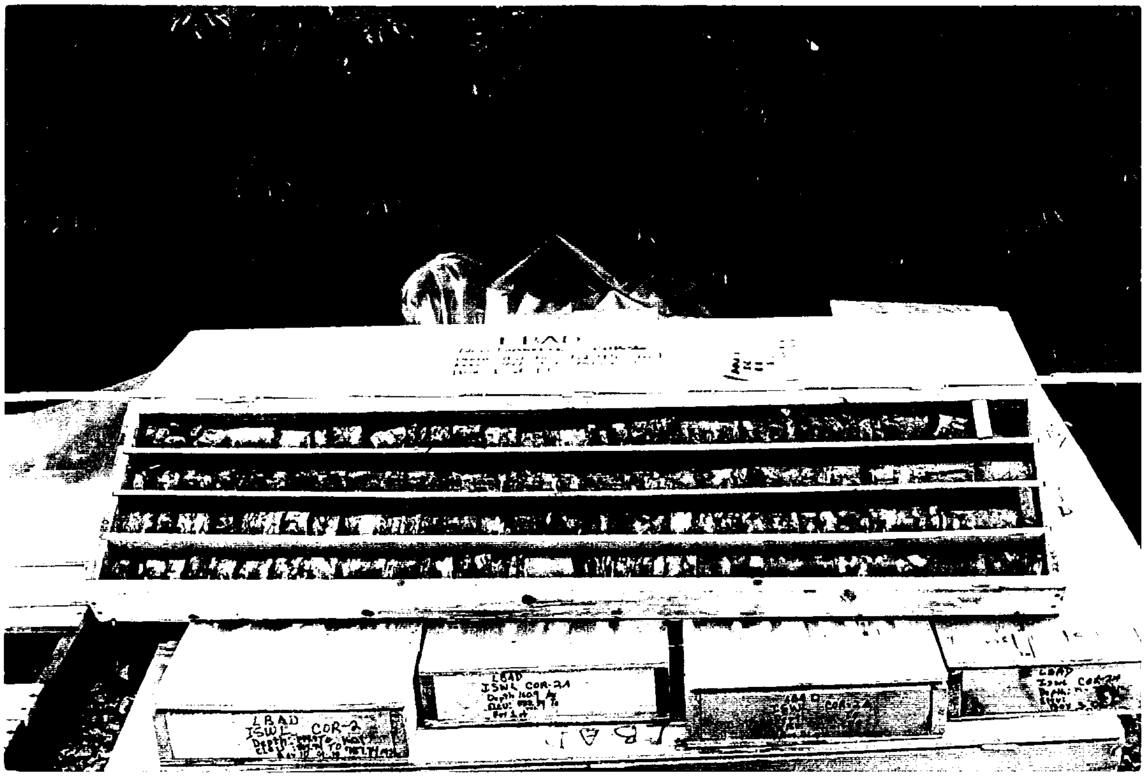
G NO: *Cor-4 Waste Lagoons*

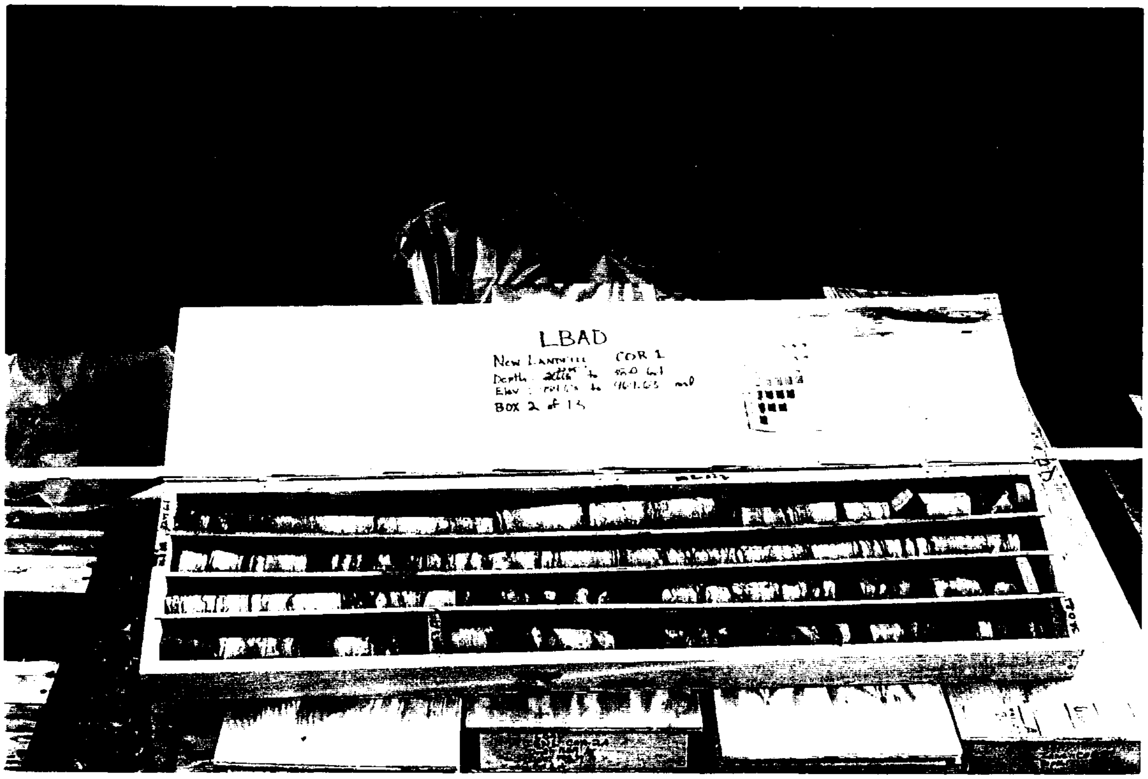
PAGE *6* OF *6*

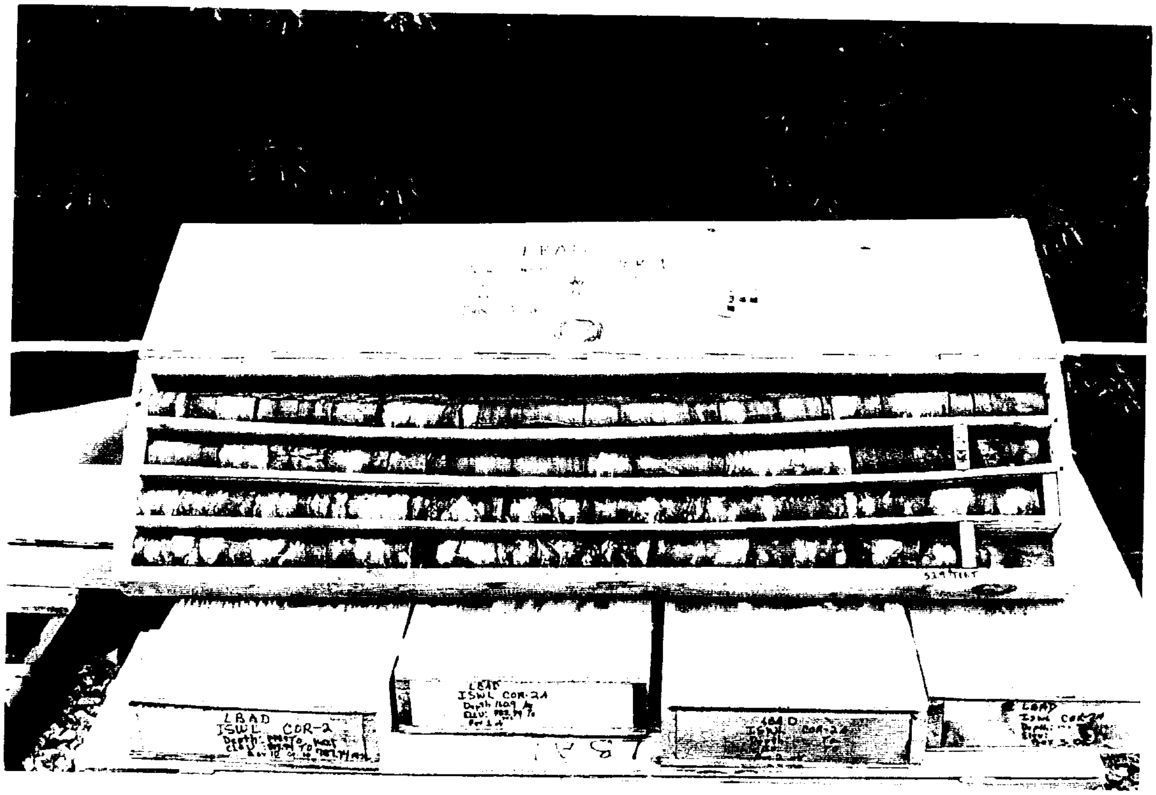
RQD.	REC	ROCK STRUCTURE	WEATHERING	FIELD HARDNESS	DISCONTINUITIES								REMARKS
7580					TYPE	SKETCH	DIP ANGLES	SHAPE	ROUGHNESS	COATINGS - INFILLINGS	LONGEST CORE PIECE (In)	SPACING	
		nodular to Horizontal	None	Hard									
		Nodular to Horizontal	None	Hard									
		Semi-nodular Horizontal	None	Hard									

LOGGED BY ______________________

CORE-1
NEW LANDFILL
8 feet to 185.3 Feet



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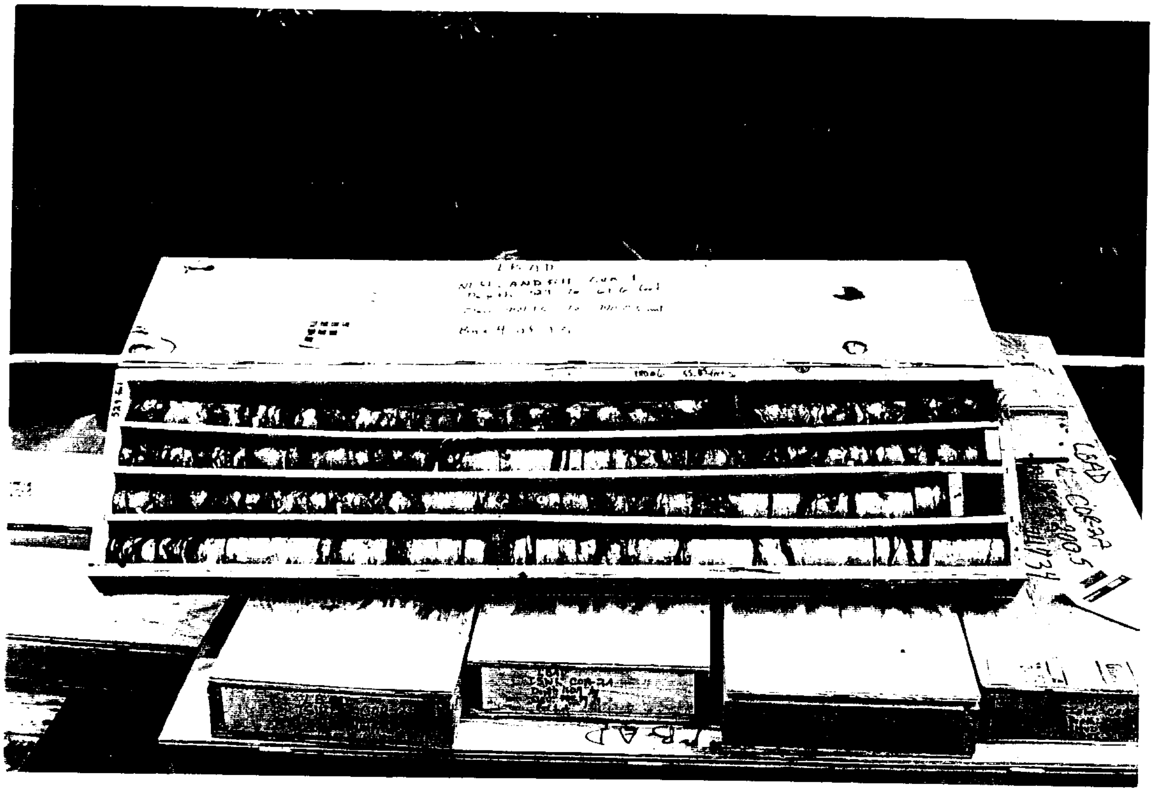
ISWL COR-2
LBAD
ISWL COR-2A
LBAD
ISWL COR-2A
LBAD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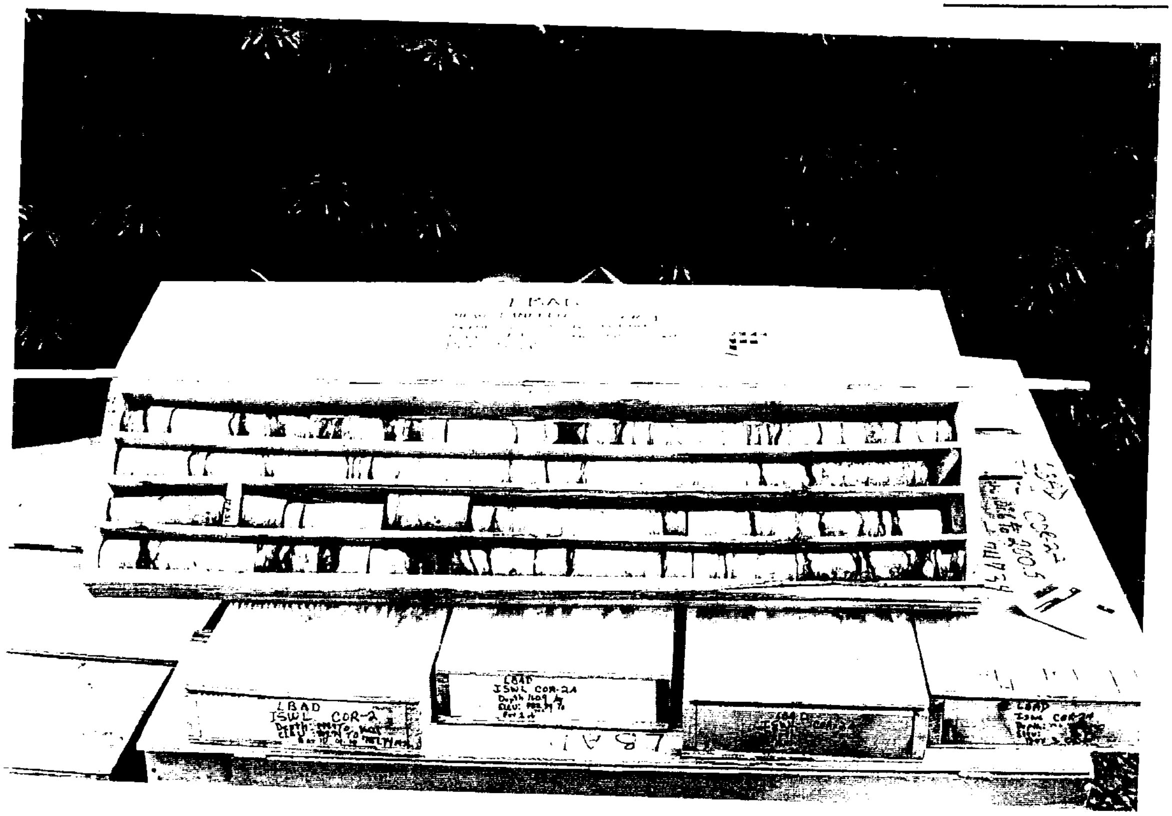
LBAD
COR-2A
LBAD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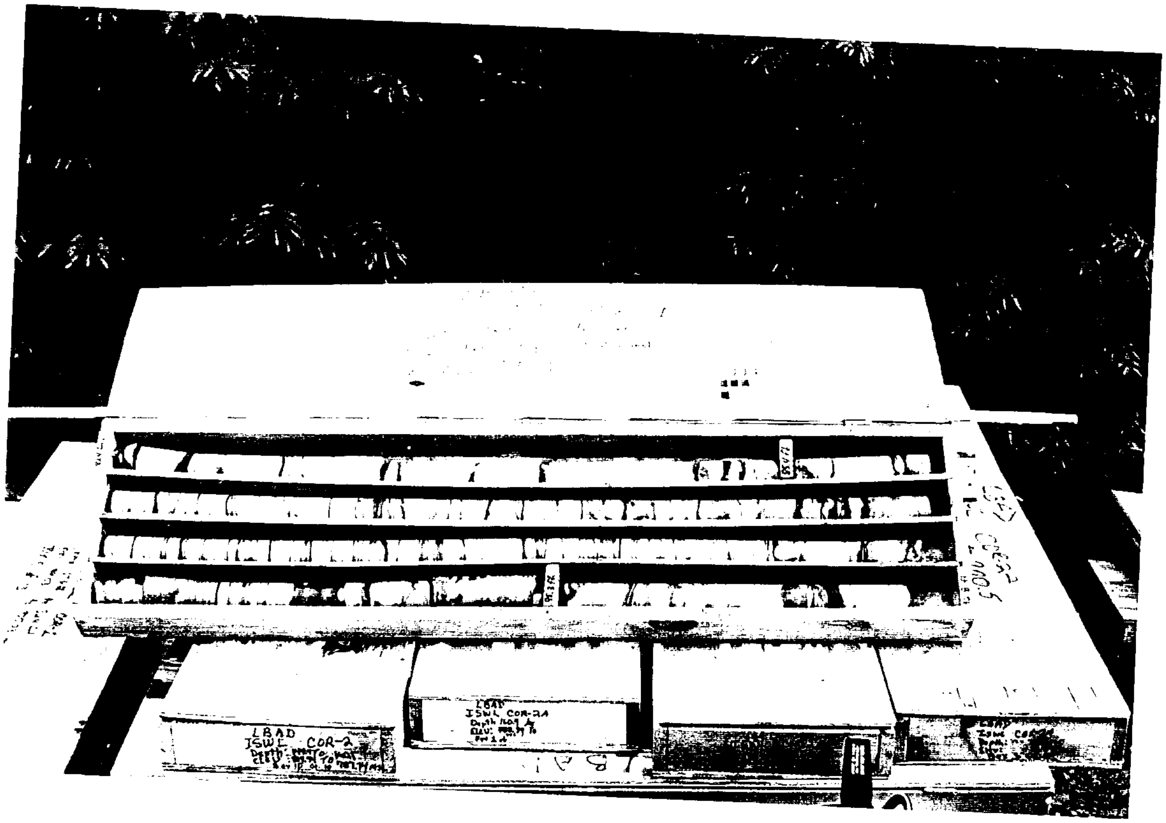
LBAD
ISWL COR-2A
LBAD
ISWL COR-2A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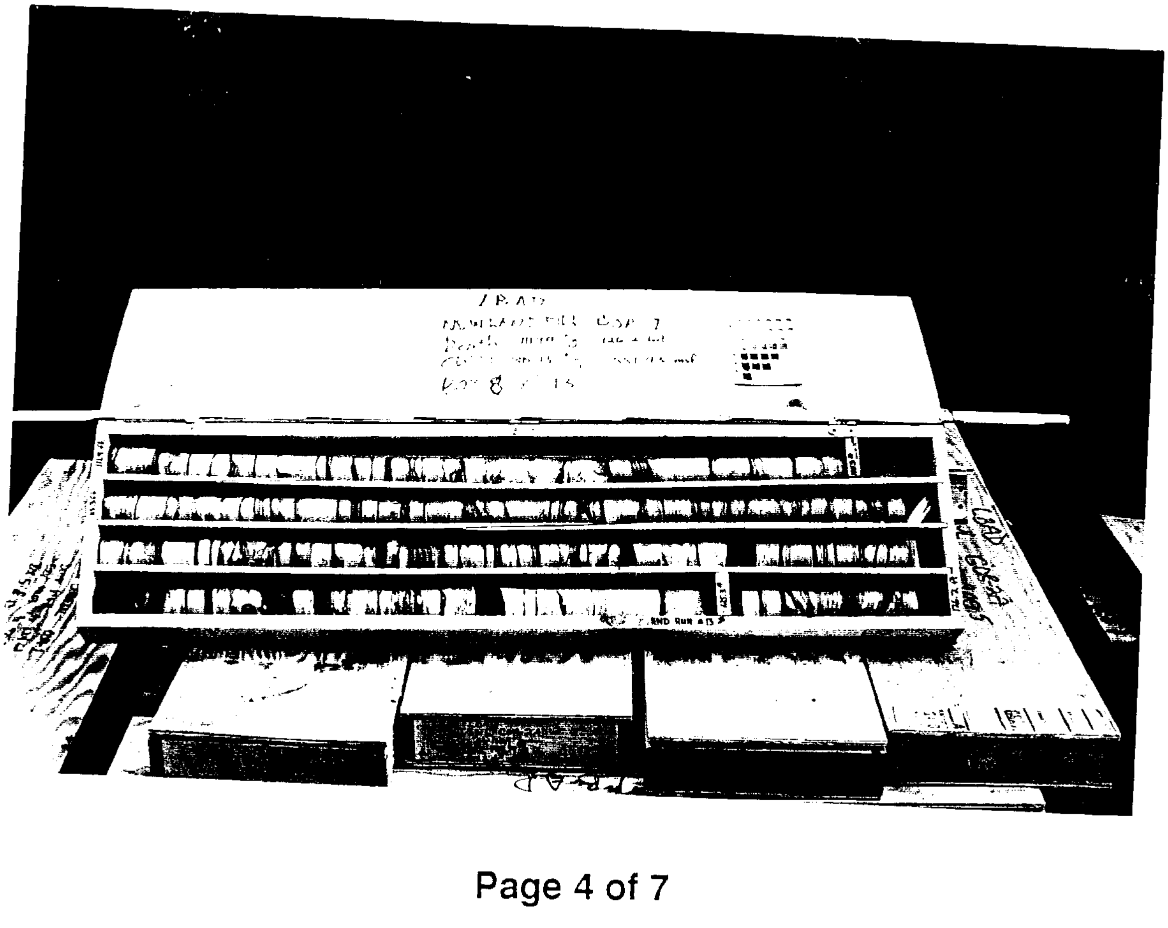
ISWL COR-2
LBAD
ISWL COR-2A
LBAD
ISWL COR-2A


LBAD
ISWL COR-2A
LBAD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END RUN #13
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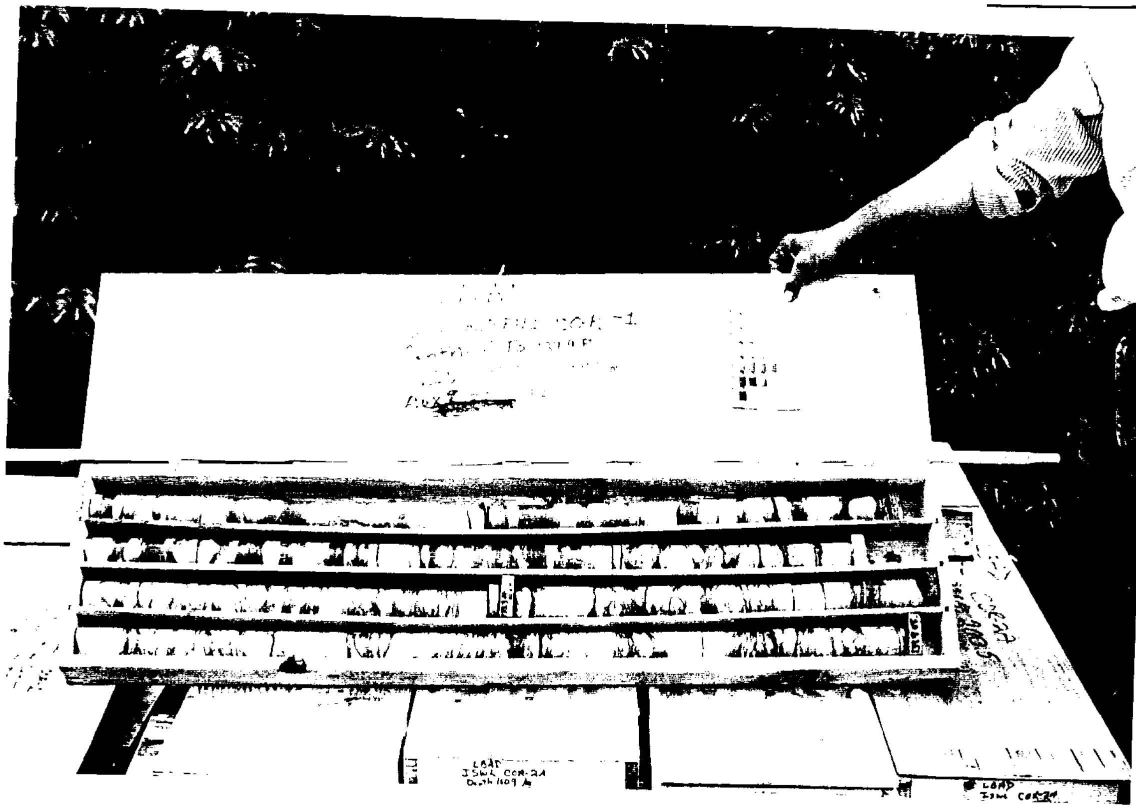
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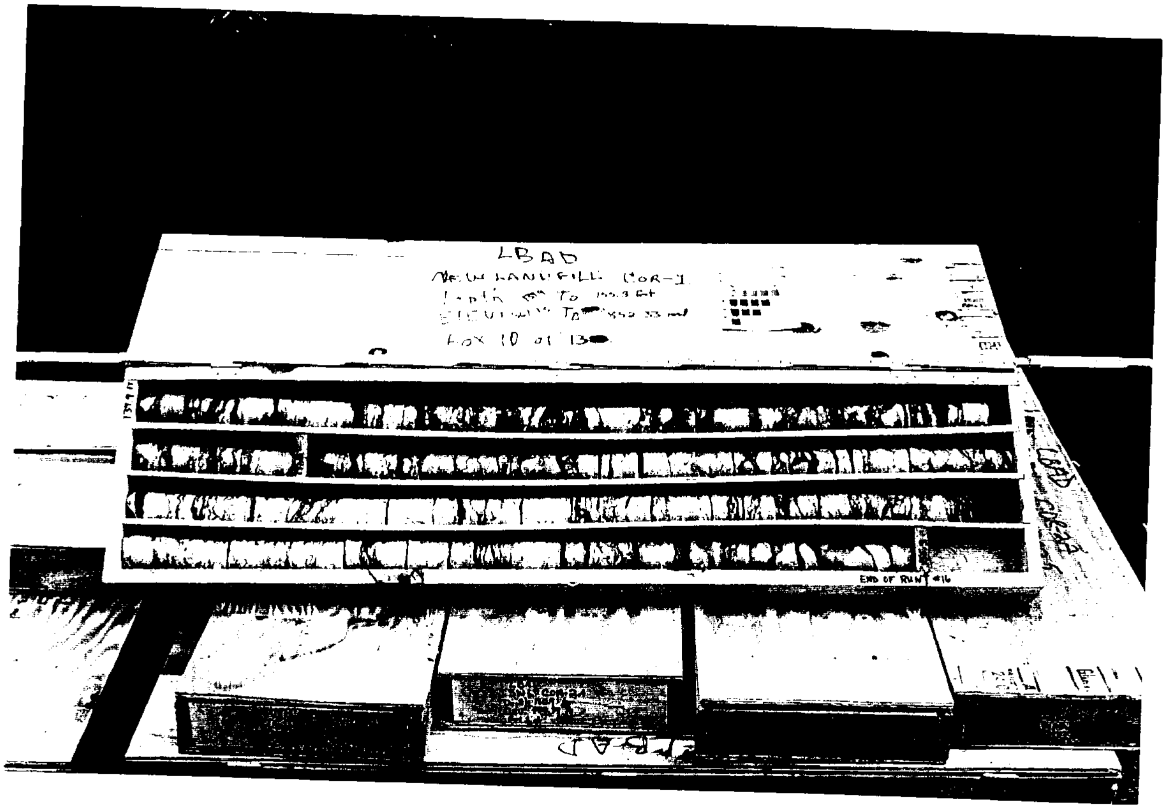
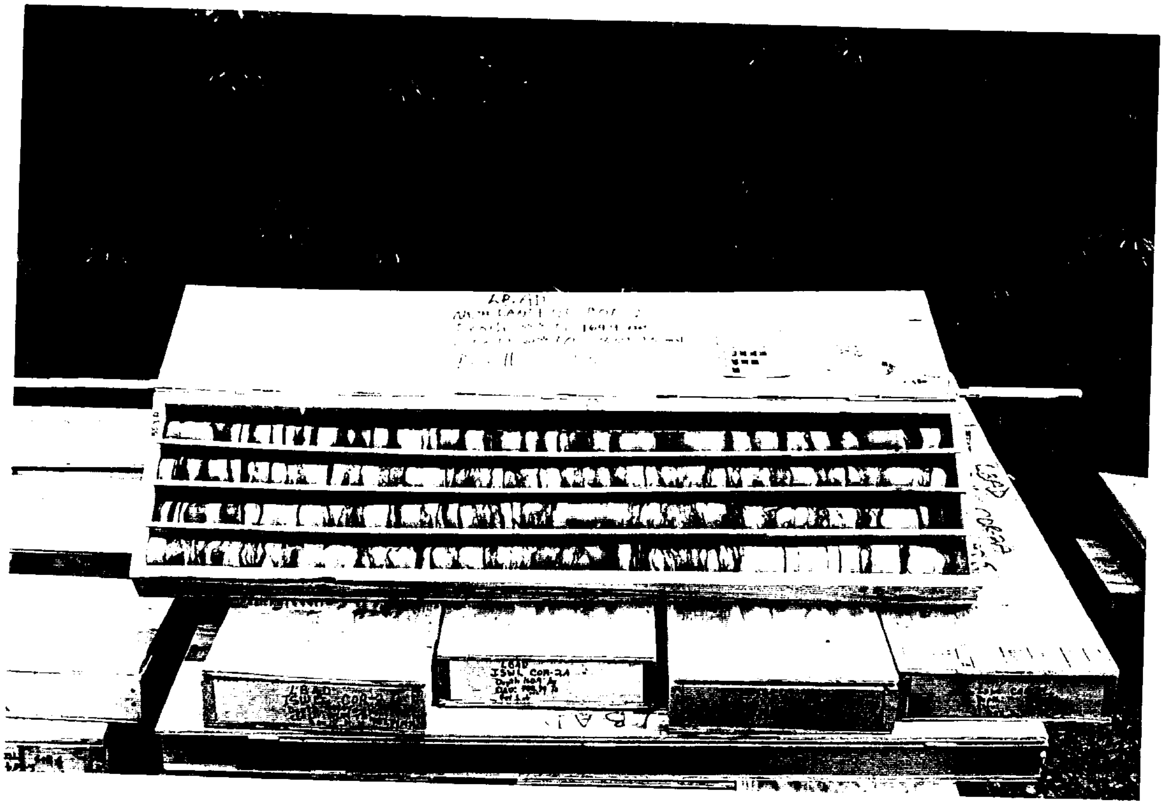
ISWL COR-2A
Depth 1109 ft
LBAD
ISWL COR-2A


LBAD
NEW LANDFILL COR-1
Box 10 of 13
END OF RUN #16
LBAD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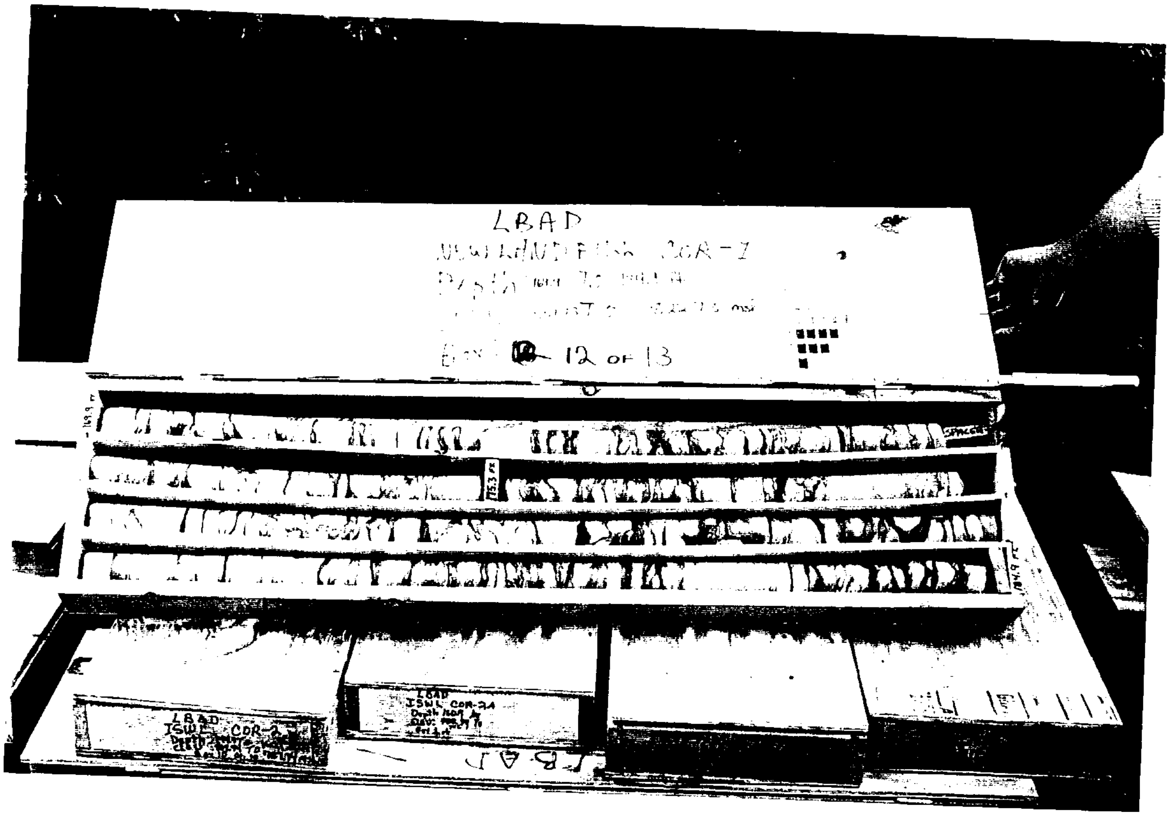
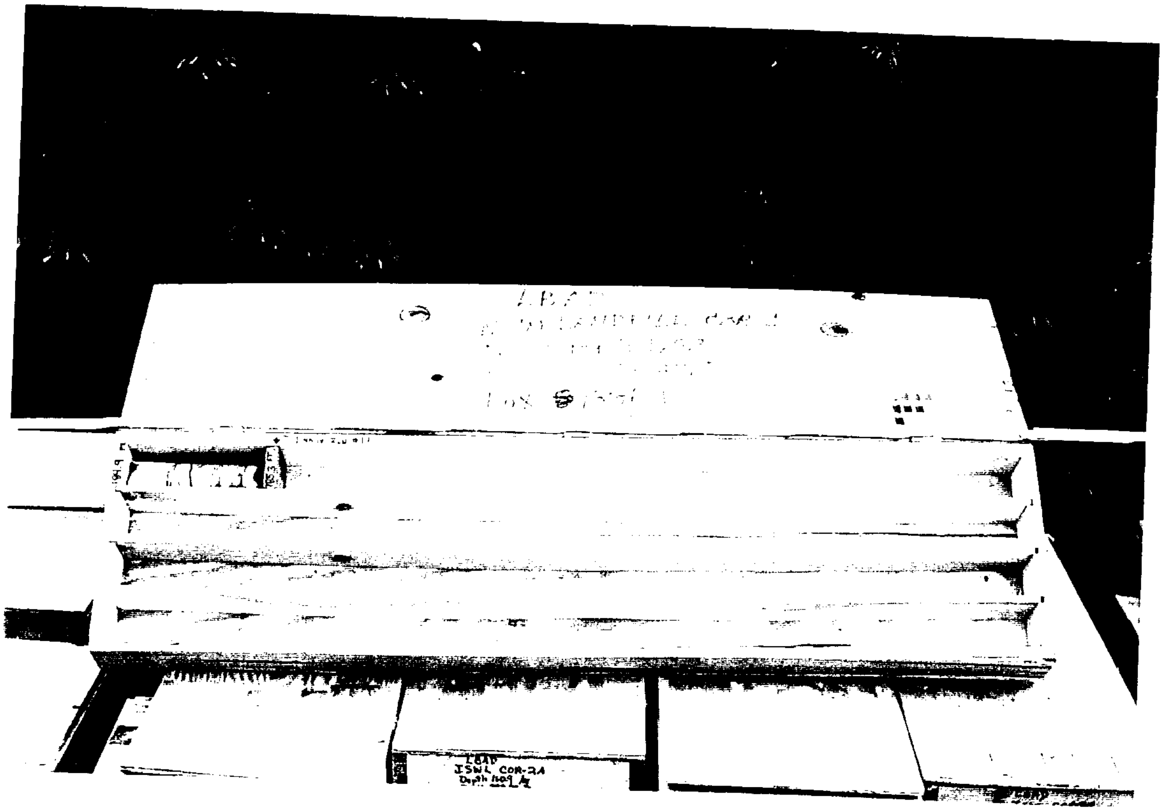
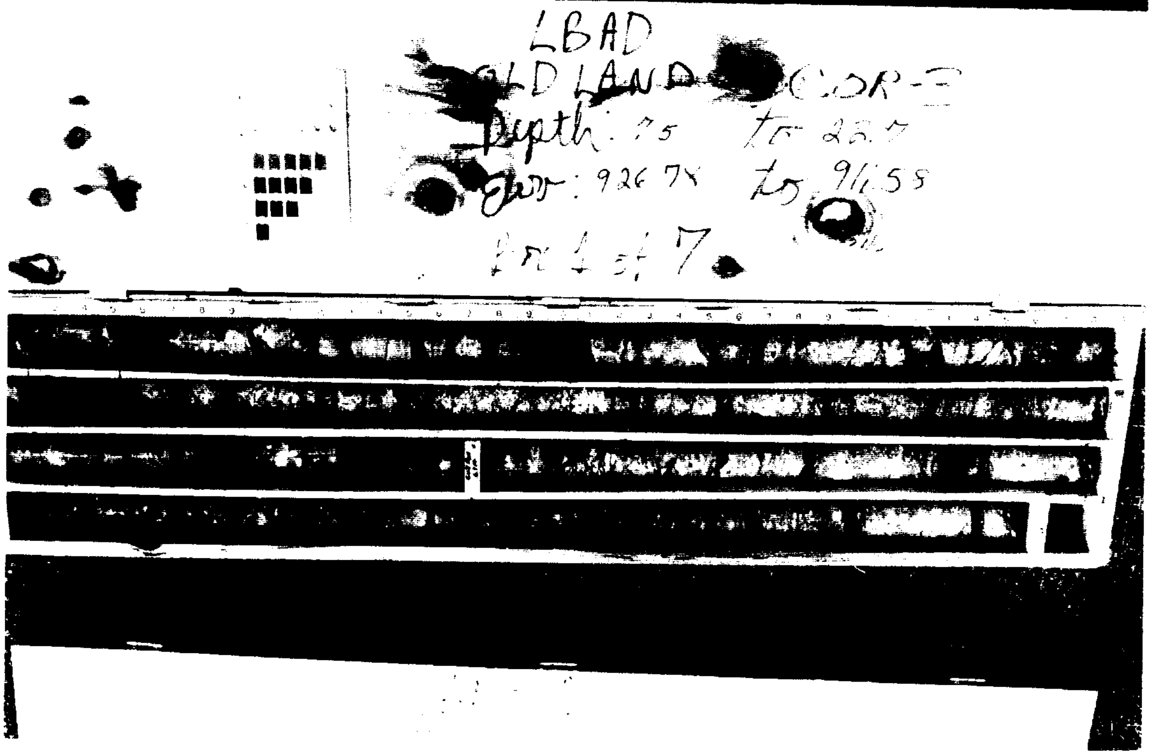
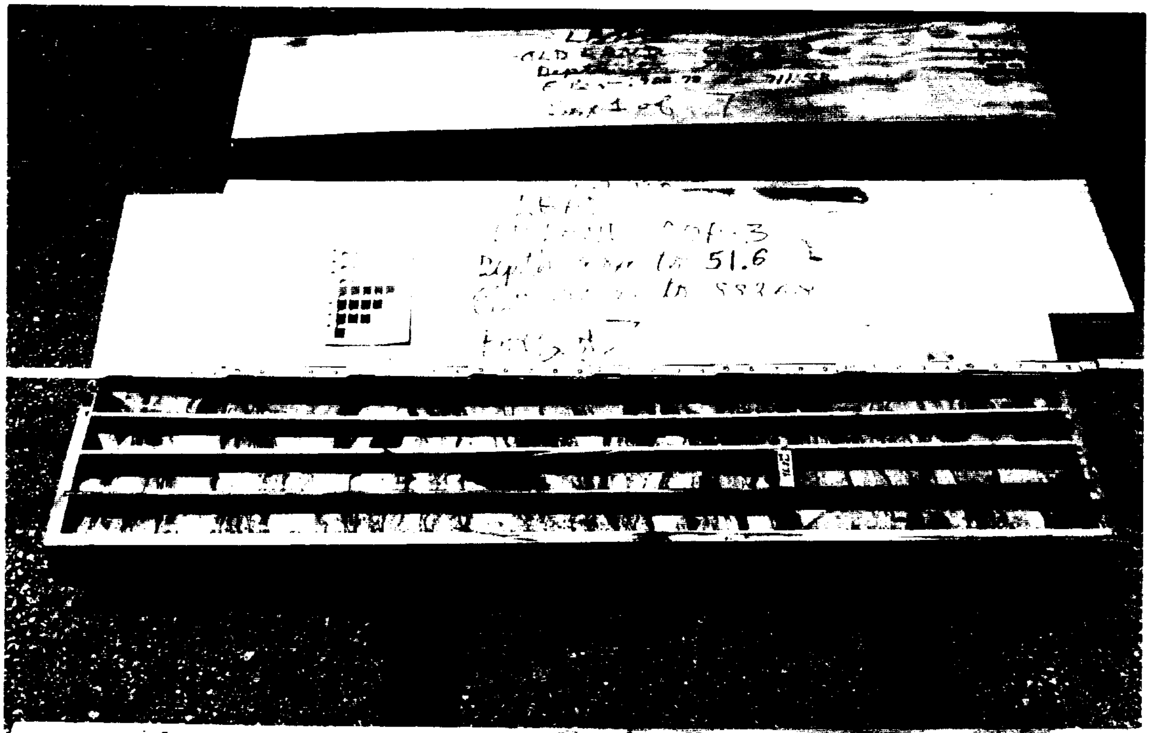
LBAD
LBAD
ISWL COR-2A


LBAD
COR-2
Box 12 of 13
SPACER
LBAD
ISWL COR-2
LBAD
ISWL COR-2A
LBAD


LBAD
LBAD
ISWL COR-2A

CORE-3
OLD LANDFILL
7.5 feet to 106.8 feet





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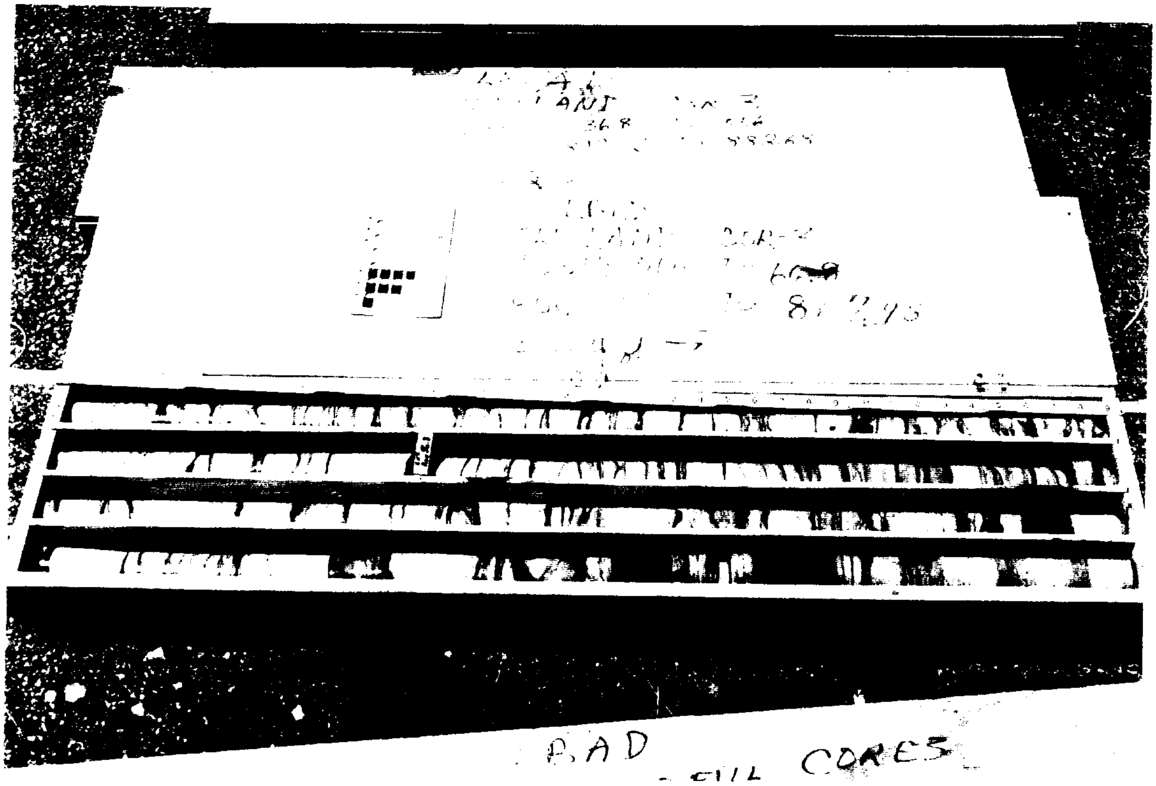
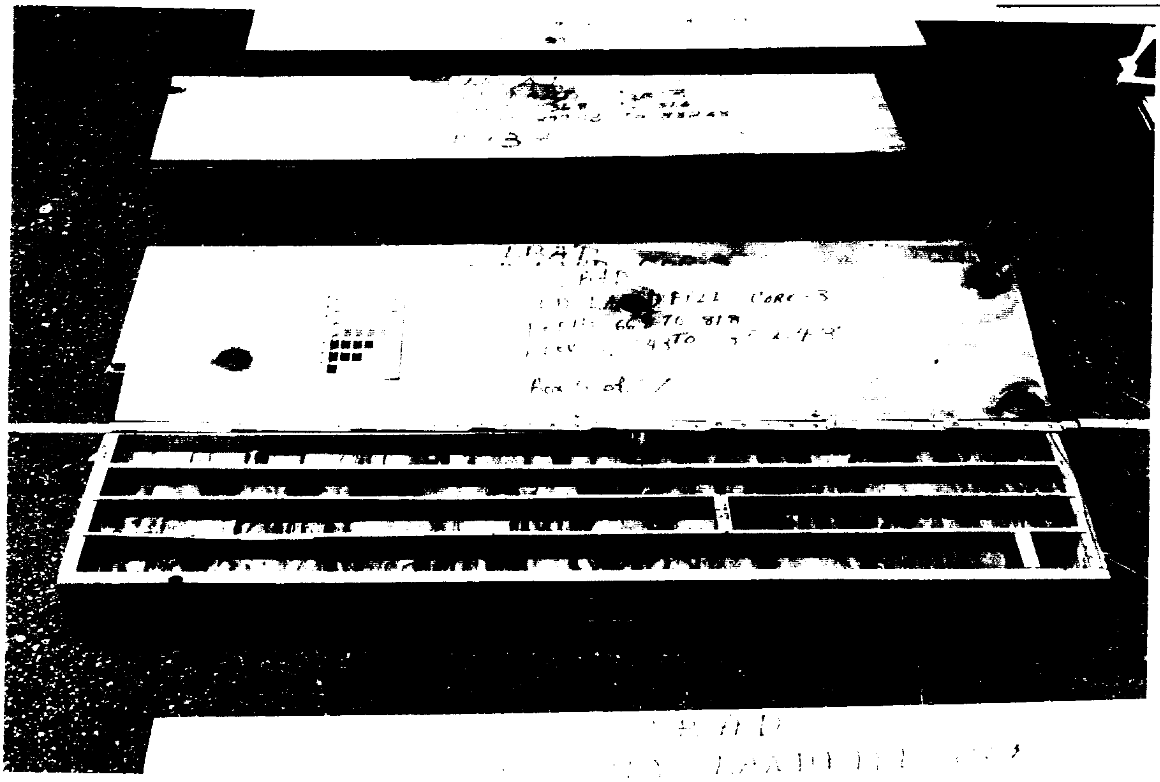
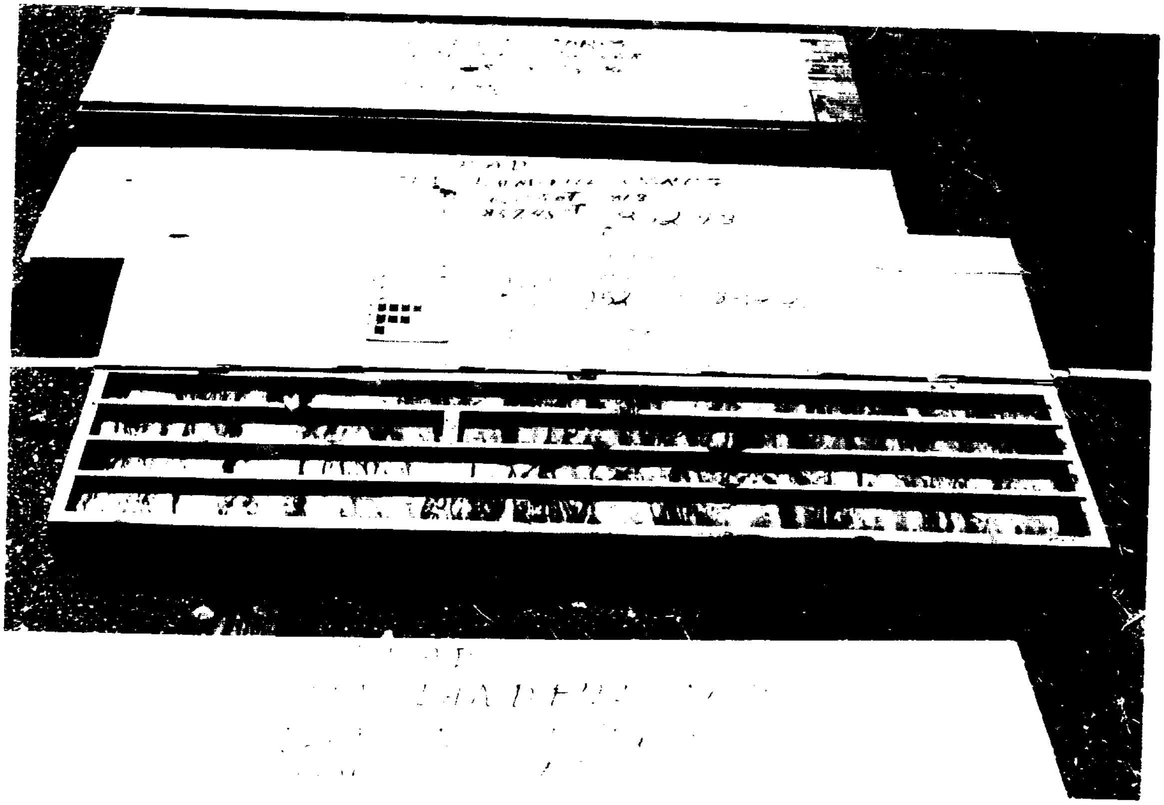
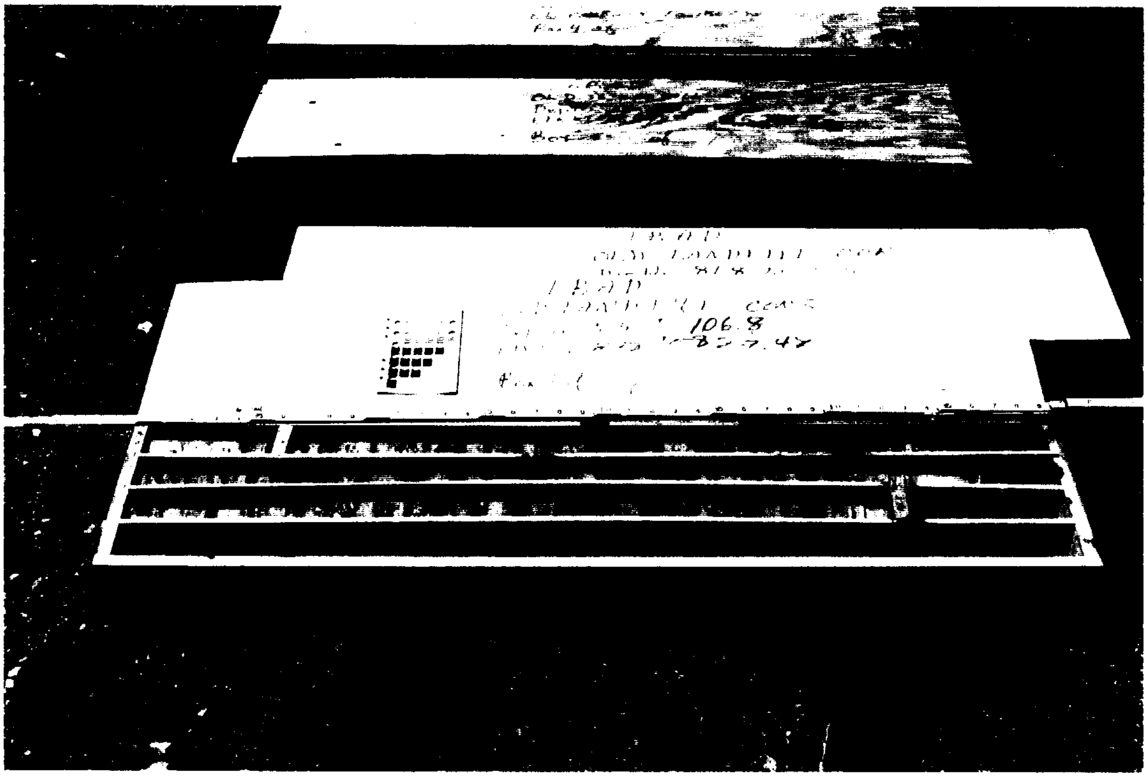


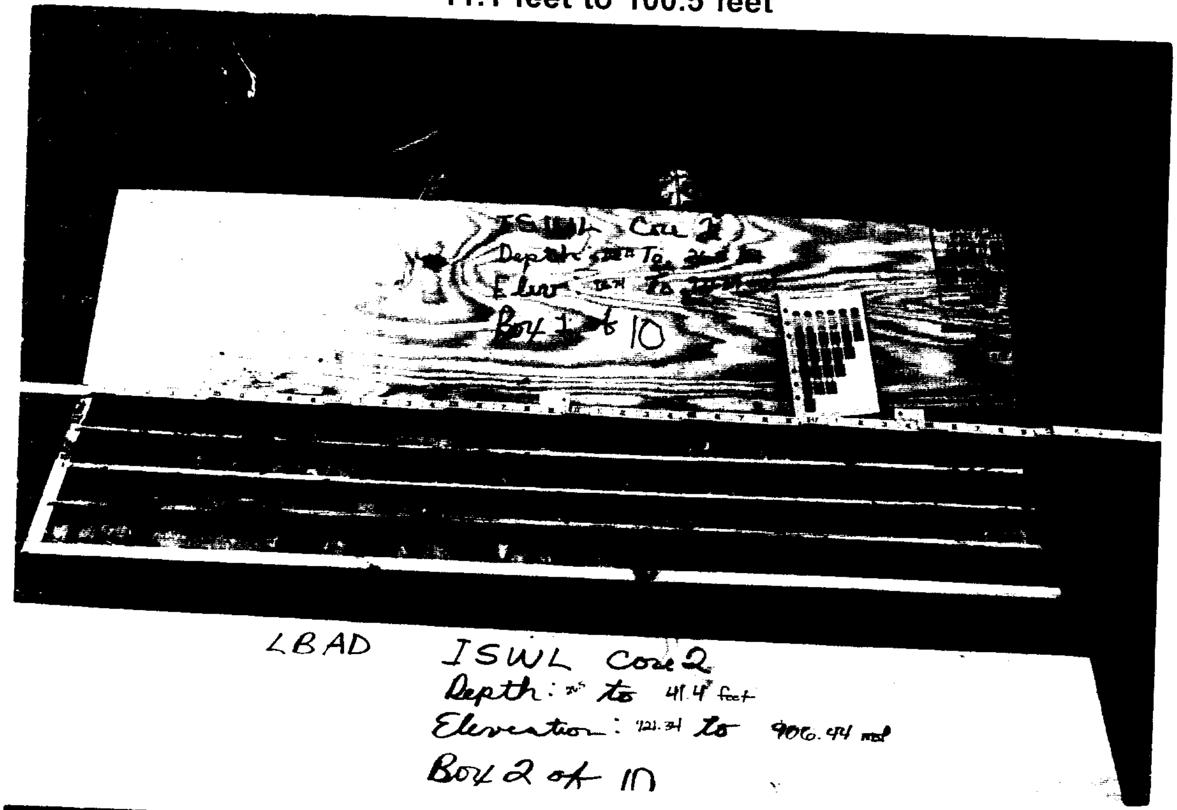
B.A.D - soil CORES





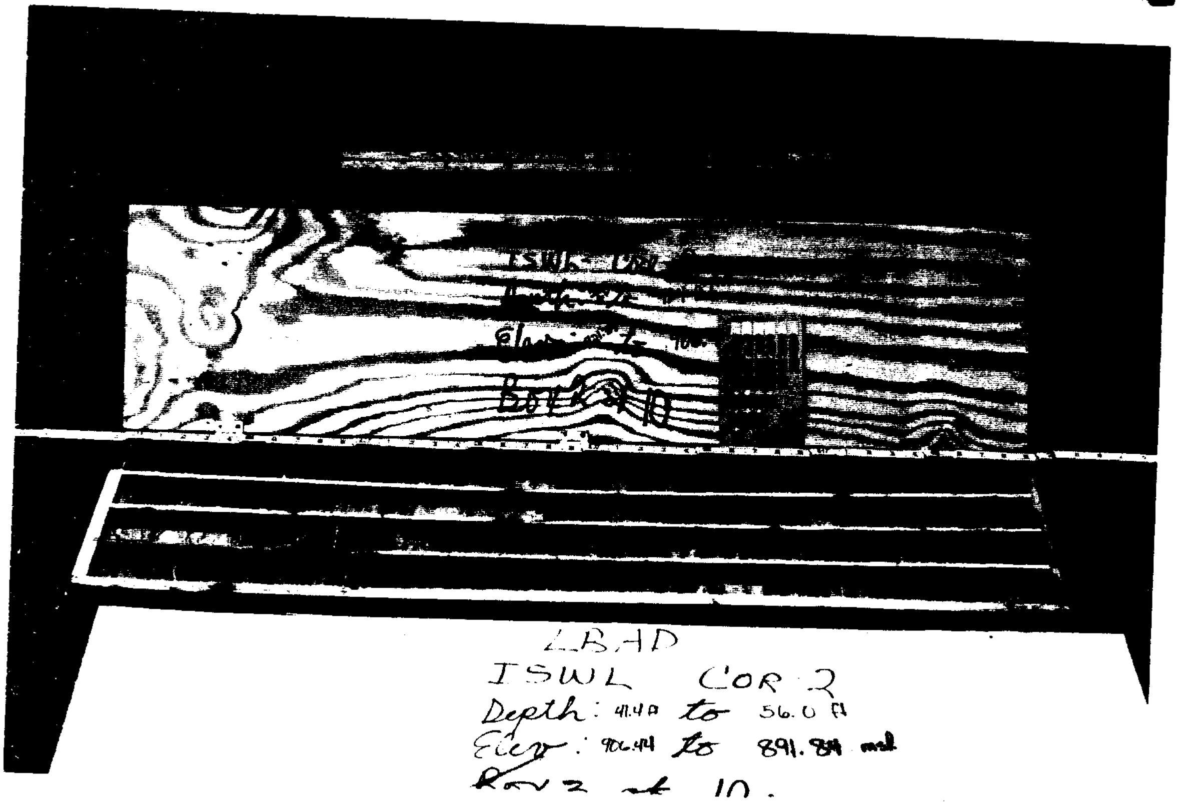

106.8

CORE-2
INDUSTRIAL AND SANITARY WASTE LANDFILL
11.1 feet to 100.5 feet



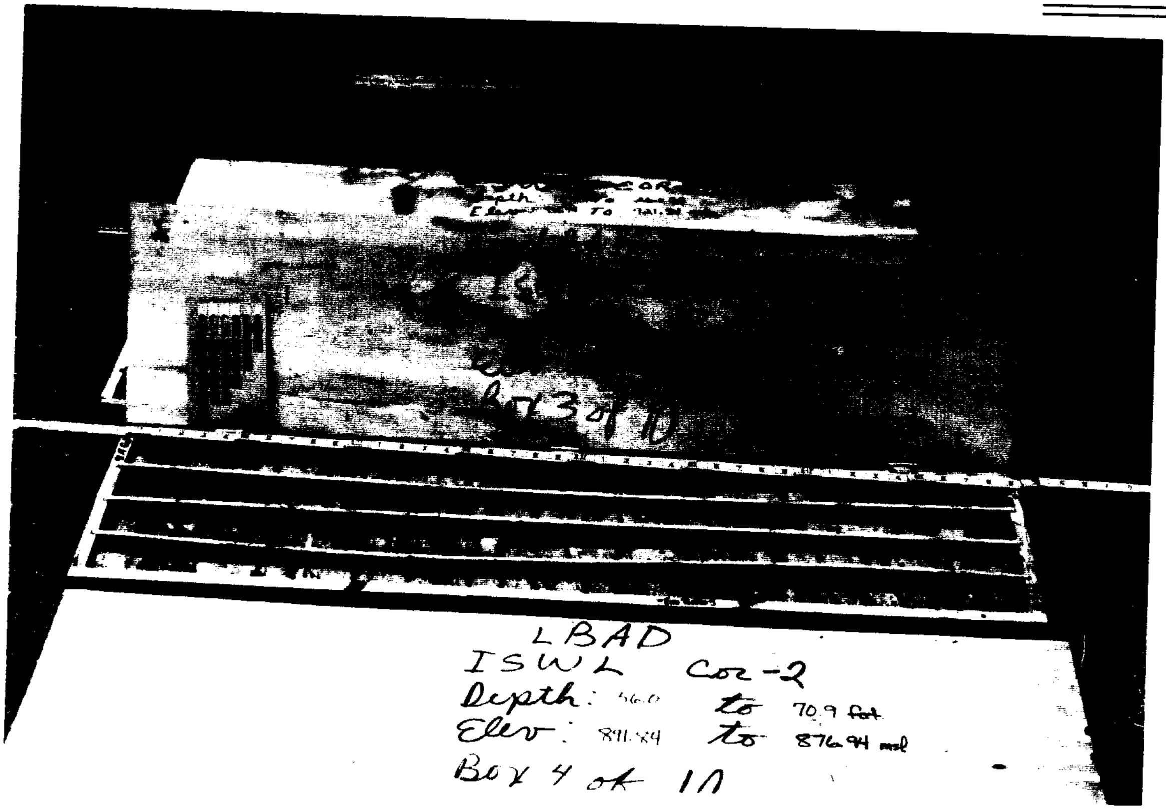
LBAD

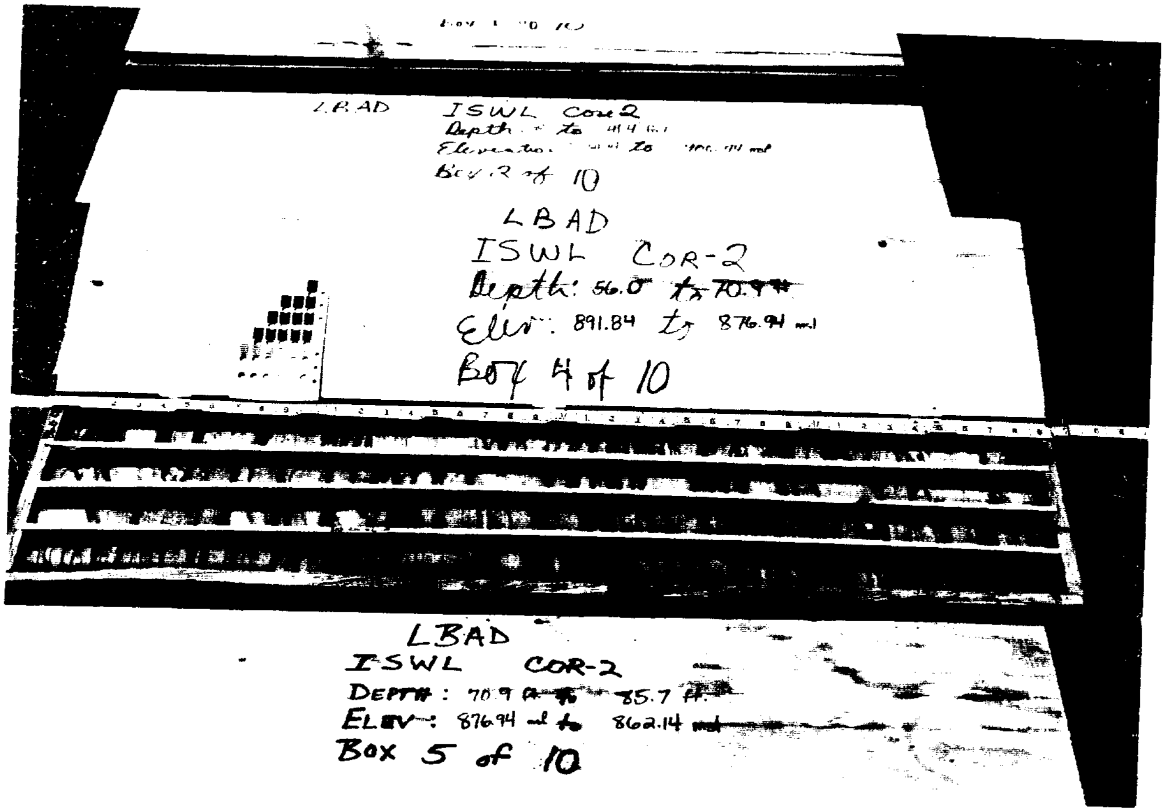
ISWL Core 2
Depth: 26.5 to 41.4 feet
Elevation: 921.34 to 906.44 msl
Box 2 of 10

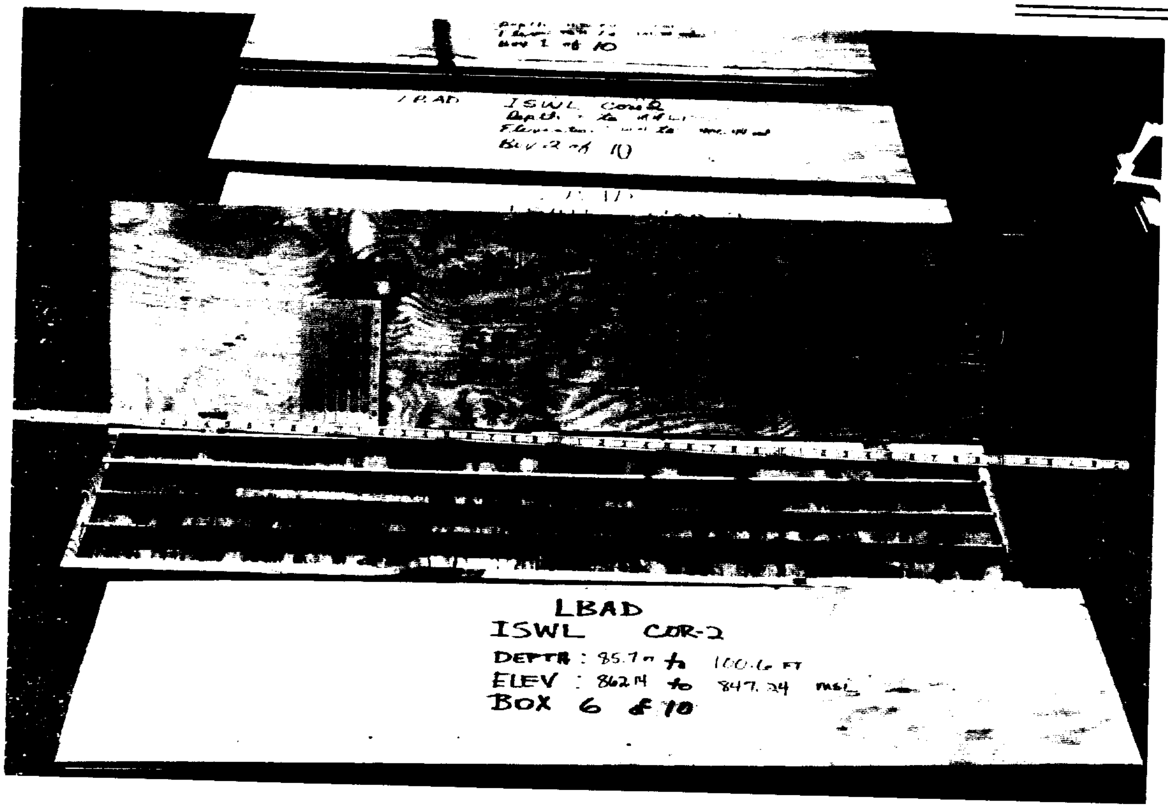


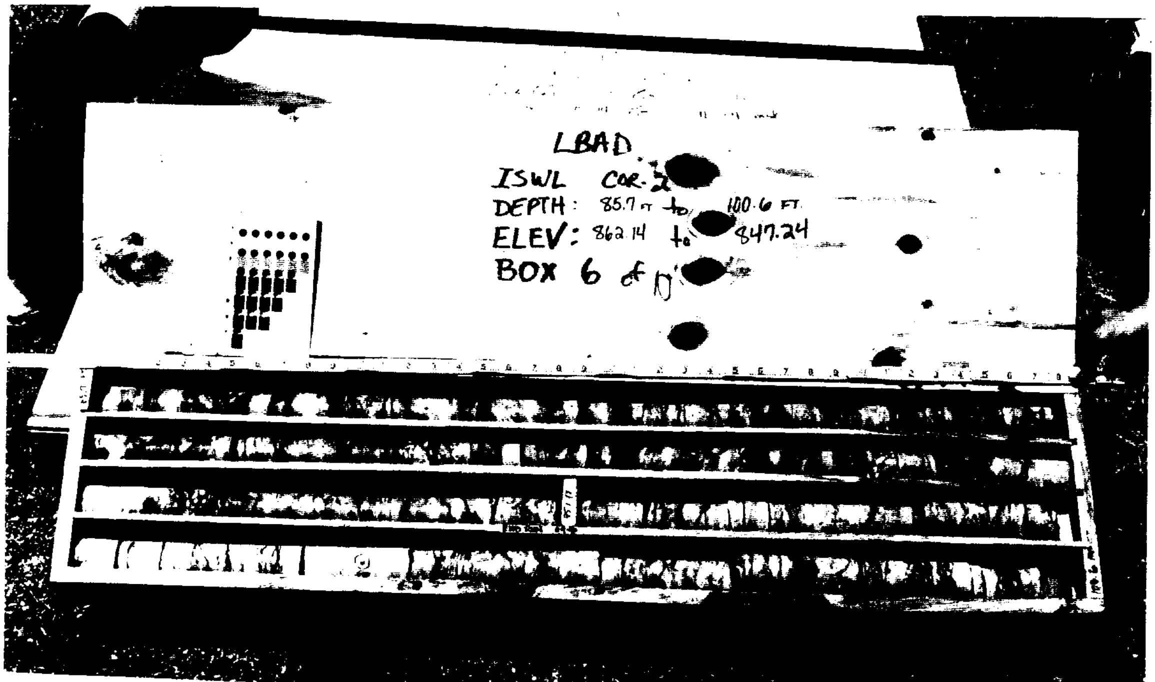
LBAD

ISWL COR 2
Depth: 41.4 ft to 56.0 ft
Elev: 906.44 to 891.84 msl
Box 3 of 10.

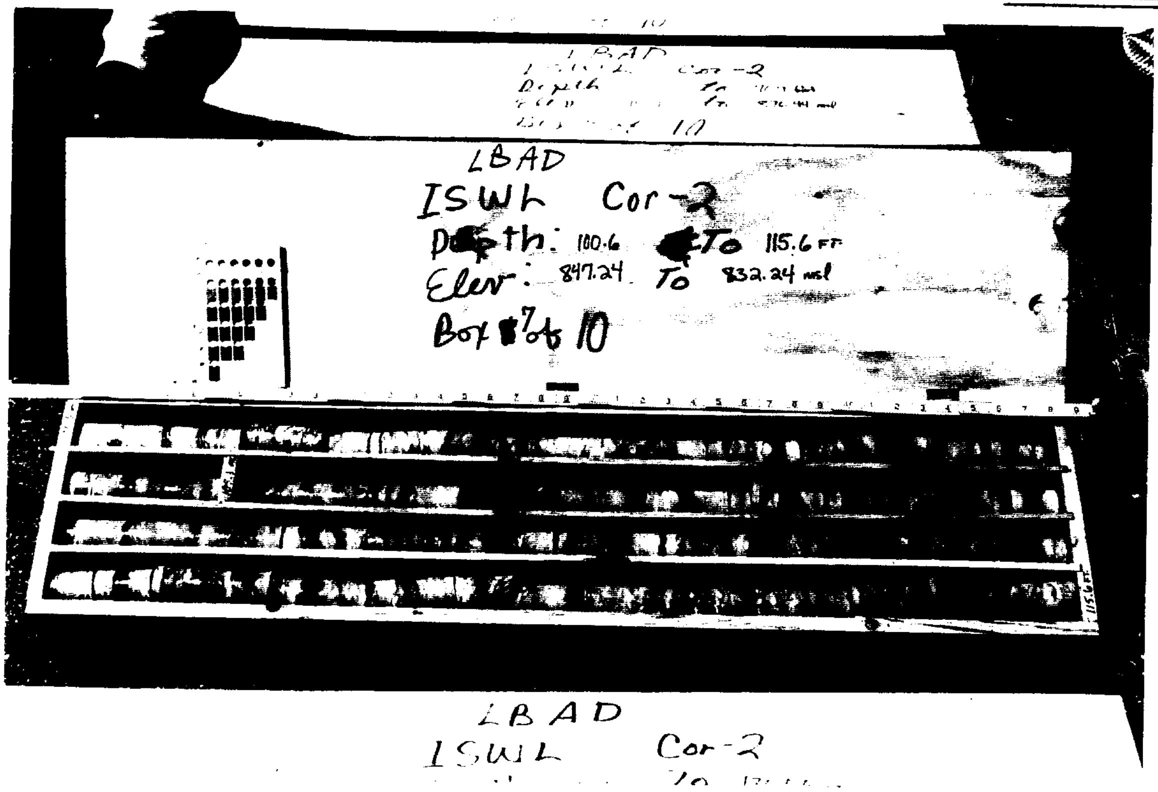

Box 3 of 10
LBAD
ISWL Cor-2
Depth: 56.0 to 70.9 feet
Elev: 891.84 to 876.94 msl
Box 4 of 10

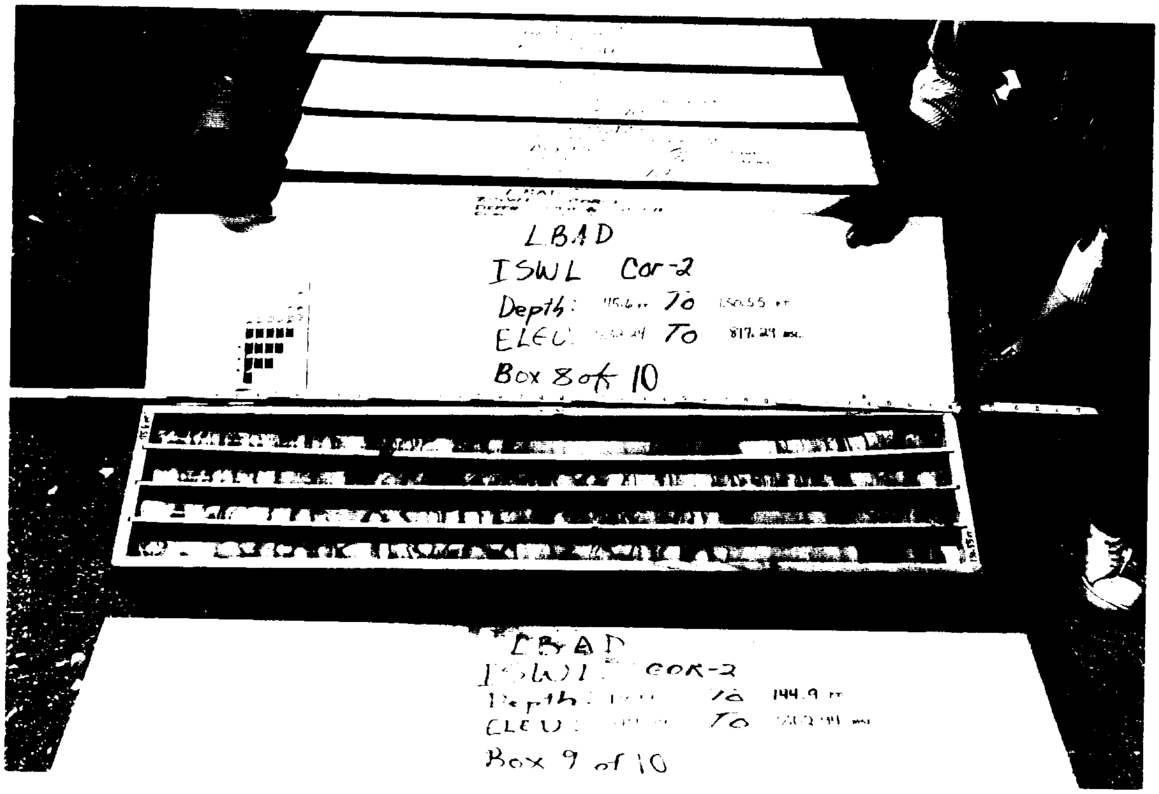

LBAD ISWL Core 2
Box 2 of 10
LBAD
ISWL COR-2
Depth: 56.0 to 70.9 ft
Elev: 891.84 to 876.94 msl
Box 4 of 10
LBAD
ISWL COR-2
DEPTH: 70.9 ft to 85.7 ft
ELEV: 876.94 msl to 862.14 msl
Box 5 of 10

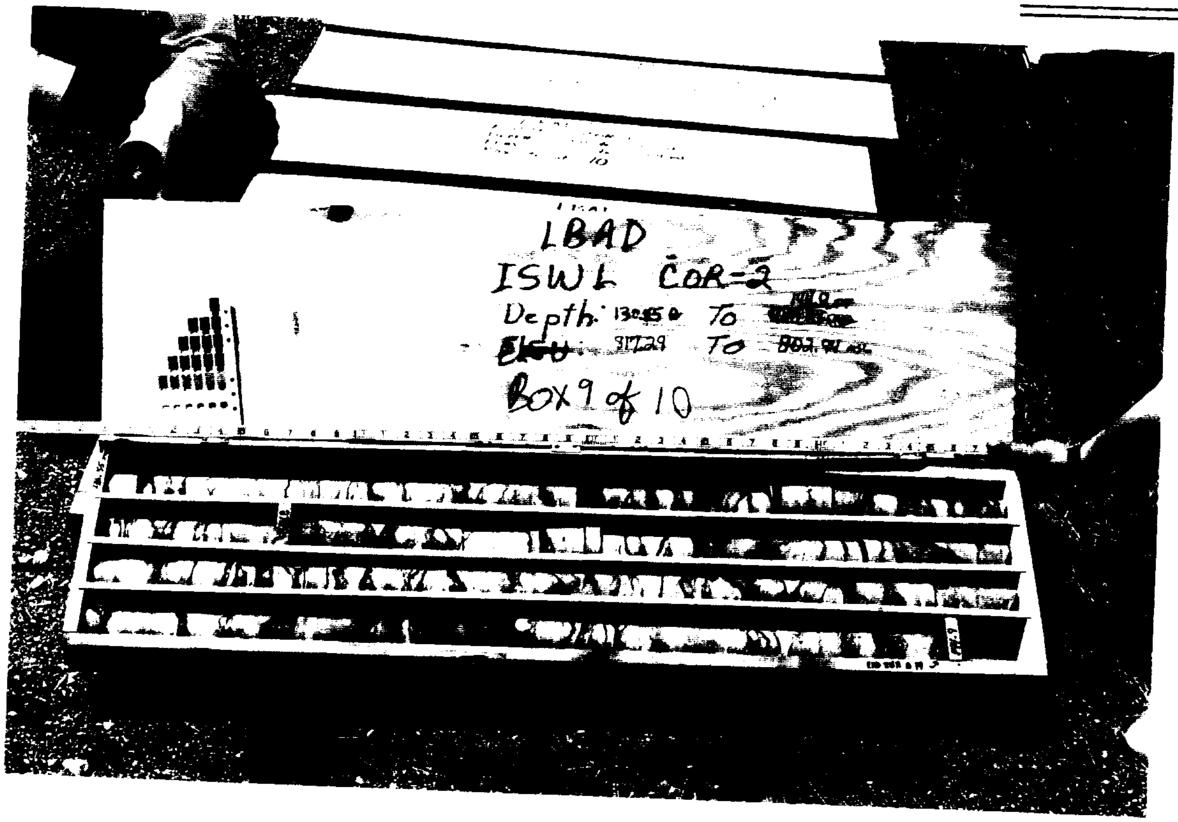


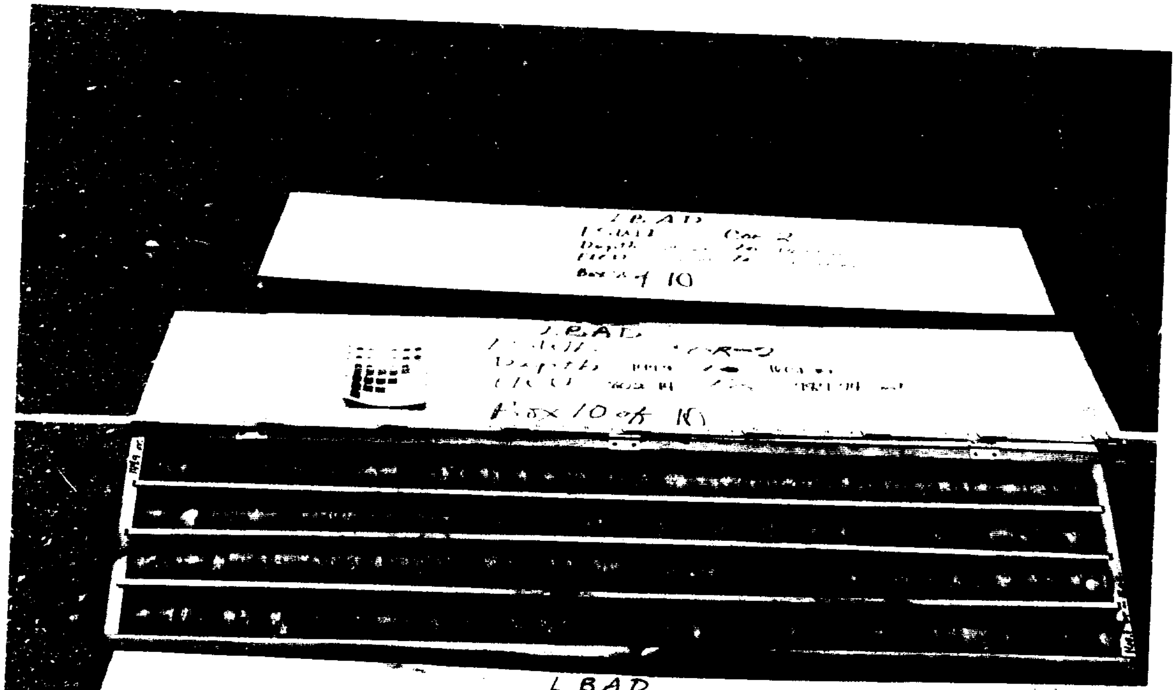


LBAD
ISWL Cor-2

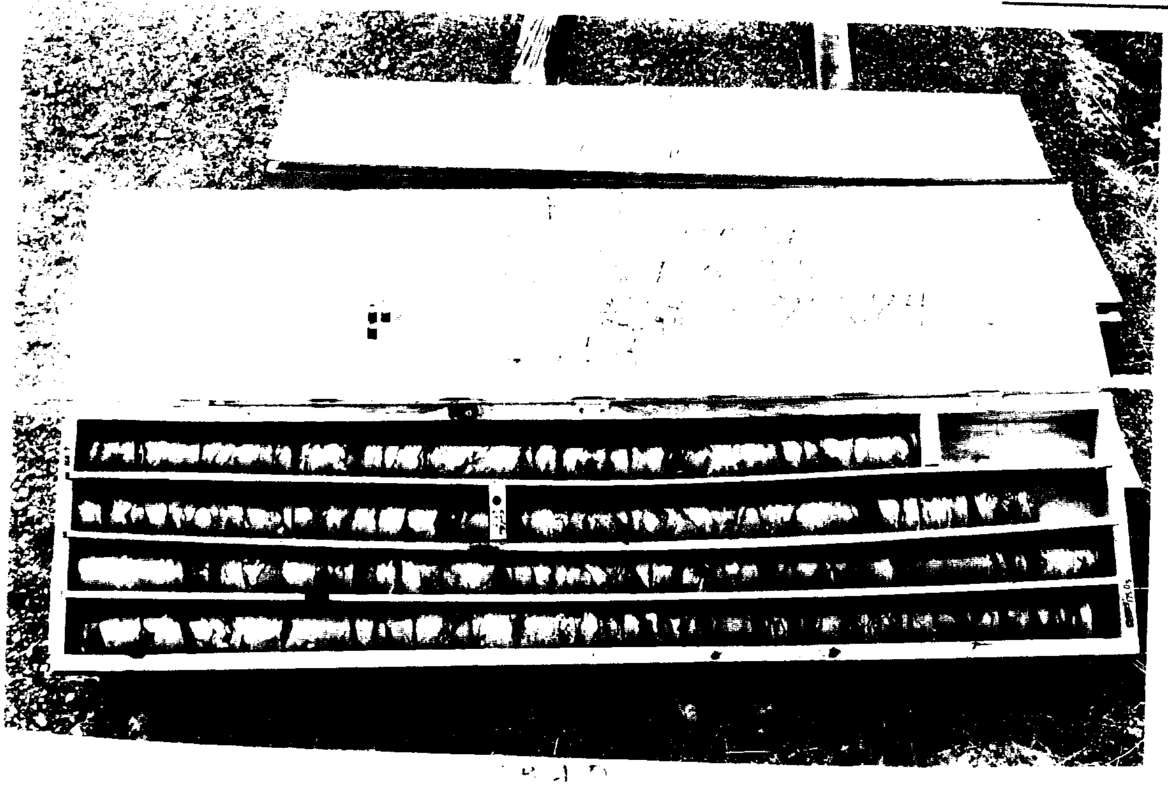

LBAD
ISWL Cor-2
Depth: 100.6 To 115.6 FT
Elev: 847.24 To 832.24 msl
Box 7 of 10
115.6 FT
LBAD
ISWL Cor-2

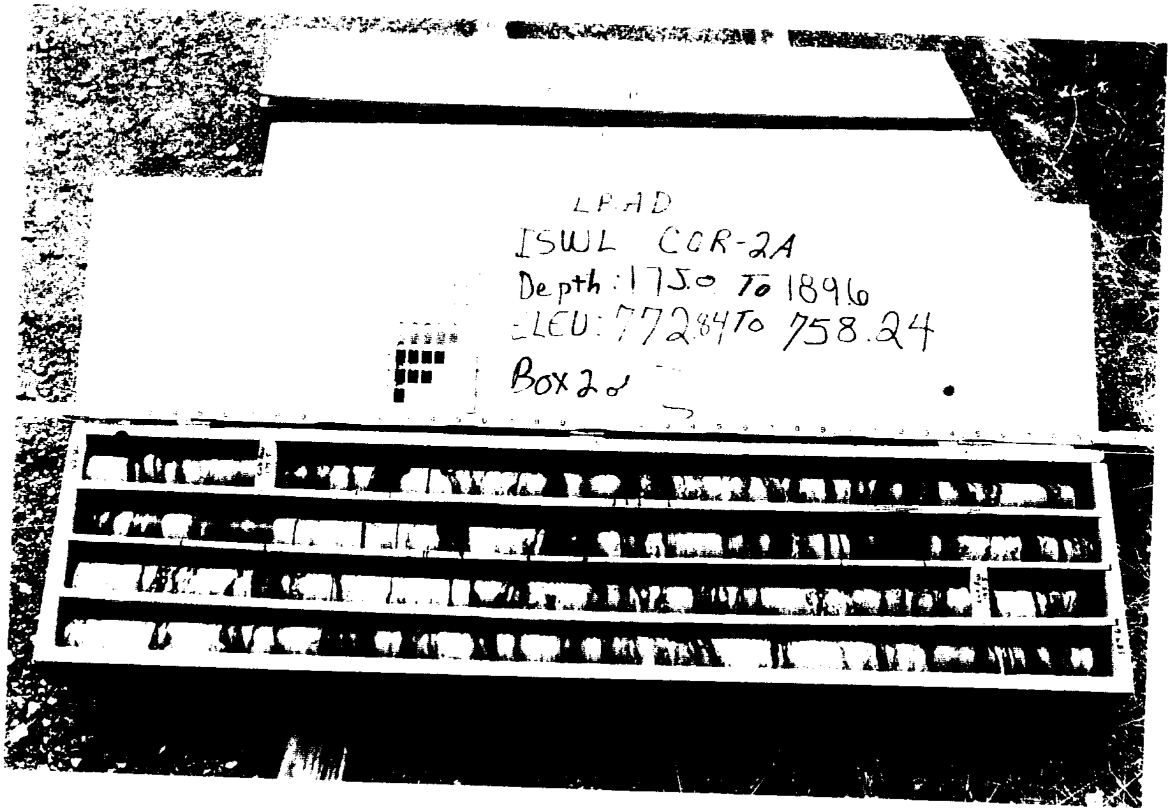

LBAD
ISWL Cor-2
Depth: 115.6 FT To 130.55 FT
ELEV: 832.24 To 817.24 msl
Box 8 of 10
LBAD
ISWL COR-2
Depth: To 144.9 FT
ELEV: To msl
Box 9 of 10

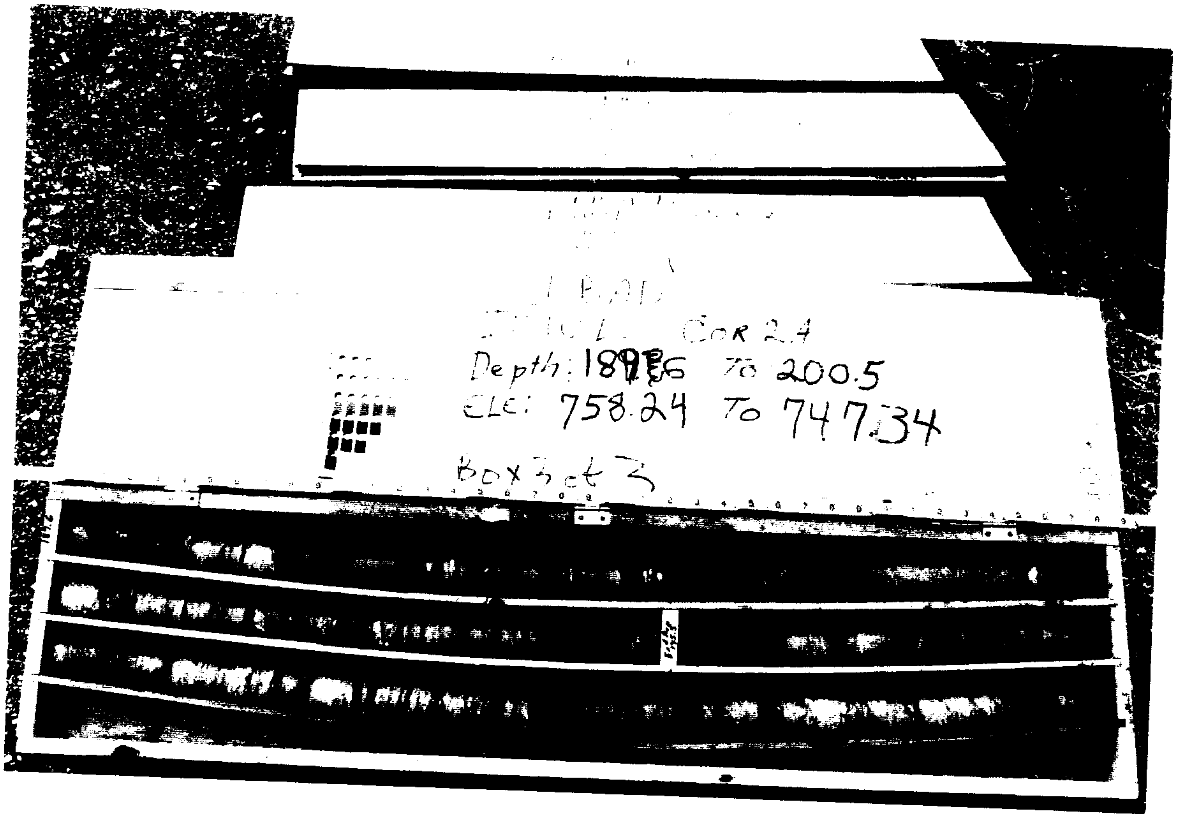




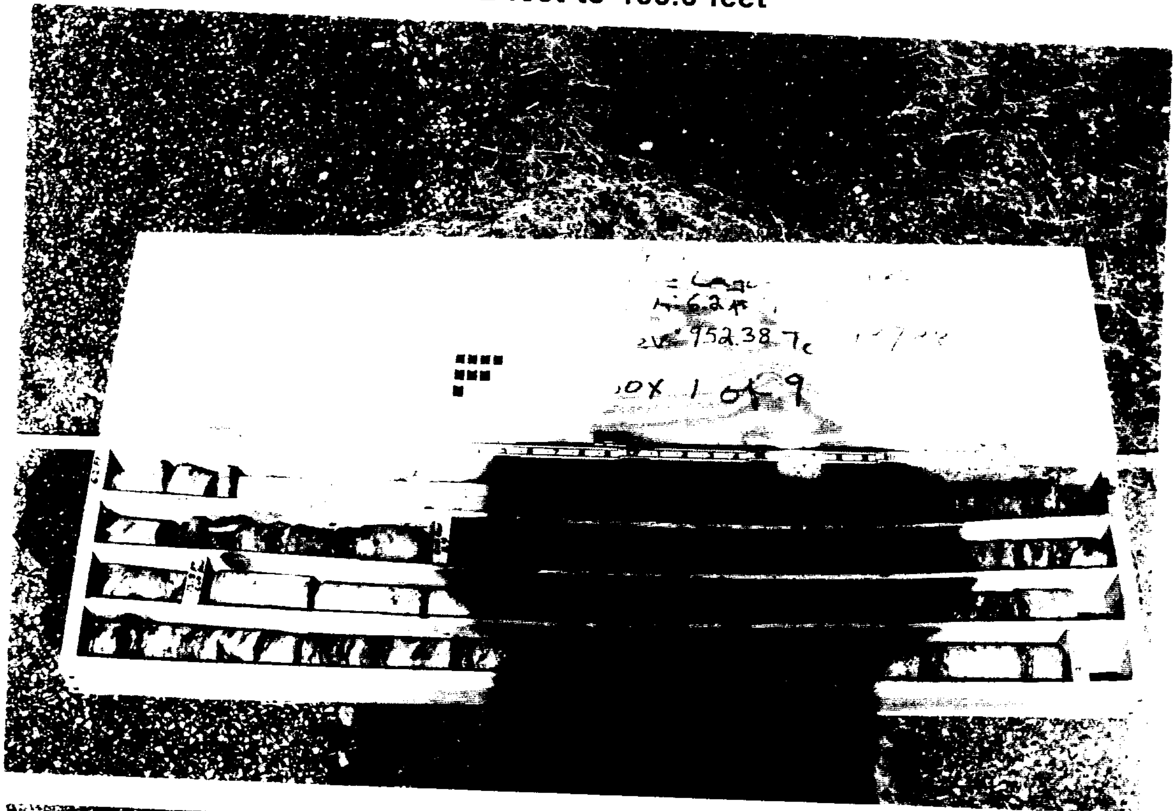
LBAD
ISWL COR-2A
Depth: 160.9 To 175.0
ELEV: ~~787.34~~ 786.94 TO 772.84

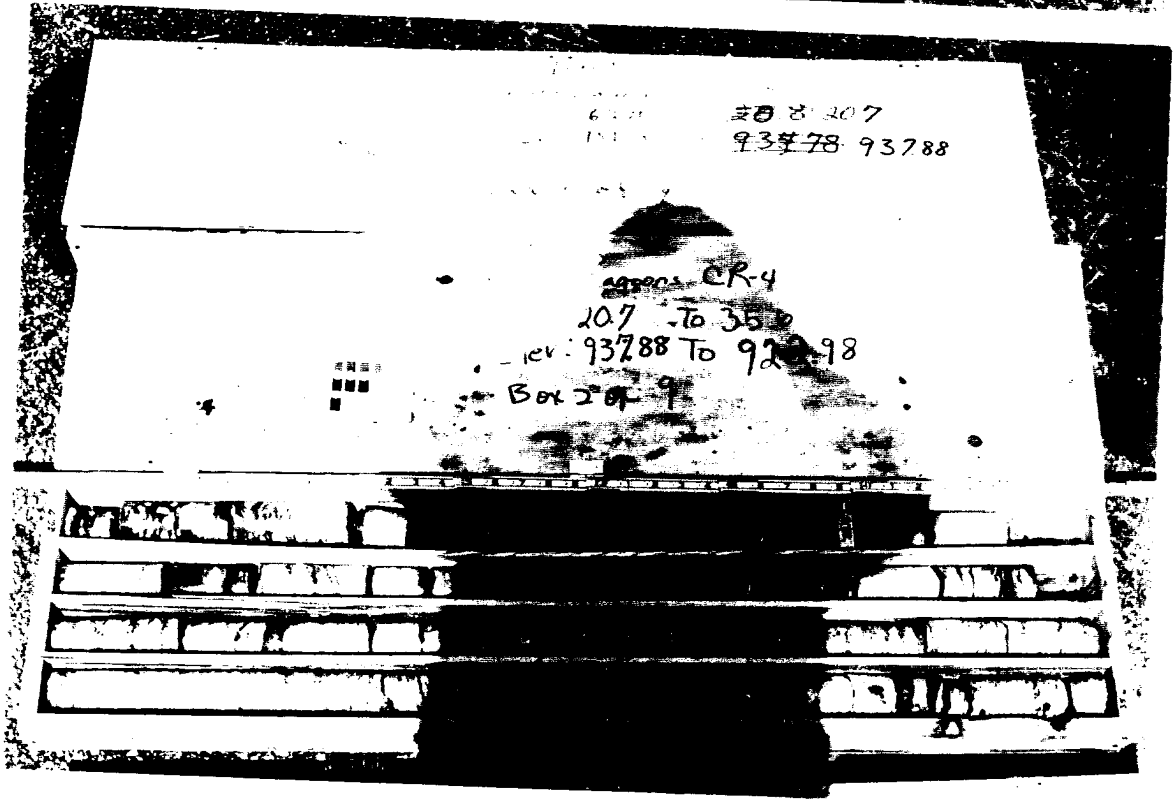



LPAD
ISWL CCR-2A
Depth: 175.0 To 189.6
ELEV: 772.84 To 758.24
Box 2a

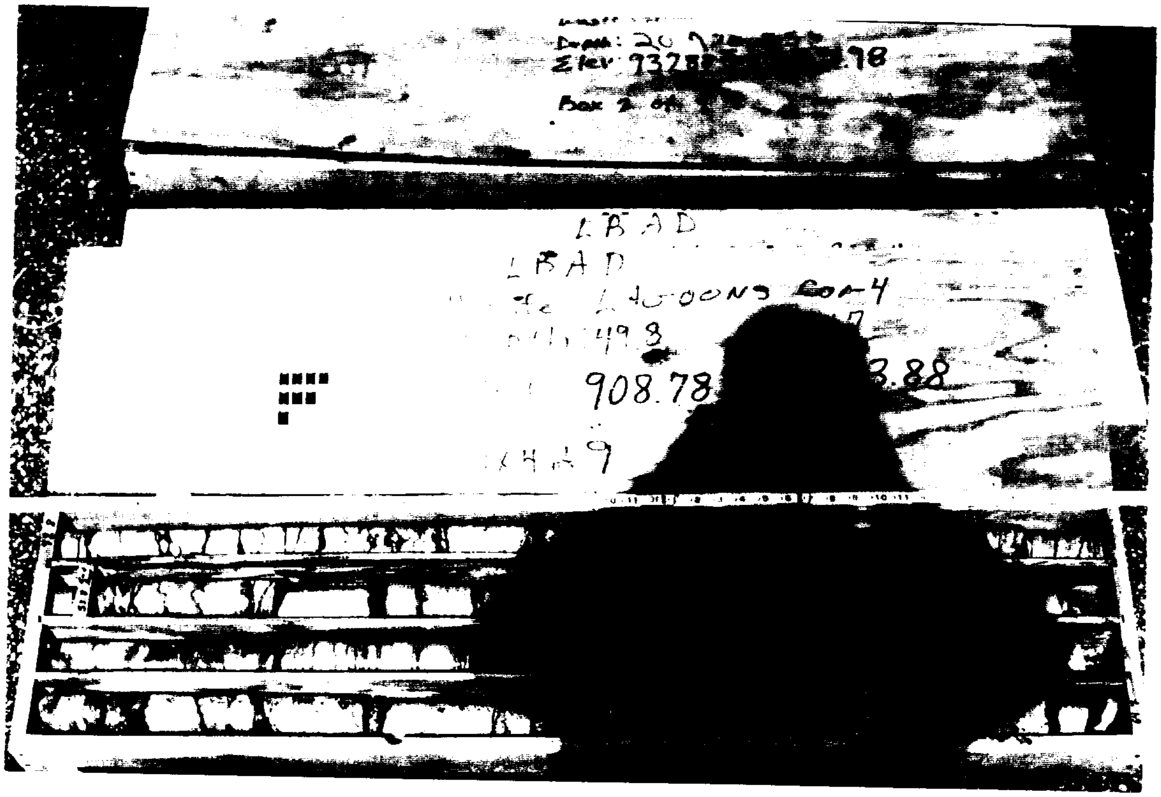

Cor 2.4
Depth: 189.6 To 200.5
ELE: 758.24 To 747.34
Box 3 of 3

CORE-4
WASTE LAGOONS
6.2 feet to 133.6 feet

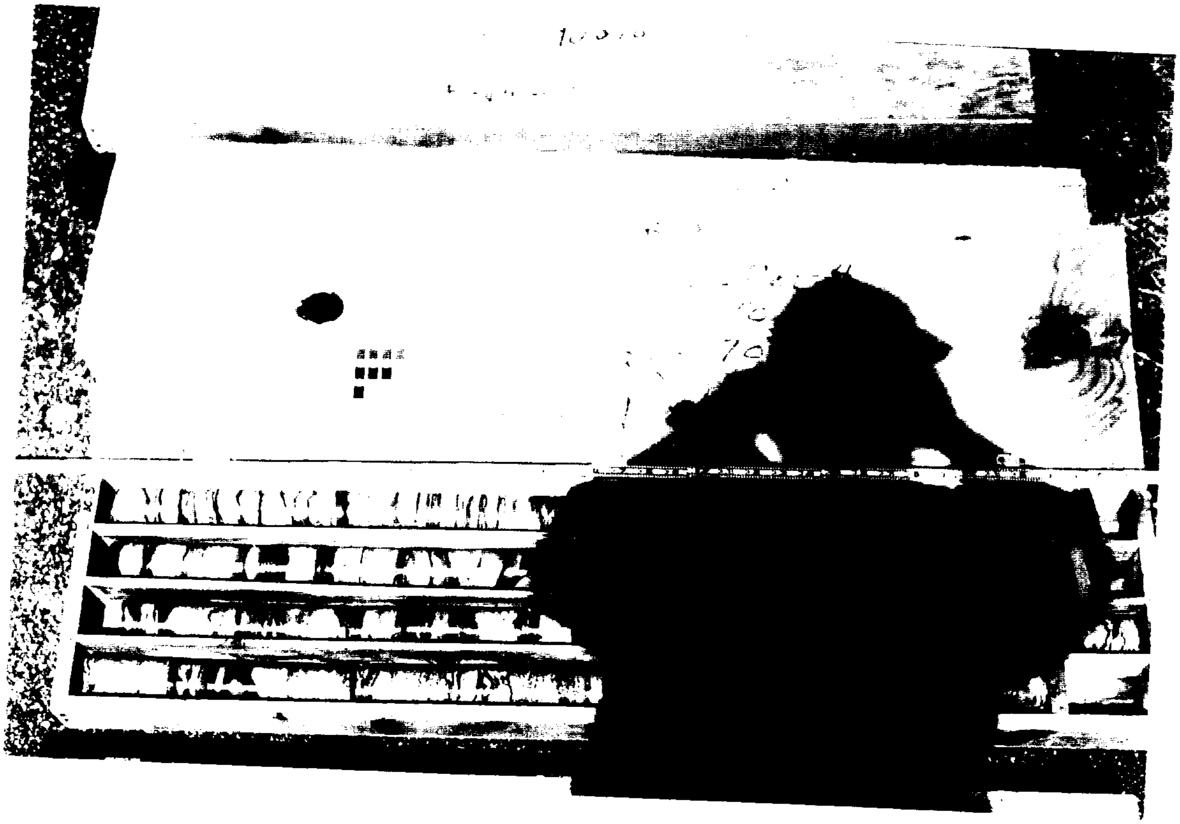


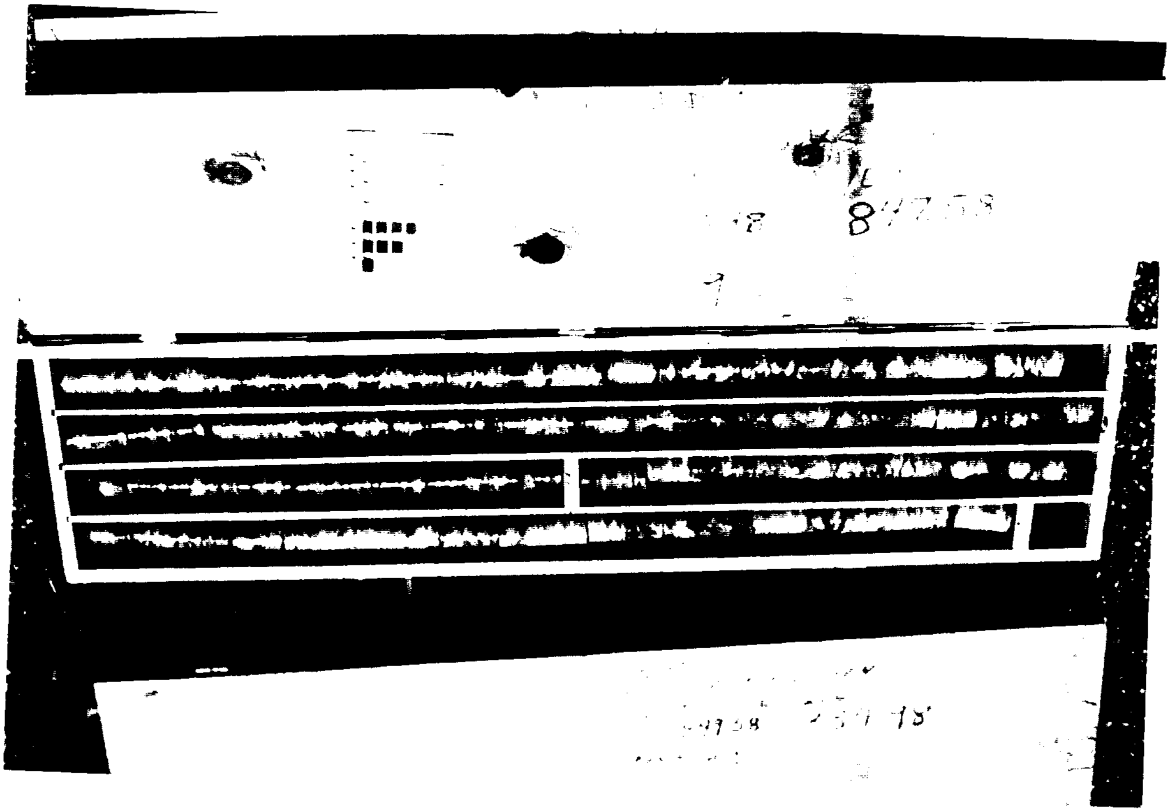



GR-4
941.9


Depth: 20
Elev 932
.98
Box 2 of
LBAD
LBAD
Lagoons Cor-4
498
908.78
3.88
449


108 78

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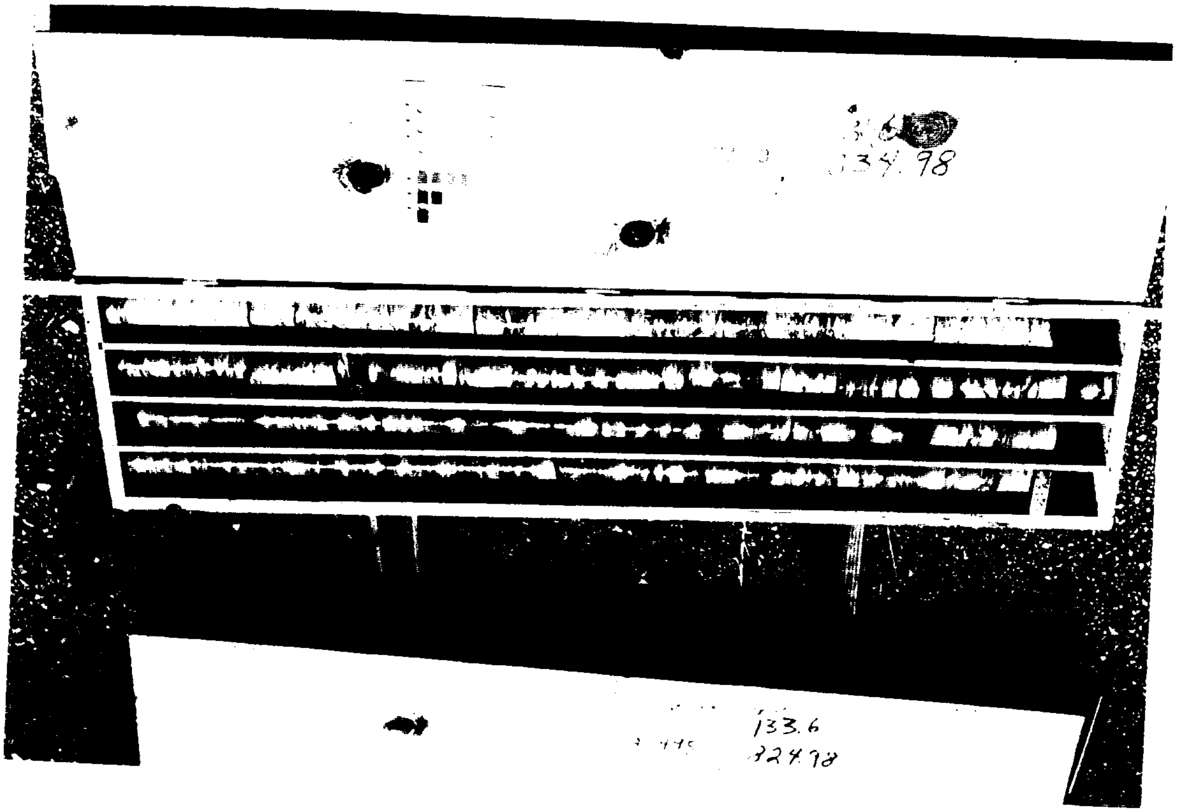
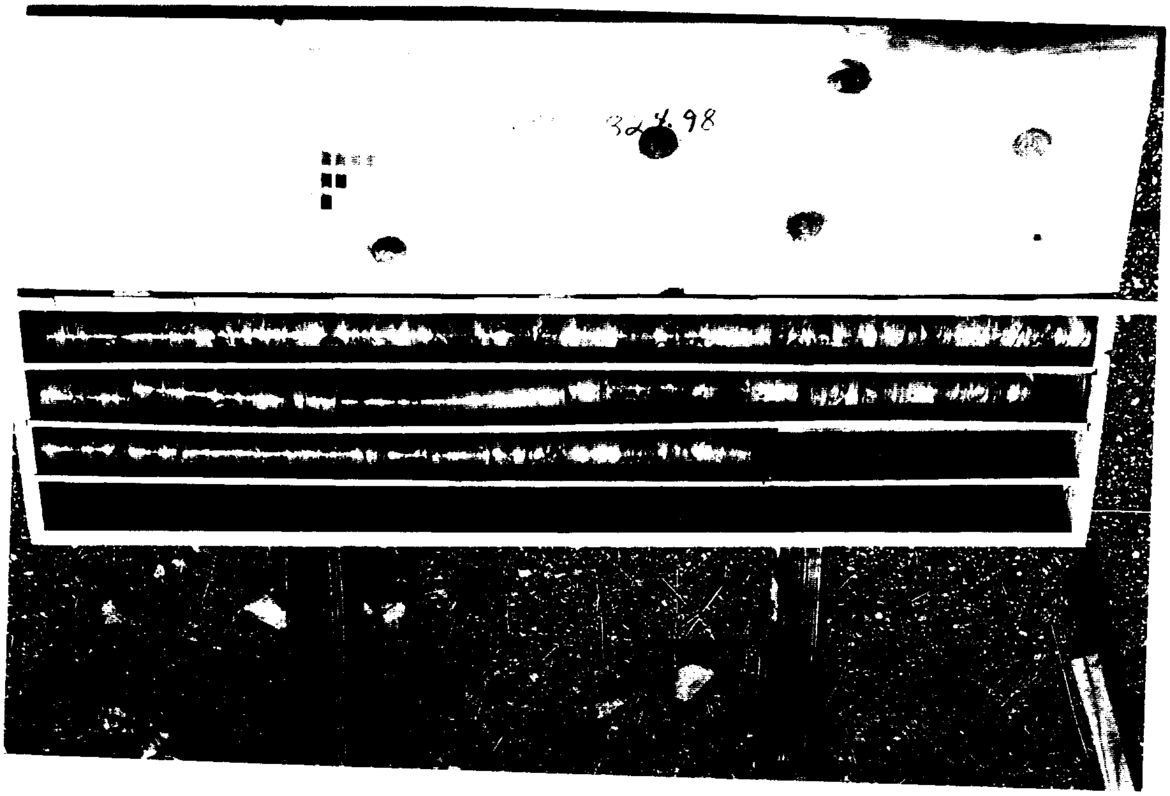

133.6
324.78


321.98

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :		SHEET 1 OF 7	BORING NO.
SITE LOCATION: Core #2	JOB NO.		
	LOCATION:	GROUND ELEV.	TOTAL DEPTH
DRILL CONTRACTOR:	ENG/GEO:	BEGUN :	
DRILL RIG:	DRILLER:	FINISHED:	
HOLE SIZE:	WEATHER:	GROUND WATER (DEPTH/ELEV.): /	
DRILLING METHOD:	DRILLING FLUID/SOURCE:	TOP OF ROCK (DEPTH/ELEV.):	

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	11									
	12									
	13									
	14									
	15						LST (Shale 20-30% interbedded)			
Box 1	16									
	17									
	18									
	19									
	20									
	21									
	22									
	23									
	24									
	25									
	26									
	27									
	28									
	29									
	30									
Box 2	31						LST (Shale 20% interbedded)			
	32									
	33									
	34									
	35									
	36									
	37									
	38									
	39									

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #2

JOB NO.

SHEET 2 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 2	40									
	41									
42	42									
	43									
	44									
	45									
	46									
Box 3	47						LST (25-35% shale Interbedded)			
	48									
	49									
	50									
	51									
	52									
	53									
	54									
	55									
56	56									
	57									
	58									
	59									
	60									
	61									
Box 4	62						LST (35-40% shale Interbedded)			
	63									
	64									
	65									
	66									
	67									
	68									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #2

JOB NO.

SHEET 3 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 4	69									
	70									
71	71									
	72									
	73						LST + Shale 50/50%			
	74									
75	75									
	76									
	77									
Box 5	78									
	79						LST (40-45% shale Interbedded)			
	80									
	81									
	82									
	83									
	84									
85	85									
	86									
	87									
	88									
	89									
	90						LST & Shale 50/50%			
Box 6	91									
	92									
	93									
95	94									
	95									
	96									
	97						LST (shale 30-40% Interbedded)			

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #2

JOB NO.

SHEET 4 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 6 98									
99						LST (30-40% shale interbedded)			
100									
101									
102									
103									
104									
105									
106									
Box 7 107						LST (30-40% shale Interbedded)			
108									
109									
110									
111									
112									
113									
114									
115 115									
116									
117									
118									
119									
120									
Box 8 121						LST (20-30% shale Interbedded)			
122									
123									
124									
125									
126									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #2

JOB NO.

SHEET 5 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	127									
Box 8	128						LST (20-30% shale interbedded)			
	129									
	130									
	131									
	132									
	133									
	134									
	135									
	136									
Box 9	137						LST (25-35% shale Interbedded)			
	138									
	139									
	140									
	141									
	142									
145	143									
	144									
	145									
	146									
	147									
	148									
Box 10	149						LST (40-50% shale interbedded)			
	150									
	151									
	152									
	153									
	154									
	155									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :		SHEET 6 OF 7	BORING NO.
SITE LOCATION: Core #2	JOB NO.		
	LOCATION:	GROUND ELEV.	TOTAL DEPTH
DRILL CONTRACTOR:	ENG/GEO:	BEGUN :	
DRILL RIG:	DRILLER:	FINISHED:	
HOLE SIZE:	WEATHER:	GROUND WATER (DEPTH/ELEV.): /	
DRILLING METHOD:	DRILLING FLUID/SOURCE:	TOP OF ROCK (DEPTH/ELEV.):	

Box 10

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
156									
157						LST (.40-50% shale interbedded)			
158									
159									
160									

Core 2A
Bx 1

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
161									
162									
163									
164									
165						LST (40-50% shale interbedded)			
166									
167									
168									
169									
170									
171									
172									
173									
174									
175									

175

Core 2A
Box 2

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
176									
177									
178									
179						LST (30-40% shale Interbedded)			
180									
181									
182									
193									
184									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core # 2

JOB NO.

SHEET 7 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Core 2A Box 2	185									
	186									
	187						LST (30-40% shale Interbedded)			
	188									
190	189									
	190									
	191									
Core 2A	192						LST & Shale 50/50%			
	193									
Box 3	194									
	195									
96	196									
	197									
	198						Lst (shale 30-40% interbedded)			
	199									
	200									
	201									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #1

JOB NO.

SHEET 1 **OF** 2

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

Box 1

24 —

Box 2

31 —

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
8						8' TO 23.5' Predominately Shale with interbedded LST.			20% LS 80% Sh
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24						23.5 TO 31' LST - Little shale			80% LS 20 Sh
25									
26									
27									
28									
29									
30									
31						Shale predominately			80 Sh 20 LS
32									
33									
34									
35									
36									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :

SITE LOCATION: Core #1

JOB NO.

SHEET 2 OF 2

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 2	37						Shale (con't)			
38	38									
	39									
	40									
	41									
	42						LST 80% LS			
	43									
	44									
	45									
Box 3 46	46									
	47									
	48									
	49						50/50 LST - shale			
	50									
	51									
	52									
	53									
54	54									
	55									
	56									
	57						Shale - Little LST			80 Sh 20 LS
Box 4	58									
	59									
	60									
6	61									
	62									
	63									
	64						80 LST - 20 Little shale			
	65									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :

SITE LOCATION: Core #1

JOB NO.

SHEET 3 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 4	66						LST			
	67									
	68									
	69									
	70									
	71									
	72									
Box 5	73									
	74									
	75						LST (10% shale)			
	76									
	77									
	78									
	79									
	80									
	81									
	82									
	83									
	84									
	85									
	86						LST - (10-15% Shale) Interbedded			
Box 6	87									
	88									
	89									
	90									
	91									
	92									
	93									
	94									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :

SITE LOCATION: Core #1

JOB NO.

SHEET 4 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 6	95						LST (10-15% shale) Interbedded			
	96									
	97						Lst (15-20% Shale) Interbedded			
	98									
	99									
	100									
	101									
	102									
	103									
Box 7	104									
	105									
	106									
	107									
	08									
	109									
	110									
	111									
	112						Lst (20-25% shale) Interbedded)			
	113									
	114									
	115									
	116									
	117									
Box 8	118									
	119									
	120									
	121									
	122									
	123									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #1

JOB NO.

SHEET 5 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

126 Box 8

Box 9

Box 10

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
124						LST (20-25% Shale) Interbedded			
125									
126									
127						LST (30-40% shale Interbedded)			
128									
129									
130									
131									
132									
133									
134									
135									
136									
137									
138									
139									
140									
141						LST (40% shale Interbedded)			
142									
143									
144									
145									
146									
147									
148									
149									
150									
151									
152									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :		SHEET 6 OF 7	BORING NO.
SITE LOCATION: Core #1	JOB NO.		
	LOCATION:	GROUND ELEV.	TOTAL DEPTH
DRILL CONTRACTOR:	ENG/GEO:	BEGUN :	
DRILL RIG:	DRILLER:	FINISHED:	
HOLE SIZE:	WEATHER:	GROUND WATER (DEPTH/ELEV.): /	
DRILLING METHOD:	DRILLING FLUID/SOURCE:	TOP OF ROCK (DEPTH/ELEV.):	

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 10	153									
	154									
	155									
	156									
	157									
	158									
	159									
	160						LST (40-45% shale interbedded)			
	161									
Box 11	162									
	163									
	164									
	165									
	166									
	167									
	168									
	169									
	170									
	171									
	172									
	173									
Box 12	174									
	175						LST (30-40% shale interbedded)			
	176									
	177									
	178									
	179									
	180									
	181									

SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #1

JOB NO.

SHEET 7 OF 7

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

Box 12

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
182									
183						LST (30-40% shale interbedded)			
184									
185									
186						LST (20-30% shale interbedded)			

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: core #3

JOB NO.

SHEET 1 OF 4

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	7									
	8									
	9									
	10									
	11									
	12						LST (20-25% shale interbedded)			
Box 1	13									
	14									
	15									
	16									
	17									
	18									
19	19									
	20									
	21						Shale (30-40% LST interbedded)			
	22									
23	23									
	24									
	25									
	26									
	27						LST (20-25% shale interbedded)			
Box 2	28									
	29									
	30									
	31									
	32									
	33									
	34									
	35									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core #3

JOB NO.

SHEET 2 OF 4

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 2	36									
	37									
	38									
	39									
	40									
	41									
Box 3	42									
	43						LST (20-30% shale Interbedded)			
	44									
	45									
	46									
	47									
	48									
	49									
	50									
52	51									
	52									
	53									
	54									
	55									
	56									
Box 4	57									
	58						LST (30-40% shale interbedded)			
	59									
	60									
	61									
	62									
	63									
	64									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :

SITE LOCATION: Core #3

JOB NO.

SHEET 3 OF 4

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 4	65									
	66						LST (30-40% shale interbedded)			
67	67									
	68									
	69									
	70									
	71									
6 ·5	72						LST (35-45% shale Interbedded)			
	73									
	74									
	75									
	76									
	77									
	78									
	79									
	80									
	81									
82	82									
	83									
	84									
	85									
Box 6	86						LST (30 - 40% shale Interbedded)			
	87									
	88									
	89									
	90									
	91									
	92									
	93									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core # 3

JOB NO.

SHEET 4 OF 4

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
Box 6	94									
	95						LST (30-40% shale Interbedded)			
	96									
96	97									
	98									
	99									
	100									
	101									
	102						LST (shale 25-35% interbedded)			
	103									
	104									
	105									
	106									
	107									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :

SITE LOCATION: Core # 4

JOB NO.

SHEET 1 OF 5

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	6									
	7									
	8									
	9									
	10									
	11									
Box 1	12						LST (30-40% shale interbedded)			
	13									
	14									
	15									
	16									
	17									
	18									
	19									
	20									
21	21									
	22									
	23									
	24									
Box 2	25									
	26						LST (20-30% shale Interbedded)			
	27									
	28									
	29									
	30									
	31									
	32									
	33									
	34									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :
SITE LOCATION: Core #4
JOB NO.
SHEET 2 OF 5
BORING NO.
LOCATION:
GROUND ELEV.
TOTAL DEPTH
DRILL CONTRACTOR:
ENG/GEO:
BEGUN :
DRILL RIG:
DRILLER:
FINISHED:
HOLE SIZE:
WEATHER:
GROUND WATER (DEPTH/ELEV.): /
DRILLING METHOD:
DRILLING FLUID/SOURCE:
TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	35									
	36									
	37						LST (shale 10-15% interbedded)			
	38						shale (LST 30-35% interbedded)			
	39									
	40									
Box 3	41									
	42									
	43						LST (shale 20% interbedded)			
	44									
	45									
	46									
	47									
	48									
	49									
50	50									
	51									
	52									
	53									
	54									
Box 4	55									
	56									
	57						LST (30-35% shale interbedded)			
	58									
	59									
	60									
	61									
	62									
	63									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :

SHEET 3 OF 5

BORING NO.

SITE LOCATION: Core #4

JOB NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	64									
65	65									
	66									
	67									
	68									
	69									
	70									
Box 5	71									
	72						LST (20-30% shale interbedded)			
	73									
	74									
	75									
	76									
	77									
	78									
	79									
80	80									
	81									
	82									
	83									
	84									
Box 6	85						LST (35-45% shale interbedded)			
	86									
	87									
	88									
	89									
	90									
	91									
	92									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

PROJECT :
SITE LOCATION: Core #4
JOB NO.
SHEET 4 OF 5
BORING NO.
LOCATION:
GROUND ELEV.
TOTAL DEPTH
DRILL CONTRACTOR:
ENG/GEO:
BEGUN :
DRILL RIG:
DRILLER:
FINISHED:
HOLE SIZE:
WEATHER:
GROUND WATER (DEPTH/ELEV.): /
DRILLING METHOD:
DRILLING FLUID/SOURCE:
TOP OF ROCK (DEPTH/ELEV.):

	DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
	93									
	94									
95	95						LST/shale 50/50%			
	96									
	97									
Box 7	98									
	99									
	100									
	101									
	102									
	103									
104	104						LST (30-40% shale interbedded)			
	105									
	106									
	107									
	108									
	109						LST (30-40% shale interbedded)			
	110									
	111									
	112									
	113									
Box 8	114									
	115									
	116									
	117									
	118									
	119									
	120									
	121									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

Metcalf & Eddy, Inc.
ENGINEERS

GEOLOGIC LOG

M&E

PROJECT :

SITE LOCATION: Core #4

JOB NO.

SHEET 5 OF 5

BORING NO.

LOCATION:

GROUND ELEV.

TOTAL DEPTH

DRILL CONTRACTOR:

ENG/GEO:

BEGUN :

DRILL RIG:

DRILLER:

FINISHED:

HOLE SIZE:

WEATHER:

GROUND WATER (DEPTH/ELEV.): /

DRILLING METHOD:

DRILLING FLUID/SOURCE:

TOP OF ROCK (DEPTH/ELEV.):

Box 8

124

B .9

DEPTH	SAMPLE TYPE/NO.	SAMPLE DEPTH	SAMPLE RECOVERY	BLOW COUNT (per 6 inches) OR DRILLING TIME (min/ft)	% RECOVERY OR RQD	SAMPLE DESCRIPTION	ELEVATION	GRAPHIC LOG	STRATIGRAPHIC DESCRIPTION
122									
123									
124									
125									
126									
127									
128						LST (35–45% shale interbedded)			
129									
130									
131									
132									
133									
134									
135									

SAMPLE TYPES
SS=SPLIT SPOON, ST=SHELBY TUBE
R=ROCK CORE, O=OTHER

NOTES:

BORING NO.:

APPENDIX C

APPENDIX C
SOIL GAS DATA, TARGET ENVIRONMENTAL SERVICES, INC.

SOIL GAS DATA

LEXINGTON BLUEGRASS ARMY DEPOT
LEXINGTON, KENTUCKY

TARGET ENVIRONMENTAL SERVICES, INC.

SOIL GAS DATA

LEXINGTON BLUEGRASS ARMY DEPOT
LEXINGTON, KENTUCKY

PREPARED FOR

METCALF & EDDY
2800 CORPORATE EXCHANGE DRIVE, SUITE 250
COLUMBUS, OHIO 43231

PREPARED BY

TARGET ENVIRONMENTAL SERVICES, INC.
9180 RUMSEY ROAD
COLUMBIA, MARYLAND 21045
(410) 992-6622

AUGUST 1993

SAMPLE COLLECTION AND ANALYSIS

On August 25-31, 1993, **TARGET Environmental Services, Inc. (TARGET)** conducted a soil gas survey at the **Lexington Bluegrass Army Depot** in Lexington, Kentucky. A total of 287 soil gas samples were collected from depths of 1 to 4 feet. Samples collected at depths less than 4 feet were the result of probe refusal. The majority of the samples were successfully collected at depths of 3.5 to 4 feet. The sampling locations are shown on the accompanying copy of the field map.

To collect the samples a 1/2-inch hole was produced to a depth of approximately 4 feet by using a drive rod. Where pavement was present, a rotary hammer was employed for penetration prior to using the drive rod. The entire sampling system was purged with ambient air drawn through an organic vapor filter cartridge, and a stainless steel probe was inserted to the full depth of the hole and sealed off from the atmosphere. A sample of in-situ soil gas was then withdrawn through the probe and used to purge atmospheric air from the sampling system. A second sample of soil gas was withdrawn through the probe and encapsulated in a pre-evacuated glass vial at two atmospheres of pressure (15 psig). The self-sealing vial was detached from the sampling system, packaged, labeled, and stored for laboratory analysis. All sampling holes were backfilled with bentonite and the surface repaired with like material upon completion of the sampling.

Prior to the day's field activities all sampling equipment, slide hammer rods and probes were decontaminated by washing with soapy water and rinsing thoroughly. Internal surfaces were flushed dry using pre-purified nitrogen or filtered ambient air, and external surfaces were wiped clean using clean paper towels.

All of the samples collected during the field phase of the survey were analyzed by **Maryland Spectral Services, Inc.** (MSS) according to EPA Method 624, modified for vapor analysis on a gas chromatograph equipped with a mass spectrometer. Vinyl chloride was standardized for this analysis.

The results of the laboratory analysis of the soil gas samples are reported in micrograms per liter (µg/l) and included in this report as received from **MSS**. Copies of the sample chain-of-custody forms are also included.

Quality Assurance/Quality Control (QA/QC) Evaluation

Field QA/QC Samples

Field control samples were collected at the beginning and end of each day's field activities and after every twentieth soil gas sample. These QA/QC samples were obtained by filtering ambient air through a dust and organic vapor filter cartridge and encapsulating as described above. These samples were numbered 501-523 and the laboratory results of their analysis are included along with the field samples. Concentrations of all analytes were below the reporting limit in all field control samples.

Laboratory QA/QC Samples

To document analytical repeatability, a duplicate analysis was performed on all samples exhibiting detectable levels of vinyl chloride. Additional samples were chosen for replicate analysis so that the total number of replicate analyses was ten percent (10%) of the total field sample number. Laboratory Method Blanks were analyzed after every tenth field sample. The results of these analyses are included as received.

SAMPLE DATA SUMMARY PACKAGE

Table of Contents

1. Narrative

NARRATIVE

Laboratory Name: Maryland Spectral Services, Inc. (MSS)

Date Samples Delivered to MSS Laboratory:
26 August - 1 September 1993

Project: SBME-2

Project Manager: Ms. Connie Thorne

Results for the following samples are included in this data package:

Client I.D.	MSS I.D.	Matrix	Analysis
1	930826-01	Vapor	Vinyl chloride
2	930826-02	Vapor	Vinyl chloride
3	930826-03	Vapor	Vinyl chloride
4	930826-04	Vapor	Vinyl chloride
5	930826-05	Vapor	Vinyl chloride
6	930826-06	Vapor	Vinyl chloride
7	930826-07	Vapor	Vinyl chloride
8	930826-08	Vapor	Vinyl chloride
9	930826-09	Vapor	Vinyl chloride
10	930826-10	Vapor	Vinyl chloride
11	930826-11	Vapor	Vinyl chloride
12	930826-12	Vapor	Vinyl chloride
13	930826-13	Vapor	Vinyl chloride
14	930826-14	Vapor	Vinyl chloride
15	930826-15	Vapor	Vinyl chloride
16	930826-16	Vapor	Vinyl chloride
17	930826-17	Vapor	Vinyl chloride
18	930826-18	Vapor	Vinyl chloride
19	930826-19	Vapor	Vinyl chloride
20	930826-20	Vapor	Vinyl chloride
21	930826-21	Vapor	Vinyl chloride
22	930826-22	Vapor	Vinyl chloride
23	930826-23	Vapor	Vinyl chloride
24	930826-24	Vapor	Vinyl chloride
25	930826-25	Vapor	Vinyl chloride
26	930826-26	Vapor	Vinyl chloride
27	930826-27	Vapor	Vinyl chloride
28	930826-28	Vapor	Vinyl chloride
29	930826-29	Vapor	Vinyl chloride
30	930826-30	Vapor	Vinyl chloride
31	930826-31	Vapor	Vinyl chloride
32	930826-32	Vapor	Vinyl chloride
33	930826-33	Vapor	Vinyl chloride
34	930826-34	Vapor	Vinyl chloride
35	930826-35	Vapor	Vinyl chloride
36	930826-36	Vapor	Vinyl chloride
37	930826-37	Vapor	Vinyl chloride
38	930826-38	Vapor	Vinyl chloride
39	930826-39	Vapor	Vinyl chloride
40	930826-40	Vapor	Vinyl chloride
501	930826-41	Vapor	Vinyl chloride
502	930826-41	Vapor	Vinyl chloride
503	930826-41	Vapor	Vinyl chloride
41	930827-01	Vapor	Vinyl chloride
42	930830-41	Vapor	Vinyl chloride
43	930827-03	Vapor	Vinyl chloride
44	930827-04	Vapor	Vinyl chloride
45	930827-05	Vapor	Vinyl chloride

NARRATIVE (Continued)

46	930827-06	Vapor	Vinyl chloride
47	930827-07	Vapor	Vinyl chloride
48	930827-08	Vapor	Vinyl chloride
49	930827-09	Vapor	Vinyl chloride
50	930827-10	Vapor	Vinyl chloride
51	930827-11	Vapor	Vinyl chloride
52	930827-12	Vapor	Vinyl chloride
53	930827-13	Vapor	Vinyl chloride
54	930827-14	Vapor	Vinyl chloride
55	930827-15	Vapor	Vinyl chloride
56	930827-16	Vapor	Vinyl chloride
57	930827-17	Vapor	Vinyl chloride
58	930827-18	Vapor	Vinyl chloride
59	930827-19	Vapor	Vinyl chloride
60	930827-20	Vapor	Vinyl chloride
61	930827-21	Vapor	Vinyl chloride
62	930827-22	Vapor	Vinyl chloride
63	930827-23	Vapor	Vinyl chloride
64	930827-24	Vapor	Vinyl chloride
65	930827-25	Vapor	Vinyl chloride
66	930827-26	Vapor	Vinyl chloride
67	930827-27	Vapor	Vinyl chloride
68	930827-28	Vapor	Vinyl chloride
69	930827-29	Vapor	Vinyl chloride
70	930827-30	Vapor	Vinyl chloride
71	930827-31	Vapor	Vinyl chloride
72	930827-32	Vapor	Vinyl chloride
73	930827-33	Vapor	Vinyl chloride
74	930827-34	Vapor	Vinyl chloride
75	930827-35	Vapor	Vinyl chloride
76	930827-36	Vapor	Vinyl chloride
77	930827-37	Vapor	Vinyl chloride
78	930827-38	Vapor	Vinyl chloride
79	930827-39	Vapor	Vinyl chloride
80	930827-40	Vapor	Vinyl chloride
504	930827-41	Vapor	Vinyl chloride
505	930827-42	Vapor	Vinyl chloride
506	930827-43	Vapor	Vinyl chloride
81	930830-01	Vapor	Vinyl chloride
82	930830-02	Vapor	Vinyl chloride
83	930830-03	Vapor	Vinyl chloride
84	930830-04	Vapor	Vinyl chloride
85	930830-05	Vapor	Vinyl chloride
86	930830-06	Vapor	Vinyl chloride
87	930830-07	Vapor	Vinyl chloride
88	930830-08	Vapor	Vinyl chloride
89	930830-09	Vapor	Vinyl chloride
90	930830-10	Vapor	Vinyl chloride
91	930830-11	Vapor	Vinyl chloride
92	930830-12	Vapor	Vinyl chloride
93	930830-13	Vapor	Vinyl chloride
94	930830-14	Vapor	Vinyl chloride
95	930826-01	Vapor	Vinyl chloride
96	930826-02	Vapor	Vinyl chloride
97	930826-03	Vapor	Vinyl chloride
98	930826-04	Vapor	Vinyl chloride
99	930826-05	Vapor	Vinyl chloride
100	930826-06	Vapor	Vinyl chloride
101	930826-07	Vapor	Vinyl chloride
102	930826-08	Vapor	Vinyl chloride
103	930826-09	Vapor	Vinyl chloride

NARRATIVE (Continued)

104	930830-24	Vapor	Vinyl chloride
105	930830-25	Vapor	Vinyl chloride
106	930830-26	Vapor	Vinyl chloride
107	930830-27	Vapor	Vinyl chloride
108	930830-28	Vapor	Vinyl chloride
109	930830-29	Vapor	Vinyl chloride
110	930830-30	Vapor	Vinyl chloride
111	930830-31	Vapor	Vinyl chloride
112	930830-32	Vapor	Vinyl chloride
113	930830-33	Vapor	Vinyl chloride
114	930830-34	Vapor	Vinyl chloride
115	930830-35	Vapor	Vinyl chloride
116	930830-36	Vapor	Vinyl chloride
117	930830-37	Vapor	Vinyl chloride
507	930830-38	Vapor	Vinyl chloride
508	930830-39	Vapor	Vinyl chloride
509	930830-40	Vapor	Vinyl chloride
118	930830-42	Vapor	Vinyl chloride
119	930830-43	Vapor	Vinyl chloride
120	930830-44	Vapor	Vinyl chloride
121	930830-45	Vapor	Vinyl chloride
122	930830-46	Vapor	Vinyl chloride
123	930830-37	Vapor	Vinyl chloride
124	930830-48	Vapor	Vinyl chloride
125	930830-49	Vapor	Vinyl chloride
126	930830-50	Vapor	Vinyl chloride
127	930830-51	Vapor	Vinyl chloride
128	930830-52	Vapor	Vinyl chloride
129	930830-53	Vapor	Vinyl chloride
130	930830-54	Vapor	Vinyl chloride
131	930830-55	Vapor	Vinyl chloride
132	930830-56	Vapor	Vinyl chloride
133	930830-57	Vapor	Vinyl chloride
134	930830-58	Vapor	Vinyl chloride
135	930830-59	Vapor	Vinyl chloride
136	930830-60	Vapor	Vinyl chloride
137	930830-61	Vapor	Vinyl chloride
138	930830-62	Vapor	Vinyl chloride
139	930830-63	Vapor	Vinyl chloride
140	930830-64	Vapor	Vinyl chloride
141	930830-65	Vapor	Vinyl chloride
142	930830-66	Vapor	Vinyl chloride
143	930830-67	Vapor	Vinyl chloride
144	930830-68	Vapor	Vinyl chloride
145	930830-69	Vapor	Vinyl chloride
146	930830-70	Vapor	Vinyl chloride
147	930830-71	Vapor	Vinyl chloride
148	930830-72	Vapor	Vinyl chloride
149	930830-73	Vapor	Vinyl chloride
150	930830-74	Vapor	Vinyl chloride
151	930830-75	Vapor	Vinyl chloride
152	930830-76	Vapor	Vinyl chloride
153	930830-77	Vapor	Vinyl chloride
154	930830-78	Vapor	Vinyl chloride
155	930830-79	Vapor	Vinyl chloride
156	930830-80	Vapor	Vinyl chloride
157	930830-81	Vapor	Vinyl chloride
158	930830-82	Vapor	Vinyl chloride
159	930830-83	Vapor	Vinyl chloride
160	930830-84	Vapor	Vinyl chloride
161	930830-85	Vapor	Vinyl chloride

NARRATIVE (Continued)

162	930830-86	Vapor	Vinyl chloride
163	930830-87	Vapor	Vinyl chloride
164	930830-88	Vapor	Vinyl chloride
165	930830-89	Vapor	Vinyl chloride
166	930830-90	Vapor	Vinyl chloride
510	930830-91	Vapor	Vinyl chloride
511	930830-92	Vapor	Vinyl chloride
512	930830-93	Vapor	Vinyl chloride
513	930830-94	Vapor	Vinyl chloride
167	930831-181	Vapor	Vinyl chloride
168	930831-182	Vapor	Vinyl chloride
169	930831-183	Vapor	Vinyl chloride
170	930831-184	Vapor	Vinyl chloride
171	930831-185	Vapor	Vinyl chloride
172	930831-186	Vapor	Vinyl chloride
173	930831-187	Vapor	Vinyl chloride
174	930831-188	Vapor	Vinyl chloride
175	930831-189	Vapor	Vinyl chloride
176	930831-190	Vapor	Vinyl chloride
177	930831-191	Vapor	Vinyl chloride
178	930831-192	Vapor	Vinyl chloride
179	930831-193	Vapor	Vinyl chloride
180	930831-194	Vapor	Vinyl chloride
181	930831-195	Vapor	Vinyl chloride
182	930831-196	Vapor	Vinyl chloride
183	930831-197	Vapor	Vinyl chloride
184	930831-198	Vapor	Vinyl chloride
185	930831-199	Vapor	Vinyl chloride
186	930831-200	Vapor	Vinyl chloride
514	930831-201	Vapor	Vinyl chloride
515	930831-202	Vapor	Vinyl chloride
187	930831-43	Vapor	Vinyl chloride
188	930831-44	Vapor	Vinyl chloride
189	930831-45	Vapor	Vinyl chloride
190	930831-46	Vapor	Vinyl chloride
191	930831-47	Vapor	Vinyl chloride
192	930831-48	Vapor	Vinyl chloride
193	930831-49	Vapor	Vinyl chloride
194	930831-50	Vapor	Vinyl chloride
195	930831-51	Vapor	Vinyl chloride
196	930831-52	Vapor	Vinyl chloride
197	930831-53	Vapor	Vinyl chloride
198	930831-54	Vapor	Vinyl chloride
199	930831-55	Vapor	Vinyl chloride
200	930831-56	Vapor	Vinyl chloride
201	930831-57	Vapor	Vinyl chloride
202	930831-58	Vapor	Vinyl chloride
203	930831-59	Vapor	Vinyl chloride
204	930831-60	Vapor	Vinyl chloride
205	930831-61	Vapor	Vinyl chloride
206	930831-62	Vapor	Vinyl chloride
207	930831-63	Vapor	Vinyl chloride
208	930831-64	Vapor	Vinyl chloride
209	930831-65	Vapor	Vinyl chloride
210	930831-66	Vapor	Vinyl chloride
211	930831-67	Vapor	Vinyl chloride
212	930831-68	Vapor	Vinyl chloride
213	930831-69	Vapor	Vinyl chloride
214	930831-70	Vapor	Vinyl chloride
215	930831-71	Vapor	Vinyl chloride
216	930831-72	Vapor	Vinyl chloride

NARRATIVE (Continued)

217	930831-73	Vapor	Vinyl chloride
218	930831-74	Vapor	Vinyl chloride
219	930831-75	Vapor	Vinyl chloride
220	930831-76	Vapor	Vinyl chloride
221	930831-77	Vapor	Vinyl chloride
222	930831-78	Vapor	Vinyl chloride
223	930831-79	Vapor	Vinyl chloride
224	930831-80	Vapor	Vinyl chloride
225	930831-81	Vapor	Vinyl chloride
226	930831-82	Vapor	Vinyl chloride
227	930831-83	Vapor	Vinyl chloride
228	930831-84	Vapor	Vinyl chloride
229	930831-85	Vapor	Vinyl chloride
230	930831-86	Vapor	Vinyl chloride
231	930831-87	Vapor	Vinyl chloride
232	930831-88	Vapor	Vinyl chloride
233	930831-89	Vapor	Vinyl chloride
234	930831-97	Vapor	Vinyl chloride
217	930831-73	Vapor	Vinyl chloride
218	930831-74	Vapor	Vinyl chloride
219	930831-75	Vapor	Vinyl chloride
220	930831-76	Vapor	Vinyl chloride
221	930831-77	Vapor	Vinyl chloride
222	930831-78	Vapor	Vinyl chloride
223	930831-79	Vapor	Vinyl chloride
224	930831-80	Vapor	Vinyl chloride
225	930831-81	Vapor	Vinyl chloride
226	930831-82	Vapor	Vinyl chloride
227	930831-83	Vapor	Vinyl chloride
228	930831-84	Vapor	Vinyl chloride
229	930831-85	Vapor	Vinyl chloride
230	930831-86	Vapor	Vinyl chloride
231	930831-87	Vapor	Vinyl chloride
232	930831-88	Vapor	Vinyl chloride
233	930831-89	Vapor	Vinyl chloride
234	930831-90	Vapor	Vinyl chloride
235	930831-91	Vapor	Vinyl chloride
236	930831-92	Vapor	Vinyl chloride
237	930831-93	Vapor	Vinyl chloride
238	930831-94	Vapor	Vinyl chloride
239	930831-95	Vapor	Vinyl chloride
240	930831-96	Vapor	Vinyl chloride
241	930831-97	Vapor	Vinyl chloride
242	930831-98	Vapor	Vinyl chloride
243	930831-99	Vapor	Vinyl chloride
244	930831-100	Vapor	Vinyl chloride
245	930831-171	Vapor	Vinyl chloride
246	930831-172	Vapor	Vinyl chloride
247	930831-173	Vapor	Vinyl chloride
248	930831-174	Vapor	Vinyl chloride
249	930831-175	Vapor	Vinyl chloride
516	930831-176	Vapor	Vinyl chloride
517	930831-177	Vapor	Vinyl chloride
518	930831-178	Vapor	Vinyl chloride
519	930831-179	Vapor	Vinyl chloride
520	930831-180	Vapor	Vinyl chloride
250	930901-01	Vapor	Vinyl chloride
251	930901-02	Vapor	Vinyl chloride
252	930901-03	Vapor	Vinyl chloride
253	930901-04	Vapor	Vinyl chloride
254	930901-05	Vapor	Vinyl chloride

NARRATIVE (Continued)

255	930901-06	Vapor	Vinyl chloride
256	930901-07	Vapor	Vinyl chloride
257	930901-08	Vapor	Vinyl chloride
258	930901-09	Vapor	Vinyl chloride
259	930901-10	Vapor	Vinyl chloride
260	930901-11	Vapor	Vinyl chloride
261	930901-12	Vapor	Vinyl chloride
262	930901-13	Vapor	Vinyl chloride
263	930901-14	Vapor	Vinyl chloride
264	930901-15	Vapor	Vinyl chloride
265	930901-16	Vapor	Vinyl chloride
266	930901-17	Vapor	Vinyl chloride
267	930901-18	Vapor	Vinyl chloride
268	930901-19	Vapor	Vinyl chloride
269	930901-20	Vapor	Vinyl chloride
270	930901-21	Vapor	Vinyl chloride
271	930901-22	Vapor	Vinyl chloride
272	930901-23	Vapor	Vinyl chloride
273	930901-24	Vapor	Vinyl chloride
274	930901-25	Vapor	Vinyl chloride
275	930901-26	Vapor	Vinyl chloride
276	930901-27	Vapor	Vinyl chloride
277	930901-28	Vapor	Vinyl chloride
278	930901-29	Vapor	Vinyl chloride
279	930901-30	Vapor	Vinyl chloride
280	930901-31	Vapor	Vinyl chloride
281	930901-32	Vapor	Vinyl chloride
282	930901-33	Vapor	Vinyl chloride
283	930901-34	Vapor	Vinyl chloride
284	930901-35	Vapor	Vinyl chloride
285	930901-36	Vapor	Vinyl chloride
286	930901-37	Vapor	Vinyl chloride
287	930901-38	Vapor	Vinyl chloride
521	930901-39	Vapor	Vinyl chloride
522	930901-40	Vapor	Vinyl chloride
523	930901-41	Vapor	Vinyl chloride

The samples were analyzed by USEPA Method 624, modified for vapor analysis and using capillary chromatography. The system was evaluated for compliance with USEPA mass assignment and ion abundance by analysis of 50 ng 4-Bromofluorobenzene. The mass spectrometer was then scanned from 58 to 98 a.m.u. for Vinyl chloride analysis.

A five milliliter volume of sample, together with Bromomethane with a final concentration of 50 UG/L was introduced to a purge and trap concentrator and analyzed. The system was evaluated initially for linearity and reproducibility by analysis of known concentration standard preparations of 50 UG/L, 20 UG/L, and 10 UG/L in air. The Percent Relative Standard Deviation of these measurements was 4.2 percent for instrument MSB and 9.0 percent for instrument MSA.

A known concentration check standard was analyzed at the beginning of each day at a level of 50 UG/L. In all cases, the check standard analysis exhibited a Relative Percent Difference of less than 20 percent. Also prior to the analysis of samples, a low level check standard (1 UG/L) and a Method Blank were analyzed. After each ten analyses, a

NARRATIVE (Continued)

Method Blank was analyzed. All samples exhibiting detectable Vinyl chloride were re-analyzed. Additional samples were chosen for replicate analysis so that the total number of replicate analyses was ten percent of total field sample number.

A table of results for the target compounds can be found in Section 3 of this report.

Sample, Method Blank, Sensitivity Check, and Continuing Calibration Check analysis chromatograms are provided, and are labeled for target compounds found (VCM), together with Internal Standard (BCM). Mass (m/z) 62 (for Vinyl chloride) and mass (m/z) 94 (for Bromomethane) are provided, as well.

RELEASE OF THE DATA CONTAINED IN THIS HARDCOPY DATA PACKAGE HAS BEEN AUTHORIZED BY THE LABORATORY MANAGER OR HIS DESIGNEE, AS VERIFIED BY THE FOLLOWING SIGNATURE:

Kenneth K Gill Jr
Kenneth K. Gill, Jr.

DATE: 9/10/93
10 September 1993

2. Sample Traffic Report

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

Type of analysis: FID ___ ECD ___ Other ✓ HC As Per Connie Thorne

Initial Analysis: Home Lab _____ Field Lab _____

JOB CODE: SBMC2

MSS # 930826 -

Itemized Sample List Ken Gill

01-10	11-20	21-30	31-40	41-43					
1	11	21	31	501					
2	12	22	32	502					
3	13	23	33	503					
4	14	24	34						
5	15	25	35						
6	16	26	36						
7	17	27	37						
8	18	28	38						
9	19	29	39						
10	20	30	40						

Type of Sample (circle one): Soil, Water, [✓ Soil Gas], Product

Mode of Transportation: FED EX

Sampler's Name: CHIACCHIO / STAMMER Total No. Samples: 43

More samples to come X End of job ______

Relinquished by	Date/Time	Received by	Remarks
	8/25/93		
FED EXP (9:30)	8/26/93		

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

JOB CODE: SBME2

Type of analysis: FID ___ ECD ___ Other VC

Initial Analysis: Home Lab _____ Field Lab _____

MSS 93-0077 Ken Gill Lab

Itemized Sample List

01 41	11 51	21 61	31 71	41 504					
02 42	12 52	22 62	32 72	42 505					
03 43	13 53	23 63	33 73	43 506					
04 44	14 54	24 64	34 74						
05 45	15 55	25 65	35 75						
06 46	16 56	26 66	36 76		* #	42	BROKEN IN	TRANSIT	EM
07 47	17 57	27 67	37 77						
08 48	18 58	28 68	38 78						
09 49	19 59	29 69	39 79						
10 50	20 60	30 70	40 80						

Type of Sample (circle one): Soil, Water, [✓ Soil Gas], Product

Mode of Transportation: Fed ex

Sampler's Name: Stammer / Chiaccio Total No. Samples: 43

More samples to come X End of job ____

Relinquished by	Date/Time	Received by	Remarks
A. Stamm	8-26 93		0930 8/27/93

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

JOB CODE: SBME2

Type of analysis: FID ___ ECD ___ Other VC (KEN GILL)

Initial Analysis: Home Lab _____ Field Lab _____

Itemized Sample List MSS # 93-0830-1

01 81	11 91	21 101	31 111						
02 82	12 92	22 102	32 112						
03 83	13 93	23 103	33 113						
04 84	14 94	24 104	34 114						
05 85	15 95	25 105	35 115						
06 86	16 96	26 106	36 116						
07 87	17 97	27 107	37 117						
08 88	18 98	28 108	38 507						
09 89	19 99	29 109	39 508						
10 90	20 100	30 110	40 509						

Type of Sample (circle one): Soil, Water, [✓ Soil Gas], Product

Mode of Transportation: FED EX.

Sampler's Name: STAMMER / CHIACCHIO Total No. Samples: 40

More samples to come X End of job ______

Relinquished by	Date/Time	Received by	Remarks
	8/27/93	[illegible] 0930 8/30/93	

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

JOB CODE: SBME2

Type of analysis: FID ___ ECD ___ Other VC (Ken Gill)

Initial Analysis: Home Lab _____ Field Lab _____

Itemized Sample List 93-0830 -

41 42*	51 127	6137	71 147	81 157	91 510				
42 118	52 128	62 138	72 148	82 158	92 511				
43 119	53 129	63 139	73 149	83 159	93 512				
44 120	54 130	64 140	74 150	84 160	94 513				
45 121	55 131	65 141	75 151	85 161					
46 122	56 132	66 142	76 152	86 162					
47 123	57 133	67 143	77 153	87 163					
48 124	58 134	68 144	78 154	88 164					
49 125	59 135	69 145	79 155	89 165					
50 126	60 136	70 146	80 166	90 166					

Type of Sample (circle one): Soil, Water, [✓ Soil Gas], Product

Mode of Transportation: Fedex

Sampler's Name: Stanner/Chiochio Total No. Samples: 54

More samples to come ✓ End of job ______

Relinquished by	Date/Time	Received by	Remarks
M. Stam	8-28-93		

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

JOB CODE: SBME2

Type of analysis: FID ___ ECD ___ Other UC (KEN GILL)

Initial Analysis: Home Lab _____ Field Lab _____

LISS # 93-0831

Itemized Sample List

181	167	191 177	514	201						
182	168	192 178	515	202						
183	169	193 179								
184	170	194 180								
185	171	195 181								
186	172	196 182								
37	173	197 183								
188	174	198 184								
189	175	199 185								
190	176	200 186								

Type of Sample (circle one): Soil, Water, [✓ Soil Gas], Product

Mode of Transportation: FED EX

Sampler's Name: CHIACCHIO/STAMMER Total No. Samples: 22

More samples to come X End of job ______

Relinquished by	Date/Time	Received by	Remarks
	8/29/93	Noreen Hammer	8/31/93 9:55AM FEDX

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

JOB CODE: SBME2

Type of analysis: FID ___ ECD ___ Other VC-KenGill

Initial Analysis: Home Lab _____ Field Lab _____

MSS# 93-0831 —

Itemized Sample List

43	187	53 197	63 207	73 217	83 227	93 237	~~103~~ 247	173		
44	188	54 198	64 208	74 218	84 228	94 238	~~104~~ 248	174		
45	189	55 199	65 209	75 219	85 229	95 239	~~105~~ 249	175		
44	190	56 200	66 210	76 220	86 230	96 240	~~106~~ 516	176		
47	191	57 201	67 211	77 221	87 231	97 241	~~107~~ 517	177		
48	192	58 202	68 212	78 222	88 232	98 242	~~108~~ 518	178		
9	193	59 203	69 213	79 223	89 233	99 243	~~109~~ 519	179		
50	194	60 204	70 214	80 224	90 234	~~100~~ 244	~~110~~ 520	180		
51	195	61 205	71 215	81 225	91 235	~~101~~ 171 245				
52	196	62 206	72 216	82 226	92 236	~~102~~ 246 172				

Type of Sample (circle one): Soil, Water, [✓ Soil Gas,] Product

Mode of Transportation: Fedex

Sampler's Name: N. Stammer / D. Chindic Total No. Samples: 68

More samples to come X End of job ______

Relinquished by	Date/Time	Received by	Remarks
N. Stammer	8-30-93	Noreen Hanna	8/31/93 9:55AM FEDX

TARGET ENVIRONMENTAL SERVICES, INC.

CHAIN OF CUSTODY

JOB CODE: SBME2

Type of analysis: FID ___ ECD ___ Other TC- Ken Gill

Initial Analysis: Home Lab _____ Field Lab _____

Itemized Sample List 93-0901- 01→41

01	250	11 260	21 270	31 280	41 523					
02	251	12 261	22 271	32 281						
03	252	13 262	23 272	33 282						
04	253	14 263	24 273	34 283						
05	254	15 264	25 274	35 284						
06	255	16 265	26 275	36 285						
07	256	17 266	27 276	37 286						
08	257	18 267	28 277	38 287						
09	258	19 268	29 278	39 521						
10	259	20 269	30 279	40 522						

Type of Sample (circle one): Soil, Water, [✓ Soil Gas], Product

Mode of Transportation: Fedex

Sampler's Name: N Stanner/D. Chiacchio Total No. Samples: 41

More samples to come X End of job ______

Relinquished by	Date/Time	Received by	Remarks
N. Stanner	8-31-93	Noreen Hammer	9-1-93 9:52AM FEDX

3. Results of Analysis of Samples

MARYLAND SPECTRAL SERVICES, INC.
1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 2

Sample I.D.	1	2	3	4	5	6	7
Lab I.D.	93082601	93082602	93082603	93082604	93082605	93082606	93082607
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Date Analyzed	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	8	9	10	11	12	13	14
Lab I.D.	93082608	93082609	93082610	93082611	93082612	93082613	93082614
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Date Analyzed	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	2.1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	15	16	17	18	19	20	21
Lab I.D.	93082615	93082616	93082617	93082618	93082619	93082620	93082621
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Date Analyzed	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-27-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	22	23	24	25	26	27	28
Lab I.D.	93082622	93082623	93082624	93082625	93082626	93082627	93082628
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Date Analyzed	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

< = LESS THAN GIVEN DETECTION LEVEL
N.D. = NOT DETECTED

MARYLAND SPECTRAL SERVICES, INC.
1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 2

Sample I.D.	29	30	31	32	33	34	35
Lab I.D.	93082629	93082630	93082631	93082632	93082633	93082634	93082635
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Date Analyzed	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	36	37	38	39	40	501	502
Lab I.D.	93082636	93082637	93082638	93082639	93082640	93082641	93082642
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93	08-26-93
Date Analyzed	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	503
Lab I.D.	93082643
Date Received	08-26-93
Date Analyzed	08-27-93
Volume Injected	5.0 ML
Instrument ID	MSB
Units:	UG/L AIR
Compound	
Vinyl chloride	< 0.5

< = LESS THAN GIVEN DETECTION LEVEL
N.D. = NOT DETECTED

MARYLAND SPECTRAL SERVICES, INC.
1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: S5ME2
Page 1 of 2

Sample I.D.	41	42	43	44	45	46	47
Lab I.D.	93082701	93083041	93082703	93082704	93082705	93082706	93082707
Date Received	08-27-93	08-30-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-27-93	08-30-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	48	49	50	51	52	53	54
Lab I.D.	93082708	93082709	93082710	93082711	93082712	93082713	93082714
Date Received	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-27-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	55	56	57	58	59	60	61
Lab I.D.	93082715	93082716	93082717	93082718	93082719	93082720	93082721
Date Received	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	62	63	64	65	66	67	68
Lab I.D.	93082722	93082723	93082724	93082725	93082726	93082727	93082728
Date Received	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

< = LESS THAN GIVEN DETECTION LEVEL
N.D. = NOT DETECTED

MARYLAND SPECTRAL SERVICES, INC.
1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 2

Sample I.D.	69	70	71	72	73	74	75
Lab I.D.	93082729	93082730	93082731	93082732	93082733	93082734	93082735
Date Received	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	76	77	78	79	80	504	505
Lab I.D.	93082736	93082737	93082738	93082739	93082740	93082741	93082742
Date Received	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93	08-28-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	506
Lab I.D.	93082743
Date Received	08-27-93
Date Analyzed	08-28-93
Volume Injected	5.0 ML
Instrument ID	MSB
Units:	UG/L AIR
Compound	
Vinyl chloride	< 0.5

< = LESS THAN GIVEN DETECTION LEVEL
N.D. = NOT DETECTED

MARYLAND SPECTRAL SERVICES, INC.
1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 2

Sample I.D.	81	82	83	84	85	86	87
Lab I.D.	93083001	93083002	93083003	93083004	93083005	93083006	93083007
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	88	89	90	91	92	93	94
Lab I.D.	93083008	93083009	93083010	93083011	93083012	93083013	93083014
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	95	96	97	98	99	100	101
Lab I.D.	93083015	93083016	93083017	93083018	93083019	93083020	93083021
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	102	103	104	105	106	107	108
Lab I.D.	93083022	93083023	93083024	93083025	93083026	93083027	93083028
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

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N.D. = NOT DETECTED

MARYLAND SPECTRAL SERVICES, INC.
1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 2

Sample I.D.	109	110	111	112	113	114	115
Lab I.D.	93083029	93083030	93083031	93083032	93083033	93083034	93083035
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	116	117	507	508	509
Lab I.D.	93083036	93083037	93083038	93083039	93083040
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound					
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

< = LESS THAN GIVEN DETECTION LEVEL
N.D. = NOT DETECTED

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 2

Sample I.D.	118	119	120	121	122	123	124
Lab I.D.	93083042	93083043	93083044	93083045	93083046	93083047	93083048
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	125	126	127	128	129	130	131
Lab I.D.	93083049	93083050	93083051	93083052	93083053	93083054	93083055
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	132	133	134	135	136	137	138
Lab I.D.	93083056	93083057	93083058	93083059	93083060	93083061	93083062
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	139	140	141	142	143	144	145
Lab I.D.	93083063	93083064	93083065	93083066	93083067	93083068	93083069
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.5	< 0.5

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MARYLAND SPECTRAL SERVICES, INC.
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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 2

Sample I.D.	146	147	148	149	150	151	152
Lab I.D.	93083070	93083071	93083072	93083073	93083074	93083075	93083076
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	153	154	155	156	157	158	159
Lab I.D.	93083077	93083078	93083079	93083080	93083081	93083082	93083083
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	160	161	162	163	164	165	166
Lab I.D.	93083084	93083085	93083086	93083087	93083088	93083089	93083090
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	0.9	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	510	511	512	513
Lab I.D.	93083091	93083092	93083093	93083094
Date Received	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound				
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 4

Sample I.D.	167	168	169	170	171	172	173
Lab I.D.	930831181	930831182	930831183	930831184	930831185	930831186	930831187
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	174	175	176	177	178	179	180
Lab I.D.	933083188	930831189	930831190	930831191	930831192	930831193	930831194
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	181	182	183	184	185	186	514
Lab I.D.	930831195	930831196	930831197	930831198	930831199	930831200	930831201
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	515
Lab I.D.	930831202
Date Received	08-31-93
Date Analyzed	08-31-93
Volume Injected	5.0 ML
Instrument ID	MSA
Units:	UG/L AIR
Compound	
Vinyl chloride	< 0.5

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1500 Caton Center Drive Baltimore, MD 21227

VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 4

Sample I.D.	187	188	189	190	191	192	193
Lab I.D.	93083143	93083144	93083145	93083146	93083147	93083148	93083149
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	194	195	196	197	198	199	200
Lab I.D.	93083150	93083151	93083152	93083153	93083154	93083155	93083156
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	201	202	203	204	205	206	207
Lab I.D.	93083157	93083158	93083159	93083160	93083161	93083162	93083163
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	208	209	210	211	212	213	214
Lab I.D.	93083164	93083165	93083166	93083167	93083168	93083169	93083170
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	09-01-93	09-01-93	08-31-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 3 of 4

Sample I.D.	215	216	217	218	219	220	221
Lab I.D.	93083171	93083172	93083173	93083174	93083175	93083176	93083177
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	222	223	224	225	226	227	228
Lab I.D.	93083178	93083179	93083180	93083181	93083182	93083183	93083184
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	09-01-93	09-01-93	09-01-93	09-01-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	0.5	< 0.5	< 0.5	< 0.5	2.6

Sample I.D.	229	230	231	232	233	234	235
Lab I.D.	93083185	93083186	93083187	93083188	93083189	93083190	93083191
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	236	237	238	239	240	241	242
Lab I.D.	93083192	93083193	93083194	93083195	93083196	93083197	93083198
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	09-01-93	09-01-93	09-01-93	08-31-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

< = LESS THAN GIVEN DETECTION LEVEL
N.D. = NOT DETECTED

MARYLAND SPECTRAL SERVICES, INC.
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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 4 of 4

Sample I.D.	243	244	245	246	247	248	249
Lab I.D.	93083199	930831170	930831171	930831172	930831173	930831174	930831175
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	08-31-93	08-31-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	1.0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	516	517	518	519	520
Lab I.D.	930831176	930831177	930831178	930831179	930831180
Date Received	08-31-93	08-31-93	08-31-93	08-31-93	08-31-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound					
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 2

Sample I.D.	250	251	252	253	254	255	256
Lab I.D.	93090101	93090102	93090103	93090104	93090105	93090106	93090107
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	257	258	259	260	261	262	263
Lab I.D.	93090108	93090109	93090110	93090111	93090112	93090113	93090114
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	264	265	266	267	268	269	270
Lab I.D.	93090115	93090116	93090117	93090118	93090119	93090120	93090121
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	271	272	273	274	275	276	277
Lab I.D.	93090122	93090123	93090124	93090125	93090126	93090127	93090128
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 2

Sample I.D.	278	279	280	281	282	283	284
Lab I.D.	93090129	93090130	93090131	93090132	93090133	93090134	93090135
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5

Sample I.D.	285	286	287	521	522	523	
Lab I.D.	93090136	93090137	93090138	93090139	93090140	93090141	
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	
Date Analyzed	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-9< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 2

Sample I.D.	9	19	30	39	48	49	68
Lab I.D.	93082609	93082619	93082630	93082639	93082708	93082709	93082728
Date Received	08-26-93	08-26-93	08-26-93	08-26-93	08-27-93	08-27-93	08-27-93
Date Analyzed	08-26-93	08-27-93	08-27-93	08-27-93	08-28-93	08-28-93	08-28-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP
Vinyl chloride	2.3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	101	111	112	113	114	115	116
Lab I.D.	93083021	93083031	93083032	93083033	93083034	93083035	93083036
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	117	507	508	509	144	160	244
Lab I.D.	93083037	93083038	93083039	93083040	93083068	93083084	93083170
Date Received	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-31-93
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-31-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	0.6	0.8	1.0

Sample I.D.	224	228	282	287	521	522	523
Lab I.D.	93083180	93083184	93090133	93090138	93090139	93090140	93090141
Date Received	08-31-93	08-31-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-01-93	08-31-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP
Vinyl chloride	0.3	2.5	0.5	< 0.5	< 0.5	< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 2 of 2

Sample I.D.	250	251	252	253	254	255	256
Lab I.D.	93090101	93090102	93090103	93090104	93090105	93090106	93090107
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-02-93	09-02-93	09-02-93	09-02-93	09-02-93	09-02-93	09-02-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	257	258	259	260	261	262	263
Lab I.D.	93090108	93090109	93090110	93090111	93090112	93090113	93090114
Date Received	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93	09-01-93
Date Analyzed	09-02-93	09-02-93	09-02-93	09-02-93	09-02-93	09-02-93	09-02-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP	QC REP
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	264
Lab I.D.	93090115
Date Received	09-01-93
Date Analyzed	09-02-93
Volume Injected	5.0 ML
Instrument ID	MSB
Units:	UG/L AIR
Compound	QC REP
Vinyl chloride	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies
Project: SBME2
Page 1 of 1

Sample I.D.	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
File Name:	0828VCBLKA1	0828VCBLKA2	0830VCBLKA1	0830VCBLKA2	0830VCBLKA4	0830VCBLKA5	0830VCBLKA6
Date Analyzed	08-28-93	08-28-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSA
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
File Name:	0831VCBLKA1	0831VCBLKA2	0831VCBLKA3	0901VCBLKA1	0901VCBLKA2	0901VCBLKA3	0826VCBLKB1
Date Analyzed	08-31-93	08-31-93	08-31-93	09-01-93	09-01-93	09-01-93	08-26-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSA	MSA	MSA	MSA	MSA	MSA	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
File Name:	0826VCBLKB2	0827VCBLKB1	0827VCBLKB2	0827VCBLKB3	0828VCBLKB1	0828VCBLKB2	0830VCBLKB1
Date Analyzed	08-26-93	08-27-93	08-27-93	08-27-93	08-28-93	08-28-93	08-30-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
File Name:	0830VCBLKB2	0830VCBLKB3	0830VCBLKB4	0830VCBLKB5	0830VCBLKB6	0831VCBLKB1	0831VCBLKB2
Date Analyzed	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-31-93	08-31-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample I.D.	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
File Name:	0831VCBLKB3	0901VCBLKB1	0901VCBLKB2	0901VCBLKB3	0901VBLKB4	0902VCBLKB1
Date Analyzed	08-31-93	09-01-93	09-01-93	09-01-93	09-01-93	09-02-93
Volume Injected	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID	MSB	MSB	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound						
Vinyl chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

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VINYL CHLORIDE BY PURGE AND TRAP/GC/MS

Client Name: Target Companies

Project: SBME2

Page 1 of 1

Sample I.D.	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM
File Name:	0828VCSA1	0830VCSA1	0831VCSA1	0901VCSA1	0826VCSB1	0827VCSB1	0828VCSB1
Date Analyzed:	08-28-93	08-30-93	08-31-93	09-01-93	08-26-93	08-27-93	08-28-93
Volume Injected:	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID:	MSA	MSA	MSA	MSA	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound							
Vinyl chloride	1.1	1.1	1.2	1.1	1.3	0.9	0.8

Sample I.D.	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM	1 UG/L VCM
File Name:	0830VCSB1	0831VCSB1	0901VCSB1	0902VCSB1
Date Analyzed:	08-30-93	08-31-93	09-01-93	09-02-93
Volume Injected:	5.0 ML	5.0 ML	5.0 ML	5.0 ML
Instrument ID:	MSB	MSB	MSB	MSB
Units:	UG/L AIR	UG/L AIR	UG/L AIR	UG/L AIR
Compound				
Vinyl chloride	1.0	0.8	0.8	0.9

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